Powering Primary Healthcare through Solar in India

Lessons from Chhattisgarh

ADITYA RAMJI, SASMITA PATNAIK, SUNIL MANI, AND HEM H. DHOLAKIA

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COUNCIL ON ENERGY, ENVIRONMENT AND WATER (CEEW)

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Executive Summary

For a long time, the focus of electricity access has been largely at the household level. It is only recently that access to electricity is also being recognised as critical for public services like electricity for health facilities, schools and street lighting. In health facilities, regular electricity access is necessary for deliveries, storage of vaccines, provision of emergency services, supply of clean water, and retention of skilled staff. In India, Primary Health Centres (PHCs) ensure last-mile delivery of healthcare services, that is, at the village level. However, one in every two PHCs in India, and one in every three in Chhattisgarh, is either un-electrified or suffers from irregular power supply. This extent of power deficiency across PHCs could hamper the provision of healthcare services in the country. Still, the impact of access to electricity on healthcare service delivery has rarely been explored in detail in India.

While performing relatively better than India as a whole in terms of electricity access for its PHCs, Chhattisgarh is no different when it comes to health outcomes. Indeed, the infant mortality rate (IMR) in rural Chhattisgarh (43) is higher than that in rural India (41). Although Chhattisgarh is a power-surplus state, only 66% of PHCs have regular power supply. To augment electricity supply at the PHCs, the Chhattisgarh Renewable Energy Development Agency (CREDA), in collaboration with the Chhattisgarh Health Department, installed off-grid solar photo-voltaic (PV) systems of 2 kW each starting in 2012. We carried out an evaluation study to assess the impact of the installation of solar PV systems on improving access to electricity at the PHCs, and thereby improving health service delivery. The evaluation was intended to:

i. Understand the synergy between electricity access and delivery of healthcare services

ii. Evaluate the impact of installed solar PV systems on addressing gaps in access to electricity

iii. Assess the gaps in the transition to higher standards of primary healthcare in Chhattisgarh

A comprehensive questionnaire on health and energy was administered to a total of 147 PHCs (83 solar and 64 non-solar) in 15 districts of Chhattisgarh. The synergy between access to electricity and delivery of healthcare services was explored by classifying the PHCs into two sub-groups: (a) power-deficit PHCs: defined as PHCs with regular power supply of 20 hours or less a day; and (b) non-power-deficit PHCs: defined as PHCs with regular power supply of more than 20 hours a day. Some of the key findings were:

▪ Combined capacity unable to meet needs

About one-third (36%) of all sample PHCs reported that their electricity needs were not met by the available sources of electricity supply. Second, although the duration of power supply in a day averaged about 20.5 hours, the quality of electricity supply differed across districts.

▪ Ability to provide care on demand

About 90% of the PHCs reported undergoing power cuts between 9.00 a.m. and 4.00 p.m., a period during which the PHC functions at its peak capacity. In addition, emergency and delivery services are subject to the need of the patient, and hence require access to electricity on demand. Power cuts in the evenings could significantly affect the ability of PHCs to provide the required service.

▪ Cold chain and newborn care

The ability of a PHC to operate cold chain and newborn care equipment is substantially influenced by its access to regular electricity supply. About 22.4% of power-deficit PHCs currently rely exclusively on solar as a backup to run cold chain equipment. About 21% of power-deficit PHCs do not have solar backup to operate newborn care equipment.

- ## Transition to higher standards of care

About one-third of power-deficit and power non-deficit PHCs reported power cuts in the evening. About 46% of PHCs were in the power-deficit category and without the support of solar PV systems. This affects the ability of PHCs to transition to higher standards of providing 24x7 health services as suggested by the new guidelines of IPHS.

- ## Other needs

Access to regular electricity also enables access to regular water supply for many PHCs. About 37% of the sample PHCs reported that their water supply was adversely affected due to lack of electricity supply. The lack of adequate and quality water supply compromises the ability to provide basic, routine services such as child delivery, and weakens the ability to prevent and control infections (WHO, 2015b).

Significant opportunities exist to simultaneously address the (often competing) goals of energy access, energy security, resource management, and health outcomes. Solar for health is one such opportunity. Chhattisgarh provides evidence to scale this intervention to meet the national targets for both health and energy.

1. Health: The Essential Element of Well-being

It is widely recognised that health and well-being play a vital role in development and poverty reduction. Various studies have reinforced the idea that good health is one of the most valued aspects of well-being and a critical element in the quality of life (Palmore, & Luikart, 1972; Bowling, 1995). Good health also represents instrumental values through the enhancement of opportunities to participate in education, training, and the labour market (Ross, & Wu, 1996; Bloom, Canning, & Sevilla, 2004; Hemp, 2004)

As a consequence, various metrics, including the Human Development Index (HDI) and the Multidimensional Poverty Index (MPI), have some parameters that reflect the status of good health of a community. HDI considers life expectancy, and MPI considers nutrition and child mortality in their respective health indicators. The last MPI calculation (2005–06) suggests that in India health deprivation is the second most important driver of poverty after living standards (UNDP, 2016).

The Sustainable Development Goals (SDGs), apart from setting targets for reduction in maternal and child mortality and other health risks, explicitly state the need for universal health coverage (UHC) as well as recognise the need for an affordable and robust health delivery system (UN, 2016; Reich, et al., 2016). UHC includes financial risk protection, access to quality essential healthcare services, and access to safe, effective, quality, and affordable essential medicines and vaccines for all (WHO, 2016).

In India, about 55% of all households depend on the public health system to meet their healthcare needs. This dependence is higher in rural areas. About 58% of the rural population identifies a government or public health facility as their first point of treatment (DLHS-4, 2013). However, only 37% of people have access to in-patient facilities within a 5-km distance (KPMG- OPPI, 2016). For most people, the PHC at the village level serves as the first point of contact or the first referral unit. Therefore, the effective functioning of PHCs plays an important role in facilitating UHC.

To extend this basic facility to the public, the National Rural Health Mission (NRHM)[1] has adopted a norm of 'time to care' that mandates the setting up of a health facility within 30 minutes of walking distance from habitations in selected districts of hilly and desert areas where access is a problem (MoHFW, 2013). However, the lack of healthcare infrastructure has been a limiting factor in the ability of the system to provide timely and quality care to all those who need it. The poor state of health infrastructure led to India being ranked 143 out of 188 countries in the first global assessment of the SDG health performance published in the *Lancet* in 2016 (Mascarenhas, 2016).

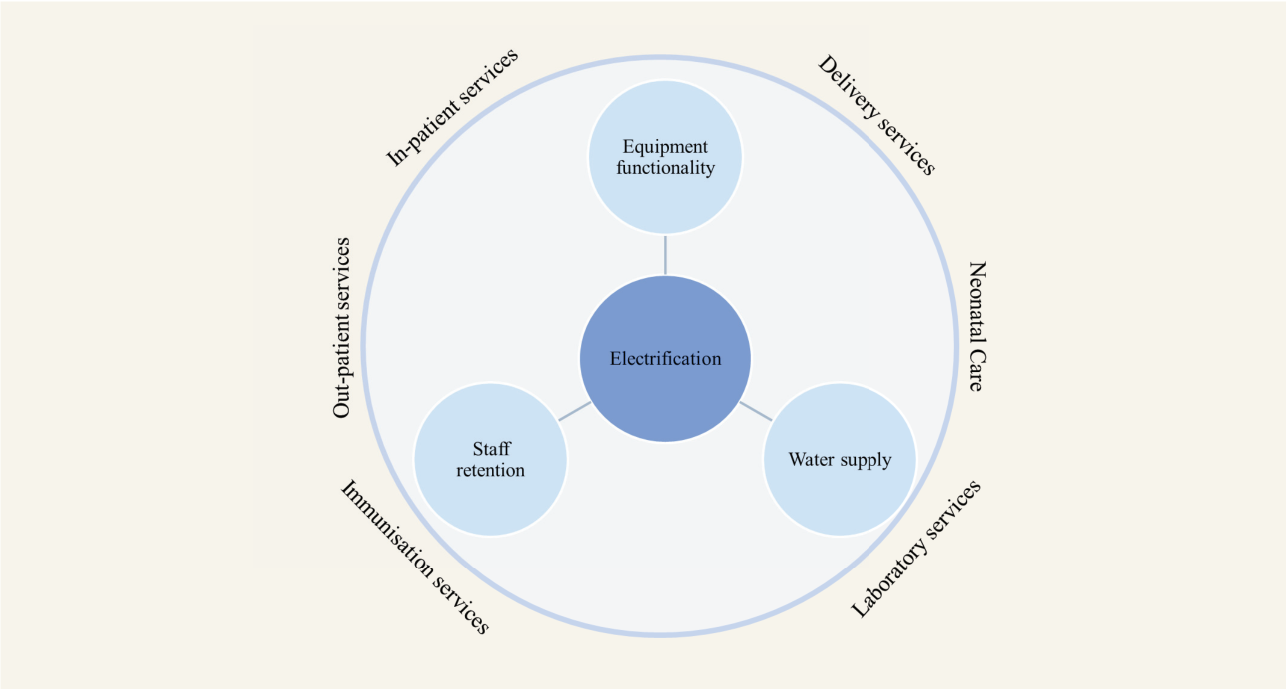
1.1 Electricity as an enabler of health service delivery

Health system infrastructure has conventionally focused on the availability of tangible physical spaces, furniture, and equipment essential for delivery of healthcare services (Chauhan, Mazta, Dhadwal, & Sandhu, 2016). Along with the building and equipment, availability of utility services such as electricity and water is imperative for the functioning of a health facility, and is an important determinant of effective delivery of essential health services (WHO, 2015a). For instance, the use of radiant warmers for newborn care, cold chain

1 The National Rural Health Mission (NRHM), launched by the Government of India in 2005, seeks to provide effective healthcare to the rural population across the country through a robust health delivery system.

storage for vaccines, and nighttime deliveries are all dependent on the availability of reliable power. A recent publication by the WHO and the World Bank maintains that besides improving the direct functionality of health facilities, access to electricity is equally instrumental in attracting and retaining skilled health workers, especially in rural areas (WHO, 2015a).

Figure 1: Electricity access as a critical enabler of health service delivery



Source: *CEEW Analysis, 2017*

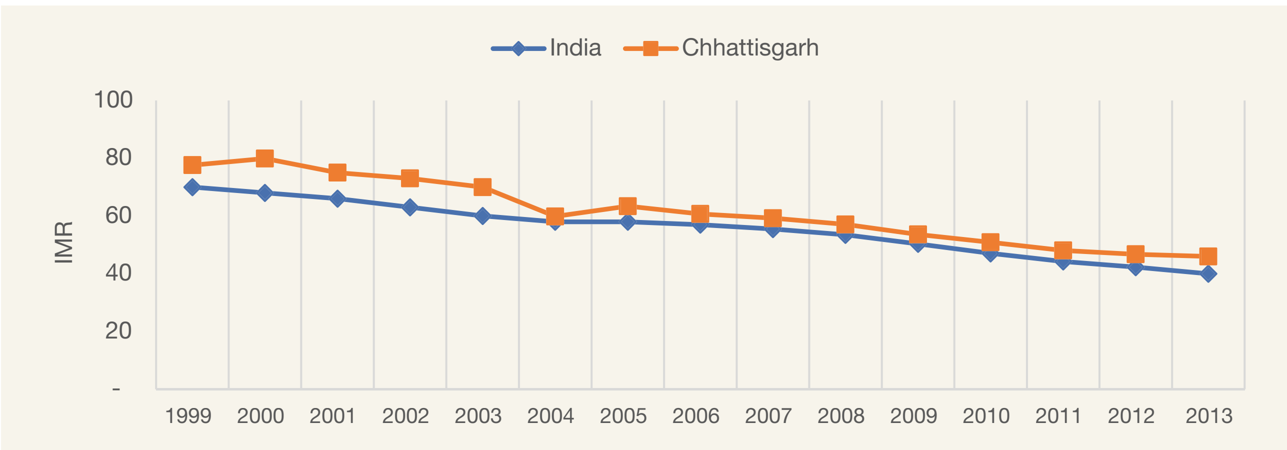
Ensuring reliable and equitable access to electricity, however, remains a compelling challenge for many states in India. According to the Rural Health Statistics 2016, about 4.6% of functional PHCs in India are un-electrified, implying that over 38 million rural households depend on health facilities that have no electricity (CEEW Analysis). The DLHS-4 data indicate that one out of every two PHCs suffers from unreliable power supply or has no electricity access at all. The electrification situation of PHCs across the states reveals significant variation. States like Andhra Pradesh, Bihar, Haryana, and Himachal Pradesh indicate 100% electrification of PHCs, whereas 42.5% of PHCs in Jharkhand and 18% of PHCs in Arunachal Pradesh are un-electrified (RHS, 2016). However, it should be noted that the RHS data only state whether a PHC has a physical electricity connection or not, and do not consider the reliability and quality of electricity supply, which is captured by the DLHS-4 survey to some extent. Despite having no un-electrified PHCs, only 40% of PHCs in Haryana have regular electricity supply, while Telangana has about 57% of such PHCs (DLHS-4, 2013). This results in health facilities having to rely on expensive backup options like diesel generators that have significant cost implications.

2. Chhattisgarh: State of Healthcare and Health Infrastructure

The state of Chhattisgarh was carved out of Madhya Pradesh in 2000. According to the Census 2011, over 76% of its population lives in rural areas. The population and household profile reveals that about 71% of households have electricity, with 14.4% have piped water supply (Galhotra, Padhy, Pal, Giri, & Nagarkar, 2014). As a state with a predominantly rural population, Chhattisgarh faces the challenges of inadequately skilled human resources, poor physical infrastructure, and other supply-side gaps with respect to the delivery of quality healthcare.

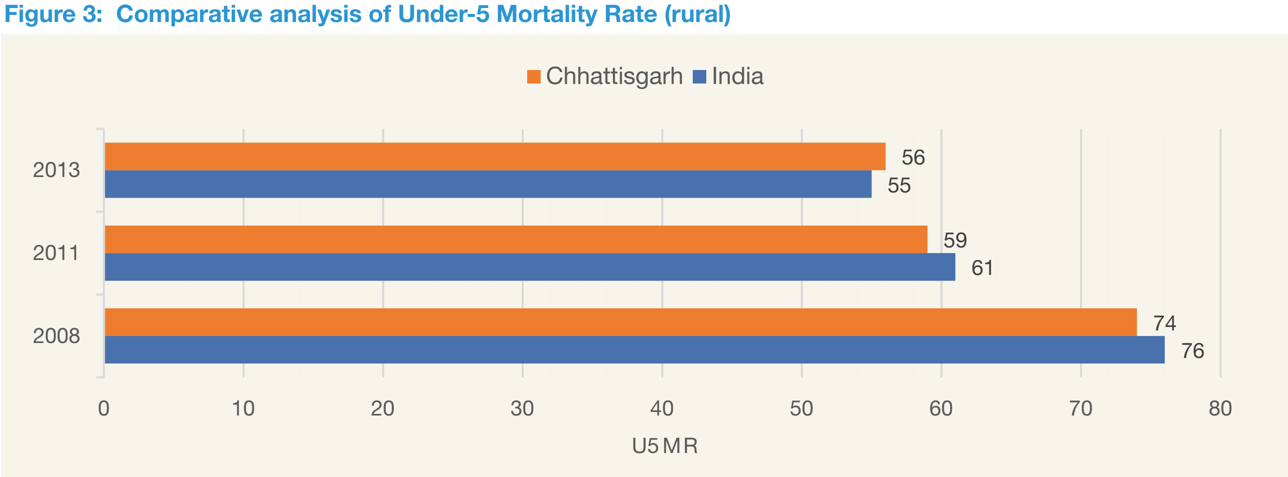
According to the Sample Registration System (SRS) 2016, Chhattisgarh has an IMR of 41 and a death rate of 7.5, both of which are higher than the national average of 37 and 6.5 respectively (SRS, 2016). The latest data on maternal mortality rate (MMR) report a higher figure for Chhattisgarh (221) as compared to the Indian average of 167 (SRS, 2011-13).

Figure 2: Comparative analysis of Infant Mortality Rate (IMR)



Source: *SRS, 2016*

Figure 3: Comparative analysis of Under-5 Mortality Rate (rural)



Source: *SRS, 2016*

As per the latest National Family Health Survey (NFHS)-4, 67 % of the births in rural Chhattisgarh are institutional deliveries. However, less than 20% of women in rural Chhattisgarh received full antenatal care, and less than 9% of home deliveries were conducted by a skilled birth attendant (NFHS-4, 2015-16).

2.1 State of infrastructure in Primary Health Centres

Chhattisgarh has 790 functioning PHCs, of which about 81.5% operate in government buildings (RHS, 2016). However, only about 57% of the PHCs function on a 24x7 basis (DLHS-4, 2013).

Only 26.7% of the PHCs conducted at least 10 deliveries in the month preceding the survey, and about 19.5% of the PHCs in Chhattisgarh had a functional vehicle to transport patients (DLHS-4, 2013). The state also faces an acute shortage of doctors across PHCs, with over 55.7% of the sanctioned positions lying vacant as of 2016 (RHS, 2016). As per DLHS- 4, more than half of the PHCs surveyed did not have a Medical Officer in position, while only 44% of the PHCs had a residential quarter for the Medical Officer (DLHS-4, 2013).

As discussed earlier, one of the key enablers of healthcare delivery is the availability of electricity. Almost 7.2% of the PHCs in Chhattisgarh have no access to electricity, in comparison to the national average of 4.6% (RHS, 2016). Furthermore, no district reported 100% regular power supply for PHCs (DLHS-4, 2013). As per DLHS-4, about one-third of the PHCs in Chhattisgarh are either un-electrified or without regular power supply. Of those without regular supply, 63% did not have a generator facility available with them.

To address the problem of electricity access, various innovative and decentralised solutions have been deployed, including those based on renewable energy technologies, particularly solar. Such solutions not only offer a reliable source of electricity for a fixed duration, but also provide the co-benefits of a clean source of energy as compared to diesel generators, thus presenting a low-carbon option for the healthcare system. Solar-based solutions for electricity access are not only a cleaner source of electricity, but also make an economic case for their adoption, with the cost of solar power being lower than that of a unit of electricity from diesel.

2.2 Solar as an opportunity

Solar energy has the potential to provide energy access to communities in rural and resource-constrained settings. In the current context, solar energy could play a vital role as an enabler of healthcare delivery in areas that have no or inadequate access to grid power. It can compensate for lack of regular power supply and enable uninterrupted provision of health services. Solar rooftop systems can meet the needs of lighting, refrigeration, water pumping, and, in many cases, permit the use of advanced medical equipment in health facilities. Solar-powered refrigerators are also popular for vaccine and blood storage (WHO, 2015a). CEEW's analysis estimates that rooftop solar systems of 5kWp capacity could meet 70% or more of the peak power requirement in PHCs (Agrawal, Ramji, & Dholakia, 2016). Solar power can also compensate for fluctuations in voltage that affect the working and life of medical equipment (UNICEF and UNIDO, 2016). Gradual reduction in the price of solar energy technologies has made it affordable for facilities to maintain and operate solar PV systems.

Some states in India, including Chhattisgarh, Maharashtra, and Tripura, have already deployed solar PV systems to power PHCs and sub-divisional as well as district hospitals. The challenges in expanding solar energy in healthcare arise from the need to allocate limited resources for other infrastructural needs and from the lack of adequate recognition of the opportunities for solar-based electrification of PHCs. However, the current situation also provides unprecedented scope for solar energy to bridge the gaps in electricity access in healthcare facilities.

2.3 Evaluation of solar PV rooftop systems in Primary Health Centres

To improve access to electricity at PHCs, the Government of Chhattisgarh, through CREDA, installed 2 kWp off-grid solar PV rooftop systems across 570 PHCs in the state between the years 2012 and 2016. However, while this and similar other interventions have been implemented, there has been very limited or no documentation of the details of the intervention design nor has an evaluation been conducted to understand the impact of improved electricity access on healthcare services. The lessons learnt from such interventions will play an important role in ensuring coherent policy planning for electrification of PHCs and, at the same time, will also provide key insights for other state governments interested in replicating similar projects. Further, such an evaluation will also help in the better allocation of resources for a phase-wise implementation plan under the yearly Programme Implementation Plan (PIP) of the National Health Mission, both at the central and state levels.

This study has the following aims:

1. Understand the synergy between electricity access and delivery of healthcare services
2. Evaluate the impact of installed solar PV systems in addressing gaps in access to electricity
3. Assess the gaps in transition to higher standards of primary healthcare in Chhattisgarh

Box 1: The solar PHC programme in Chhattisgarh: The genesis

WHY?

Primary Health Centres (PHCs) in remote areas of Chhattisgarh faced serious difficulties in gaining access to reliable electricity which significantly affected their ability to provide quality healthcare services to the dependent population. While officials at the National Health Mission (NHM) in Chhattisgarh were grappling with these challenges, the Chhattisgarh Renewable Energy Development Agency (CREDA) was already addressing the issues of access to electricity in tribal ashrams, hostels, and schools in remote areas of the state.

HOW?

Various interactions during state-level meetings or events allowed both the State NHM and CREDA to learn about each other's work and the challenges they faced, leading to the genesis of the idea of installing solar PV systems at PHCs that lacked access to reliable electricity.

INTERVENTION

The initial objective of NHM was to install solar PV systems to provide power for basic lighting at PHCs. However, CREDA returned with a comprehensive proposal for a system design that could support cold chain and other basic equipment along with lighting. This was welcomed by NHM, and in consultation with district-level NHM officials, PHCs that could benefit the most from such an intervention were identified. The service conditions of the proposal specified that CREDA would be responsible for the operation and maintenance of the systems and the solar systems would have a guaranteed warranty period of five years. These conditions were instrumental in influencing the decision to install solar PV systems at PHCs. The first installations took place in 2011–12, followed by further consultations leading to the subsequent expansion and installation of solar PV systems in PHCs across all districts of Chhattisgarh. Funds for this intervention were allocated under the PIP of the State NHM between 2011 and 2013.

This initiative has been included among NHM's best practices and innovations, and has been recognised for improving the quality of healthcare service provided at PHCs through better access to electricity. It is also a noteworthy example of inter-departmental collaboration enabling optimal outcomes, thereby ensuring significant benefits for citizens.

3. Research Methodology and Sampling Design

3.1 Research methodology

To assess the impact of electricity on the delivery of healthcare services, it is essential to understand the current state of electricity access across PHCs, the range of services provided by them, and how improved access to electricity (in this case, through solar) can lead to positive healthcare outcomes. Further, the existing status of electricity access is to be evaluated in light of its reliability, availability, quality, and affordability, among other parameters, such that all the essential services being provided by a PHC are delivered without any hindrance or delay.

The study relies on a combination of research tools to assess each of the above-mentioned dimensions of access to electricity and provision of healthcare service delivery in PHCs. To begin with, a detailed literature review was undertaken to understand the nature of essential health services provided by the primary healthcare system in India, and the constraints faced by the system in delivering the same. The literature review also helped in setting the context for this study.

3.2 Questionnaire design

Based on the insights from the literature review and discussions with sector experts on public health and energy, it was decided to carry out a primary survey. The questionnaire included questions on both quantitative and qualitative aspects in order to capture essential information on the following: (i) range of services provided by the PHC; (ii) current state of electricity supply along with power backup options; (iii) availability of essential equipment to provide essential healthcare services; (iv) availability of manpower at the PHC; (v) perception of the staff regarding the importance of electricity in delivering various healthcare services; (vi) the contribution of power backup alternatives, including solar PV systems (if any), in improving access to electricity; and (vii) the nature of benefits provided by the solar PV system in a PHC (if installed). The questionnaire was administered to the Medical Officers (if available) or to any other health professional in-charge of the PHC at the time this survey was conducted.

The questionnaire was predominantly quantitative, but also included a few qualitative questions to capture the experience of Medical Officers in PHCs with solar PV systems, and to understand the impact of electricity on the delivery of healthcare services at PHCs, if any.

3.3 Analysis

At the time the study was conceptualised, there existed no baseline data with regard to the state of electricity access across PHCs or the level of health service delivery, thus making it difficult to carry out a pre- and post-intervention analysis. Given that there was no baseline study carried out prior to the intervention, the sampling strategy involved dividing the sample almost equally across PHCs with solar PV systems and PHCs without solar to capture the difference between such PHCs in terms of their state of electricity access and the impact of electricity access on health service delivery.

At the same time, this evaluation has been placed within the larger context of electricity access and its various dimensions, thus leading to a more holistic consideration of the existing sources of electricity in a PHC (grid and other power backup options), and of their role as an energy system in enabling the functioning of a PHC. The evaluation also contextualises electricity within the domain of infrastructure, the scope of definition of which did not give sufficient importance to electricity access and water supply in ensuring quality health service delivery.

The overall frame of analysis thus evaluates the existing sources of electricity supply in a PHC, the availability of services, the differences in the quality of delivery of healthcare services, if any, and the correlation of these differences to the provision of solar PV systems (wherever possible).

3.4 Limitations of the study

Despite the best intended efforts, lack of availability of baseline data imposes some limitations on the methodological approach undertaken for the study. Further, health as a subject does not have a linear relationship with any single input, and most often is influenced by a combination of multiple factors, such as availability of skilled manpower, availability of equipment, accessibility of the PHC by road, and disease profile of the region. To attribute all differences in performance to a single variable, for example, access to electricity, means failing to acknowledge the larger context. Hence, the study can only highlight the importance of electricity access for quality health service delivery, but does not go as far as identifying or stating any specific relations. This evaluation has relied on correlations rather than causations for the purpose of drawing inferences from the data collected.

Some other limitations and considerations of the study are:

i. The average number of out-patients, deliveries, immunisations, etc. could be a function of time and some other specific drivers such as government schemes and targeted programmes, all of which the survey may not have adequately captured due to lack of available data.

ii. Overall inferences may have been influenced by some district-level factors such as administrative efficacy and risk of conflict due to left-wing extremism, which have not been accounted for in the study.

iii. For the statistical analysis of the test of proportions, the time effect is absent, since all the data was collected at the same point of time and the intervention was also carried out within a short period across the solar PHCs.

iv. Although an attempt was made to cover an equal number of PHCs with and without solar PV systems in each district, in some cases the sample sizes are different. This was due to the lack of availability of an adequate number of PHCs without solar PV systems or logistical difficulties in accessing some PHCs.

3.5 Sampling strategy

A complete list of PHCs was obtained from the State Health Mission of Chhattisgarh. The list of 570 PHCs that were solar electrified as of October 2016 was provided by CREDA. A two-stage stratified random sampling approach was adopted to select the PHCs to be surveyed.

The stratified random sampling approach involved two stages:

1. In the first stage (Stage I), a sample set of districts was selected on the basis of certain health indicators to ensure that they are representative of the state

2. In the second stage (Stage II), a sample set of solar and non-solar PHCs was chosen based on a random sampling from each of the sampled districts

For Stage I, the most recent district-level data sets available for Chhattisgarh, namely the District Level Household & Facility Survey (DLHS)-4, the Annual Health Survey (AHS) 2012–13, and the National Cold Chain and Vaccine Management Resource Centre (NCCVMRC) database, were used. The period covered by these surveys was prior to the installation of solar panels in PHCs in Chhattisgarh.

A major problem in stratifying the districts was that in the duration between the administration of the DLHS survey and the present, Chhattisgarh was further divided into 27 districts as compared to the 16 districts earlier. The DLHS-4 and the AHS (2012–13) had data only for the 16 districts (according to the old administrative division). Given that the intervention of solar PHCs was done across the new administrative divisions, the DLHS and AHS data had to be reconciled to the 27 districts to allow for effective stratification and sampling. However, since no new district-level information was available with regard to the 11 new districts, the best possible and most statistically sound method of reconciling the data was to assume that the new districts would have the same health indicators as their parent districts, given that these regions were also covered as part of the DLHS round. Given that the DLHS-4 and AHS data were collected prior to the solar PHC intervention, this method ensured that the choice of health indicators for sampling (on the basis of which the districts would be stratified) would be independent of the intervention.

The specific health indicators used for stratification were restricted to a subset of health indicators that would be measurable in the short term. The choice of using IMR and MMR as variables was avoided because changes in these variables are observed over significantly longer periods of time, and are affected by a host of other factors as well. Thus, the sampled districts have been stratified based on indicators that would possibly see greater short-term effects due to the enhanced functionality of the PHC, resulting from improved electricity access due to the solar intervention.

Based on this rationale, four district-level health indicators were identified: (i) average number of OPD (out-patient department) patients visiting the PHC each month; (ii) average number of deliveries in the PHC each month; (iii) percentage of fully immunised children (based on the eligible population identified under the National Health Mission (NHM); and (iv) share of PHCs that are functional cold chain points (CCPs) as a proportion of the total number of CCPs in that district. The data for these indicators were obtained from the DLHS-4 survey, the AHS (2012–13), and the NCCVMRC database.[2]

All of these indicators were then combined to form an overall health index for ranking the districts. To create the index, a normalisation technique called Feature Scaling (or Min-Max Scaling)[3] was used. Finally, an average Index Value (IV)[4] was constructed taking a simple average of all the four individual parameter index values such that the score would range between 0 and 1. The average IV was used as the stratification criterion for choosing the sample districts.

A higher average IV indicates that the district is doing better across the four parameters together. A much better insight can be obtained when districts are arranged according to their average IV in ascending order (Table 1). Based on the analysis, Kawardha district with an average IV of 0.89 was ranked the highest, while Durg district with an average IV of 0.22 was ranked the lowest. Using the average IV, districts were arranged in three categories, with the cut-off for each category being defined as the 33rd and 66th percentile of the range of the IV. Thus, the three categories were: (i) Category 1 if the average IV ranged between 0 and 0.36; (ii) Category 2 if the average IV ranged between 0.36 and 0.47; and (iii) Category 3 if the average IV ranged between 0.47 and 1.[5]

2 Summary statistics for all the sampling variables have been included as Annexure I.
3 Min-Max scaling
4 Normalised Index Values (IV) for all the districts have been included as Annexure II.
5 Category 1 if 0 $\leq$ Average IV < 0.37; Category 2 if 0.37 < Average IV < 0.48; Category 3 if 0.48 $\leq$ Average IV $\leq$ 1 (values have been taken up to four decimal points to ensure accuracy)

Table 1: District-wise average IV and category classification

S. No.	District	Average Index Value (IV)	Category
1	Durg	0.22	1
2	Bilaspur	0.23	1
3	Mungeli	0.28	1
4	Jashpur	0.29	1
5	Bemetera	0.32	1
6	Janjgir-Champa	0.32	1
7	Balod	0.32	1
8	Gariaband	0.35	1
9	Bijapur	0.36	1
10	Dantewada	0.38	2
11	Surajpur	0.41	2
12	Sukma	0.43	2
13	Surguja	0.44	2
14	Balrampur	0.45	2
15	Raigarh	0.45	2
16	Balodabazar	0.46	2
17	Narayanpur	0.46	2
18	Kanker	0.47	2
19	Koriya	0.48	3
20	Raipur	0.48	3
21	Bastar	0.48	3
22	Kondagaon	0.56	3
23	Rajnandgaon	0.59	3
24	Dhamtari	0.60	3
25	Mahasamund	0.64	3
26	Korba	0.74	3
27	Kawardha	0.90	3

Source: CEEW Analysis, 2017

Based on calculations from the sampling exercise, we randomly sampled a total of 15 districts across the three categories.

For Stage II of the sampling, five solar and non-solar PHCs each were selected in each district using simple random sampling. However, certain districts did not have the requisite number of five solar and five non-solar PHCs. For example, Narayanpur district has a total of eight PHCs (four solar and four non-solar). Similarly, Bijapur district has only four non-solar PHCs. In such cases, the additional requirement of the sample was selected from the sampled districts that had the average IV closest to that of the district in question.

Table 2: List of sampled districts with number of sampled solar and non-solar PHCs

District	Number of solar PHCs	Number of non-solar PHCs	Total number of PHCs
Bastar	7	3	10
Bijapur	4	3	7
Durg	5	5	10
Gariaband	8	4	12
Janjgir-Champa	5	5	10
Jashpur	5	5	10
Kawardha	5	5	10
Kondagaon	5	5	10
Koriya	5	5	10
Narayanpur	4	2	6
Raigarh	6	7	13
Rajnandgaon	6	4	10
Sukma	7	3	10
Surajpur	5	5	10
Surguja	6	3	9
Total	**83**	**64**	**147**

Source: CREDA 2016; CEEW Analysis, 2017

4. Analysing Electricity Access and Its Impact on Healthcare Services in PHCs in Chhattisgarh

4.1 Understanding overall healthcare provisions and electricity access

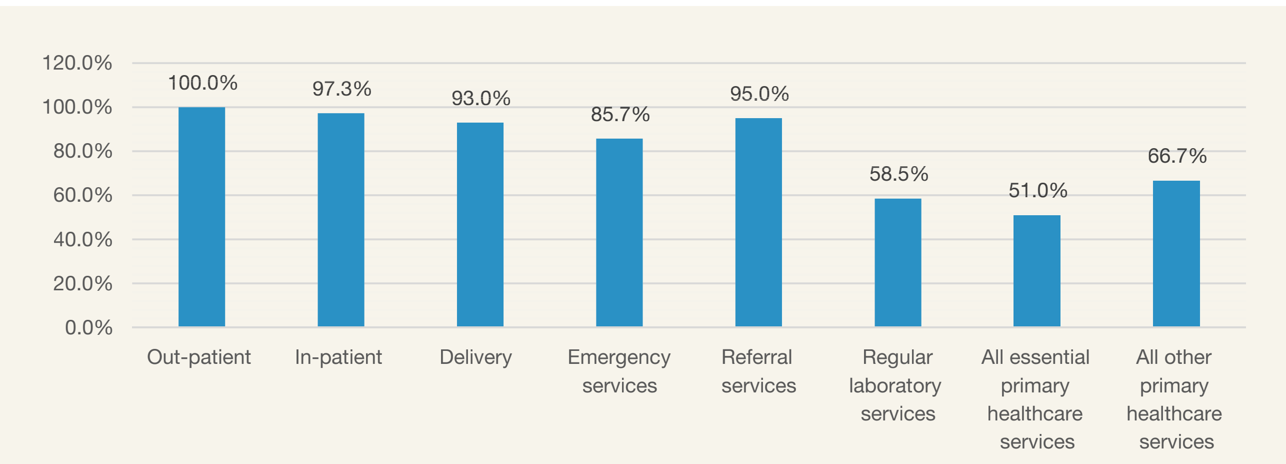
While the objective of this evaluation is to understand the impact of improved electricity access on primary health services, it is important to set the context in terms of the state of health services and infrastructure. The primary aim of any health system is to ensure effective and quality care at the time of need, and therefore access to electricity is important, but only as an enabler of these services. It cannot have an impact in isolation, without sufficient equipment, other infrastructure, and manpower.

The following sections provide an overview of the state of healthcare infrastructure and the level of services (both healthcare and electricity) available based on the data from the sample survey of PHCs across 15 districts in Chhattisgarh. The analysis uses the IPHS guidelines as a reference for the overall situational analysis of PHCs in Chhattisgarh.

4.1.1 Type of services provided

Essential primary healthcare services include out-patients (OPD), in-patients (IPD), emergency care, referral care, laboratory services, and delivery services.

Figure 4: Proportion of PHCs by type of services provided

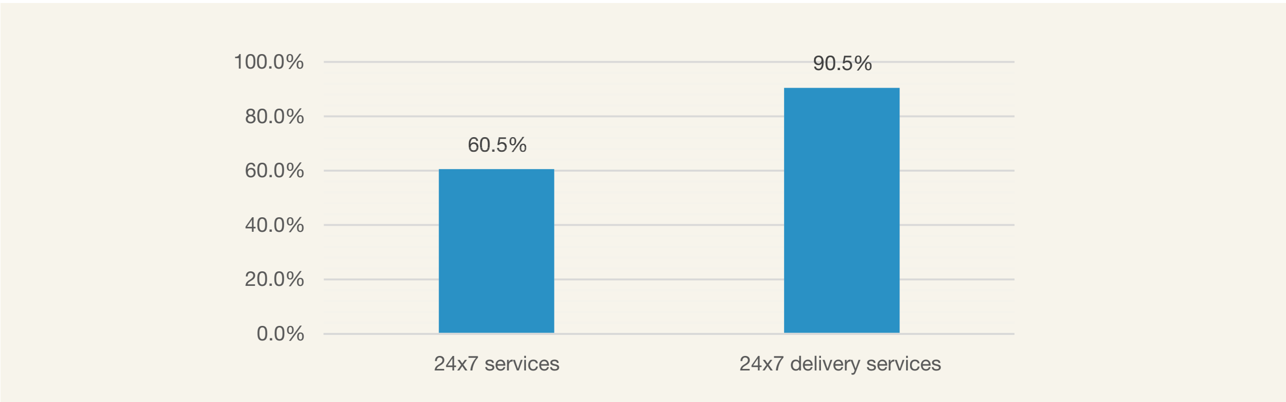


Source: *CEEW Analysis, 2017*

All the PHCs in the sample provide OPD services. However, about 49% of the total PHCs do not provide *all essential primary healthcare services,* mainly due to the lack of laboratory services. If laboratory services were to be excluded, then almost 80% of the PHCs would provide all essential services. About 67% of the PHCs provide other primary health services such as primary management of wounds, fractures, and burns.

While the number of PHCs in a particular area is defined by a population metric, very often the case load is disproportionate, either due to poor services in a particular PHC or because of difficulty in accessibility, which results in people going to other PHCs or health facilities to avail healthcare services. To provide access to quality and timely care for the population, especially in cases where the Community Health Centre (CHC) or the District Hospital is over an hour away or is not easily accessible, IPHS recommends that PHCs should become functional round-the-clock, with the provision of 24x7 nursing facilities. Such PHCs (when the CHC is over an hour away) should also provide 24x7 emergency care (IPHS, 2012). Of the sample PHCs in Chhattisgarh, 60% reported providing 24x7 services.

Figure 5: Proportion of PHCs providing 24x7 services

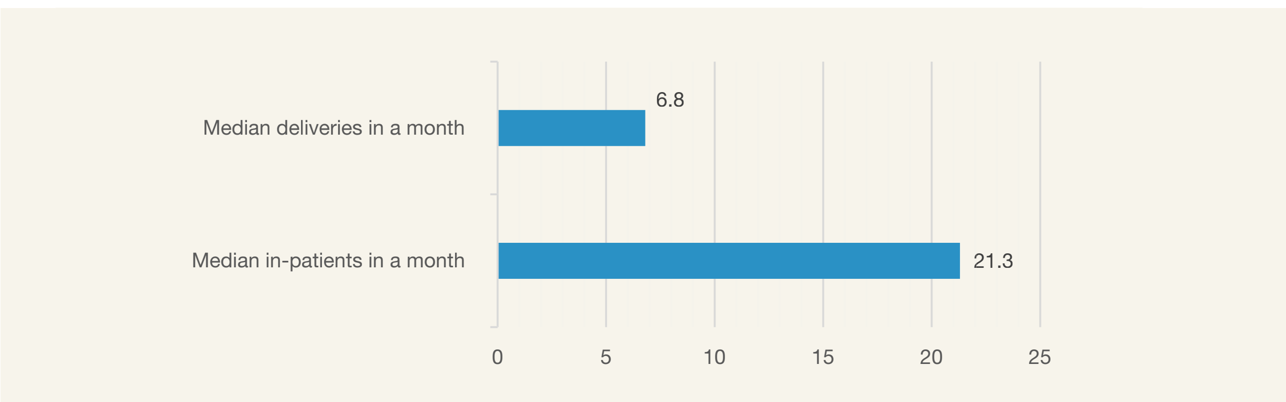


Source: *CEEW Analysis, 2017*

4.1.2 Patient statistics

The median number of out-patients catered to by the PHCs in Chhattisgarh is 537, as compared to an all-India median of 599 (DLHS-4, 2013). The median number of in-patients in a month across all PHCs in Chhattisgarh is 21.3, as compared to the national median of 5. Chhattisgarh also performs better than the national median of 4 deliveries per month. The higher figures indicate the extent of dependency on the public healthcare system and the importance of ensuring its effective functionality.

Figure 6: Performance of PHCs (July to December 2016)



Source: *CEEW Analysis, 2017*

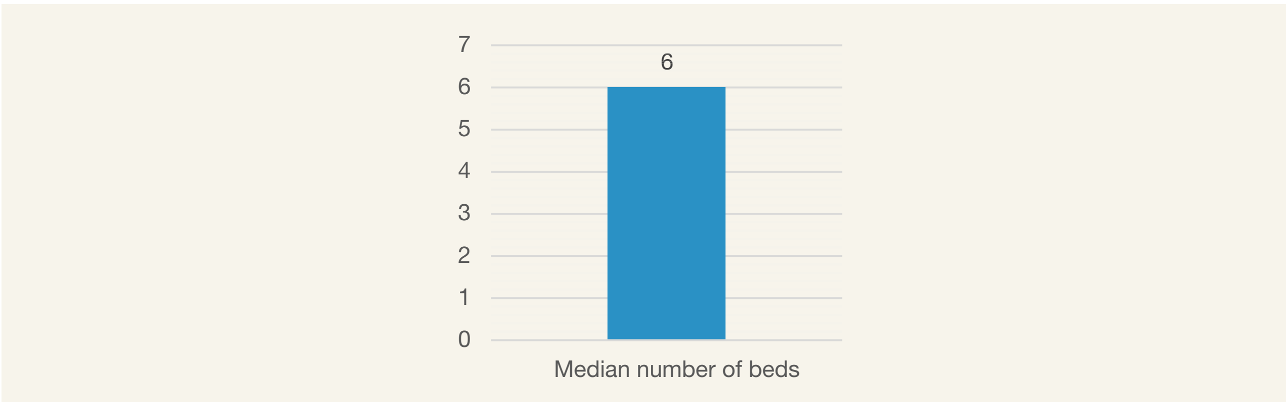
4.1.3 Infrastructure

The quality of services provided at a PHC is strongly linked to the availability of infrastructure. The physical infrastructure of public healthcare facilities broadly includes the state of the buildings, water supply, electricity, and communications technology, the quality of access roads, and the availability of equipment (both medical and non-medical) in working condition (Mbatha & Lutge, 2007). The non-physical infrastructure, although equally critical, includes the availability of adequate manpower. Ensuring the availability of both physical and non-physical infrastructure is essential to providing quality healthcare services.

4.1.3.1 Bed availability

The number of beds available varied both across as well as within districts. The IPHS standards recommend at least four to six beds in a PHC, a criterion that most PHCs report fulfilling, with the median number of beds available being six.

Figure 7: PHCs by median number of beds available



Source: *CEEW Analysis, 2017*

4.1.3.2 Cold chain and neonatal care

Cold chain and neonatal care equipment plays a critical role in improving health outcomes. Incomplete immunisation coverage has a significant impact on the incidence of preventable illnesses and mortality in both developing and developed countries (Figueiredo, et al., 2016). NRHM recommends that all vaccines in facilities below the district level should be stored in an ice-lined refrigerator (ILR).

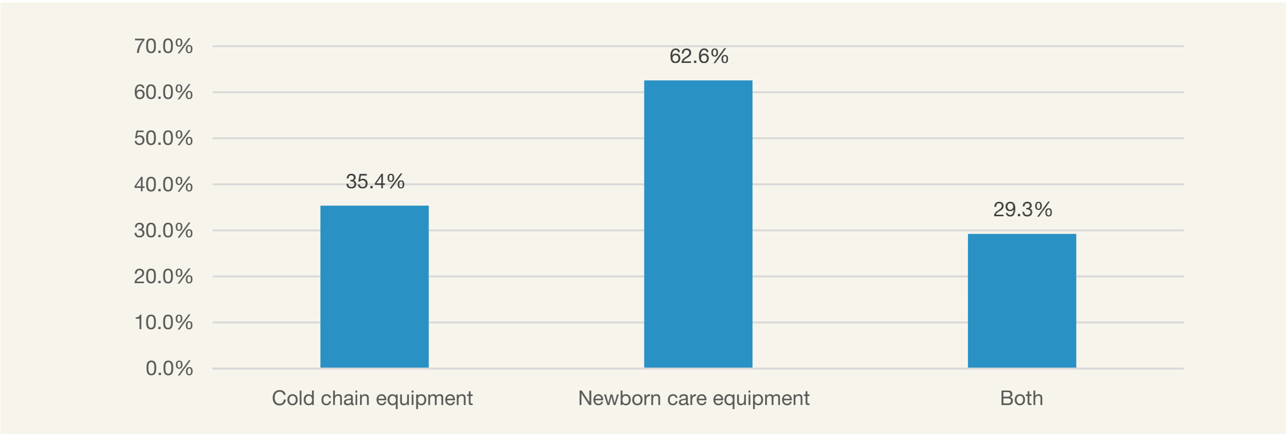
The NCCVMRC[6] database reveals that about 379 PHCs in Chhattisgarh are CCPs. According to RHS (2016), the total number of functional PHCs in Chhattisgarh is 790, which means that only about 48% of the PHCs in the state are CCPs. The National Cold Chain Management Information System (NCCMIS) data also show that about 10% of the primary-level CCPs in Chhattisgarh are non-functional. Further analysis indicates that the non-functional CCPs are concentrated in districts like Bastar, Rajnandgaon, and Bilaspur.

Neonatal care is aimed at reducing the number of neonatal deaths from various causes like sickness, premature birth, and low birth weight. About half of all neonatal deaths in India occur because of prematurity and low birth weight (Saha, 2016).

6 The Ministry of Health and Family Welfare (MoHFW) set up the National Cold Chain and Vaccine Management Resource Centre (NCCVMRC). The objective of the NCCVMRC is to facilitate the establishment of a high-quality, effective, and efficient immunisation supply chain in India to ensure universal immunisation coverage through safe and potent vaccines.

The neonatal mortality rate in rural Chhattisgarh in 2012–13 was 34 (AHS, 2012-13) as compared to the national average of 30 (World Bank, 2013), and the OECD average between 1 and 3 (World Bank, 2013). Equipment such as radiant warmers and incubators plays an important role in reducing neonatal mortality.

Figure 8: Proportion of PHCs with critical equipment



Source: *CEEW Analysis, 2017*

Newborn care equipment includes radiant warmer or incubator
Cold chain equipment includes deep freezer and ice-lined refrigerator

While 63% of all PHCs have an incubator or radiant warmer, only 35% have a deep freezer and ILR (Figure 8). This is in contrast to the all-India average of 63% PHCs having cold chain equipment and 46% PHCs having functional radiant warmers (DLHS-4, 2013).

About a quarter (25%) of all PHCs in Chhattisgarh have both cold chain and newborn care equipment as compared to the all-India average of 40%. The proportion of PHCs with both cold chain and newborn care equipment needs to be increased if the combined need for neonatal care and full immunisation is to be met.

4.1.3.3 Other equipment

Table 3 shows the proportion of PHCs across all districts with other necessary and desirable equipment.

Table 3: Proportion of PHCs by type of equipment

Equipment	Essential or desirable as per IPHS	Proportion of PHCs (in %)
Steriliser	Essential	72.1
Autoclave	Essential	48.3
Suction machine	Essential	77.5
Centrifuge	Desirable	38.8
Light microscope	Essential	57.8
Electric water pump	Desirable	70.0
Water filtration machine	Desirable	61.9

Source: *CEEW Analysis, 2017*

4.1.3.4 Manpower

Availability of trained manpower is critical to providing the necessary healthcare services and to maintaining the required quality of care. RHS 2016 reveals that about 56% of the sanctioned positions for doctors in PHCs were vacant in Chhattisgarh.

Yet human resources account for more than 50% of the overall operating costs of PHCs (Prinja, et al., 2016). Table 4 highlights the shortage of key staff across the sample PHCs in Chhattisgarh. About 75% of all the PHCs in Chhattisgarh do not have a full-time doctor, and almost 35% have no staff nurse. This situation of understaffing can have implications for the quality of service provided by PHCs.

Table 4: Proportion of PHCs by availability of key manpower

Manpower	Proportion of PHCs (in %)
At least one Doctor - MBBS	25.1
At least one Staff Nurse	65.3
At least one Pharmacist	72.0
At least one LHV	49.7
At least one Lab Technician	51.7

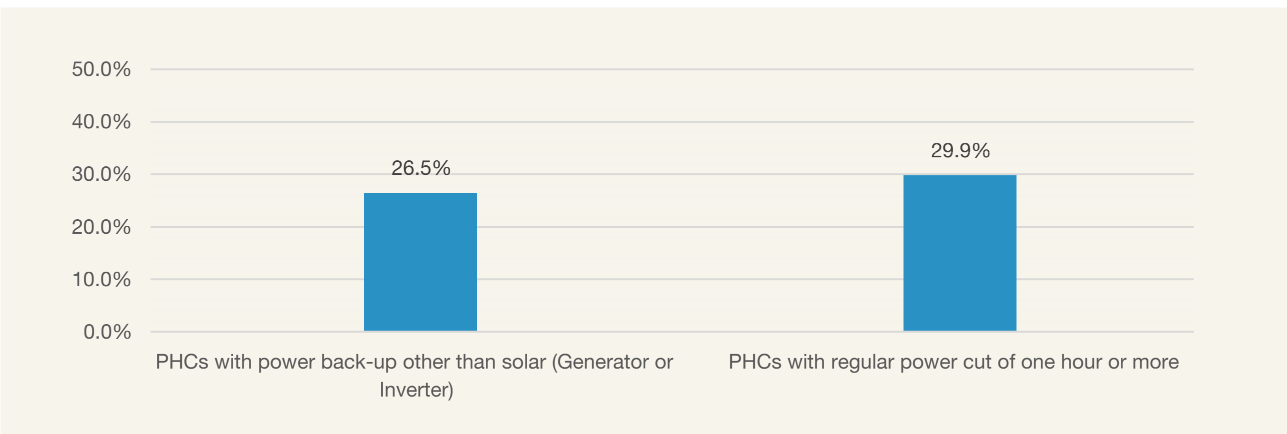
Source: *CEEW Analysis, 2017*

4.1.3.5 Quality of electricity access

This section analyses the duration of power supply along with the frequency of power cuts and the availability of backup options (generator set or inverter) at the PHCs. For the purpose of this analysis, only power cuts of an hour or more were considered, as it was found that power cuts of shorter duration were not a significant barrier to the delivery of services (WHO, 2015a). The objective was to focus on PHCs facing power cuts of longer duration that could significantly affect the ability of the staff to provide the required healthcare service.

The data revealed that of the total 147 PHCs surveyed, 134 were connected to the grid, which means that about 9% of the sample PHCs were un-electrified, a figure that is closer to the RHS 2016 data, indicating that 7.2% of the PHCs were without electricity supply. Some of the non-electrified PHCs had taken temporary or short-term illegal connections to meet their electricity needs. The average duration of power supply from the grid across all PHCs was 20.5 hours per day. About 13.4% of the grid-connected PHCs received an average power supply of less than 18 hours a day. The median duration of a power cut was about 2.25 hours, with the power cuts occurring mostly in the peak functioning hours of the PHC, that is, between 9.00 a.m. and 5.00 p.m. About 55% of the PHCs that are connected to the grid reported power cuts between 12.00 p.m. and 4.00 p.m., while about 32% of the PHCs reported power cuts between 9.00 a.m. and 12.00 p.m. Thus, even though the duration of the average supply of the grid is about 20 hours, the incidence of power cuts during the peak functioning time of the PHC, given that out-patient services are provided only in the day, is a barrier to the effective delivery of quality healthcare services.

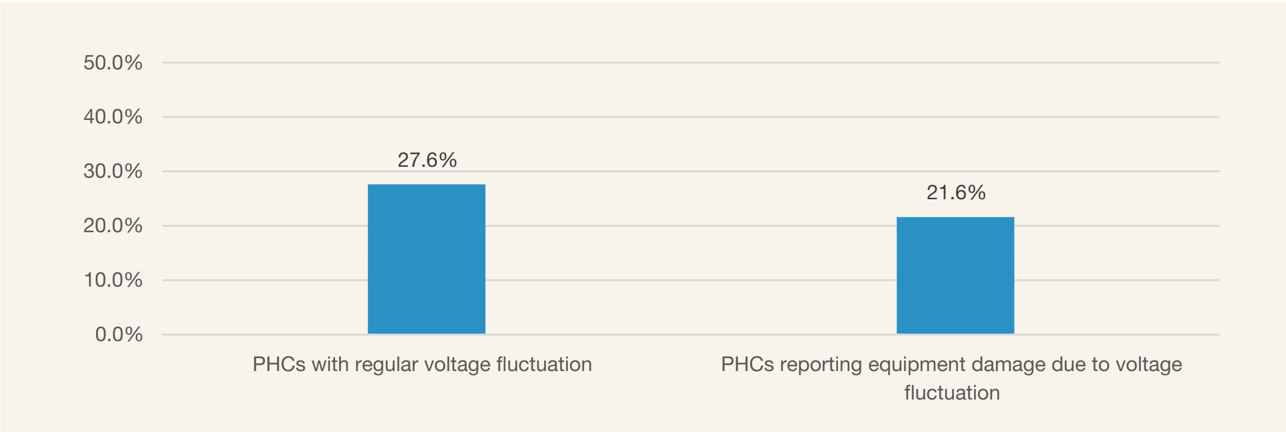
Figure 9: Proportion of PHCs by backup and incidence of power cuts



Source: *CEEW Analysis, 2017*

Voltage fluctuation can affect the functioning of critical equipment and sometimes also cause damage. About 28% of PHCs reported regular voltage fluctuations. Almost 22% of PHCs reported having suffered equipment damage due to voltage fluctuation (Figure 10). Damage to equipment due to voltage fluctuation creates an additional burden on the healthcare system in terms of cost, as this equipment has to be either repaired or replaced. Further, it also adds to the social health cost, as non-functionality of equipment could lead to a delay in the delivery of healthcare services.

Figure 10: Proportion of PHCs by incidence of voltage fluctuation and equipment damage

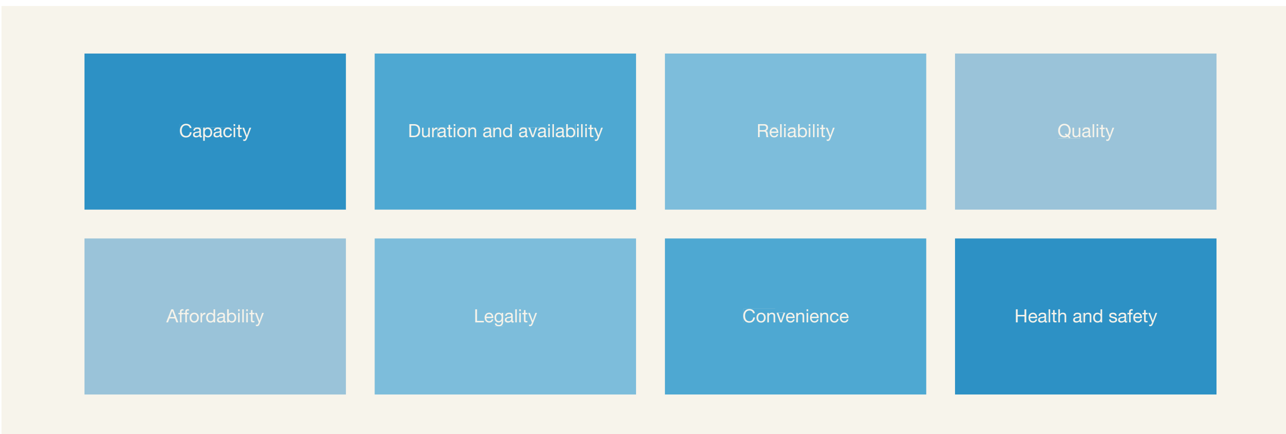


Source: *CEEW Analysis, 2017*

5. Understanding the Synergy between Electricity Access and Healthcare Service Delivery across PHCs in Chhattisgarh

As stated in Section 4.1.3, electricity access is not only about having a physical electricity connection, but is also about the availability of electricity at the time of need and of the electricity being of an acceptable quality. The recognition of the multidimensional nature of electricity access is essential to ensure that the benefit of every rupee spent on electricity services is maximised from a societal perspective. This means that, *ceteris paribus*, there is a higher probability of receiving quality health services given an assured level of electricity service and supply. The proposed multidimensional approach to electricity access has been adopted from the World Bank framework (Figure 11). The approach calls for a comprehensive understanding of electricity access that extends beyond connectivity to include quality, reliability, affordability, and so on.

Figure 11: Multidimensional aspects of electricity access



Source: *Capturing the multidimensionality of electricity access (World Bank/ESMAP, 2014/16)*

Eight dimensions have been used to understand, define, and measure electricity access. These are capacity, duration and availability, reliability, quality, affordability, legality, convenience, and health and safety (Table 5).

Table 5: Multidimensionality of electricity access

Aspects of multidimensionality	
Capacity	Capacity is defined as the peak load that can be connected to the given electricity connection. It determines the level of services that can be used by a PHC. Even though the capacity depends on the kind of services provided by the PHC, it usually ranges from 6 kW to 10 kW for a typical PHC.
Duration and availability	IPHS guidelines call for all PHCs to move towards the provision of 24x7 services. For a PHC to run 24x7, it would need to have 24x7 power supply. However, even for a PHC that is not a 24x7 PHC, the minimum requirement is access to electricity throughout its daytime functioning hours.
Reliability	Reliability means certainty of power supply at a PHC at any given time. Predictable power supply enables the staff of the facility to make informed decisions around power backup and to envisage any impact on services.
Quality	The quality of power supply accounts for voltage fluctuation. High-quality power supply would have no or minimal voltage fluctuation. This factor becomes significant in light of equipment damage resulting from voltage fluctuation.
Affordability	The final cost of electricity should be affordable for the user, whether it is a household or a public institution such as a PHC. In addition, in the absence of adequate power supply from the grid, backup options should be equally affordable. Affordability may be gauged by the proportion of the monthly budget spent on meeting electricity needs or by comparing per unit cost of electricity from different sources.
Legality	Legal connections enable the user to demand better electricity services. This has important implications for the overall supply and reliability of the power generation system. A legal connection will not only provide permanent access to electricity for a PHC, but will also significantly influence the quality and reliability of the supply.
Convenience	The source of electricity, whether from the grid or from the power backup, should be convenient to access and to use.
Health and safety	The source of energy has an impact on the health of the user in particular and on the environment in general. Given increasing concerns about rapid climate change and rising air pollution, there is a need to transition to cleaner and healthier forms of fuel for electricity generation.

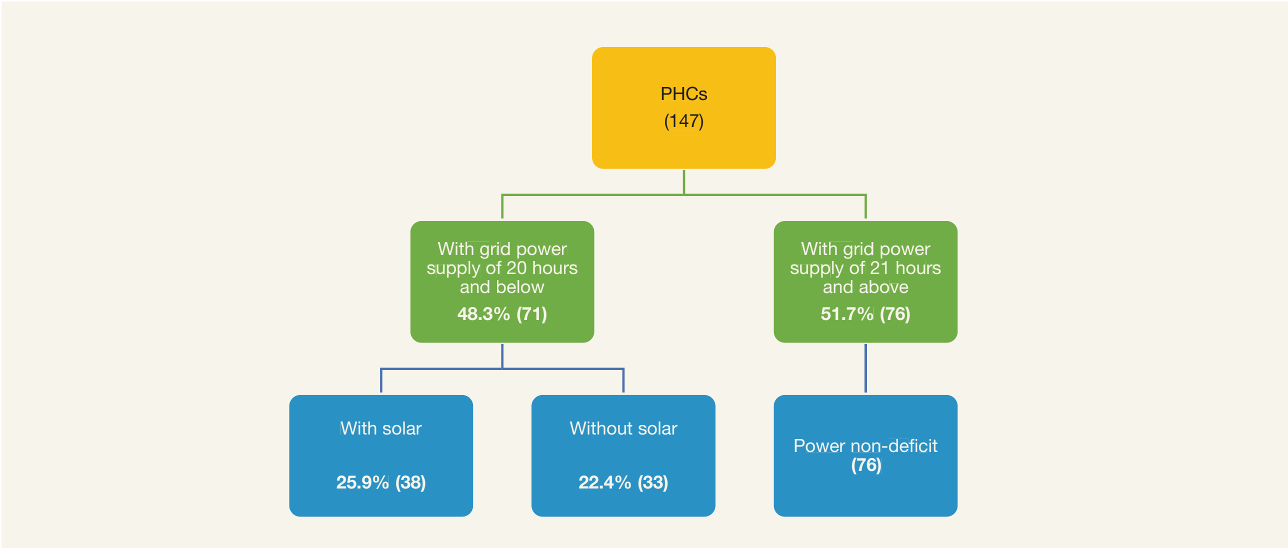
Source: CEEW Analysis, 2017 adapted from World Bank/ESMAP, 2014/16

An evaluation of the situation of electricity access across PHCs using such an approach will present an accurate picture of the impact of electricity access on healthcare service delivery. Various dimensions of electricity access in the context of health services have been elaborated upon in the following sections of the report.

To better understand the synergy between electricity access and health service delivery, all PHCs have been classified into two broad categories, with the subsequent analysis of health service delivery and the role of solar PV systems in augmenting electricity supply being carried out in the given frame of analysis (Figure 12). Thus, the overall framework of the evaluation incorporates the multidimensional aspects of electricity access within the frame of analysis explained below.

It should be noted that the analysis in the subsequent sections of this chapter has also considered the aspect of 'health and safety' in the context of electricity access, wherein the choice of the electricity source is equally important in realising a cost-effective, resource-efficient, and sustainable healthcare system. For the most part, the diesel generator has been the preferred option for power backup in the past, but solar is a cleaner and cost-effective option compared to diesel (Kuldeep, et al., 2016). It should also be noted that with most PHCs in Chhattisgarh (less than 7.5% of sample PHCs) not having diesel generators, and with inverters not having the capacity to support cold chain or critical care equipment, solar as a backup will play a critical role in providing an assured, reliable, and high-quality electricity service.

Figure 12: Frame of analysis



Source: *CEEW Analysis, 2017*

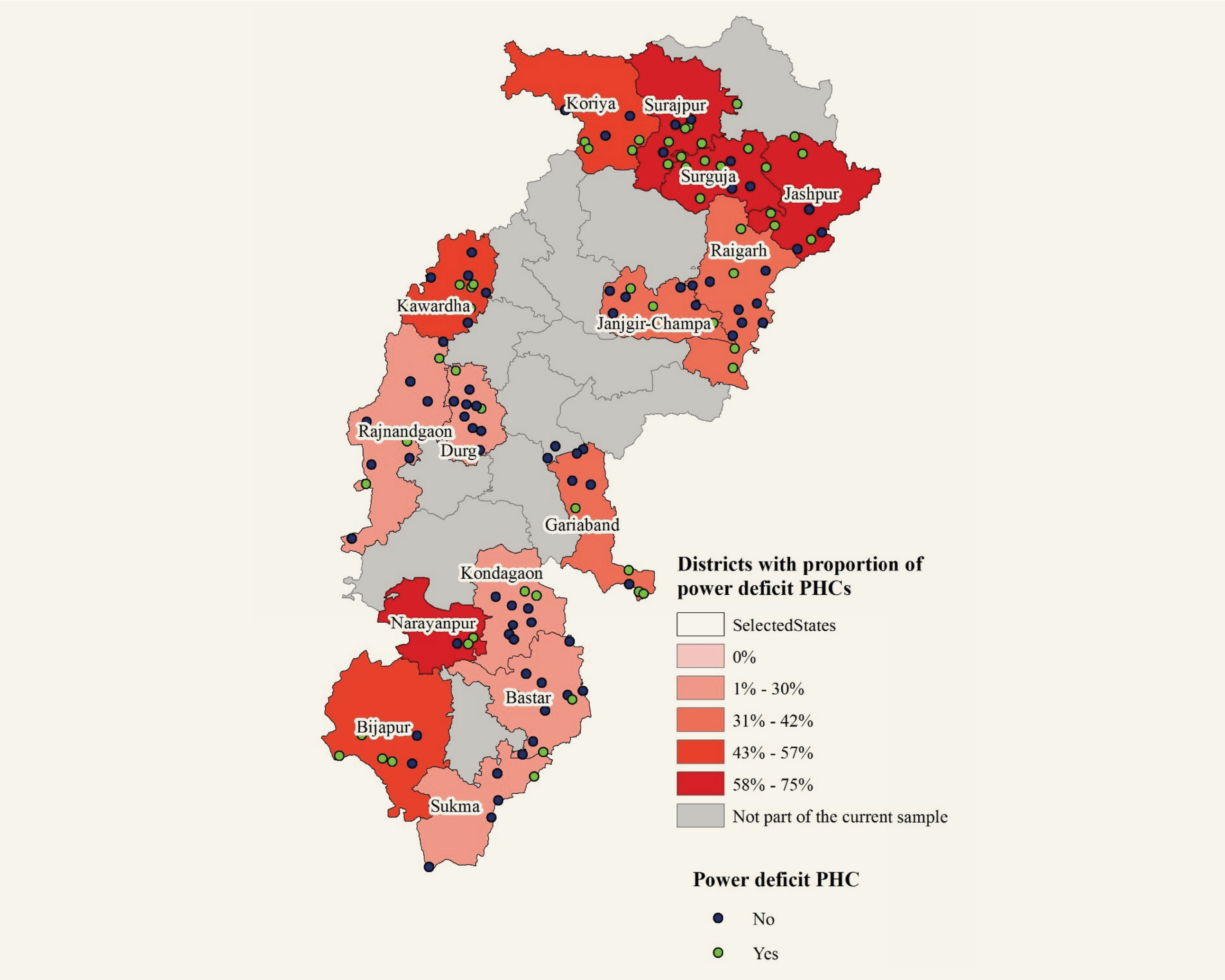
While the average hours of daily grid electricity supply were reported as 20.5 hours per day, it was also known that the solar PV system installed in some of the sample PHCs provided a backup for four to five hours. Thus, the definition of a power-deficit PHC is used as in the classification below:

i. Power-deficit PHC is defined as a facility that receives an average daily power supply of 20 hours or less (from the grid)

ii. Power non-deficit PHC is defined as a facility that receives more than 20 hours of average power supply in a day (from the grid)

Figure 13 provides a snapshot of the district-wise distribution of power-deficit PHCs from the sample in Chhattisgarh. In the northern districts of Surajpur, Surguja, and Jashpur, more than 50% of the PHCs in each district were found to be power-deficit. In the southern part of the state, Narayanpur district has a similar proportion of power-deficit PHCs.

Figure 13: District-wise snapshot of power-deficit PHCs

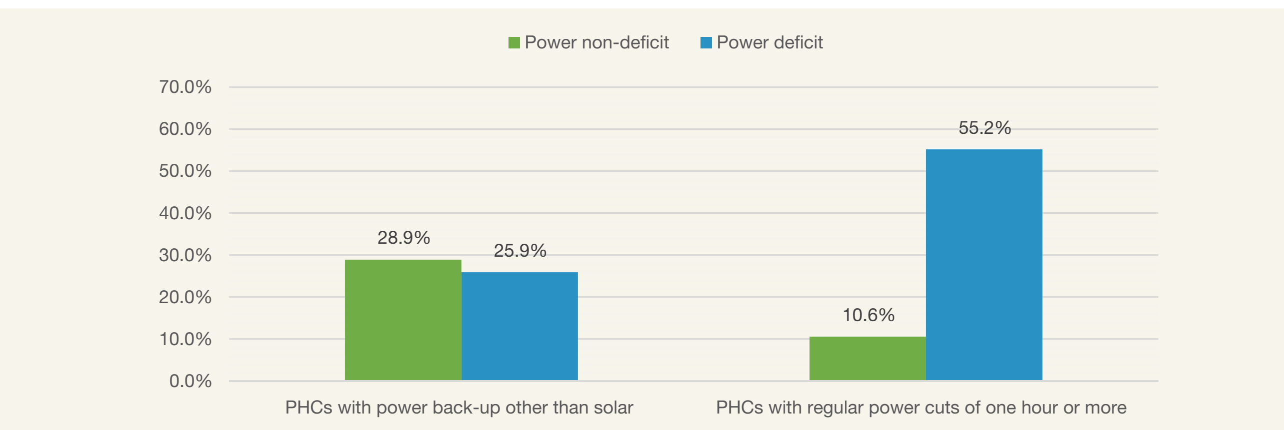


Source: *CEEW Analysis, 2017*

5.1 Current state of electricity access

To begin with, it is important to understand the state of electricity access across PHCs in the context of its multidimensionality. The reliability and quality of power are two of the most important dimensions that drive the final benefit accruing to a consumer in the use of each unit of electricity.

Figure 14: Proportion of power-deficit and power non-deficit PHCs by power backup and incidence of power cuts

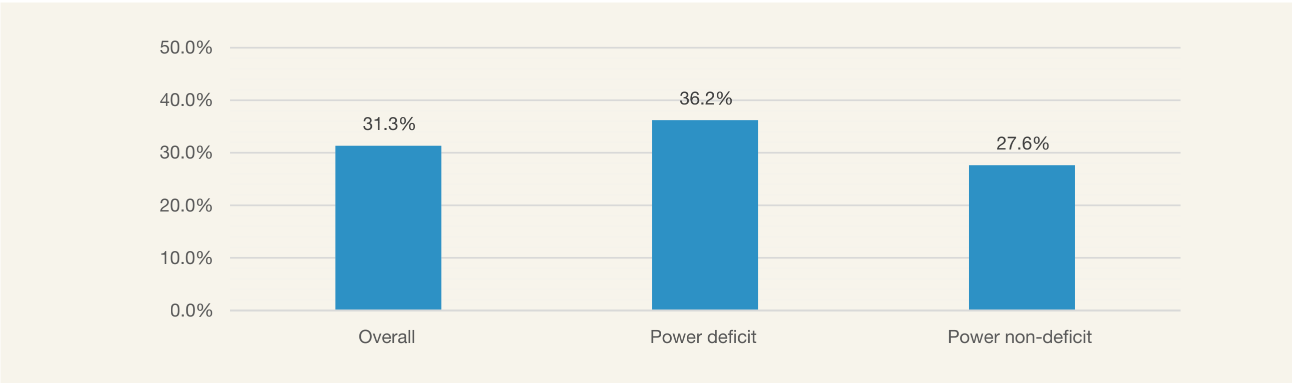


Source: CEEW Analysis, 2017

As seen in Figure 14, a higher proportion of power-deficit PHCs reported facing power cuts of one hour or more on a regular basis (55.52%), with 'regular' being defined as the incidence of a power cut of a defined duration on four or more days in a week.

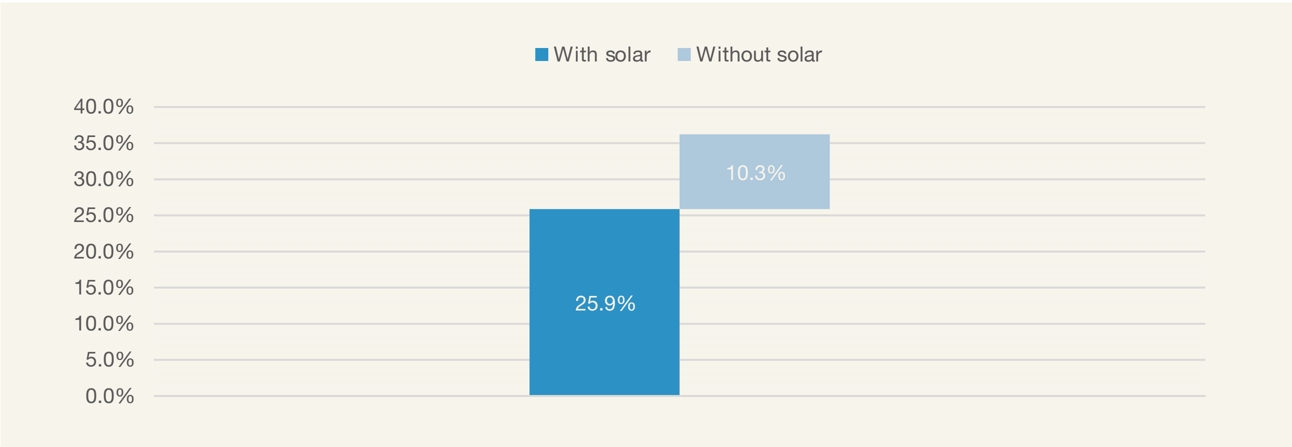
As stated in Chapter 4, about 90% of the PHCs reported undergoing power cuts between 9.00 a.m. and 4.00 p.m., a period during which the PHC functions at its peak capacity, as all services are running. This also points to the importance of power backup during the day, as even when 20 hours of power supply is available from the grid, the lack of power availability when it is most needed makes the role of backup options such as solar important. Specific focus on power cuts in the evenings is helpful in understanding the importance of power backup in a PHC (Figures 15 and 16). Emergency and delivery services by definition are subject to the need of the patient, and hence cannot be bound by limitations of time. When it is necessary to attend to a patient during evening hours, access to electricity becomes critical. In light of such needs, irrespective of the type of PHC (power-deficit or non-deficit), power cuts in the evening hours can affect the ability of a PHC to provide patient care.

Figure 15: Proportion of power-deficit and power non-deficit PHCs by incidence of power cuts in evening



Source: CEEW Analysis, 2017

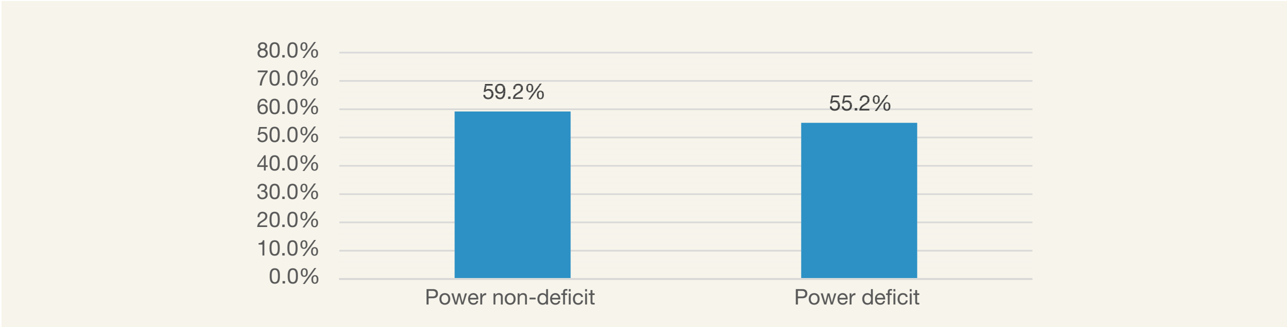
Figure 16: Proportion of power-deficit PHCs with incidence of power cuts in evening



Source: CEEW Analysis, 2017

Almost one-third of both power-deficit and non-deficit PHCs experience power cuts in the evening. Further analysis of power-deficit PHCs reveals that about 26% of *power-deficit PHCs that experience power cuts in the evening* have the provision of solar systems to support their electricity needs. However, 10.3% of power-deficit PHCs have no solar backup despite experiencing power cuts in the evening. With solar being a cleaner and more cost-effective option as compared to diesel generators, a targeted intervention to solarise these PHCs could help the staff in ensuring quality care for patients.

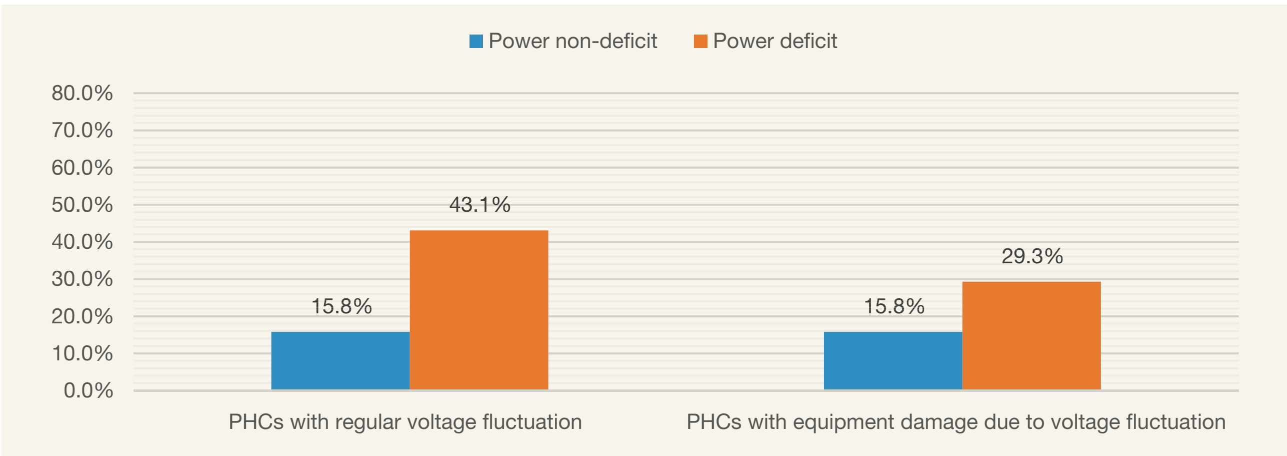
Figure 17: Proportion of PHCs with solar systems



Source: CEEW Analysis, 2017

While almost 60% of power non-deficit PHCs have a solar system, only about half of power-deficit PHCs have a solar system. This presents scope for the prioritisation of solar for power-deficit PHCs.

Figure 18: Proportion of power-deficit and non-deficit PHCs by incidence of voltage fluctuation and equipment damage



Source: *CEEW Analysis, 2017*

More than 60% of all PHCs reported voltage fluctuation (Figure 18). However, power-deficit PHCs reported higher and more frequent levels of voltage fluctuation and equipment damage, with 43.1% of power-deficit PHCs reporting voltage fluctuation and 29.3% reporting equipment damage. Of the PHCs that suffered voltage fluctuations, 49% reported their incidence between 12.00 p.m. and 4.00 p.m.

5.2 Current state of healthcare services provided that require electricity access

5.2.1 24x7 services

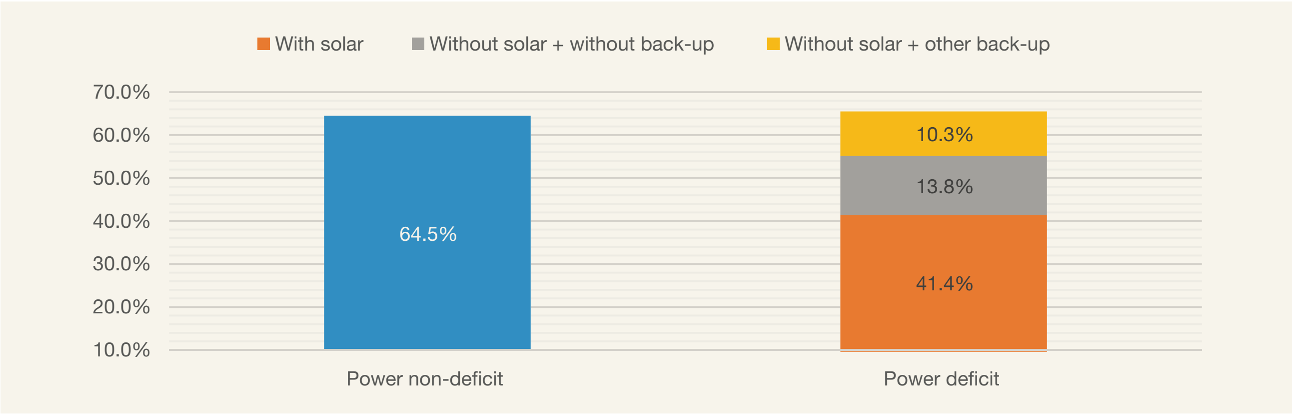
The data indicates that almost equal proportions of power-deficit (64.5%) and power non-deficit (65.5%) PHCs provide 24x7 services in Chhattisgarh (Figure 19). When the proportions of power-deficit and power non-deficit PHCs providing 24x7 services were compared using the two-tailed[7] two-sample test of proportions to assess the difference between the two samples,[8] no statistically significant difference could be found. This

7 A two-tailed test is a statistical test in which the critical area of a distribution is two-sided and tests whether a sample is greater than or less than a certain range of values. If the sample being tested falls into either of the critical areas, the alternative hypothesis is accepted instead of the null hypothesis.

8 P-Value for two-tailed two-sample test: 0.9043

indicates that lack of electricity access may not necessarily affect the provision of 24x7 services, although this does not provide any evidence regarding the quality of the services being delivered.

Figure 19: Proportion of PHCs providing 24x7 services



Source: CEEW Analysis, 2017

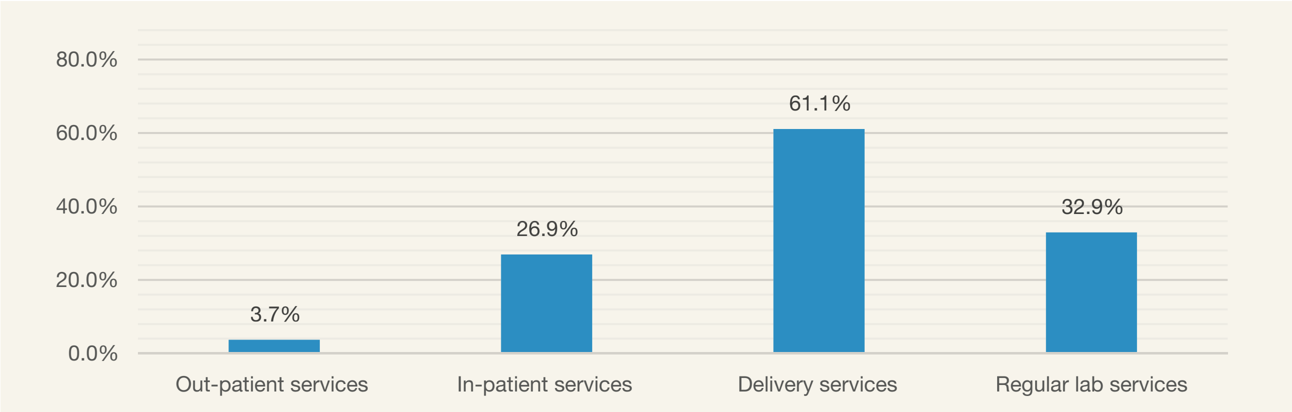
Forty-one per cent of the power-deficit 24x7 PHCs have a solar system as backup. About 10% of the power-deficit PHCs have an alternative power backup (generator/inverter). However, 13.8% of the power-deficit PHCs are providing 24x7 services without any form of power backup (solar/generator/invertor). Further, of the power-deficit PHCs, 22.4% reported power cuts in the evening. Given the challenge of dealing with unreliable and poor-quality power supply from the grid, this factor could limit the capacity of the PHCs to provide round-the-clock care.

5.2.2 Services affected by lack of electricity access

Some healthcare services are more dependent on access to electricity than others. As part of the evaluation, the Medical Officer or the Rural Medical Assistant (RMA) was asked to state the degree to which services are affected due to lack of access to electricity (with three options: not affected, somewhat affected, and severely affected). More than 60% of all PHCs reported that delivery services were severely affected due to lack of electricity, followed by laboratory and in-patient services. Therefore, only the inclusion of these services will not be sufficient in the future, and ensuring reliable and high-quality supply of electricity will also be essential.

Out-patient services were found to be the least affected, with less than 4% PHCs reporting any impact due to poor electricity supply. This is probably due to the fact that since this is a service provided during the day, between 9.00 a.m. to 4.00 p.m., the poor state of electricity supply may not hinder the basic diagnostics of a patient by the PHC staff.

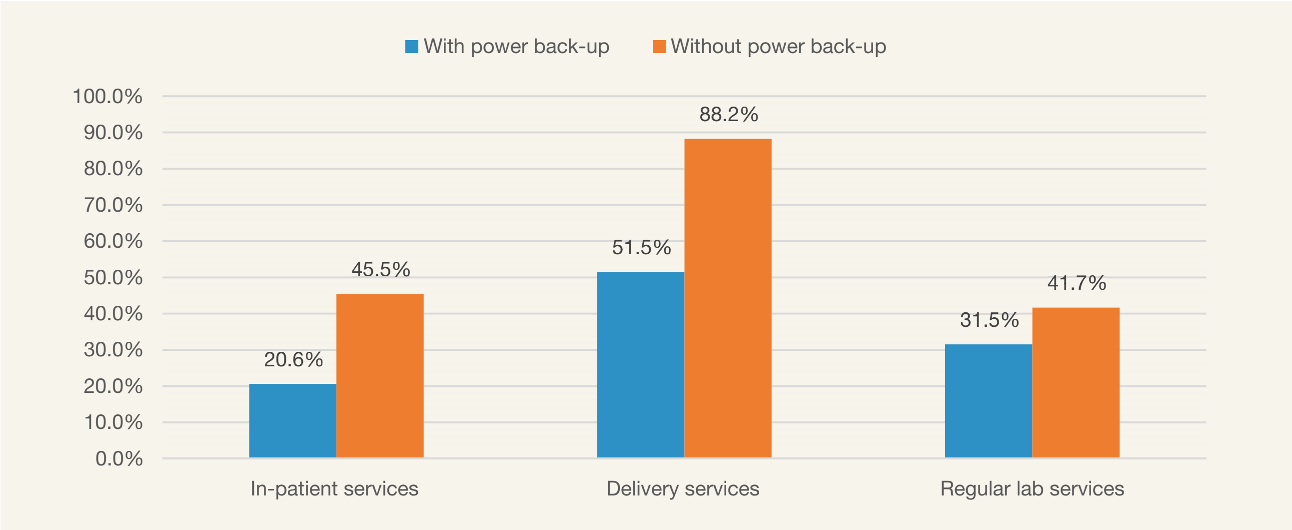
Figure 20: Proportion of PHCs reporting severely affected services due to lack of electricity



Source: CEEW Analysis, 2017

Further analysis of responses from the sample PHCs reveals the varying degrees to which these services are affected depending on whether or not the PHC had some kind of power backup (generator/invertor/solar). As expected, a higher proportion of the PHCs without power backup reported services being severely affected as compared to the PHCs with power backup, with delivery services being the worst affected in both cases (Figure 21).

Figure 21: Proportion of PHCs with and without any power backup reporting services being affected due to lack of electricity



Source: *CEEW Analysis, 2017*

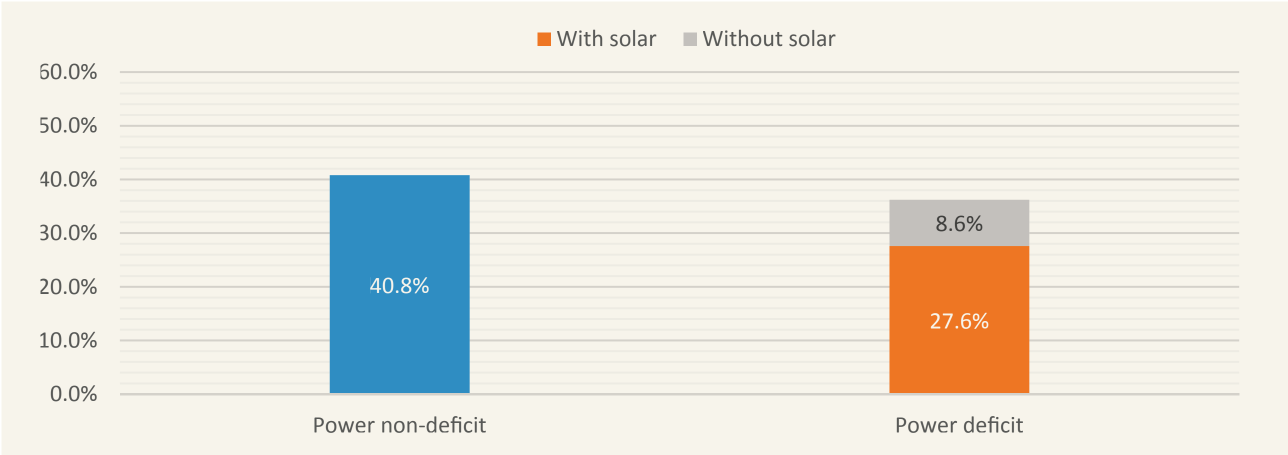
A two-tailed two-sample test of proportions was carried out for all the three services mentioned above to assess if there was any statistical significance in the relatively lower proportion of power non-deficit PHCs reporting impacts due to lack of electricity. PHCs that reported being severely affected due to lack of electricity were found to be significantly higher in number among power-deficit PHCs for in-patient and delivery services. However, the extent to which laboratory services were affected was not significantly different between the two groups.

5.2.3 Cold chain services

As elaborated in earlier sections, cold chain equipment is critical for storage of vaccines and drugs, and its availability at the PHC also ensures timely dispensation of immunisation and vaccine cycles to children and expectant mothers. Electricity access is critical to ensuring that deep freezers and ILRs are able to maintain the requisite temperatures for storage. Loss of vaccines and drugs due to non-functional cold chain equipment, either due to lack of electricity or due to technical issues, adds significantly to the cost of the public health system.[9] The existing model implemented by CREDA connects all cold chain equipment with the solar system to ensure 24x7 functionality.

9 P-Value of two-tailed two-sample test of proportions for: In-patient – 0.005, Delivery – 0.0002, Laboratory services – 0.486

Figure 22: Proportion of PHCs with cold chain equipment



Source: *CEEW Analysis, 2017*

About 41% of power non-deficit PHCs reported having both the cold chain equipment that is, deep freezer and ILR (Figure 22). Since they are adequately powered by grid electricity (power non-deficit), the situation provides an opportunity to increase the number of PHCs with cold chain equipment in the remaining 59% power non-deficit PHCs, thus ensuring better cold chain services at the primary level.

A two-tailed two-sample test of proportions was carried out to see if power non-deficit PHCs have better availability of cold chain equipment,[10] and the finding reveals that there was no significant difference with respect to availability of cold chain equipment in the PHCs between the two groups.

Nevertheless, about 7% of power-deficit PHCs are operating cold chain equipment without solar or any other power backup, while 22.4% of power-deficit PHCs currently rely exclusively on solar to run cold chain equipment. PHCs without any power backup should be prioritised for solarisation to enhance their ability to provide immunisation services.

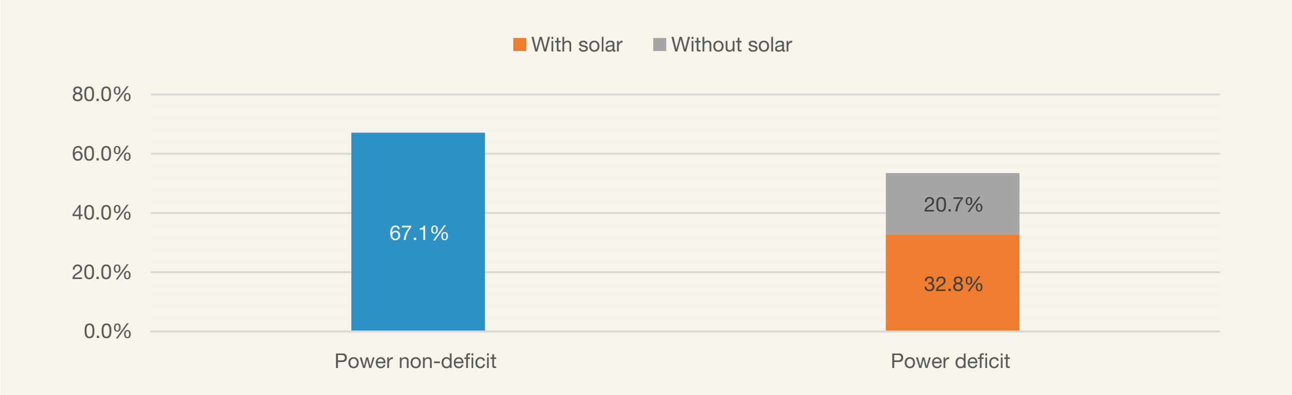
5.2.4 Neonatal care services

Radiant warmers and incubators are critical equipment for neonatal care and require access to electricity on demand. About 21% of power-deficit PHCs did not have solar backup to operate the equipment. Further, about 15% of these power-deficit PHCs had no form of other backup as well (generator/invertor/solar). This presents a strong case for prioritising the installation of solar systems across power-deficit PHCs that currently have no backup or those that rely on expensive alternatives such as diesel generators.

A two-tailed two-sample test of proportions was run to see if power non-deficit PHCs have better availability of newborn equipment, and the result was found significant,[11] implying that better access to electricity had a statistically significant relation to the availability of neonatal care equipment (incubator or radiant warmer), and thus implying better neonatal care services.

10 P-Value of two-tailed two-sample test of proportions for availability of cold chain equipment: 0.5898
11 P-Value of two-tailed two-sample test of proportions for availability of newborn care equipment: 0.1069

Figure 23: Proportion of PHCs with radiant warmer or incubator



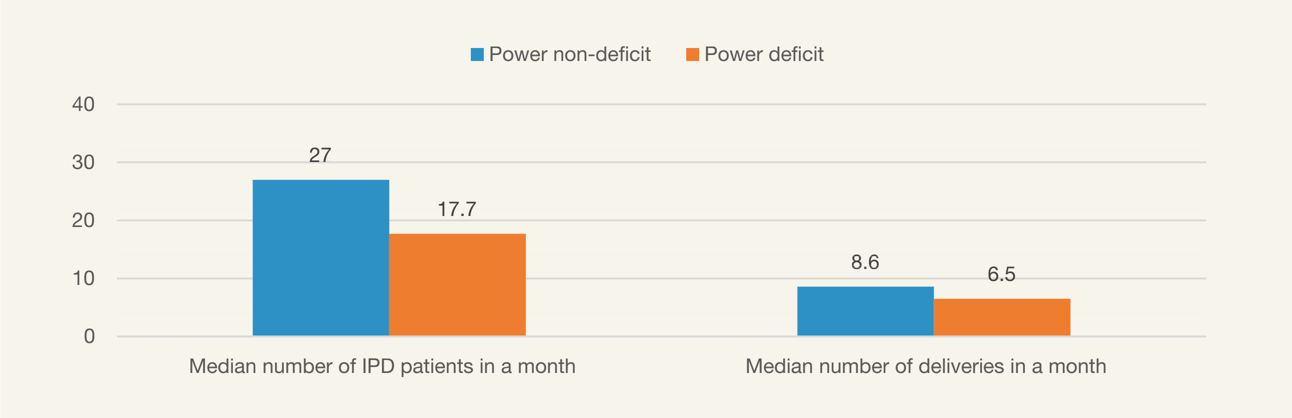
Source: *CEEW Analysis, 2017*

5.2.5 In-patient and delivery services

Power non-deficit PHCs report a higher number of average in-patients and deliveries in a month. Even in power-deficit PHCs, those with solar indicate a higher median value than those without solar (Figure 25).

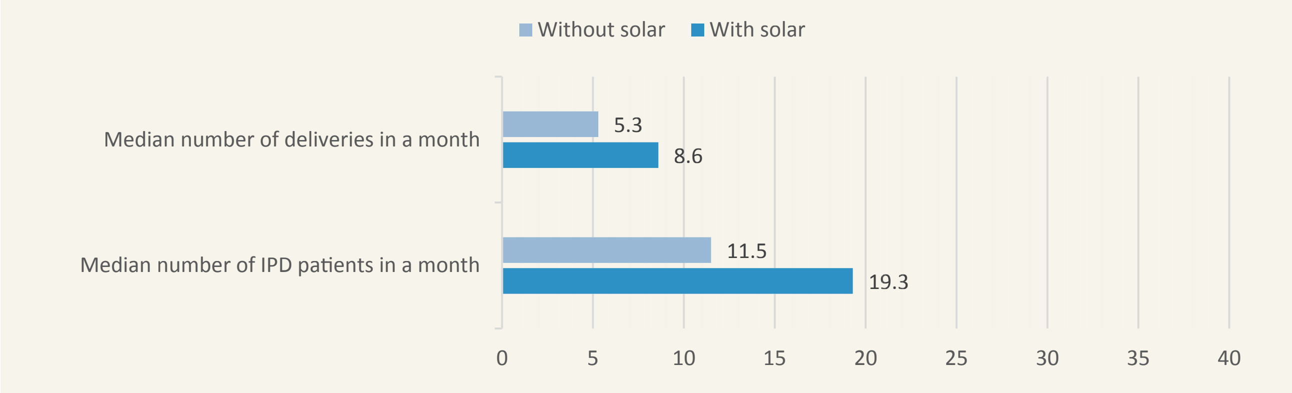
A two-tailed two-sample non-parametric equality of medians test was run to see if the median numbers of in-patients and deliveries were significantly higher in power non-deficit PHCs, and it was found significant for in-patients, but insignificant for deliveries. This highlights that better access to electricity has an impact on the number of in-patients, probably indicating both the ability of a PHC to admit and care for patients, as well as the willingness of the patient to be admitted in a PHC with better electricity services.

Figure 24: Median values of patients and deliveries



Source: *CEEW Analysis, 2017*

Figure 25: Median values of patients and deliveries in power-deficit PHCs



Source: *CEEW Analysis, 2017*

The findings in Figures 24 and 25, when corroborated through qualitative questions on the utility of solar systems, yield important insights. More patients were willing to get admitted, when essential, because of improved lighting and running fans in the PHCs, indicating that the comfort of the patient is an important aspect in the assessment of the quality of care. Furthermore, the staff at the PHCs indicated that they were better equipped to handle emergency cases and deliveries, particularly during the night, due to the reliable electricity service provided by the solar systems, which had been difficult earlier during power cuts.

Almost all the power-deficit PHCs reported experiencing regular or occasional power cuts. Of the power-deficit PHCs that reported a higher number of in-patients in a month than the median value for the sample, 79% reported experiencing power cuts between 12.00 p.m. and 4.00 p.m., thus implying that services could be affected during the peak functioning hours of the PHCs.

5.2.6 Water supply

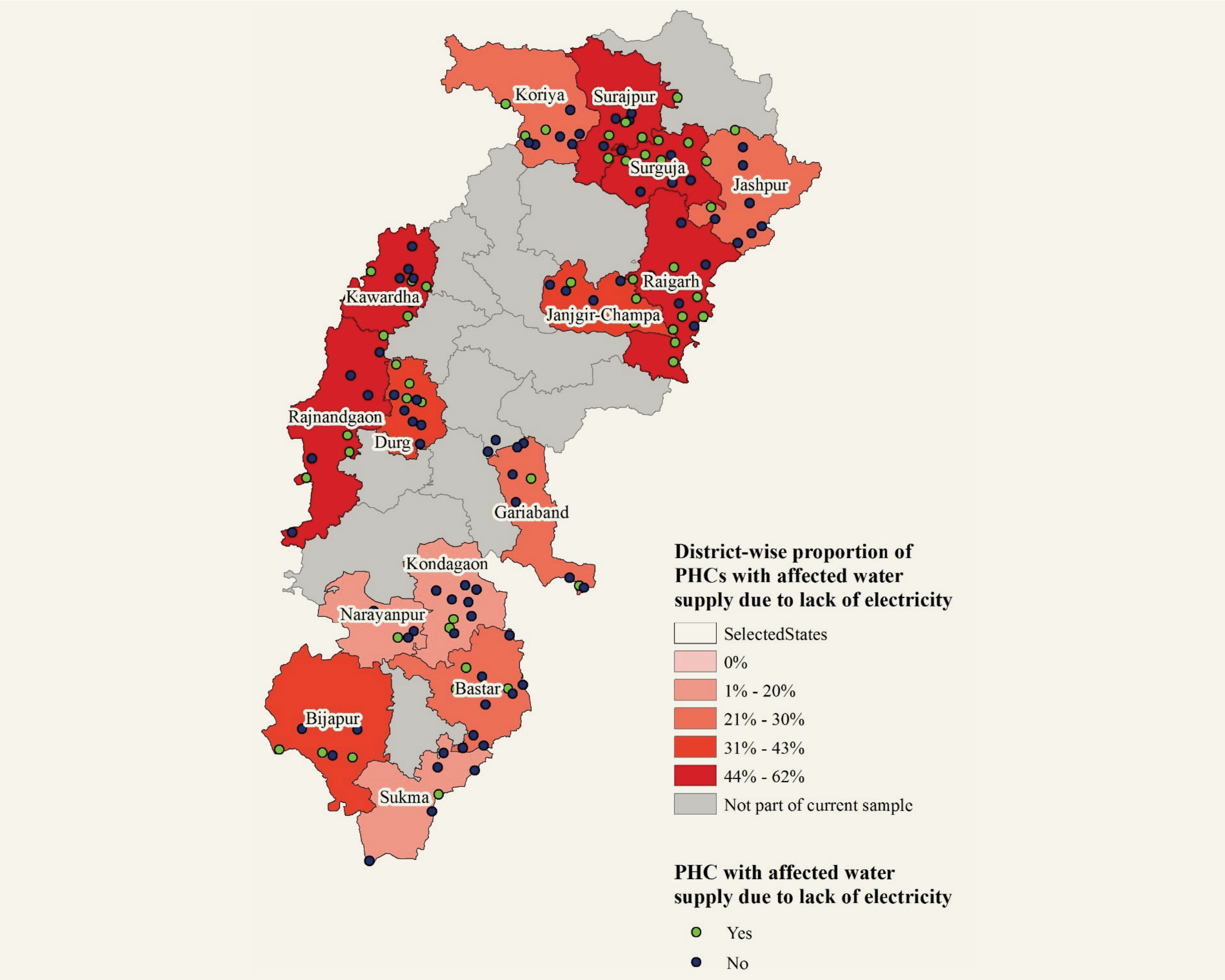
Healthcare facilities require access to water supply for performing procedures such as delivery and treatment of wounds. They also require access to water for sanitation and hygiene, equipment sterilisation, and drinking water supply.

WHO's publication on Water, Sanitation, and Hygiene (WASH), based on studies of 54 countries and representing 66,101 facilities, reveals that 38% of healthcare facilities do not have an improved water source, 19% do not have improved sanitation, and 35% do not have water and soap for hand-washing. The lack of adequate and quality water supply compromises the ability to provide basic, routine services, such as child delivery, and undermines the ability to prevent and control infections (WHO, 2015b). Beyond the increased risk of infection, the lack of drinking water or the non-availability of safe sanitation facilities in health facilities may discourage women from giving birth in these facilities and/or contribute to delays in seeking care (Velleman, et al., 2014).

About 83% of the surveyed PHCs reported having sufficient water supply for their needs, with about 76% of the PHCs being dependent on a borewell or tube-well for their water supply. Seventy per cent of the PHCs reported having an electric water pump, with 97% indicating that the pumps were in a functional state. About 38% of the PHCs reported not having a water filtration machine, essential for the provision of potable water. About 37% of all the sample PHCs reported that their water supply was adversely affected due to lack of electricity supply.

About 86% of the sample PHCs have either an electric water pump or a water filtration unit or both. Of these, about 48% are power-deficit PHCs, of which almost all reported negative impact of poor electricity services on water availability.

Figure 26: District-wise proportion of PHCs with affected water supply due to lack of electricity



Source: CEEW Analysis, 2017

5.3 Summary of key findings

▪ Combined capacity unable to meet needs

Using the framework of multidimensionality, access to electricity across all PHCs surveyed in Chhattisgarh has been analysed. First, it is assumed that the combined capacity of all electricity sources available should be able to meet the electricity needs of the PHCs. However, about one-third (36% of the sample) of all sample PHCs reported that their electricity needs were not met by the available sources of electricity supply. Second, although the duration of power supply in a day averaged about 20.5 hours, the quality of electricity supply varied across districts. Evening power cuts were prominent in about a third of the PHCs (31.3%). More than 60% of all PHCs reported voltage fluctuation, with most reporting the same during the peak working hours of a PHC (12.00 p.m.–4.00 p.m.).

▪ Ability to provide care on demand

About 90% of the PHCs reported experiencing power cuts between 9.00 a.m. and 4.00 p.m., during which the PHC functions at its peak capacity. Similarly, emergency and delivery services are subject to the need of the patient, and hence require access to electricity on demand. Power cuts in the evening could significantly affect the ability of the PHCs to provide the required service. According to a statistical test for the median number of in-patients, the differences between power-deficit and power non-deficit PHCs is significant.

▪ Cold chain and newborn care

The ability of a PHC to operate cold chain and newborn care equipment is substantially influenced by its access to regular electricity supply. Electricity access is critical to ensuring that deep freezers and ILRs are able to maintain the requisite temperatures for storage. About 22.4% of power-deficit PHCs rely exclusively on solar as a backup to run cold chain equipment. About 21% of power-deficit PHCs do not have solar backup to operate newborn care equipment.

▪ Transition to higher standards of care

About one-third of power-deficit and power non-deficit PHCs reported power cuts in the evening. About 46% of PHCs were in the power-deficit category and without the support of solar PV systems. This affects the ability of PHCs to transition to higher standards of providing 24x7 health services as called for by the new guidelines under IPHS.

▪ Other needs

Access to regular electricity also enables access to regular water supply for many PHCs. About 37% of the sample PHCs reported that their water supply was adversely affected due to lack of electricity supply. The lack of adequate and quality water supply compromises the ability to provide basic, routine services such as child delivery, and also undermines the ability to prevent and control infections (WHO, 2015b).

6. Evaluation of Solar Primary Health Centres

The insights from Chapters 4 and 5 indicate the important role of electricity access in enabling quality health services, and also make the case for an effective power backup solution that can augment electricity supply in case of poor grid reliability across PHCs. Solar PV systems have emerged as a long-term cost-effective solution for providing a reliable backup. Various studies have shown the favourable economics of electricity from solar as compared to the conventional alternative of diesel generators (Lemaire, 2011). Further, in the context of climate change, the solar-based solution is a cleaner source as compared to diesel, and hence is a welcome shift in the context of low-carbon health systems.

The primary aim of the intervention is to augment the electricity supply at the PHC to enable its effective functioning. Of the sample PHCs, 56% are solar PHCs. Of these, about 45% are power-deficit PHCs. Among these, the average duration of a reported power cut is about three to five hours. The solar system is also designed to provide backup for a similar duration. It is also interesting to note that the power-deficit PHCs using diesel generators as backup run the generator for about three to four hours each day. It would be beneficial both economically and environmentally to opt for solar over diesel. A cost comparison shows that one unit of electricity from a diesel generator costs about INR 24–26 per kWh, while using solar with battery costs around INR 12–14 per kWh (Kuldeep, et al., 2016). With the cost of solar panels coming down in the last few years, the significant other cost is that of storage. Having said that, the low-cost, low-emission option provided by solar offers overall benefits to both society and the health system.

The solar PHCs installed in Chhattisgarh are all off-grid systems, that is, generation and consumption happen on-site, with the solar system not interacting with the grid at all. This is an effective model, given that the load at the PHC is sufficient to consume the power generated from the solar PV system.

6.1 System design

Most of the solar PV systems installed for each PHC have been of 2 kWp capacity. Each solar PV system was provided with a stack of twenty-four 200 Ah/48 V batteries. For a typical well-equipped PHC in Chhattisgarh, the data indicate that such a facility consumes about 30–40 units a day. With the average duration of reported power cuts being two to three hours, the solar system with its storage design can easily provide a backup of close to three to four hours, thus augmenting the grid supply.

The original design of the system envisaged the inclusion of lights and fans in the OPD room, the labour room, and the cold chain room, and also the connection of the deep freezer and the ILR to ensure that the cold chain equipment did not suffer due to lack of electricity supply. The solar PHCs surveyed were asked to report on which of the essential services were connected to the solar PV system as well as the various equipment whose loads were served by solar. Some of the key findings were:

- Most of the solar PHCs reported OPD services (86.5%), in-patient services (94%), and delivery services (91%) having solar as a backup, while about 52% PHCs reported even laboratory services being served by solar.
- The primary equipment connected were lights and fans.
- Over 70% PHCs having cold chain equipment reported the deep freezer and ILR being connected to solar.

- Of the solar PHCs providing laboratory services, over 65% reported connecting the microscope and the centrifuge to solar as well.
- Only 46% of PHCs with a radiant warmer indicated having solar as backup for neonatal care.

6.2 Operation and maintenance of the solar systems

CREDA has a dedicated Operation and Maintenance (O&M) Cell within its organizational setup. The cell regularly monitors the performance of all the systems installed by CREDA, and provides repair and maintenance services as and when required. CREDA deploys staff at the district level, with each technical staff of the O&M team being assigned a particular route. The assigned staff is responsible for regularly monitoring and addressing the O&M needs of all the solar systems installed along the route. They make weekly visits to each site, and complete a checklist, which is also signed by the Medical Officer in the case of a PHC, which acts as a check that the visit has been made. In addition, in case of any complaint, the phone numbers of all the key district staff of CREDA are provided to the PHC, so that there is no delay in registering the complaint and to ensure that timely action is taken. Further, CREDA's O&M Cell also coordinates with the system integrator on issues of replacement, repair, and warranty as per the terms and conditions of the annual maintenance contract (AMC). CREDA's approach has led to the effective functioning of the systems installed and has allowed the health system to focus on health service delivery.

Almost 94% of the solar PHCs reported that the solar PV system was functional, with the non-functional systems reporting issues with either the battery or the invertor. Even though only five solar PHCs of the sample reported non-functionality, they were asked to report on whether they had registered a complaint with the service agency and if the response had been timely. All the PHCs reported that a complaint had been registered and that visits were made by the service agent within the stipulated time. It was noted that while the PHCs report to the service agent and to CREDA about the non-functionality of the system, the same is not reported to the State NHM department. Given that the objective of the State NHM is to ensure a functioning health system, it is important to maintain the functional status of the solar PV systems at the PHC level as well as to facilitate better policy planning for assured electricity supply to PHCs.

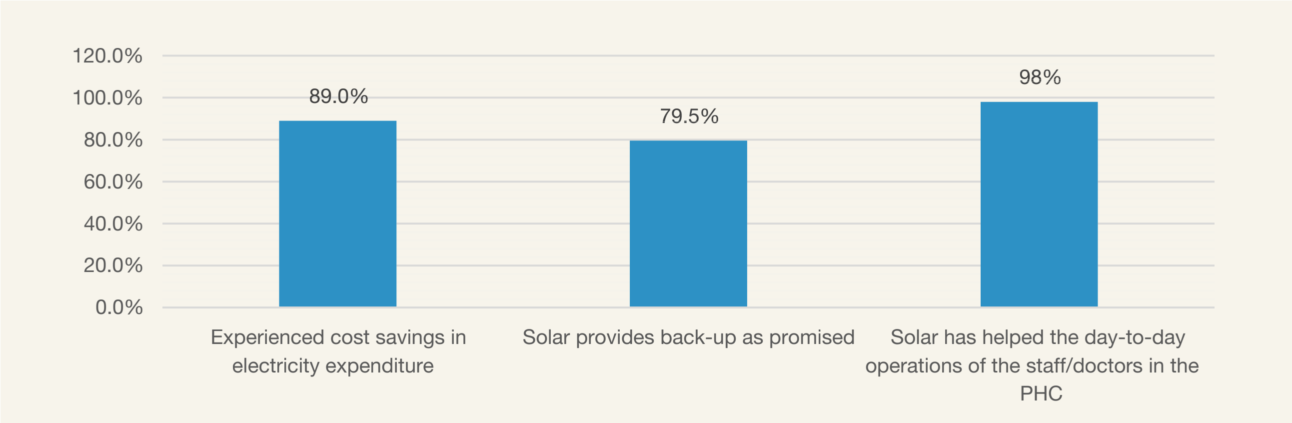
While the solar system is monitored and taken care of by CREDA and its team, it is important for the end user to understand the basic operations of the system so as to utilise it effectively and derive its maximum benefits. Only 6% of the solar PHCs surveyed reported having received any training on the basic O&M of the solar system. This finding is important on two counts. First, awareness of the benefits of the solar system helps the PHC staff to better identify the equipment and services that need to have solar as a backup so as to ensure their effective functioning and service delivery. Second, in the case of an improving grid supply situation, as seen in Chhattisgarh, there is a tendency to rely less on the solar system. As the grid supply tends to be 24x7, the use of the solar system will keep declining, thus impacting the battery life and longevity of the system. This would mean that battery would have to be replaced more frequently than if it were to be charged and discharged regularly. Thus, the training of the PHC staff in this regard would ensure that even in a full-grid supply situation, they will continue to use the solar system for a few hours during the day to ensure its functioning. In the longer term, this would lead to electricity cost savings, as once the payback period is over, the electricity generated from solar will be of negligible cost as compared to that from the grid.

6.3 Perceptions of, and impact on, service delivery

As part of the evaluation, the PHCs were asked to report on their perception of the performance of solar systems and its impact on service delivery. Of the solar PHCs surveyed, almost all reported that the presence of a solar system and availability of electricity during power cuts has helped in conducting the daily operations of the staff and of doctors at the facility. With regard to system performance, about 80% of the solar PHCs reported that the system provided electricity backup for the specified duration as initially promised during installation. A majority of them also reported observing cost savings in electricity expenditure (Figure 26).

This claim could not be substantiated with evidence on electricity consumption even though data was collected on the same. It was observed that accurate records of bill details were not maintained at the PHC level either due to non-availability of bills or, as found in many cases, because the bills were sent directly to the district headquarters.

Figure 27: PHCs by type of benefit derived from solar system

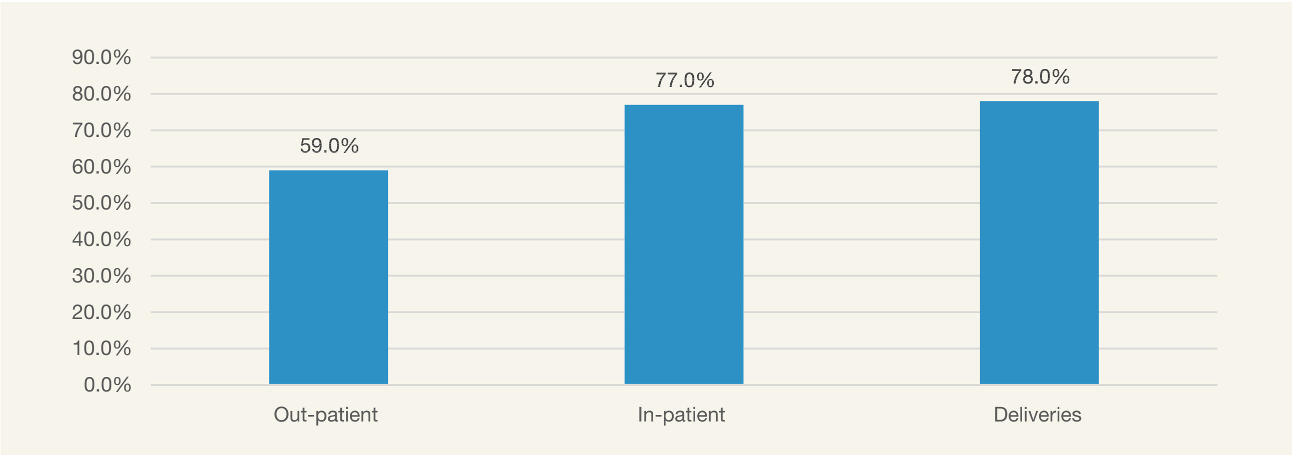


Source: *CEEW Analysis, 2017*

The PHC staff were asked to respond to an open-ended question on whether they were satisfied with the overall performance of the solar system. A qualitative assessment of their responses provides further insights into their perceptions about the benefits of the solar system. Some of the key insights are:

- Installation of solar systems reduced the impact of power cuts on the ability or capacity of the PHC to provide services.
- Services such as cold chain, in-patient care, and deliveries were seen to be less impacted due to lack of grid supply after the installation of solar (Figure 27).
- Service provision during the night, especially delivery and emergency cases, has benefitted from the installation of solar, which has provided a reliable power backup.
- Some PHCs also reported having reduced incidence of equipment damage due to voltage fluctuation after the equipment was connected to the solar system.
- However, some PHCs reported problems with solar systems that were five years old or more, primarily with regard to the associated costs and delays in the O&M of the system in the post-warranty period.
- Some PHCs affected by the lack of reliable power supply asked for an increase in the size of the solar systems so that they could serve a greater load at the PHC through solar and thereby reduce their dependence on the grid.

Figure 28: PHCs reporting improvement in services due to solar



Source: *CEEW Analysis, 2017*

6.4 Sufficiency of electricity

Last but not least, all PHCs were asked if they were able to meet all their electricity needs using the available options (including solar, diesel generators, and/or inverter) along with the grid. About 64% of the PHCs indicated that they were able to meet all their electricity needs. Of the solar PHCs, 84% reported that their electricity needs were met by a combination of the grid and solar. Of the solar PHCs falling in the power-deficit category, about 79% indicated that they were able to meet their electricity needs as per their requirement. This highlights the importance of solar as a reliable backup and also underlines its importance as a complementary source to the grid, with the objective of providing a reliable, cost-effective, and environmentally sustainable electricity system for the PHC.

7. Indian Public Health Standards (IPHS)

PHCs were set up in India on the recommendation of the Central Council of Health in 1953 to provide comprehensive healthcare to the rural population. However, soon after their establishment, these centres came under serious criticism due to their inability to provide adequate health coverage (IPHS, 2012). The reasons for this ranged from unavailability of doctors and other required staff to inadequate physical infrastructure. Eventually, a need was felt for uniform national standards against which the performance of health service delivery could be assessed to drive improvement in the quality of health services. In an attempt to standardise and improve healthcare services across all rural areas, the Indian Public Health Standards (IPHS) were issued by MoHFW in 2007 (revised in 2012) as a set of uniform standards for public healthcare facilities (IPHS, 2012). IPHS provides a reference point for achieving uniformity in public healthcare infrastructure and services across states and union territories with the aim of providing a minimum service level of healthcare to all citizens across the country. Although subscribing to IPHS is essential to ensure an acceptable standard of healthcare across India, only 20.8% of the functional PHCs in the country adhere to the IPHS norms, while Chhattisgarh is yet to transition towards meeting the standards (RHS, 2016). NRHM has also emphasised the need for public health institutions in rural areas to be upgraded from their present level to meet the IPHS norms (IPHS, 2012).

From the perspective of service provision, IPHS set minimum service-level benchmarks for all the activities of a PHC, including services, infrastructure, manpower, equipment, and drugs. It categorises all benchmarks as essential and desirable, with the aim of having all states strive to meet the essential criteria so as to ensure uniform health services and consistent quality of care across the country, and fulfilling these desirable criteria is seen as an added advantage. The IPHS guidelines further classify PHCs into two types: Type A PHCs with delivery load of less than 20 deliveries per month; and Type B PHCs with delivery load of 20 or more deliveries per month.

In this analysis, the current state of services across the sample PHCs surveyed in Chhattisgarh has been compared with the benchmarks of IPHS for essential services, equipment, and manpower. As PHCs transition to comply with IPHS norms, their electricity requirements will also increase, as the extent of services and equipment and the magnitude of other ancillary needs will also increase. Hence, it is important to understand the anticipated shortfall in compliance with IPHS norms. This analysis will provide an overview of the potential increase in electricity demand, and the effort required to ensure a standardised and fully functional primary health system.

Table 6: Proportion of PHCs in Chhattisgarh providing services recommended by IPHS

Essential IPHS services	Percentage of PHCs
Out-patient services	100
In-patient services	97
Emergency services	86
Referral services	95
Laboratory services	59
Delivery services	93

Source: *CEEW Analysis, 2017*

As far as essential IPHS services are concerned, most of the sample PHCs in Chhattisgarh are providing the minimum set of essential services (Table 5). However, about 41% of the PHCs do not provide laboratory services and about 14% do not provide emergency services.

Table 7: Proportion of PHCs in Chhattisgarh with equipment recommended by IPHS

Essential IPHS equipment	Percentage of PHCs
Computer with internet facility	42
Electric water pump	70
Water filtration machine	62
Steriliser	72
General-purpose refrigerator	42
Ice-lined refrigerator	41
Deep freezer	39
Radiant warmer	62
Autoclave	48
Light microscope	58
Suction machine	78

Source: *CEEW Analysis, 2017*

Most of the PHCs do not have the minimum set of equipment as outlined in the IPHS (Table 6). The districts of Sukma, Surajpur, Bastar, Koriya, Janjgir-Champa, and Kondagaon have the maximum shortfall with regard to the availability of essential equipment. Most of these districts are concentrated in the extreme north or in the extreme south of Chhattisgarh. Furthermore, it is also observed that the shortfall in equipment is higher across power-deficit PHCs. For instance, 46% of the power-deficit PHCs lack a computer with an internet connection, while the same is true for only 24% of the power non-deficit PHCs. Again, 50% of the power-deficit PHCs do not have a radiant warmer, as compared to 28% of the power non-deficit PHCs.

It is also observed that close to 60% of the sample PHCs do not have either a deep freezer, ILR or general or all-purpose refrigerator, thus impacting cold chain services at the primary level.

Box 2: Improving cold chain points at the primary level

As per Census 2011, the total rural population of Chhattisgarh is 19.6 million. Of this, about 15% (or roughly around 2.94 million) are children (aged between 0 to 6 years). RHS 2016 reports that there are about 790 functional PHCs in rural Chhattisgarh. Hence, a PHC probably caters to about 3,721 children on an average.

As reported in the sample survey, 60% of the PHCs did not have cold chain equipment, translating into 474 PHCs without cold chain facilities each catering to 3,721 children.

This means that about 1.76 million children (about 60% of the total number of children aged between 0 to 6 years) in rural areas do not have access to vaccines at the primary level of healthcare. To immunise these children, vaccines will be required to be brought from the block or district hospital whenever the need arises. Alternatively, it might compel people to travel to the block or district hospital to get immunised. Both these scenarios could have implications for the immunisation rates in the state, the timeliness of delivery of health services, and the cost for both the health system and the community, in terms of logistics and transportation, respectively. Operationalisation of cold chain points at the PHC level can improve the efficiency of the immunisation services for the staff and provide better access to such services for the community.

Source: *CEEW Analysis, 2017*

Table 8: Proportion of PHCs in Chhattisgarh having staff as recommended by IPHS

Essential IPHS manpower	Percentage of PHCs
At least 1 Medical Officer – MBBS	25
At least 1 Pharmacist	72
At least 1 Data Accountant	69
At least 3 ANMs (Staff Nurses) for Type A PHC and at least 4 ANMs (Staff Nurses) for Type B PHC	20
At least 1 LHV	50
At least 1 Laboratory Technician	52

Source: *CEEW Analysis, 2017*

Trained manpower is a critical requirement for health service delivery. Equipment and infrastructure availability alone cannot ensure improvement in the quality of health service delivery. PHCs in Chhattisgarh lag in their compliance with the IPHS norms as far as manpower availability is concerned (Table 8). Almost two-thirds of the sample PHCs do not have a Medical Officer (MBBS), and a similar number have fewer than the prescribed number of ANMs, who play a critical role in ensuring quality care for the community and who also serve as the first point of contact between the community and the health system. Thus, the availability of skilled and adequate manpower is essential for ensuring quality healthcare services, and, at the same time, the availability of reliable and quality electricity supply enables them to deliver these services.

7.1 Indian Public Health Standards (IPHS) gap analysis

While the previous section focuses on the overall gap between the current level of service delivery of the primary health system in Chhattisgarh and the IPHS norms, it is equally important to understand the district-level scenario. A disaggregated analysis at the district level will provide key insights to the key decision-makers, which include the State Health Mission and the district administration, thereby facilitating better allocation of resources, both financial and otherwise, as well as allowing a phased implementation strategy to be put in place.

To conduct a district-level gap analysis of the PHCs with respect to the IPHS guidelines, the concept of 'deficit ratio' has been introduced. A PHC is assigned a gap score of '0' whenever it complies with the IPHS standard for a particular parameter (say, equipment). It is given a gap score of '1' for each unit deficit when compared to the benchmark. Thus, the gap score can be greater than 1. For example, in the case of equipment, if the IPHS benchmark states that it is essential for a PHC to have at least one radiant warmer, and if this equipment is found to be absent, then a deficit score of 1 is assigned for that parameter. Similarly, if a PHC is supposed to have three nurses as per the IPHS norms, and is found to have only one nurse, then it is assigned a deficit score of 2 for that parameter.

For each aspect, the gap score is a sum of the total gap. The deficit ratio for each aspect is calculated by dividing each PHC's gap score with the maximum gap score, that is, if the PHC were to meet none of the criteria (for example, 6, in the case of services provided; or 11, in the case of equipment availability). Thus, each PHC has a deficit ratio for equipment, manpower, and services. The deficit ratios of individual PHCs are aggregated at the district level to determine a district-level deficit ratio, which is the average of the deficit ratios of all the PHCs in that particular district. The higher the deficit ratio, the greater the effort and the larger the resources that will be required for the primary health system in the district to meet the IPHS norms.

The gap analysis has been carried out for three aspects under the IPHS standards – equipment, manpower, and services. For the purposes of the gap analysis, only the 'essential' service-level benchmarks have been taken, as this is the least that any PHC is envisaged to have, in order to provide a minimum level of quality healthcare.[12]

Table 9: District-wise deficit ratios

District	Equipment	Manpower	Services
Bijapur	0.42	0.32	0.02
Surajpur	0.56	0.39	0.02
Surguja	0.18	0.15	0.02
Janjgir-Champa	0.36	0.53	0.03
Rajnandgaon	0.25	0.41	0.03
Jashpur	0.38	0.39	0.05
Kawardha	0.34	0.45	0.05
Raigarh	0.38	0.37	0.06
Koriya	0.62	0.35	0.08
Kondagaon	0.55	0.42	0.10
Narayanpur	0.48	0.35	0.11
Bastar	0.58	0.42	0.12
Gariaband	0.53	0.38	0.15
Durg	0.39	0.24	0.20
Sukma	0.60	0.40	0.22
Chhattisgarh	0.44	0.37	0.09

Source: *CEEW Analysis, 2017*

7.1.1 Equipment gap

Koriya, Sukma, and Bastar are the poorest performing districts as far as compliance with the IPHS equipment inventory is concerned, while Surguja and Rajnandgaon are the best performing districts (Table 9). However, a deficit ratio of 0.44 for Chhattisgarh as a whole suggests that PHCs in the state have poor compliance with IPHS equipment inventory. A detailed analysis of equipment availability at the district level yields a few interesting observations.

While 62% of the PHCs have computers, only 42% have computers with an internet connection, leading to the gap score being non-zero. The availability of a computer and of an internet connection at a PHC is important from the perspective of regular data entry for the Health Management Information System (HMIS) and the cold chain database (NCCVMRC), which are databases for tracking the performance of the health system. Further, the lack of equipment such as refrigerator, deep freezer, ILR, and autoclave is the main driver of the deficit ratio in each of the 15 districts.

7.1.2 Manpower gap

With regard to manpower deficit, Janjgir-Champa, Kawardha, Bastar, Rajnandgaon, and Sukma are some of the poorly performing districts. Medical Officers are the frontline health managers and service providers, qualified by their training to handle complex medical emergencies. In the absence of Medical Officers in PHCs, emergency cases will have to be served by CHCs or district hospitals, which can lead to significant delay in providing care, thereby increasing the risk to patient lives. Significantly, almost all the districts lack Medical Officers at the PHC level, except Durg and Bijapur.

Similarly, most PHCs in every district do not meet the requirement of having at least three ANMs and at least one LHV. ANMs and LHVs are critical to improving institutional delivery and to reducing infant mortality,

12 The essential criteria for manpower, equipment, and services are already given in Tables 5, 6, and 7.

especially in a context where almost 75% of all PHCs in Chhattisgarh do not have an MBBS doctor. This could be an important reason for the low level of institutional births (only 66.8%) and the high IMR (56 per 1,000 live births) in rural Chhattisgarh (NFHS-4, 2015-16).

7.1.3 Services gap

The deficit ratio for services being provided by PHCs was found to be only 0.09, which indicates a high achievement rate. The primary gap in services has been the lack of laboratory services across most PHCs in the state. At the same time, while the facilities are providing most of the essential services, the lack of adequate equipment and manpower could result in lower quality of care. This adds to the social cost of health because people are compelled to visit private health clinics or unqualified doctors in villages, and, in some cases, have to travel longer distances to nearby cities or towns for quality medical care. Thus, while availability of services at the PHC is a necessary condition, it is not sufficient for ensuring quality healthcare, for which other conditions such as availability of equipment, manpower, and electricity supply have to be equally fulfilled.

7.2 IPHS on electricity access

Delivery of quality healthcare services is distinct from the mere provision of these services, for quality cannot be ensured unless the health facility is equipped with better infrastructure, including enablers such as electricity access. There is an urgent need to meet the basic requirements as given in the IPHS norms, specifically to shift the focus to quality healthcare service delivery. As highlighted throughout this study, the role of electricity access as an enabler of service delivery is critical, while lack of equipment and manpower will only compound the problem.

IPHS guidelines suggest that a PHC should have power supply with a backup option. Only about 42% of the PHCs surveyed in Chhattisgarh meet this IPHS guideline, wherein they are connected to the grid and have some form of power backup, either a diesel generator set, or an inverter or solar. Districts like Bastar, Rajnandgaon, Kondagaon, and Kawardha perform poorly in this regard, whereas districts like Jashpur, Gariaband, and Raigarh perform better, with more than 60% of their PHCs connected to the grid and have some form of power backup.

Table 9 highlights the interplay between poor electricity access and deficit ratios of equipment and manpower, as per the IPHS norms.

Table 10: State of electricity access and IPHS deficit ratios

District	Deficit ratio			Proportion of	
	Equipment	Manpower	Services	Power-deficit PHCs (%)	Power-deficit PHCs with backup (%)
Kondagaon	0.55	0.42	0.1	30	10
Rajnandgaon	0.25	0.41	0.03	30	20
Kawardha	0.34	0.45	0.05	50	20
Bastar	0.58	0.42	0.12	40	30
Durg	0.39	0.24	0.2	20	40
Janjgir- Champa	0.36	0.53	0.03	40	50
Surajpur	0.56	0.39	0.02	70	50
Narayanpur	0.48	0.35	0.11	83	50
Surguja	0.18	0.15	0.02	67	56
Bijapur	0.42	0.32	0.02	57	57
Sukma	0.60	0.4	0.22	40	60
Koriya	0.62	0.35	0.08	70	60
Raigarh	0.38	0.37	0.06	38	62
Gariaband	0.53	0.38	0.15	42	67
Jashpur	0.38	0.39	0.05	70	70

Source: *CEEW Analysis, 2017*

Kondagaon and Bastar districts have only 10% and 30% of their sample PHCs, respectively, meeting the criteria of grid connection and power backup. Further, the deficit ratios for both equipment (0.55) and manpower (0.42) are higher than the state average. The poor state of electricity services will act as a barrier to the effective functioning of available equipment and adversely affect the ability of the staff to carry out their duties.

Rajnandgaon, Kawardha, Durg, and Janjgir-Champa while having a lower deficit ratio for equipment (which indicates a higher achievement ratio), have a very low share of PHCs connected to the grid with power backup.

The district of Surajpur has high deficit ratios for manpower and equipment as compared to the state average. Also, 70% of its PHCs are power deficit. To further compound the problem, only 50% of the surveyed PHCs report having power backup.

Overall, eight districts report having 50% or less of their PHCs with both grid connectivity and power backup. Of these, seven districts have a high deficit ratio for either manpower or equipment, or both.

8. Key Lessons for Electricity Access and Intervention Designs

The role of electricity as an enabler of the cost-effective and targeted delivery of health services is being recognised across the world. The present study is one of the first evaluations in India of the role of electricity access on health outcomes in the state of Chhattisgarh. The insights from this study encompass several areas – electricity access and health; the special role of electricity in cold chain management and neonatal health; and design, operation, and maintenance of solar systems for health.

The key insights from the study are as follows:

1. **Mainstream electricity access as a critical component of health system infrastructure**

   The current evaluation provides evidence for the importance of electricity as a critical component of health infrastructure. We find that PHCs that do not have any power deficit (that is, access to reliable electricity for adequate duration) have better performance metrics than those without electricity access. This is seen across indicators like provision of emergency services, deliveries conducted, and in-patient as well as out-patient care. Further, we find that these improvements in service delivery are correlated with better health outcomes for the community. Analysis of AHS data reveals a statistically significant positive correlation of districts having a higher share of power-deficit PHCs with IMR and U-5MR, and a statistically significant negative correlation with the proportion of fully immunised children.[13] Therefore, health policy should include electricity access as a critical component of health infrastructure (in addition to manpower, drugs, equipment, etc.).

2. **Augment electricity supply with solar systems and give priority to power-deficit health facilities**

   The current study finds that solar systems play a pivotal role in the functioning of equipment and in the maintenance of cold chain services across PHCs in Chhattisgarh. On average, power-deficit PHCs with electricity supply augmented by solar perform significantly better in terms of service delivery than those without such systems. Priority should be given to power-deficit PHCs, especially those that have been designated to provide 24x7 services.

3. **Tailor solar system design based on local needs and considerations**

   The design of the solar system should be based on the state of electricity access across health centres. For some places, a higher-capacity system and/or greater storage requirement may involve a higher initial capital investment while other back-up alternatives might have lower financial cost. At the same time, it should be noted that solar systems offer a competitive payback period, with lower O&M costs, thus strengthening the case for them to be the preferred choice.

   It is also recommended that PHCs be equipped with off-grid solar systems as opposed to on-grid systems. This recommendation is aimed at addressing technical and regulatory challenges at the state level with regard to net-metering connections in the case of rooftop solar systems. Given that the load of the PHC is

13 P-values: IMR = 0.01; Proportion of fully immunised children = 0.00; and Under-5 Mortality Rate = 0.00. IMR and U5MR have a direct correlation with higher proportions of power-deficit PHCs in a district, while the proportion of fully immunised children has an inverse correlation with the share of power-deficit PHCs in a district.

highest during the day, when generation is also at its peak, it makes the business case for the use of solar as a primary mode of supply, and not just as backup.

There is an opportunity to expand the network of CCPs at the primary level, wherein assured cold chain services can be provided without electricity access being a barrier. The current operational model of CREDA connects the cold chain equipment with the solar PV systems to enable round-the-clock functionality of cold chain equipment. Solarisation of power-deficit PHCs will not only help in the uninterrupted functioning of existing cold chain equipment but will also allow for the expansion of these services in other PHCs. Similarly, providing solar as a source of electricity can also ensure neonatal care services as and when needed, with radiant warmers and incubators having assured functionality with solar as a backup. Further, there is potential to pilot solar-based cold chain equipment and radiant warmers, which could especially serve remote regions.

Also, during the evaluation, the two key points that emerged with regard to the system design were: (i) connect the staff quarters to the solar system, thus making it easier for them to stay at the facility, especially during the night; (ii) connect the electric water pump and the water filtration unit, thus ensuring adequate supply of drinking water and water for other uses.

4. **The impact and sustained use of solar are driven by robust operations and maintenance services**

   The O&M Cell of CREDA regularly monitors the installed solar PV systems and is in charge of all repairs and replacements. This initiative has been instrumental in ensuring the smooth functioning of solar systems in the PHCs, resulting in minimal issues in adoption. Such institutional arrangements present a case for replication in other states to ensure system uptake and utilisation.

5. **Scaling solar systems across health centres is in India's strategic interest**

   Scaling solar across health centres in India is aligned with the goals of the National Solar Mission (NSM) as well as with the aims of NHM. NSM has a target of achieving an installed capacity of 100 GW of solar by 2022 of which 40 GW is envisaged to come from rooftop solar. Providing solar to all PHCs across the country (5 kW systems) can contribute about 160 MW of the rooftop target. If solar were to be extended to cover Sub-Centres (1 kW systems) and CHCs (8 kW systems), the total potential would be about 415 MW. At the same time, electricity access can be an enabler to achieve the NHM's health targets. Therefore, exploring synergies would strategically align India's health and energy targets.

There are significant opportunities to simultaneously address the (often competing) goals of energy access, energy security, resource management, and health outcomes. Solar for health is one such opportunity to achieve this goal. Chhattisgarh provides evidence for scaling this intervention to meet the national goals for both health and energy.

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11. Annexures

Annexure I: Summary statistics of selected parameters for stratification

S. No.	District	Average no. of OPD patients in a month	Percentage of PHCs that are functional CCPs	Average no. of deliveries in a month	Percentage of fully immunised children
1	Koriya	485	47.06	4	82.08
2	Surguja	333	52.00	9	70.49
3	Surajpur	333	44.44	9	70.49
4	Balrampur	333	53.33	9	70.49
5	Jashpur	415	47.06	4	63.80
6	Raigarh	386	37.04	5	88.63
7	Korba	335	81.82	11	85.01
8	Janjgir-Champa	245	61.54	3	77.13
9	Bilaspur	352	20.00	8	61.71
10	Mungeli	352	33.33	8	61.71
11	Kawardha	544	64.71	13	90.01
12	Rajnandgaon	423	67.86	10	69.82
13	Durg	347	46.67	4	60.00
14	Balod	347	70.37	4	60.00
15	Bemetera	347	69.57	4	60.00
16	Raipur	413	58.62	5	76.77
17	Balodabazar	413	52.94	5	76.77
18	Gariaband	413	27.27	5	76.77
19	Mahasamund	491	66.67	7	81.17
20	Dhamtari	593	65.38	5	72.44
21	Kanker	541	39.13	4	79.38
22	Bastar	410	43.18	6	83.59
23	Kondagaon	410	61.11	6	83.59
24	Narayanpur	410	37.50	6	83.59
25	Dantewada	543	53.33	4	57.79
26	Sukma	543	66.67	4	57.79
27	Bijapur	543	50.00	4	57.79

Source: *CEEW Analysis, 2017*

Annexure II: Results of all the 4 normalised Index Values (IV) and average Index Value

S. No.	District	IV of average no. of OPD patients in a month	IV of percentage of PHCs that are functional CCPs	IV of average no. of deliveries in a month	IV of percentage of fully immunised children	Average IV
1	Koriya	0.69	0.44	0.03	0.75	0.48
2	Surguja	0.25	0.52	0.61	0.39	0.44
3	Surajpur	0.25	0.40	0.61	0.39	0.41
4	Balrampur	0.25	0.54	0.61	0.39	0.45
5	Jashpur	0.49	0.44	0.06	0.19	0.29
6	Raigarh	0.41	0.28	0.18	0.96	0.45
7	Korba	0.26	1.00	0.86	0.84	0.74
8	Janjgir-Champa	0.00	0.67	0.00	0.60	0.32
9	Bilaspur	0.31	0.00	0.49	0.12	0.23
10	Mungeli	0.31	0.22	0.49	0.12	0.28
11	Kawardha	0.86	0.72	1.00	1.00	0.90
12	Rajnandgaon	0.51	0.77	0.70	0.37	0.59
13	Durg	0.29	0.43	0.11	0.07	0.22
14	Balod	0.29	0.81	0.11	0.07	0.32
15	Bemetera	0.29	0.80	0.11	0.07	0.32
16	Raipur	0.48	0.62	0.23	0.59	0.48
17	Balodabazar	0.48	0.53	0.23	0.59	0.46
18	Gariaband	0.48	0.12	0.23	0.59	0.35
19	Mahasamund	0.71	0.75	0.37	0.73	0.64
20	Dhamtari	1.00	0.73	0.23	0.45	0.60
21	Kanker	0.85	0.31	0.07	0.67	0.47
22	Bastar	0.47	0.38	0.29	0.80	0.48
23	Kondagaon	0.47	0.67	0.29	0.80	0.56
24	Narayanpur	0.47	0.28	0.29	0.80	0.46
25	Dantewada	0.86	0.54	0.11	0.00	0.38
26	Sukma	0.86	0.75	0.11	0.00	0.43
27	Bijapur	0.86	0.49	0.11	0.00	0.36

Source: *CEEW Analysis, 2017*

Annexure III: District-level snapshot of health and electricity

Table 11: Code guide for district tables

Parameter	Code	
Is the PHC 24x7?	Yes	
	No	
24x7 delivery services?	Yes	
	No	
All essential services?	All six are Yes	
	Any one is No	
At least 6 beds?	Yes	
	No	
Power backup other than solar?	Any one is Yes	
	Both are No	
Functional cold chain equipment?	Both are Yes	
	Any one is No	
Functional radiant warmer?	Yes	
	No	
Duration of power cut	Categories	<0.5, 0.5, 1,2, 3, >3
Time of power cuts	Categories	M, A, E, N
Time of voltage fluctuation	Categories	M, A, E, N
Unpaid bills	None	
	Yes	
OPD, IPD, deliveries, lab	Not affected	
	Somewhat affected	
	Severely affected	
	Service not provided	x

Source: *CEEW Analysis, 2017*

1. Bastar

PHC name	Provides 24x7 services	Provides 24x7 delivery services	Provides all essential primary healthcare services	At least 6 beds	Power backup available other than solar	Functional cold chain equipment	Functional radiant warmer	State of electricity services				Impact of electricity on services			
								Time of day of power cuts	Avg. duration of power cut (hrs)	Time of day of voltage fluctuation	Unpaid bills	OPD	IPD	Deliveries	Lab
Singanpur								NA	0	Afternoon	None				
Adawal								Morning + Evening	>3	Morning	None				
Alnar								Afternoon	2	Afternoon	None				
Ghotia								Evening	0.5	Evening	None				
Kolawal								Afternoon + Evening	3	Evening	None				
Kurandi								Morning + Afternoon	0.5	Afternoon	None				
Nagarnar								NA	0	Afternoon	None				
Neganar								Morning	4	Morning	None				x
Pakhnakongera								NA	0						
Tirtha								NA	0						

Source: *CEEW Analysis, 2017*

2. Bijapur

PHC name	Provides 24x7 services	Provides 24x7 delivery services	Provides all essential primary healthcare services	At least 6 beds	Power backup available other than solar	Functional cold chain equipment	Functional radiant warmer	State of electricity services				Impact of electricity on services			
								Time of day of power cuts	Avg. duration of power cut (hrs)	Time of day of voltage fluctuation	Unpaid bills	OPD	IPD	Deliveries	Lab
Cherpal								NA	0	Night	None				
Kutru								Morning	3	None	None				
Elmidi								Morning + Afternoon + Evening	>3	Morning	None				x
Awapalli/ Pusgudi								Morning + Afternoon + Evening	>3	Morning	None				
Basaguda								Afternoon + Evening	>3	Evening	None				x
Tarlaguda								All day	>3	All day	None				
Madder								Afternoon	2	Afternoon	None				

Source: *CEEW Analysis, 2017*

3. Durg

PHC name	Provides 24x7 services	Provides 24x7 delivery services	Provides all essential primary healthcare services	At least 6 beds	Power backup available other than solar	Functional cold chain equipment	Functional radiant warmer	State of electricity services				Impact of electricity on services			
								Time of day of power cuts	Avg. duration of power cut (hrs)	Time of day of voltage fluctuation	Unpaid bills	OPD	IPD	Deliveries	Lab
Gadadeeh								Afternoon	<0.5	Afternoon	None				
Nagpura								Morning	<0.5	None	None				
Batrel								Evening	<0.5	None	None				x
Pendrawan								Morning + Afternoon	3	Afternoon	None				
Pureina								Afternoon	1	None	None		x		x
Khursipar								NA	0	None	None		x	x	x
Machandur								Afternoon	3	None	None				
Hanoda								Afternoon	<0.5	None	None				
Junwani								Afternoon	<0.5	None	Yes				x
Nandkatthi								Afternoon + Evening	>3	Afternoon	None				

Source: *CEEW Analysis, 2017*

4. Gariaband

PHC name	Provides 24x7 services	Provides 24x7 delivery services	Provides all essential primary healthcare services	At least 6 beds	Power backup available other than solar	Functional cold chain equipment	Functional radiant warmer	State of electricity services				Impact of electricity on services			
								Time of day of power cuts	Avg. duration of power cut (hrs)	Time of day of voltage fluctuation	Unpaid bills	OPD	IPD	Deliveries	Lab
Kondkera								Evening	0.5	Afternoon	None				
Khadma								Afternoon	1	Afternoon	None				
Pathsivni								Morning	1	Afternoon	None				
Urmal								Evening	2	Evening	Yes				
Amlipadar								Morning	1	All day	None				
Jhargaon								Afternoon	2	All day	Yes				
Kopra								None	0	Afternoon	None				
Kochbay								Evening	1	None	None				x
Kosmi								Afternoon	2	Afternoon	Yes				
Piperchedi								Evening	1	Evening	None				x
Jhakarpara								Afternoon + Evening	3	Evening	Yes				x
Diwanmuda								Afternoon + Evening	2	Afternoon	None				x

Source: *CEEW Analysis, 2017*

5. Janjgir-Champa

PHC name	Provides 24x7 services	Provides 24x7 delivery services	Provides all essential primary healthcare services	At least 6 beds	Power backup available other than solar	Functional cold chain equipment	Function-al radiant warmer	State of electricity services				Impact of electricity on services			
								Time of day of power cuts	Avg. duration of power cut (hrs)	Time of day of voltage fluctuation	Unpaid bills	OPD	IPD	Deliveries	Lab
Ghoghari								Afternoon	2	None	None				
Adbhar								Night	1	None	None				
Kotmi								Morning + Afternoon	2	None	None				x
Katrenagar/ Sonthi								Evening	3	Evening	None				x
Kapan								Afternoon	4	Evening	None				x
Dalhapodi								All day	0.5	None	Yes				x
Devari								None	0	None	Yes				x
Bhaiso								None	0	All day	Yes				x
Salkha								Evening	2	None	None		x		x
Jarve B								Morning	3	None	None				x

Source: *CEEW Analysis, 2017*

6. Jashpur

PHC name	Provides 24x7 services	Provides 24x7 delivery services	Provides all essential primary healthcare services	At least 6 beds	Power backup available other than solar	Functional cold chain equipment	Functional radiant warmer	State of electricity services				Impact of electricity on services			
								Time of day of power cuts	Avg. duration of power cut (hrs)	Time of day of voltage fluctuation	Unpaid bills	OPD	IPD	Deliveries	Lab
Maini								Morning	<0.5	Morning	None				
Sanna								Morning	>3	None	None				
Kalia								NA	0	None	None				
Tapkara								Morning	2	Evening	None				
Bhagora								Morning	>3	None	None				x
Kolhenjharia								Afternoon	2	All day	Yes		x	x	x
Ludeg								Afternoon	<0.5	None	None				
Tamta								Morning	>3	Morning	Yes				
Baghia								NA	0	None	None				x
Champa								Morning	Night	All day	Yes				x

Source: *CEEW Analysis, 2017*

7. Kawardha

PHC name	Provides 24x7 services	Provides 24x7 delivery services	Provides all essential primary healthcare services	At least 6 beds	Power backup available other than solar	Functional cold chain equipment	Function-al radiant warmer	State of electricity services				Impact of electricity on services			
								Time of day of power cuts	Avg. duration of power cut (hrs)	Time of day of voltage fluctuation	Unpaid bills	OPD	IPD	Deliveries	Lab
Rampur								Afternoon	2	None	None				
Pondi								Evening	3	None	None				
Rengakhar								Afternoon	2	Afternoon	Yes				
Chilfi								NA	0	None	Yes				
Kukdur								Evening	>3	None	Yes				
Damapur								All day	1	Night	Yes				
Rushe								Morning	3	Evening	None				x
Pandatari								Evening	2	None	None				x
Raveli								All day	>3	Afternoon	Yes				x
Indouri								Night	>3	Evening	None				

Source: *CEEW Analysis, 2017*

8. Kondagaon

PHC name	Provides 24x7 services	Provides 24x7 delivery services	Provides all essential primary healthcare services	At least 6 beds	Power backup available other than solar	Functional cold chain equipment	Functional radiant warmer	State of electricity services				Impact of electricity on services			
								Time of day of power cuts	Avg. duration of power cut (hrs)	Time of day of voltage fluctuation	Unpaid bills	OPD	IPD	Deliveries	Lab
Lanjoda								NA	0	None	Yes				
Badedongar								Morning	1	None	None				
Kongud								NA	0	None					
Lubha								Evening	2	Afternoon	None				
Sampur								Afternoon	1	Evening	None				
Radhna								Afternoon	1	Afternoon	None				x
Chipawand								Morning + Night	2	Afternoon	None				
Kondagaon								NA	0	All day	None				
Sonabal								NA	0	None	None				x
Bamhani								Morning + After-noon	3	Evening	None			x	x

Source: *CEEW Analysis, 2017*

9. Koriya

PHC name	Provides 24x7 services	Provides 24x7 delivery services	Provides all essential primary healthcare services	At least 6 beds	Power backup available other than solar	Functional cold chain equipment	Functional radiant warmer	State of electricity services				Impact of electricity on services			
								Time of day of power cuts	Avg. duration of power cut (hrs)	Time of day of voltage fluctuation	Unpaid bills	OPD	IPD	Deliveries	Lab
Barpara								Afternoon	>3	Afternoon	None				
Chirmee								Evening	3	None	None				
Banjaridand								NA	0	None					
Udhnapur								Morning + Afternoon	>3	All day	None				
Haldibadi								Morning + Afternoon	1	None	None				
Katgodi								Evening	0.5	Afternoon	None				
Bodar								NA	0	None					
Banji								Morning + Afternoon	3	None	None				x
Kelhari								Morning + Afternoon	<0.5	None	Yes				
Ledari								Afternoon + Evening	>3	Afternoon	None				x

Source: *CEEW Analysis, 2017*

10. Narayanpur

PHC name	Provides 24x7 services	Provides 24x7 delivery services	Provides all essential primary healthcare services	At least 6 beds	Power backup available other than solar	Functional cold chain equipment	Functional radiant warmer	State of electricity services				Impact of electricity on services			
								Time of day of power cuts	Avg. duration of power cut (hrs)	Time of day of voltage fluctuation	Unpaid bills	OPD	IPD	Deliveries	Lab
Chhote Donger								Morning + Afternoon	3	Morning	None				
Dhanora								All day	>3	None	None				x
Benoor								Afternoon	2	Afternoon	None				
Dhaudai								Morning + Afternoon	3	Morning	Yes				x
Kohkameta								NA	0	None					
Kutul								NA	0	None					

Source: *CEEW Analysis, 2017*

11. Raigarh

PHC name	Provides 24x7 services	Provides 24x7 delivery services	Provides all essential primary healthcare services	At least 6 beds	Power backup available other than solar	Functional cold chain equipment	Functional radiant warmer	State of electricity Services				Impact of electricity on services			
								Time of day of power cuts	Avg. duration of power cut (hrs)	Time of day of voltage fluctuation	Unpaid bills	OPD	IPD	Deliveries	Lab
Lendhra								All day	>3	All day	None				
Bonda								All day	1.5	Night	Yes				x
Bahirkela								All day	>3	Afternoon	None				x
Chhal								NA	0	Morning	Yes				
Ganpatpur								Morning + Afternoon	>3	None	None				x
Kondatarai								Morning	2.5	None	Yes				
Chhapora								NA	0	None	None				
Badebhandar								Morning	0.5	Morning	None				
Bangursiya								Evening	>3	Evening	None				
Banora								Afternoon	3	None	None				
Kirodimal Nagar								Morning + Afternoon	2	None	None				
Urba								Night	2	None	None				
Gorpar								Evening	2	None	None				x

Source: *CEEW Analysis, 2017*

12. Rajnandgaon

PHC name	Provides 24x7 services	Provides 24x7 delivery services	Provides all essential primary healthcare services	At least 6 beds	Power backup available other than solar	Functional cold chain equipment	Functional radiant warmer	State of electricity services				Impact of electricity on services			
								Time of day of power cuts	Avg. duration of power cut (hrs)	Time of day of voltage fluctuation	Unpaid bills	OPD	IPD	Deliveries	Lab
Umarvahi								Morning + Night	2	None	None				
Aundhi								Afternoon	1	Evening	Yes				
Chilhati								NA	0	None	None				
Basdi								Evening	0.5	Evening	Yes				
Chaarbhatha								NA	0	Morning	Yes				x
Khujji								NA	0	Evening	Yes				x
Pendarbani								Afternoon	2	None	None				
Bundeli								Afternoon	>3	None	None				x
Pandahah								Evening	3	Afternoon	Yes				
Markamtola								Afternoon	1	None	Yes				

Source: *CEEW Analysis, 2017*

13.Sukma

PHC name	Provides 24x7 services	Provides 24x7 delivery services	Provides all essential primary healthcare services	At least 6 beds	Power backup available other than solar	Functional cold chain equipment	Functional radiant warmer	State of electricity services				Impact of electricity on services			
								Time of day of power cuts	Avg. duration of power cut (hrs)	Time of day of voltage fluctuation	Unpaid bills	OPD	IPD	Deliveries	Lab
Kukanaar								NA	0	Afternoon	None				x
Tongpal								Afternoon	0.5	Afternoon	Yes				
Puspal								Morning + Afternoon + Evening	>3	Morning	None				x
Gorli								NA	0	None					
Edgepal								NA	0	None					
Golapalli								Afternoon	0.5	Afternoon	None				x
Burdi								All day	>3	Night	None				x
Kerelapal								Afternoon	>3	Evening	None				x
Dornapal								Afternoon	3	None	Yes				
Gadiras								Afternoon	3	None	None				

Source: *CEEW Analysis, 2017*

14. Surajpur

PHC name	Provides 24x7 services	Provides 24x7 delivery services	Provides all essential primary healthcare services	At least 6 beds	Power backup available other than solar	Functional cold chain equipment	Functional radiant warmer	State of electricity services				Impact of electricity on services			
								Time of day of power cuts	Avg. duration of power cut (hrs)	Time of day of voltage fluctuation	Unpaid bills	OPD	IPD	Deliveries	Lab
Basdei								NA	0	None	Yes				
Parsurampur								Afternoon	3	None	None				
Umeshwarpur								Morning	2	None	None				
Mahangai								Afternoon	>3	All day	None				x
Chandarpur								Afternoon	>3	Afternoon	None				
Kamalpur								Morning	>3	Morning	None				
Karanji								Night	>3	All day	Yes				x
Batra								Evening	>3	Evening	None				
Chungadi								NA	0	None	None				x
Pendri								Afternoon	>3	Evening	None				x

Source: *CEEW Analysis, 2017*

15. Surguja

PHC name	Provides 24x7 services	Provides 24x7 delivery services	Provides all essential primary healthcare services	At least 6 beds	Power backup available other than solar	Functional cold chain equipment	Function-al radiant warmer	State of electricity services				Impact of electricity on services			
								Time of day of power cuts	Avg. duration of power cut (hrs)	Time of day of voltage fluctuation	Unpaid bills	OPD	IPD	Deliveries	Lab
Lundra								NA	0	Evening	Yes				
Lahpatra								Morning + Afternoon	<0.5	None	Yes				
Kedma								Morning + Afternoon	1	Afternoon	None				
Khamhariya								Afternoon	>3	None	Yes				
Darima								Afternoon	1	Afternoon	Yes				
Fundurdihari								Afternoon	>3	None	None				
Bandana								Evening	>3	None	None				
Barkela								NA	0	None	Yes				
Kamleshwarpur								Evening	>3	None	None				

Source: *CEEW Analysis, 2017*

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