MUWRP
Makerere University
Walter Reed Program

Health Facility Solar Assessment

Descriptive and Inferential Statistical Analysis Report

101 health facility submissions • 6 districts • 78 solar-powered facilities

Buikwe · Buvuma · Kayunga · Luwero · Mukono · Nakasongola

Prepared for MUWRP Management

July 2026

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1. Executive Summary

This report presents a statistical analysis of the MUWRP Health Facility Solar Assessment, covering 101 health facilities assessed across six districts: Buikwe, Buvuma, Kayunga, Luwero, Mukono, and Nakasongola. It examines current solar energy coverage, system performance, operational reliability, and the measurable impact of solar power on health service delivery, drawing on both descriptive statistics and formal inferential tests.

101	77.2%	70/78	45
Facilities assessed	Have solar power	Need expansion/upgrade	Installed with MUWRP support

Summary of Findings

- Solar power has reached the majority of facilities. 78 of 101 facilities (77.2%) are currently solar-powered. Of the remaining 23 facilities, 21 have formally requested installation.
- Solar installation is associated with a substantial reduction in power outages. Before solar, facilities reported outage frequency averaging 3.08 on a 0-5 scale (between "weekly" and "daily"); after solar, the average fell to 1.87 (closer to "monthly") - a reduction of approximately 39%. This improvement is statistically significant ($p < 0.001$).
- Facility staff report a consistently positive impact. Across 12 statements measuring solar's effect on services, mean agreement was 3.82 out of 5. The strongest perceived gains are in vaccine cold-chain integrity and data/records work; maternity safety, while still positive, shows the smallest gain.
- Installation source is linked to reliability outcomes. Systems installed by MUWRP are rated 3.84/5 for reliability, compared with 3.07/5 for systems installed by other actors, a statistically significant difference ($p = 0.006$).
- Solar adoption varies significantly by facility level. The relationship between facility level and solar coverage is statistically significant ($p = 0.004$); Health Centre IIIs and IVs show the highest coverage, while Health Centre IIs lag behind.
- Maintenance practice is the principal operational gap. Only 27 of 78 facilities follow a scheduled maintenance routine; the remainder service their system only when it fails (35) or not at all (16). 70 of 78 facilities report a need for expansion or upgrade.

Installed inverter capacity, once normalized to a consistent kilowatt basis, has a median of 2.00 kW across facilities (interquartile range 0.41-4.00 kW), consistent with typical health-centre-scale solar systems. Capacity is examined in detail in Section 3.2.

2. About This Assessment

2.1 Purpose and scope

The MUWRP Health Facility Solar Assessment Tool collects data on solar energy installation, performance, and impact across MUWRP-supported health facilities in Uganda. It is completed by the health facility in-charge or data officer and covers facility identification, solar system specifications, service coverage, before/after outage experience, staff-perceived impact (12 Likert statements), operations and maintenance, MUWRP's role, and for facilities without solar, current energy situation and demand for future installation.

2.2 Sample

Metric	Value
Total facility submissions	101
Facilities with solar	78 (77.2%)
Facilities without solar	23 (22.8%)
Districts covered	6 (Buikwe, Buvuma, Kayunga, Luwero, Mukono, Nakasongola)
Facility levels represented	Health Centre II, III, IV; General Hospital; NGO/Private Clinic

2.3Two broad families of statistics are used throughout:

- Descriptive statistics simply summarise what is in the data counts, percentages, averages. They describe "what happened" without claiming it would hold true elsewhere.
- Inferential statistics test whether an observed pattern (for example, that MUWRP-installed systems appear more reliable) reflects a genuine, meaningful difference, or could plausibly be due to random variation in a sample of this size. Each such test reported in this document is accompanied by a p-value. By convention, a p-value below 0.05 indicates the pattern is unlikely to have arisen by chance and is treated as statistically significant; a p-value above 0.05 indicates the data does not provide sufficient evidence to confirm the pattern, even where a difference is visually apparent.

3. Descriptive Statistics: Facility and Solar System Profile

3.1 Where solar has (and hasn't) reached

Solar coverage is high but uneven. Looking across facility level (Health Centre II/III/IV, Hospital), the difference in solar adoption rates is statistically significant (chi-square test, p = 0.004) meaning facility level genuinely predicts whether a facility has solar, it isn't just random variation in this sample.

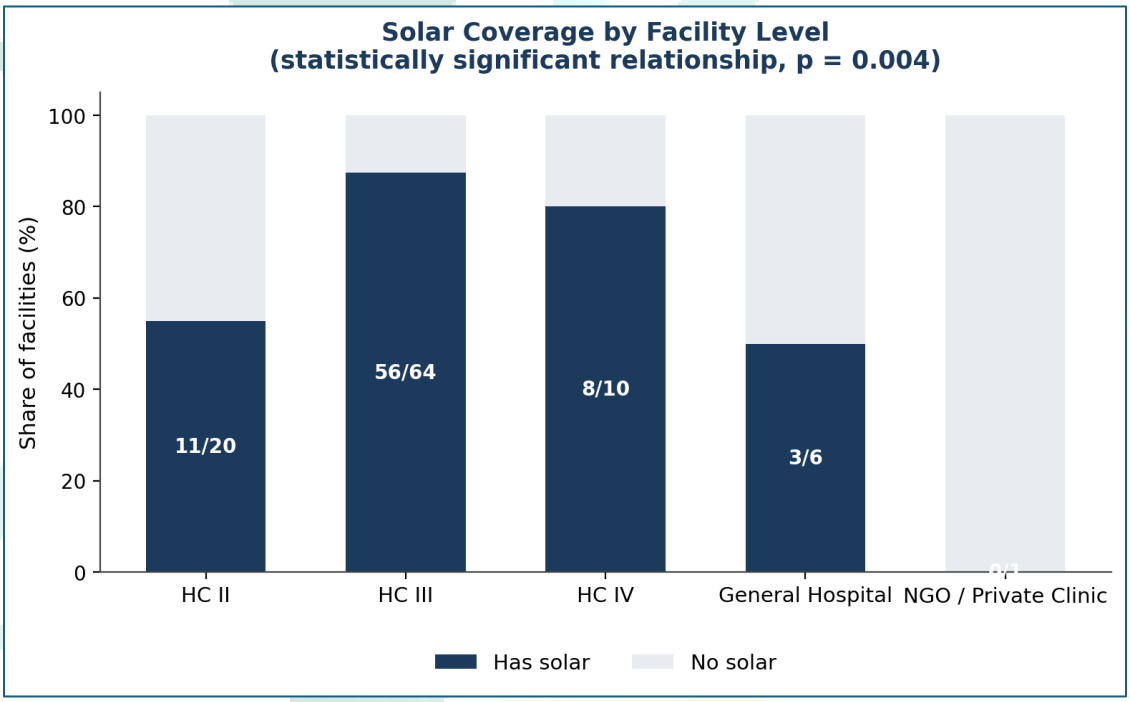

Figure 1. Solar coverage by facility level. Health Centre IIIs and IVs have the highest solar coverage; Health Centre IIs and the single NGO/private clinic lag behind.

By district, coverage ranges from about 65% to 100%, but this district-to-district spread is not statistically significant (chi-square test, p = 0.313), indicating the observed differences between districts cannot be confidently attributed to a genuine geographic pattern rather than sampling variation.

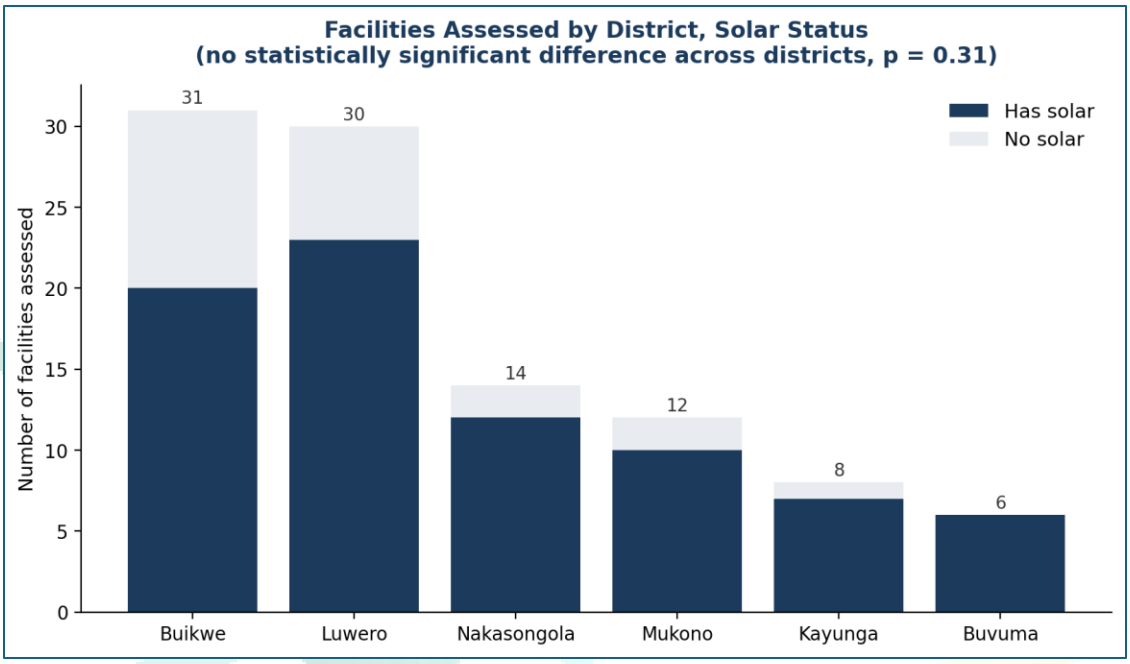

Figure 2. Facilities assessed by district, split by solar status.

3.2 Solar system specifications

Installer: MUWRP is the single largest installer, responsible for 40 of 78 solar systems (51%). Combined with PEPFAR/other USG partners (14) and the Ministry of Health (12), donor- and government-funded installation accounts for the large majority of the footprint. When asked directly whether the system was installed "by or with support from MUWRP," 45 facilities said yes and a further 3 said partially 48 of 78 systems (62%) in total.

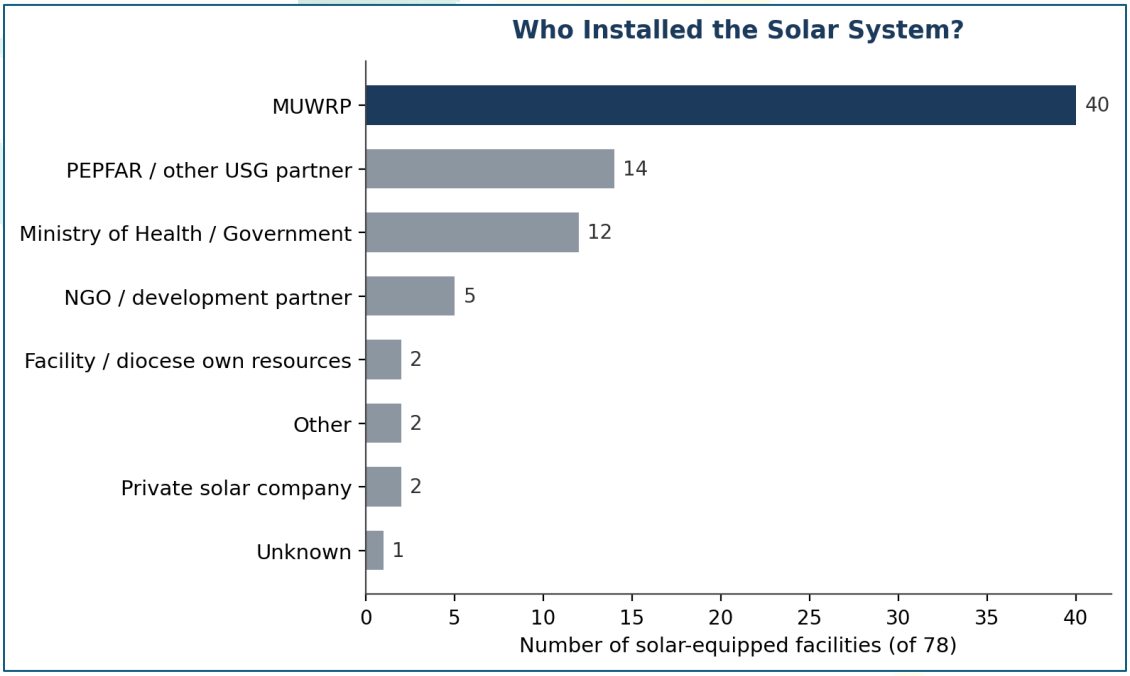

Figure 3. Installer of the current solar system, among solar-equipped facilities.

Installed capacity

The survey field recording installed inverter capacity contained a mix of units, with some entries recorded in kilowatts and others in watts. To enable a consistent comparison, all values were normalized to kilowatts: entries of 50 or below were treated as already being in kilowatts, consistent with typical health-centre-scale systems, and entries above 50 were treated as watts and converted accordingly. One facility (a Health Centre III) retained an implausible value of 420 kW even after conversion and has been treated as a residual data entry error; it is excluded from the summary statistics below but retained in the underlying dataset for verification.

On this normalized basis, installed capacity across the 77 solar facilities with a usable reading has a median of 2.00 kW (interquartile range 0.41-4.00 kW), with values ranging up to 35.00 kW. This distribution is consistent with the expected scale of solar installations at Health Centre II-IV facilities.

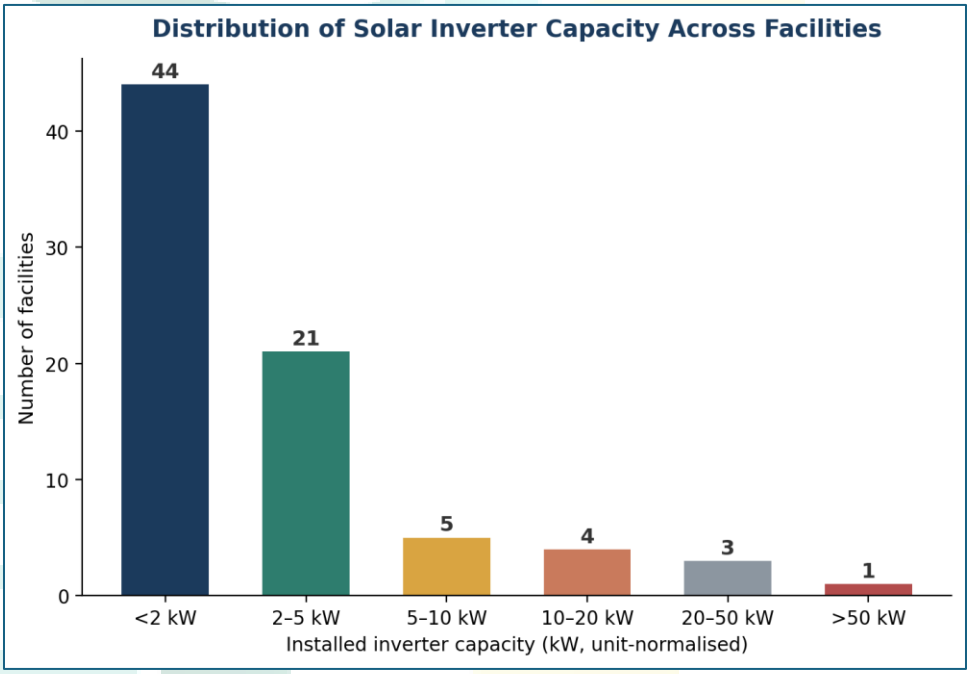

Figure 4. Distribution of installed inverter capacity across solar-equipped facilities, following unit normalization.

System type and grid relationship

27 facilities run standalone off-grid systems (solar plus batteries, no grid), 25 run hybrid systems that fall back to the national grid (UEDCL) when needed, and 11 run solar-plus-battery only. Separately, 60 of 78 solar facilities (77%) are also connected to the national grid, meaning solar functions as a backup or complement to grid power at most sites rather than a total replacement.

What solar covers within the facility

Only 10 of 78 facilities (13%) have solar powering the entire facility. The majority 54 facilities power specific departments only, and a further 14 have partial coverage with known gaps. Looking at three priority services specifically:

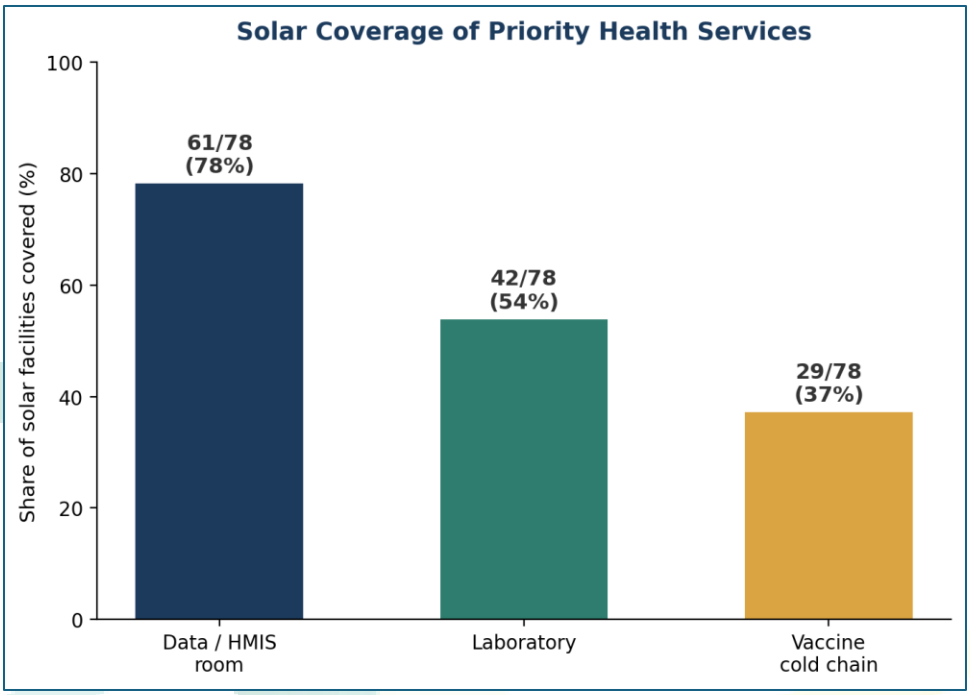

Figure 5. Share of solar-equipped facilities where solar specifically powers the data/HMIS room, laboratory, and vaccine cold chain.

- Data/HMIS rooms are the best-covered priority service: 61 of 78 facilities (78%) directly relevant to MUWRP's digital-health and paperless-records agenda.
- Laboratories are covered at 42 of 78 facilities (54%).
- Vaccine cold chain is the least-covered of the three at 29 of 78 facilities (37%) a gap worth flagging given the consequences of cold-chain failure, even though staff who do have solar-powered cold chain rate its benefit the highest of all 12 impact statements (see Section 5).

4. Outcomes: Power Reliability Before vs. After Solar

This section compares the same 78 solar-equipped facilities' experience of power outages before their solar system was installed and now, after installation. Because the same facilities are compared to themselves at two points in time, this is a "paired" comparison a stronger form of evidence than simply comparing two different groups of facilities.

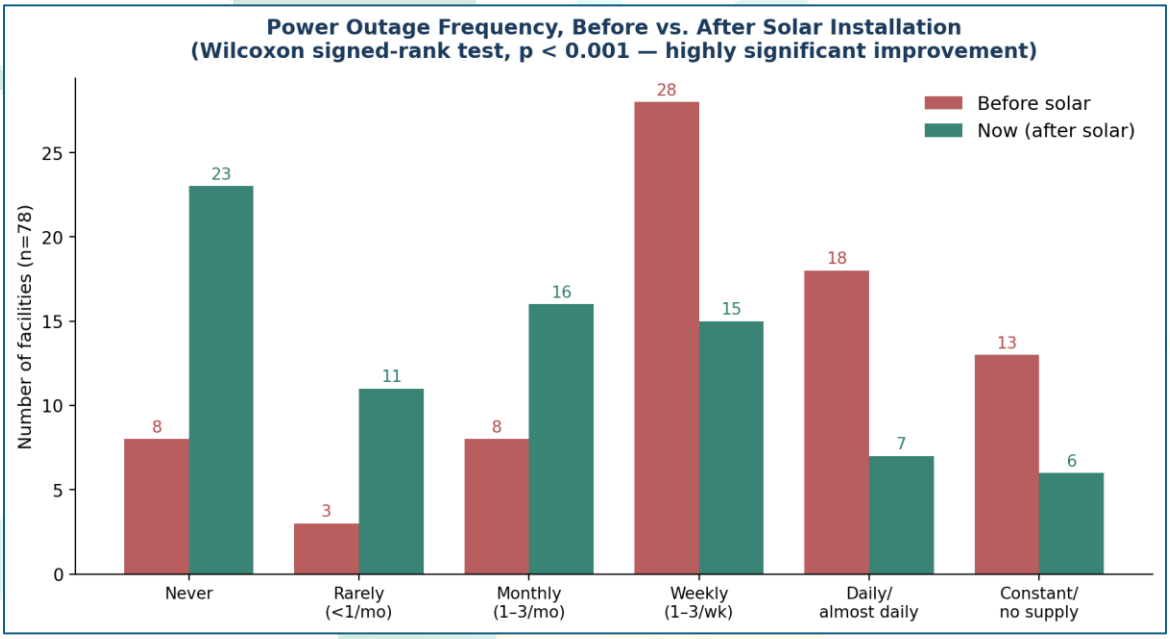

Figure 6. Distribution of self-reported outage frequency, before solar installation versus now.

4.1 What the numbers mean

We scored outage frequency on a simple 0–5 scale (0 = never, 5 = constant/no reliable supply). Before solar, the average facility scored 3.08 between "weekly" and "daily" outages. After solar, the average dropped to 1.87 closer to "monthly" outages. That is roughly a 39% reduction in reported outage frequency.

We tested whether this drop is a real effect of solar, or could just be noise, using two independent statistical tests a paired t-test and a Wilcoxon signed-rank test (a version that does not assume the data is perfectly bell-shaped, which suits ordinal survey answers like these). Both tests concur: paired t-test $p < 0.001$; Wilcoxon signed-rank test $p < 0.001$. The probability that this improvement occurred by chance is less than 1 in 1,000, making this one of the strongest and most defensible findings in the dataset: solar installation is associated with a substantial, genuine reduction in power outages.

4.2 Severity and reliability

Before solar, facilities rated how severely power problems affected their work at 1.94 on a 1–5 scale where 1 is "most severe / services completely disrupted" and 5 is "no impact" i.e., the average facility was closer to the severe end. Today, solar system reliability is rated at 3.54 out of 5 across all solar facilities, with 49 of 78 facilities (63%) rating their system "reliable" or "very reliable."

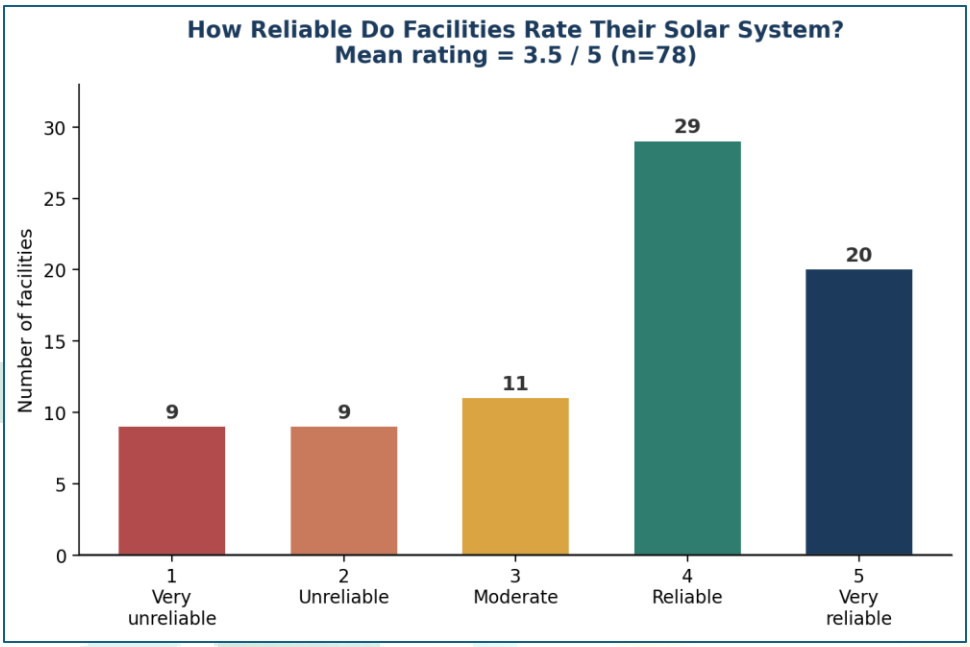

Figure 7. Distribution of facility-reported solar system reliability ratings.

60 of 78 facilities (77%) say solar has improved overall staff efficiency and productivity, with a further 16 saying it has partially improved things only 2 report no improvement at all.

5. Staff-Perceived Impact

Facility staff were asked to rate 12 statements about the effect of solar power on their services, from 1 (Strongly Disagree) to 5 (Strongly Agree). This kind of question is a "Likert scale" a standard way of turning opinions into numbers so they can be averaged and compared. A score above 3 means agreement outweighs disagreement; the further above 3, the stronger and more consistent the agreement across respondents.

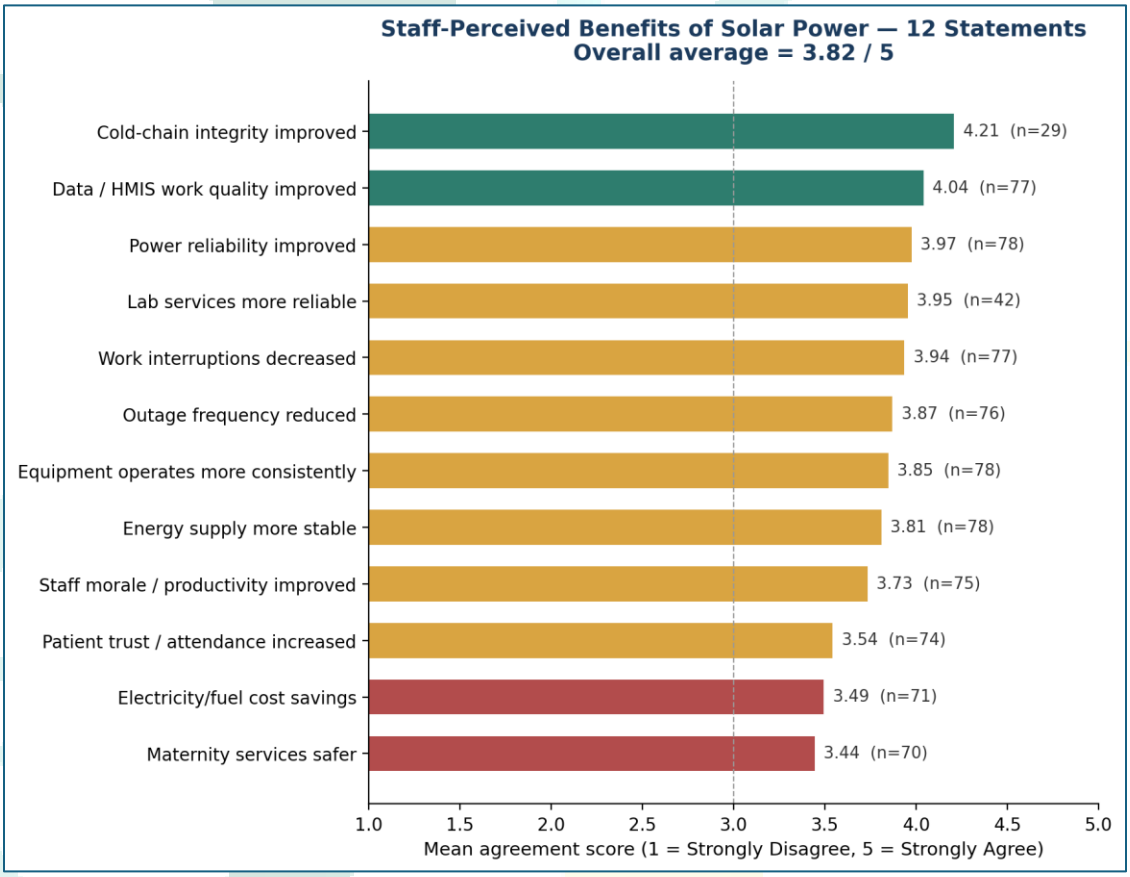

Figure 8. Mean agreement score for each of the 12 solar-impact statements, sorted lowest to highest. Green = strong agreement (≥4.0); gold = moderate agreement (3.5–4.0); red = weaker agreement (though still on the "agree" side of neutral).

5.1 Reading the pattern

- Strongest perceived benefit: vaccine/cold-chain integrity (4.21/5, though based on only the 29 facilities where solar powers the cold chain). This is a strong signal that where solar does reach the cold chain, staff see a clear, tangible benefit reinforcing the case in Section 3.2 for closing the cold-chain coverage gap.
- Close behind: data entry / health information work quality (4.04/5) directly supporting MUWRP's digital-health and records-related objectives.
- Broad, consistent agreement on the "core" outage-related statements power reliability improved, work interruptions decreased, outage frequency reduced, equipment operates more consistently all cluster tightly between 3.8 and 4.0, corroborating the before/after outage findings in Section 4.
- Weakest (but still positive) statements: maternity/delivery safety (3.44/5) and electricity/fuel cost savings (3.49/5). Both are still above the neutral midpoint of 3, but they are the areas where staff see the least dramatic gains plausibly because maternity outcomes depend on many factors beyond power, and because cost savings are only felt where solar has genuinely displaced a costly alternative like fuel generators.

Averaged across all 12 statements, the overall perceived-impact score is 3.82 out of 5 a solidly positive verdict from facility staff on the effect of solar power on their day-to-day work.

Inferential Statistics: What Predicts Better Outcomes?

This section moves beyond describing the data to testing specific relationships asking whether certain facility or system characteristics are statistically associated with better solar reliability outcomes. Each test compares reliability ratings between two or more groups of facilities.

6.1 Does MUWRP installation matter?

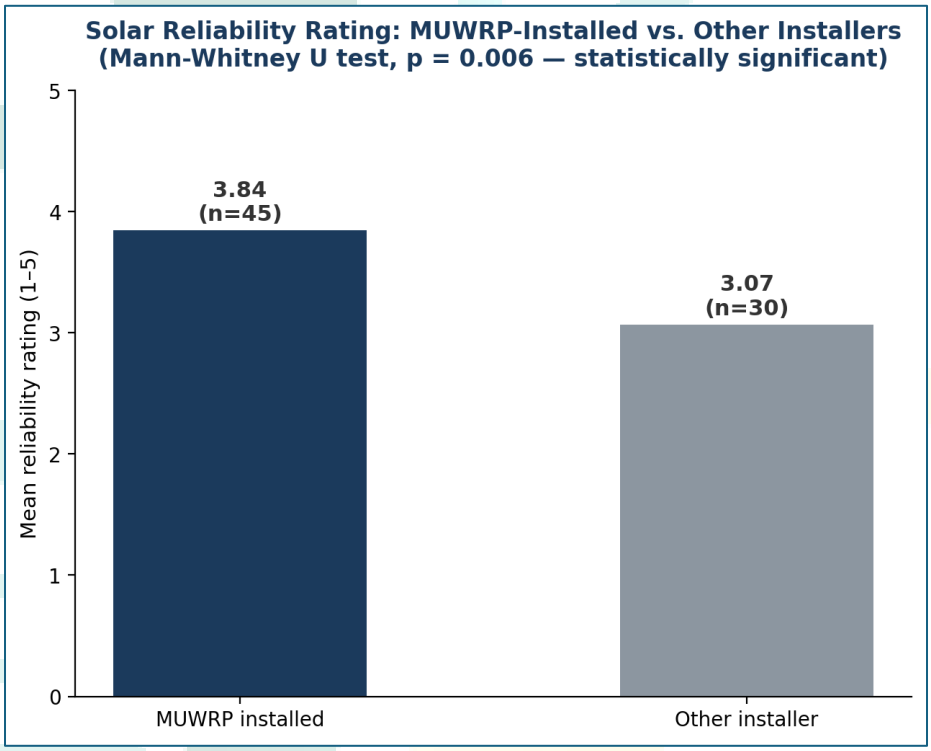

Figure 9. Mean solar reliability rating, MUWRP-installed systems versus systems installed by other actors.

Facilities whose system was installed by MUWRP rate reliability at 3.84/5 on average (n=45), compared with 3.07/5 for systems installed by other actors (n=30). A Mann-Whitney U test a method for comparing two groups on an ordinal (ranked) scale without assuming a bell-curve distribution confirms this gap is statistically significant (p = 0.006), indicating that facilities where MUWRP installed the system are genuinely more likely to report a reliable solar system than facilities relying on other installers.

6.2 Does routine (scheduled) maintenance improve reliability?

We compared facilities with a scheduled maintenance routine (monthly, quarterly, half-yearly, or annual service) against facilities that only fix problems reactively or never service the system at all. Scheduled-maintenance facilities average 3.48/5 reliability versus 3.57/5 for reactive/no-maintenance facilities (Mann-Whitney U test, p = 0.806). This difference is not statistically significant with the numbers currently available, we cannot say scheduled maintenance visibly moves the reliability needle. That is a slightly counter-intuitive finding, and it likely reflects that "reliability" here captures the system's general track record rather than its very latest condition; it should not be read as "maintenance doesn't matter" see the faults and condition data in Section 7, which tell a more concerning story about deferred maintenance.

6.3 Does being grid-connected change how reliable solar feels?

Facilities that also have national grid (UEDCL) access alongside solar rate reliability at 3.52/5, versus 3.61/5 for off-grid-only facilities (Mann-Whitney U test, p = 0.853). The two groups are statistically indistinguishable grid connection does not appear to make facilities rate their solar system meaningfully differently, suggesting the solar system's own performance, not the presence of a backup grid, drives how reliable staff perceive it to be.

6.4 Does system capacity relate to reliability?

Using the normalized capacity figures (Section 3.2), a Spearman correlation between installed capacity and reliability rating gives r = -0.02 across 78 facilities (p = 0.892) a negligible, statistically non-significant relationship. System capacity does not, on its own, predict how reliable a facility rates its solar system; installation quality and maintenance practice appear to matter substantially more than raw capacity.

6.5 Facility level and solar adoption (revisited)

As shown in Section 3.1, facility level is significantly associated with whether a facility has solar at all (chi-square test, p = 0.004). Combined with the installer and maintenance findings above, the overall pattern is consistent: MUWRP's direct involvement in installation and, where it continues, in support is the strongest identifiable driver of good outcomes in this dataset, more so than facility size, system capacity, or grid backup.

7. Operations, Maintenance, and MUWRP Support

7.1 Who maintains the systems

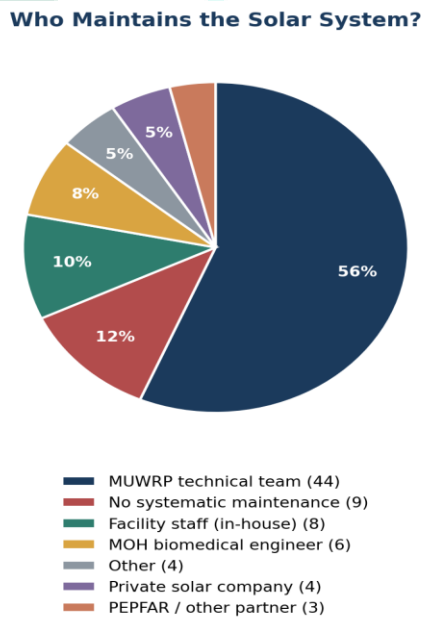

Figure 10. Who is primarily responsible for solar system maintenance, among solar-equipped facilities.

MUWRP's technical team is named as the primary maintenance provider for 44 of 78 facilities (56%) by far the largest single category, and evidence that MUWRP's role extends well beyond initial installation into ongoing operations and maintenance (O&M). Concerningly, 9 facilities (12%) report no systematic maintenance provider at all.

7.2 How often maintenance actually happens

Despite MUWRP being the named maintenance lead at most facilities, the maintenance schedule itself is largely reactive. Only 27 of 78 facilities (35%) follow any kind of scheduled routine (monthly through annual). The majority 35 facilities (45%) only carry out maintenance when something has already gone wrong, and 16 facilities (21%) report never servicing their system. This "fix it when it breaks" pattern is a known driver of shorter equipment lifespan, particularly for batteries.

Despite this, most facilities still rate the quality of maintenance received positively: 55 of 78 (71%) rate it "Good" or "Excellent" when it does happen the concern is frequency and consistency, not quality when maintenance is actually delivered.

7.3 Faults experienced

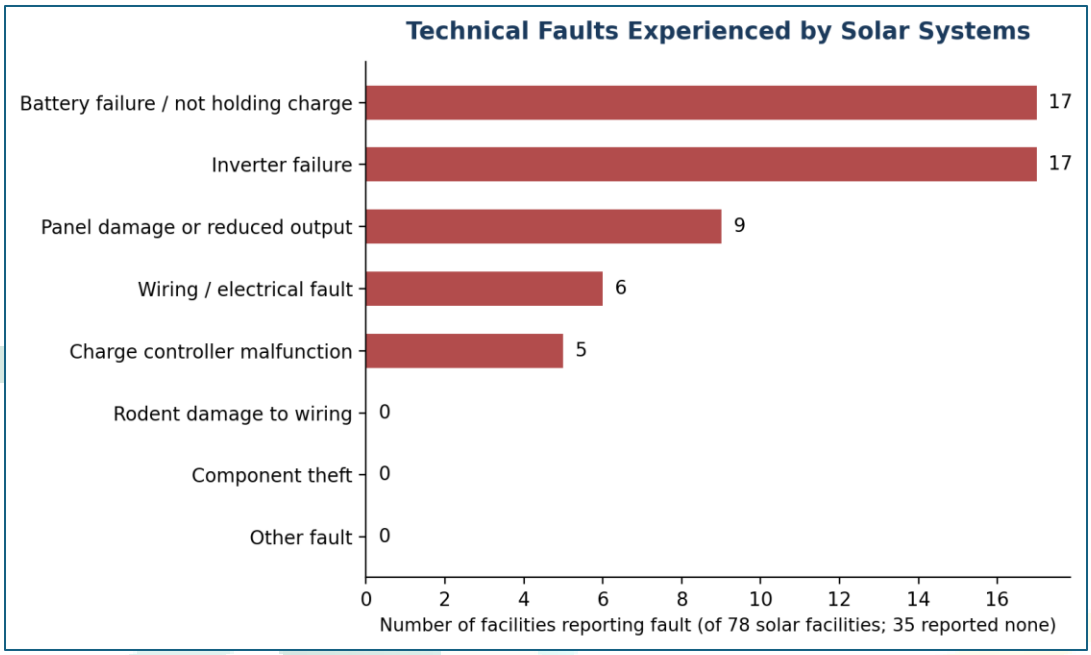

Figure 11. Technical faults reported by solar facilities (35 of 78 facilities report no faults at all).

Battery failure / not holding charge and inverter failure are tied as the most commonly reported faults, each affecting 17 facilities (22%). Both are consistent with systems that are not on a preventive maintenance schedule batteries in particular degrade faster without regular monitoring and balancing. Only 35 facilities (45%) report having experienced no faults at all.

7.4 Overall system condition and MUWRP's ongoing role

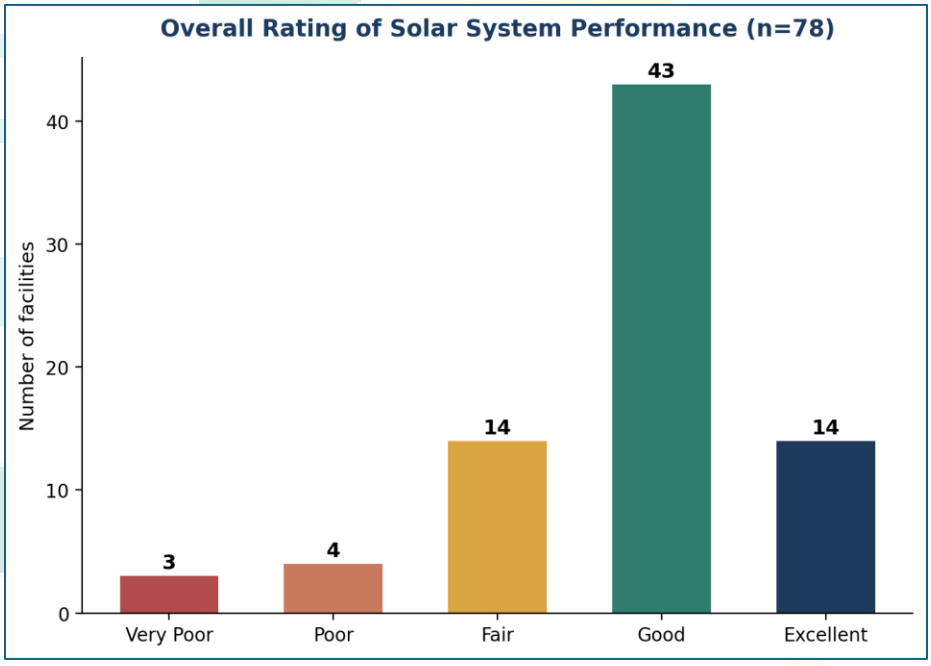

Figure 12. Overall facility rating of solar system performance.

57 of 78 facilities (73%) rate their overall system performance "Good" or "Excellent." On MUWRP's continuing support specifically: 32 facilities (41%) confirm MUWRP currently provides technical maintenance support, with a further 10 saying "partially." Only 17 facilities (22%) report having received formal staff training on solar system

use and basic maintenance from MUWRP a clear gap, since untrained facility staff cannot catch small problems (like a loose connection or a dusty panel) before they become the battery and inverter failures reported above. Where support has been given, it is rated well: 42 facilities rate MUWRP's support "Good" or "Excellent."

Looking ahead, 70 of 78 solar facilities (90%) say they need their system to be expanded or upgraded reinforcing that the current footprint, while extensive, does not yet fully meet facility power needs.

8. Facilities Without Solar: The Remaining Need

23 of the 101 assessed facilities (22.8%) do not currently have a solar power system. Nearly all of them (22 of 23) rely solely on the national grid, with 1 facility reporting no electricity access at all.

These facilities report a mean power-problem severity of 2.13 on the same 1 (most severe) to 5 (no impact) scale used for solar facilities before installation (mean 1.94 pre-solar). A statistical comparison between the two groups (Mann-Whitney U test, $p = 0.780$) finds no significant difference meaning today's non-solar facilities are experiencing power problems of broadly the same severity that solar facilities faced before their own installation. This is a useful, evidence-based way of estimating the benefit non-solar facilities stand to gain: it should look like the outage-reduction result already demonstrated in Section 4.

Demand is clear: 21 of 23 non-solar facilities (91%) say they want a solar system installed. This is a ready-made, demand-confirmed pipeline of 21 facilities for first-time installation.

9. Key Findings and Recommendations

9.1 Key findings

- Solar works. The before/after outage reduction is large (~39%) and highly statistically significant ($p < 0.001$) the strongest, most defensible result in the dataset.
- MUWRP installation quality shows up in the numbers. MUWRP-installed systems are rated significantly more reliable than systems from other installers ($p = 0.006$).
- Maintenance, not capacity, is the binding constraint. Scheduled maintenance and system capacity both show no significant link to reliability in this sample, while battery and inverter faults are common (22% each) and most facilities operate reactively rather than preventively.
- Coverage gaps remain in the highest-stakes services. Only 37% of solar facilities have solar-powered vaccine cold chain, despite it being the single highest-rated benefit where it exists.
- There is a confirmed, ready pipeline. 21 non-solar facilities want solar, facing power problems statistically indistinguishable from what solar facilities dealt with pre-installation.
- Capacity data needs verification. The inverter-capacity field is unreliable as recorded (Section 3.2) and should not be used for sizing or procurement decisions until re-verified.

9.2 Recommendations

- Prioritise the vaccine cold chain in the next round of expansions. It is both the least-covered priority service and the one with the single strongest perceived benefit when covered.
- Formalize a preventive maintenance schedule (at minimum quarterly) rather than relying on reactive fixes, specifically to reduce battery and inverter faults, which are currently the two leading fault types.
- Expand staff training on basic solar system care only a minority of facilities report having received it, and untrained staff cannot catch early warning signs.
- Treat the 21 demand-confirmed, non-solar facilities as a ready-made pipeline for first-time installation, sequenced alongside the 70 existing sites that need expansion/upgrade.
- Re-verify inverter/capacity figures at facility level (in kW, with unit confirmed on-site) before using this field for planning, lifecycle costing, or donor reporting.
- Continue and formalise MUWRP's installer/maintainer role, since it is the one factor in this dataset most clearly and significantly associated with better reliability outcomes.

Appendix: Glossary of Statistical Terms Used in This Report

Term	Definition
Descriptive statistics	Numbers that simply summarise the data collected counts, percentages, averages. They describe what was found, without claiming it applies beyond the sample.
Inferential statistics	Methods used to test whether a pattern seen in the sample is likely to be a real, meaningful effect, or could just be random chance.
Mean	The average value add up all responses and divide by how many there are.
Median	The middle value when all responses are sorted from lowest to highest. Less affected by extreme outliers than the mean.
p-value	The probability of seeing a pattern this strong (or stronger) if there were actually no real effect. A p-value below 0.05 is conventionally treated as "statistically significant" strong evidence the pattern is real, not chance.
Statistically significant	A result unlikely to have occurred by random chance alone ($p < 0.05$). It does not necessarily mean the effect is large only that we can be confident it is real.
Chi-square test	A test used to check whether two categorical variables (e.g., facility level and solar status) are related, or independent of one another.
Paired t-test / Wilcoxon signed-rank test	Tests that compare the same facilities to themselves at two points in time (e.g., before vs. after solar) a stronger form of comparison than comparing two different groups.
Mann-Whitney U test	A test that compares two different groups of facilities on an ordinal (ranked) scale, without assuming the data forms a perfect bell curve.
Correlation (Spearman's r)	A measure, from -1 to +1, of how strongly two numeric variables move together. Close to 0 means little to no relationship; close to +1 or -1 means a strong relationship.
Likert scale	A common survey format where respondents rate agreement with a statement, typically 1 (Strongly Disagree) to 5 (Strongly Agree), which can then be averaged like a number.
n (sample size)	The number of facilities or responses a particular statistic is based on. Smaller n means less certainty in the result.

Methodology note: all statistics in this report were computed from the facility-level assessment dataset using standard statistical software (Python, with the pandas and scipy libraries). Percentages are rounded to the nearest whole number; small rounding differences between figures quoted in text and corresponding totals are expected.