Maternal and Newborn Improvement (MANI) project

CASE STUDY

FINDINGS OF AN EVALUATION ON THE OUTCOMES OF GREEN ENERGY INSTALLATIONS ON MATERNAL AND NEWBORN HEALTH SERVICES IN BUNGOMA COUNTY

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January 2019

Abbreviations

ANC	Antenatal Care
BEmONC	Basic Emergency Obstetric and Newborn Care
CEmONC	Comprehensive Emergency Obstetric and Newborn Care
CHMT	County Health Management Team
DHIS2	District Health Information System 2
EmONC	Emergency Obstetric and Newborn Care
ERMS	Energy Remote Management System
KCCAP	Kenya Climate Change Action Plan
KMC	Kangaroo Mother Care
KPLC	Kenya Power and Lighting Company
KwP	Kilowatt Power
MNH	Maternal and Neonatal Health
MwP	Megawatt Power
NBU	Newborn Unit
PBF	Performance Based Financing
PPH	Post-partum Haemorrhage
PV	Photovoltaic
QuIC	Quality of Institutional Care
UNEP	United Nations Environment Programme

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1. Introduction

Kenya's economic development is the fastest in East Africa but access to energy in the health sector has remained a challenge. It is estimated that between 50 - 75% of all health facilities and 75% of district hospitals are connected to the national grid but this is under strain, resulting in a substantial number of health facilities experiencing frequent and, sometimes, long power outages.

Global efforts are being made to adopt cleaner and sustainable energy to minimize the impacts of climate change through reduction of carbon emissions. As a major consumer of energy and water, the health sector is estimated to contribute approximately 7% of the global carbon footprint and Kenya is a signatory to the Paris Climate Change Agreement that seeks to increase the use of renewable energy. To actualise this agreement, the Kenyan parliament passed the Kenya Climate Change Act of 2016 as a step towards increasing the country's share of renewable energy, the main sources of energy in Kenya are currently hydro and geothermal. Alongside this, the Kenya Climate Change Action Plan (KCCAP), signed in 2016, requires all sectors to improve access to clean renewable energy with an aim of reducing Kenya's carbon footprint.

In maternal and newborn health (MNH), power is critical not only for lighting wards and delivery rooms but for management of labour, delivery and resuscitation. Critical equipment required for emergency obstetric and new-born care (EmONC), such as medicine and blood fridges, incubators and resucitaire units only work when there is a steady supply of power. Provision of warm water in health facilities is also necessary to promote hygiene for maternity clients. Being able to wash with warm water after the delivery also encourages women to deliver at facilities, and increasing institutional delivery is a key part of reducing maternal and neonatal mortality.

2. MANI Project's Green Energy Intervention

In 2016 the DFID-funded Maternal and Newborn Improvement Project (MANI) received a contract amendment to integrate climate change aspects into its MNH programme. The finance for this came from the International Climate Fund as a result of Kenya signing the Paris Climate Change Agreement. Box 1 shows the linkages between health, energy, and climate, known as the health energy nexus, and the associated Sustainable Development Goals.

MANI's efforts to reduce the project's impact on climate change and provide sustainable green energy solutions for Kenya's health sector aimed to optimise the relationship that could be achieved between reducing carbon emissions, reducing demands on health facilities' already over-stretched budgets, and increasing the quality of care provided to women and their newborns.

Box 1: The health and energy nexus

The Health and Energy nexus articulates the inter-relationship between Sustainable Development Goals (SDGs) 3, 7 and 13: health, energy and climate. Energy plays a critical role in ensuring quality of care in the context of the social determinants of health. In health care settings, energy ensures continued service provision, promotes health and safety, functionality of medical equipment's, and general administration and staff motivation (WHO 2016).

The specific green energy interventions which MANI implemented were:

- Photovoltaic (PV) solar power and solar water heating installations
- Rainwater harvesting and storage systems installations
- Hospital sanitation improvements
- Training on infection prevention and control, and medical waste management

In 2016, energy audits were conducted in 60 health facilities in Bungoma county, where the MANI project was based. The audit determined the energy status and energy loads required for each facility. It identified that 75% of the health facilities were connected to the national grid and 3% had power back-up provided by generators. Energy outages were widespread at all facilities. These occurred up to 3 times a week and, on average, lasted 6 hours.

Based on the audit findings, a solar system was designed to provide lighting and power to critical maternal and newborn health emergency equipment at 33 health facilities in Bungoma county. Facilities were selected based on a standard set of criteria (Box 2) agreed with the County Health Management Team (CHMT) through the leadership of the County Director of Health.

Box 1: Green installation criteria

- Health facility already supported under the MANI performance based financing (PBF) intervention
- EmONC targeted facility
- Facility working 24 hours
- Health facility with at least 3 deliveries a month in 2015

The MANI project installed 57.5 kilowatt power (Kwp) solar power capacity in the health facilities, and 3,500 litre water heating equipment in a sub-set 13 of these facilities . Different sizes of solar PV were installed based on the energy requirements and level of service provided by the facility. Table 1 summarizes the different sizes of the solar PV installed and the equipment that be powered by it. This is called the designated load.

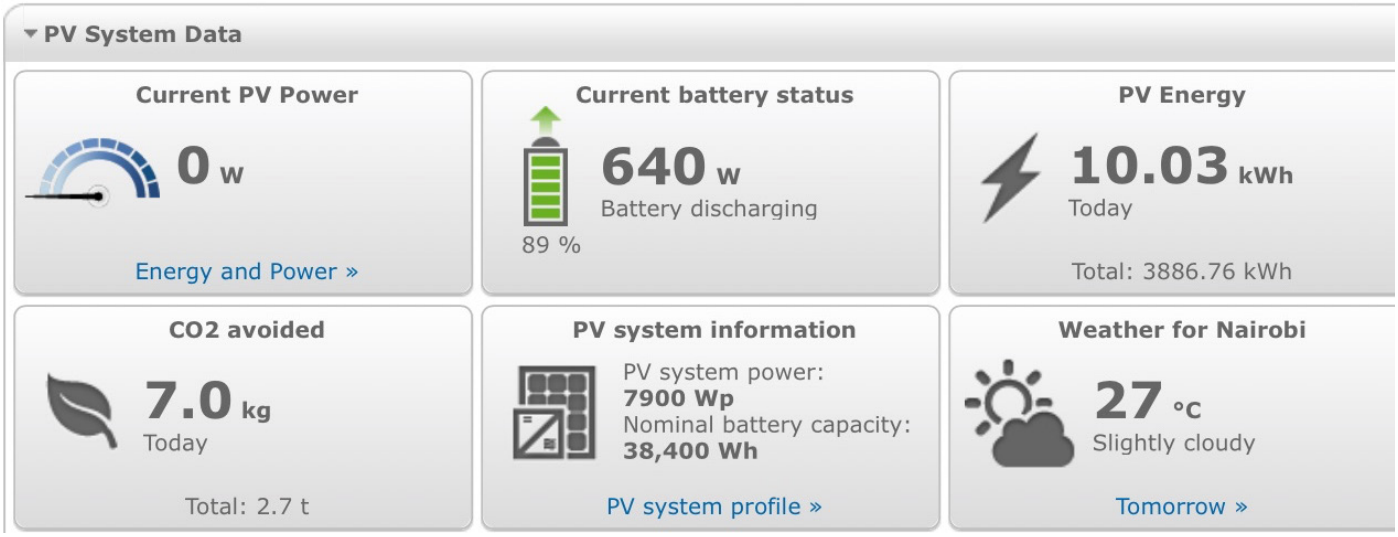
Table 1: Size and loads (the equipment powered) of solar PV installations

	Kwp Capacity	Designed Loads	Number of Facilities
1	7.5 Kwp	• Lighting • 4 fridges (for vaccines,medication and blood banks) • 4 incubators • 2 phototherapy machines • 2 suction machines • 2 resucitaire units	3 Sub-County Hospitals
2	3 Kwp	• Lighting • 2 vaccine fridges • 1 incubator • 1 phototherapy machine • 1 suction machine • 1 rescuscitaire unit	5 Health Facilities (1 Sub-County Hospital and 4 high volume Health Centres)
3	1.5 Kwp	• Lighting • 1 Incubator, • Rescuscitaire unit • 1 phototherapy machine • 2 – Medium vaccine fridge • Suction machines	3 Health Facilities
4	1 Kwp	• Lighting • 1 Incubator, • Rescuscitaire unit • 1 phototherapy machine • 2 - 240V rating vaccine fridge • Suction machines	7 Dispensaries
5	0.5 Kwp	• Lighting • 240 V vaccine fridge	15 Dispensaries

Each system had an online platform, or energy remote management system (ERMS), for monitoring power generation and carbon evaded. (Figure 1). Six months after the solar panels had been installed and functioning an evaluation was undertaken with the objectives of:

- Determining the power coverage and availability of back-up power
- Documenting the effects of green energy on MNH service delivery
- Estimating the quantity of clean power generated from the solar system, and the cost savings
- Identifying best practice and lessons learnt from solar installations in healthcare settings

This report focusses on the findings of the evaluation.



2.1 Methodology

Thirteeen facilities were purposively selected for inclusion in the study. All the facilities provided basic emergency obstetric and newborn care (BEmONC) services, were connected to the main grid and had a remote management system. This made it possible to monitor power generation, carbon units evaded and savings in reimbursements for the Kwp generated. The key difference between the facilities was that they represented each of the five different solar system installations.

A mixed methods approach was used to identify both the quantitative outcomes of the green energy installations, but also to understand their impact on facility management, health workers and women delivering at these facilities.

The following quantitative approaches were used:

- Analysis of data from the ERMS to estimate the quantity of clean energy generated, and associated cost savings
- Carbon emissions were calculated based on the United Nations Environment Programme (UNEP) approach, to determine the quantity of carbon evaded.
- Workload analysis of MNH services by comparing the annual number of clients across a three-year period (2016 - 2018) from the District Health Information System 2 (DHIS2). These were used as proxy indicators to measure improved service delivery:
- Skilled birth attendance rate
- Number of fully immunized children
- Number of 1st and 4th antenatal care visits
- Perinatal deaths trends
- Neonatal deaths trends
- Data from quarterly Quality of Institutional Care (QuIC) EmONC readiness assessments

The following qualitative approaches were also used:

- Key Informant Interviews (KIIs) were conducted with 79 participants (Table 2) from the various facilities.
- KIIs were conducted with 16 clients who received services from the health care facilities during the time of the study

The following tools were used for data collection:

- Key informant interview guide – health worker
- Key informant interview guide – client
- Energy Remote Management System
- UNEP carbon emissions calculator

Table 2: Key informant interviews

Key informants	Number
Nurse	2
Maternity nurse	23
Maternity in Charge	8
Nursing Officer in Charge	9
Deputy Nursing Officer in Charge	2
Facility in Charge	11
Deputy Facility in Charge	2
Administrator	4
Accountant	1
MoH	1
Clients	16
Total	**79**

3. Findings

3.1 Power coverage and availability of power back-up

As part of the interview process, health workers were asked to estimate the reliability of the main grid energy supply. Interviewees indicated that all the health facilities experienced some sort of power outage and when asked to approximate the reliability of the main grid energy supply, only 7 health workers reported that the main grid was more than 80% reliable. Half of the health care workers indicated that the main grid's reliability ranged from 50-80%, and 14 reported the main grid to be less than 50% reliable.

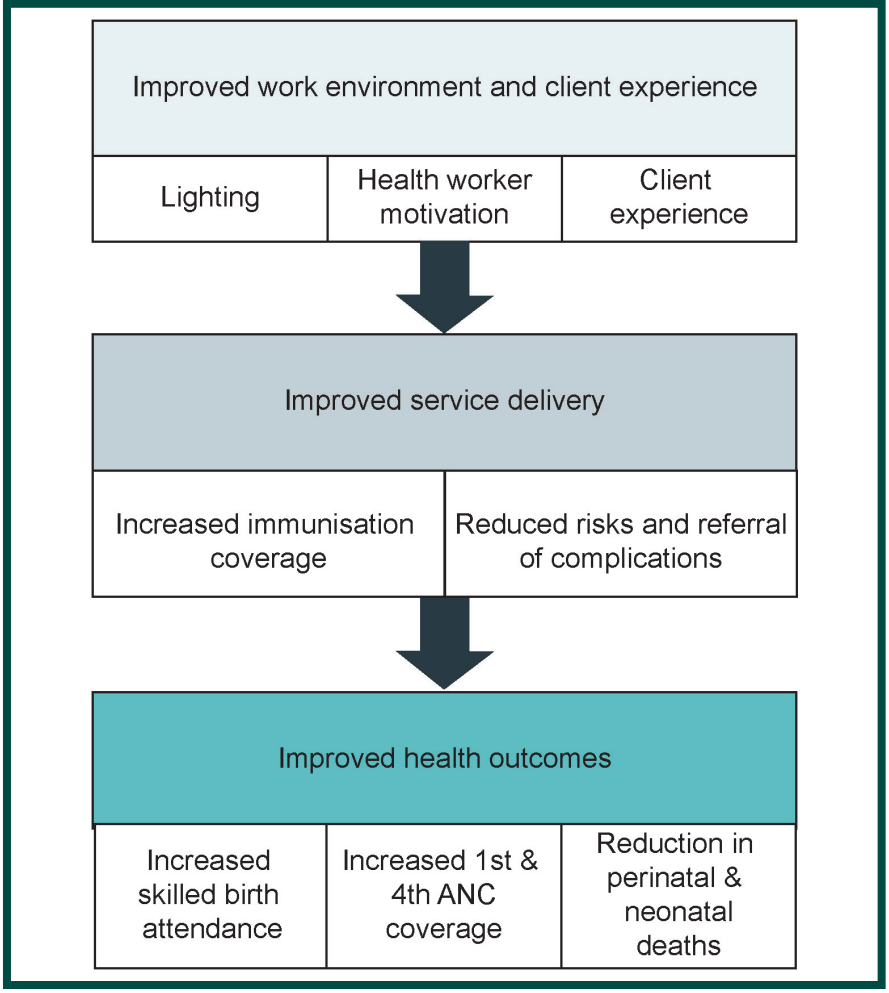
It's not that much reliable (grid power), but you can find like in a week maybe something like three days or two to three days, KPLC power is off, so most of the time we normally use the solar that you have helped us with.
Nurse in Maternity, Sinoko Sub-county hospital

The frequency of power outages from the main grid ranged from daily at specific times to twice a week. Some health workers reported that their facilities went without power for more than a week, mainly during the rainy seasons where the transformer would fail, affecting the health care facility and the surrounding areas. Because of this uncertainty of grid power, maternity nurses were tending to use solar power even when electricity was available.

3.2 Effect of Green Energy on MNH Service Delivery

Providing solar energy to the health facilities was reported to improve both the working environment for health workers but also the experience of women receiving care. Other areas of improvement reported by staff were service delivery and health outcomes (Figure 2).

Figure 2: Solar energy effects in health care facility



3.2.1 Improved work environment and client experience

The frequent power outages from the main grid experienced by health facilities led to gaps in health service delivery. The following areas were most frequently reported: sterilization, cold chain, contamination, and increased insecurity (relating to staff safety). These were seen to result in or contribute to increased neonatal deaths, reduced deliveries, increased referral cases and difficulty in providing clinical services because of poor lighting and power availability. Health care providers also described their working environment before the introduction of the green energy as: 'hell on earth', 'terrible' and unsafe.

With the introduction of green energy health workers reported a more conducive working environment, and with night-time

lighting in the wards, health care workers also felt safe, confident and comfortable. The significance of reliable lighting for providing maternity services is shown below.

Lighting

All health care providers described the challenge of poor lighting in the maternity wards when conducting deliveries, particularly at night. The health care workers pointed out that they often relied on lantern lamps, torch lights or weak lighting from mobile phones while conducting deliveries. Not surprisingly this was frustrating and impacted negatively on their motivation.

I remember there was a time, I was on night, there was no power. I didn't have paraffin, and then I received a mother with PPH (post-partum haemorrhage). So it was hard for me. I kept on waking up the staffs to come, whoever was running to come, comes and finds me in darkness, but we really managed through our phones with the small torch. We saved the mother. It was very embarrassing and that was how things have been.

Maternity nurse, Sirisia Sub-county, Sirisia

However, as a result of solar power providing sufficient light, health care workers reported that they were now easily able to identify the site of bleeding when faced with a PPH, and were thus able to rapidly stop the blood loss. This is particularly significant as PPH is the most common cause of maternal mortality.

In addition to improving the quality of the clinical care provided, the introduction of solar lighting was also reported by health workers to have enabled themselves and others to extend their work day through into the evening. This was because reliable lighting was associated with safety, brightness, cleanliness and convenience. Previously, the poor lighting meant health workers were neither able or motivated to stay late in the health facilities

Since the installation of solar, when we are doing deliveries you're comfortable. There is enough light to the room… the solar has made a difference, we can work throughout, I mean 24 hours without any problem. We take care of our patients well.

Nursing Officer in Charge, Sinoko

Communication

Health care providers said that access to solar energy also meant that they were better able to communicate with other health facilities. For maternity services this is particularly important due to the need for timely referrals. Delay in receiving appropriate care is one of the three main causes of death among women and this can often occur when referrals cannot be initiated.

Since MANI installed the solar power, it has really helped because at all times we have light and we also have sockets which are chargeable. We can charge our gadgets which we use, telephones in case of communication and that is serving us well.

Maternity nurse, Naitiri Sub-county hospital

Client Experiences

All women who participated in the evaluation very clearly articulated that their experience of delivering in the facility was substantially improved by solar power. In common with the health workers, the women particularly appreciated the light and warmth provided. Women were now able to communicate with their family members and charge electronic devices. They were also given tea and provided with warm water to bathe in after delivery. Rural women also thoroughly enjoyed the opportunity to watch TV while recovering from the delivery. Women who had previously delivered in the facility reported that the service they received was greatly improved. They also commented on how the attitude of health care providers had also improved, with less harassment during delivery. While it is not possible to provide a direct correlation between solar and improved attitude of workers towards women, the way in which increased access to power made multiple improvements to working conditions was repeatedly reported by health workers. It does seem very feasible that the intervention had very significantly contributed to this.

3.2.2 Improved Service Delivery

The qualitative interviews gave insight into the ways in which solar power enabled health workers to deliver better quality services to women delivering at these facilities. The wide ranging ways in which services improved included reduction in risk for women and their babies, fewer but more timely referrals, improved infection prevention practices and better laboratory services.

Referral services

The majority of the health care providers described the multiple ways in which power outages negatively impacted on service delivery. For example, lack of power made it difficult for them to attend to mothers who came in with pregnancy complications, leading to the need for referral, and thus putting pressure on the referral facility and its staff.

There is a night we referred 3 patients from maternity (because of power cuts). That was the worst episode. But fortunately we have not lost life because of blackouts.

MoH, Naitiri Sub-County Hospital

In addition, during power outages from the main grid, service providers at some facilities were forced to refer babies with hypothermia because they did not have a back-up power source. The introduction of solar energy, with power for lights, warmth and essential equipment improved facilities' capacity to provide 24/7 services, and has reduced unnecessary referrals.

Solar energy has made us not to refer premature babies, for example if the mother delivered a baby of 32 weeks or 30 weeks, even 28; we can keep that baby warm and then we advise the mother to do kangaroo mother care. So it has reduced referrals of low birth weight and premature babies to Bungoma.

Deputy Maternity in Charge, Kabuchai Health Centre

Sterilization and waste disposal

Ninety-five per cent of the health workers interviewed reported that before green energy was installed, the unreliability of the grid power made it hard for them to sterilize equipment and ensure proper waste disposal, particularly use of a macerator. This increased the risk of cross contamination of equipment. Poor lighting also made it difficult to maintain a sterile environment because health care providers used torches or mobile phones or paraffin lanterns for lighting while at the same time working on a patient to, for example, arrest bleeding or conduct a delivery. Continuous lighting from solar power meant that they were able to concentrate all aspects of service provision rather than working at the two extremes of either no care or emergency care which was what happened previously during power outages.

Cold-chain

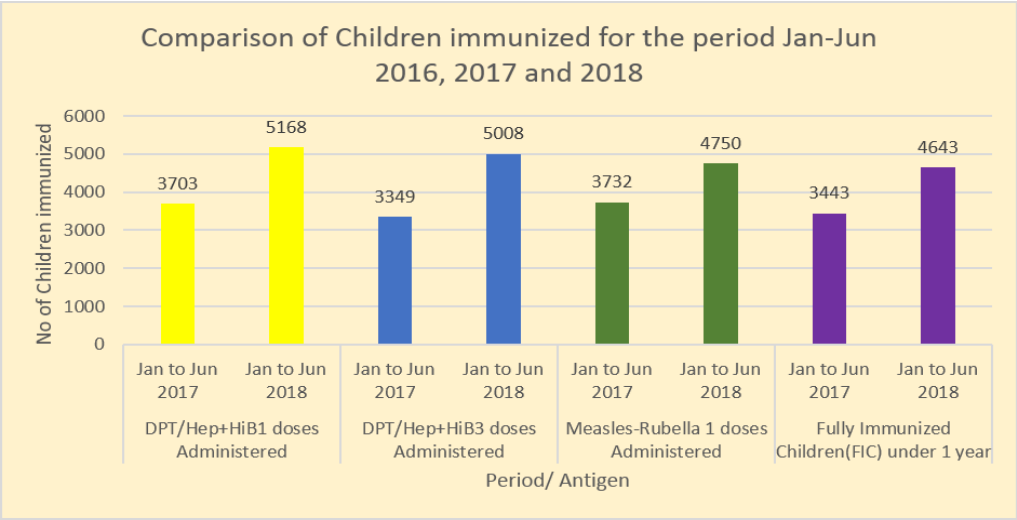
Facilities need a cold chain system to store vaccines at stable and correct temperatures before being administered to clients. Vaccines are required to be kept between 0 - 8ºC (32 - 46ºF). Once vaccines are exposed to temperatures outside this range their potency is lost. Ninety eight per cent of the health workers interviewed reported that before the introduction of the green energy, frequent power outages led to the loss of vaccines . In addition to vaccines, during national grid power outages, facilities were not able to provide other routine services that required refrigerated medication, for example emergency medicines such as oxytocin. These facilities ended up experiencing commodity wastage and financial loss.

The drug like oxytocin, it's supposed to be under that cold temperature so, when it is kept on that hot temperature, warm temperatures, those mothers when they use that drug, sometimes it never worked. Because when a mother has PPH, she could bleed a lot because the potency of the drug has been affected…There is a difference because there in the pharmacy…the main stock of oxytocin is there. So, imagine losing that whole stock of oxytocin! At least , the drugs are safe when there is solar unlike when there is not, the whole drug could go stale . In the lab the reagents are now also safe. When those warm temperatures are there, we are not sure what they are testing for, they could not give the accurate drug, maybe the reagents have changed the potency.

Nurse maternity, Bokoli Sub-County Hospital

Health workers described how the newly introduced green energy improved the cold chain system and vaccine storage conditions which meant that health facilities were able to store medications such as oxytocin within the required temperatures, retaining its effectiveness. In addition, a notable increase in the overall number of children who were fully immunized was reported (Figure 3).

Figure 3: Comparison of immunized children from 2016-2018



Blood bank services

Very importantly, three additional sub-county hospitals with 7.5Kwp were able to offer blood transfusion services as a result of the solar installation. This meant that the number of facilities in the County that were able to transfuse rose from 11 to 14. These include Government of Kenya (GoK), private, and faith-based facilities. Initially, they could not offer this service due to the unreliable grid power which made it impossible to maintain a stable cold chain system able to preserve blood and blood products.

Because of solar energy, we started having blood transfusion services. Because initially we had a blood bank but because of the unpredictable power supply we had, we could not start blood transfusion services because the blood without the required temperature will go to waste. So after getting the solar services installation and extending to the laboratory department we were comfortable starting running those services for blood transfusion. So we are able, until now we transfuse mothers with blood in case they need it.

Nurse - Chwele Sub-County Hospital

Laboratory services

Some health care workers reported that previous power outages also affected laboratory services. This included conducting general laboratory tests required for antenatal care (ANC) profiles. Nor could automated microscopes be used. Consequently, there was delay in offering services and getting results. For urgent cases, some health workers opted to refer clients to other facilities for laboratory tests. In other instances, mothers were asked to come back to the facility the following day in the hope that the electricity would have restarted.

When there was grid power outage, mothers had to wait a half day or almost the whole day sometimes for laboratory tests; there is nothing we can do. Sometimes we had to refer to a facility that is using a microscope which is not using electricity or even tell the mother to come the next day.

Facility In-Charge, Lukhome Dispensary

With the introduction of solar energy, lighting and power services were extended to the laboratories at some health facilities. This enabled lab services to continue even during espite power outages from the main grid.

Yes, like lab services we are now able to offer (these services). Initially when MANI came to install this I think there was concentration on the maternity wing but eventually I think after consultation we are able to extend the power supply from the maternity wing because we have installed many panels and a lot of power is generated we are able to extend that to the lab. Within I think three months after consultation so we are able to do lab services that we were not able to do when power goes off.

Medical Officer of Health Naitiri Sub-County Hospital

Improved neonatal care services

In addition to better care for mothers, health workers also reported that neonatal care improved at their facility because the solar systems powered heaters, resuscitation machines, oxygen machines and incubators. The majority of the health care providers reported that because they were able to provide emergency care to neonates for hypothermia, asphyxia and resuscitation, this was reducing both referrals and mortality levels.

We were losing some babies who needed resuscitation, and working at night was not comfortable because of black-outs. I remember one scenario: we had resuscitated a baby and we had put that baby on oxygen, it was during the day, but suddenly during that day power went off and it never came back, so the baby died because of outage.

Maternity Nurse Mechimeru Health Centre

3.2.3 Improved health outcomes

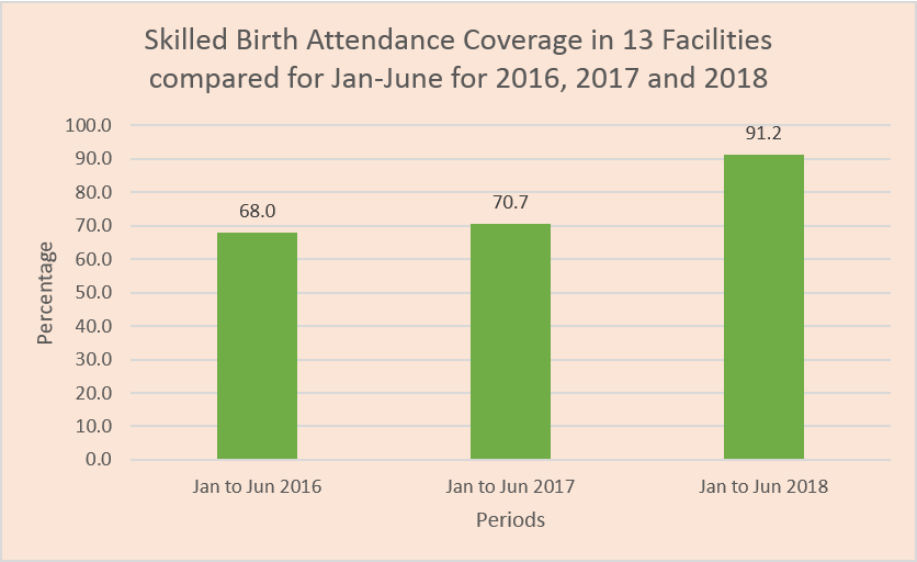
The improvements to service delivery described above were, not surprisingly, reflected in perceived better health outcomes. During their interviews, health workers described the ways in which these had improved. At the same time as the green energy intervention, MANI was also implementing a number of other initiatives to increase institutional deliveries and quality of care. The findings below will have been influenced, in part, by these but, as shown by the earlier qualitative interviews, without energy there are major limitations to what can be provided or achieved. As such, it seems appropriate to include the following as achievements which have been influenced to a significant extent by the introduction of green energy to facilities.

Increased hospital deliveries

The number of institutional deliveries increased substantially between 2016 and 2018, rising from 68% to 91% (Figure 4). Factors that encourage women to deliver at a facility include an improved environment, quality of care and respectful care. The qualitative data report earlier in this chapter show how the presence of power improved both the care that health workers were able to provide but also improved their willingness and attitude to work. An example of the

contribution of solar power to increasing the number of institutional delivers is Naitiri Hospital, where initially they could only do 90-110 deliveries per month but after the introduction of green energy they were able to cope with 135 - 250 deliveries per month.

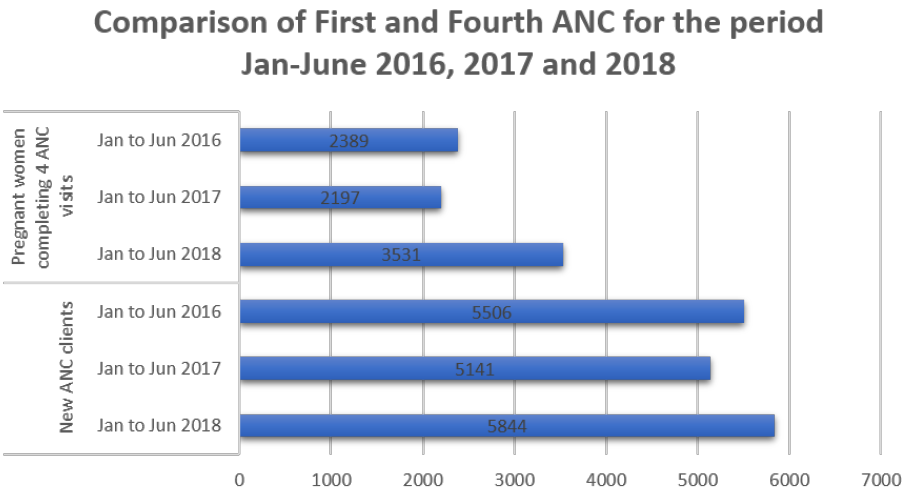
Figure 4: Skilled birth attendance coverage between 2016-2018 in 13 facilities



Increased 1st and 4th ANC attendance

This study also found an increase in new ANC clients attending the health facilities, and pregnant women completing 4 ANC visits (Figure 5). It seems that this is linked to increased and regular power which means that laboratories are able to perform the ANC profile tests. When women receive quality care, and are able to access tests and results in a reliable and timely fashion they are more likely to attend.

Figure 5: Comparison of 1st and 4th ANC visit between 2016-2018

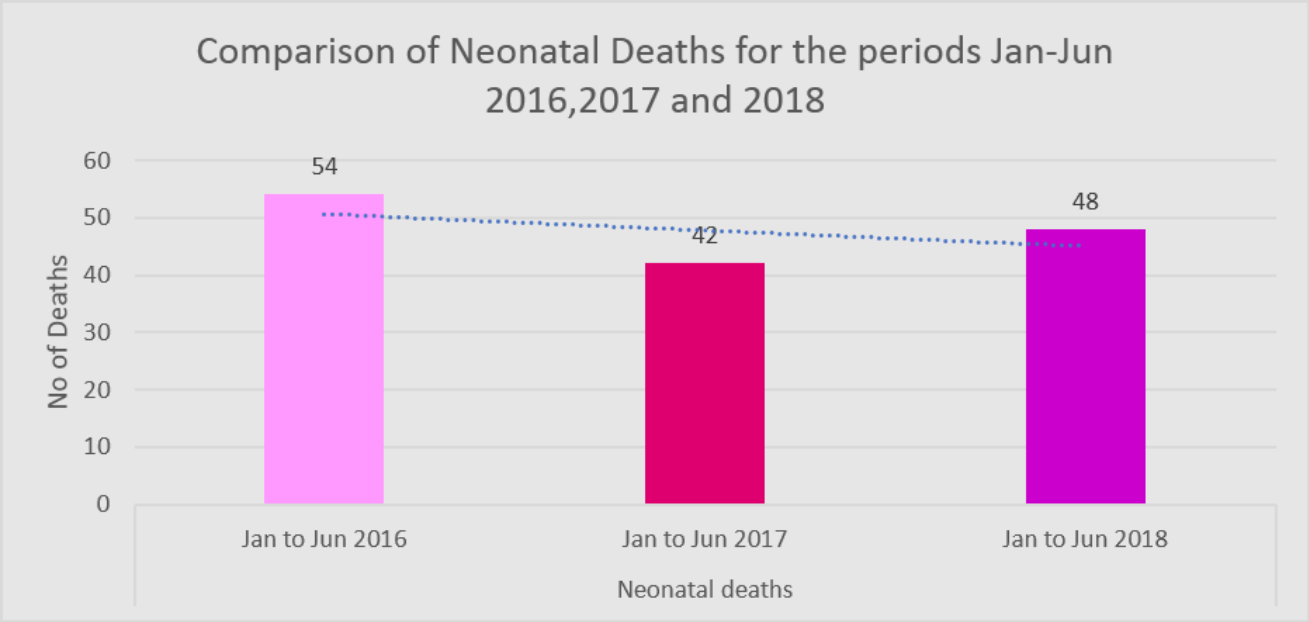


Reduction in neonatal and perinatal mortality

Equipment used for neonatal care such as radiation heaters, incubators, resuscitation machines and oxygen play a critical role in improving the survival and health indicators of neonates. It is essential that these equipment and machines are both present and functional. The presence of solar power meant that during power outages equipment continued to function as the solar energy provided an effective and long-lasting back up system.

In addition, solar power does not fluctuate significantly, so the damaging impact of power surges from the main grid was also reduced. As a result, health workers reported that critical resuscitation, incubation and radiation heating equipment were now continually functional and prevented deaths that would otherwise have occurred. Figure 6 shows the reduction in neonatal deaths at MANI facilities between 2016 and 2018. It is not possible to identify the specific impact of solar power on individual cases, but according to the health professionals who participated in the evaluation, it did have an important overall impact on prevention of deaths.

Figure 6: Neonatal Death Trend 2016-2018



"It (solar) has helped us, for example, when we are having mothers with premature deliveries and children with low scoring. When you are having that solar, you will put on the heat when you are resuscitating a baby, the baby picks up quickly; but before that, you could have resuscitation of the baby but … the baby will take a lot of time to pick up the agar score. But with the solar it is assisting us because the heater is there. It is helping us because we are not having now a problem with buying lamps and substituting with our own phones to make things go on".

Deputy Maternity In-Charge, Kabuchai Health Centre

This solar backup has really assisted us in the NBU (newborn unit) sector. We have incubators that use the solar backup. So when there is a blackout, we had some mortalities in NBU related to hypothermia because there was nothing we could do about that. But after the backup of solar, at least the perinatal deaths are very low. Maternity, I have told you working environment has been good, we haven't had any problems even these mortality cases for babies now they have reduced, you can find even in a month we don't get any, there is no issue that maybe a baby has died because of hypothermia or something there, now even when you work there it is good, that solar has helped us.

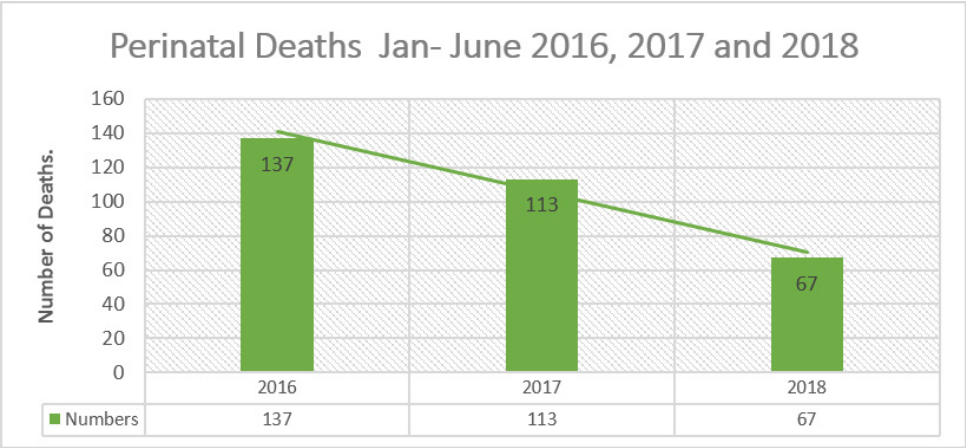
Nurse, Ndalu Health Centre

The benefits that we have had from this solar installation are quite a number…the perinatal deaths have reduced drastically because of the backup… even the skilled deliveries in our facility are so high because mothers are assured that the light system is just there. When you go to KMC it's now persistently with light and also the heat, so we are not having several perinatal deaths. If you go to incubators, incubators are using the solar, they have the solar backup in the NBU. We can manage our clients so well, especially our babies and even our mothers without any problem.

Nursing Officer In-Charge, Chwele

Data from DHIS 2016, 2017 and 2018 (January-June) shows over 50% decrease in perinatal deaths over the three years (Figure 7). Although these cannot be attributed solely to the installation of solar power, it has made an important contribution.

Figure 7: Perinatal Death Trends



3.3.4 Quantity of Green Energy Power Generated and Cost Savings

In addition to improving service delivery, green energy results in economic benefits to health facilities through savings in the cost of purchasing electricity from the grid. Being a clean energy source it also contributes to reductions in the carbon footprint and contributes to preventing climate change.

Economic benefits

Using solar energy in place of kerosene lamps reduced the time and cost of maintaining and refuelling. Facilities also made savings by reducing costs that previously accrued from drugs and reagents that spoiled due to lack of refrigeration.

Efforts were made to identify the amount of savings on facilities' electricity bills but challenges in accessing bills from both the facilities and the supplier meant this was not possible. Facility administrators did, however, acknowledge that savings were being made. These, including the savings from no longer purchasing kerosene were, in some facilities, being used to improve facility maintenance and upgrading.

Saving money is there because it (solar) also reduces the electricity bill. You know the electricity bill is not constant; sometimes it has been reduced because of the chipping-in of the solar - that one economically is viable because now you pay less. Small facilities like these ones, the money we are saving , we use to pay the water bill, we also pay casuals, sometimes we also use it to charge (re-fill) the gases (gas cannisters) for other uses also.

Administrator Sinoko Sub-County Hospital

We were able to make some assumptions about money saved based on the known amount of energy used and carbon evaded (Box 1). This gives some indication of the financial benefits of solar energy, although the actual figure is likely to be considerably higher.

Box 2: Estimated financial savings through green energy use.
Between January-June 2018 the 13 health facilities evaded a total of 17,208 Kgs of carbon and generated 24,583 Kwp.

Health facilities saved a total of Ksh: 540,804 (5,408 USD) in 6 months, based on purchasing the equivalent amount of grid power from KPLC.

3.3.5 Sustainability of the solar systems

The solar systems installed at the 13 facilities are extremely low maintenance. All that is needed is quarterly dusting, and monitoring the remote management system. Facility personnel and engineers were involved during the system set-up, and 11 biomedical engineers from the county hospital and six sub-county hospitals were trained on solar maintenance and trouble shooting.

MANI designed poster usage charts which gave information on what each system could power in order to avoid overloading. A sample poster is shown in Annex 2. Before the end of the project, most facilities reported that they had put measures in place for technical support and additional capacity building, with the aim of continuing to fully utilise the solar systems. Overall, the opinion of facility management and service providers was that solar power had resulted in benefits, required little maintenance and was worth investing in training to ensure the systems continued to work.

I am very sure you are aware maintenance of solar system is not very expensive. So long as you have trained staff who know about the connections, if there is any problem then we are okay. So by now, at Naitiri we have two maintenance officers who know the system. Were even present during installation, they know all the connections so in case of any problem they are able to do it… In case we employ another one, we will do on-job training whereon people who have been trained will train the new person.

Medical Officer of Health, Naitiri hospital

4. Challenges

Although solar energy provided continuity of basic heath care services in the event of power outages from the main grid energy supply, the systems installed did not have sufficient power to support all the different departments at the health facilities. On rainy days the lack of power was particularly significant. Nor were the solar systems installed sufficiently large to handle heavy sterilization equipment.

At the beginning of the intervention, not all facilities had a stand-by engineer available. The biomedical engineers were located at sub-county facilities and until sufficient staff are trained this will reduce the time taken to resolve any significant maintenance problems if they arise – although the systems chosen were identified for their reliability.

5. Best Practices and Lessons Learnt

The best practices and lessons learnt from this project can be grouped into three areas: implementation processes, relevance, and cost savings and efficiency.

- **Implementation Processes:** When planning for green energy installation in the health sector, clear objectives must be listed which identify the purpose, need and required outcomes. To achieve this, and identify accurately the appropriate systems, conducting an energy audit and solar system design identification is critical at the planning stage.
- **Relevance:** A context analysis should be done early on to identify health facilities to be covered by solar energy. This will help to maximize the return on the capital investment of solar for the particular health outcomes being targeted. Green energy is highly relevant in that it both ensures continual power for facilities, and makes a positive contribution to climate change reduction.
- **Cost Savings and Efficiency:** Green energy enables significant to be made from already over-stretched budgets, particularly through reduced recurrent bills. An analysis of cost recovery on the capital investment and lifespan of systems is important when selecting the system to be installed.

6. Conclusion

Embracing the health and energy nexus in Bungoma County resulted in rapid change at the facilities where solar systems were installed. Major changes included improved quality of care, better health outcomes, happier providers and users of maternity services. Cost savings were also made which some facilities re-invested into improved services.

Solar power and low maintenance green energy systems are particularly relevant for boosting and supporting grid power in remote and hard to reach facilities. The relatively low levels of technical support needed to keep the systems functioning suggest that there is a strong element of sustainability in solar systems.

A large scale study of the impact of the health and energy nexus would provide much stronger quantitative and costed data on savings made and on improved health outcomes. It would also be helpful to explore whether sustained power and its apparent impact on staff motivation could be a way of helping to reduce staff attrition. Most importantly, however, the potential impact of solar energy in reducing maternal and newborn mortality, particularly in remote and hard to reach areas suggests that health outcomes can be improved at the same time as helping to reduce climate change.

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Annex 1: Typical Solar System Design Sheet

Site						
AC LOADS	**Qty**	**Watts**	**Hrs/Day**	**Days/wk**	**WH/Day**	**Comments**
Fluorecent Lights					0	
Energy Saving bulbs					0	
Refrigerator					0	
Portable Examination Lamps					0	
Incubators					0	
Phototherapy Machine					0	
Rescuscitator					0	
Suction Machine					0	
Water pump					0	For Solar water Heating
Group of Office accessories					0	Phone chargers etc
Office Equipment (Computers)					0	1 Computer and Accessories
Oxygen Machine					0	
Inverter idle power (tare loss)					0	
PEAK AC LOAD (everything on)	**0 Watts**					
			TOTAL AC LOADS		**0**	**Watt-Hours per Day**
		EFFICIENCY / LOSS FACTORS				
BANK NOMINAL VOLTAGE	**48**	**Input**			90%	Battery Average Efficiency
					92%	Inverter Average Efficiency
					97%	Wiring & Distribution Efficiency
			Energy to Be Generated		**0**	**Watt-Hours/Day**
SOLAR PERIOD						PV loss factor
Avg. Peak Sun Hrs/Day		**Peak Sun Hours**				PV:Battery mismatch factor
Solar Tracker Gain ?						PV charge controller efficiency
			MINIMUM PV Array Required		**#DIV/0!**	**PTC Rating Watts**
BATTERY CAPACITY			Days of Energy Storage			**Input Autonomy**
			At Maximum Depth of Discharge			
			Capacity at Low-Temp			of 25°C standard rating
			MINIMUM Battery Bank Required		**#DIV/0!**	**Amp-Hours**
Enter Module STC Rating W				**Input**		**OK**
Min Array at STC W						STC Watts
Min Number of Modules Required						Calculated min number Modules
Min Practical Number of Modules Required						Actual number Modules
Practical Min Bank Size AH						Battery Bank to nearest 100AH
Inverter Size Calc (Watts)						**Model**
Single Battery Voltage				**Input**		Input value in Volts
Single Battery AH(C20)				**Input**		Input value in AH
Strings Calculation						
Series calc						
Actual Strings Calc						
Batteries in Series						
Actual Number of Strings						OK
Total number of Batteries						

Annex 2: Solar Usage Guide

GUIDELINES ON SOLAR POWER USAGE

Lighting

Fridges for both vaccines and blood bank

4 Incubators in the new-born units

2 Phototherapy machines

2 Suction machines

2 Rediant warmer when resucitating only

DO NOT USE

→ AUTOCLAVE

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