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Low Carbon Studies

Powering the Health Sector – Annex A - Literature Review

Powering the Health Sector

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1 Literature review

GVEP has reviewed secondary data from academic and development reports and project and programme evaluations to try to establish the evidence base on the health impacts of reliable sources of electricity.

The initial focus of the search was on the identification of outputs of service provision in the health facility where the energy has been provided. The assumption underpinning this choice is that the provision of power to the health care centre will immediately increase uptake for, and availability of, services with extended hours of operation. The indicators of service uptake that the team were looking for within the literature included:

- Utilization rate (all patients)
- Utilization rate (Under five)
- Antenatal Care 1st and 4th visits
- Deliveries in the health facility
- C-sections in the health facility
- Blood transfusions in the health facility
- Number of children immunized in the health facility
- Number of surgical procedures in the health facility

It became apparent early on that there was almost no literature relating to energy access and measurement of service provided, so in addition a number of other indicators were added to the search to widen the scope. These included indicators of service availability and quality including:

- Description of extra services or service time expansion provided after installation of power in the health facility using WHO health facility services assessment or comparing the current service provision with the service standards of the Government of the country.
- Recruitment of new staff or reduction of attrition rate of staff as a result of infrastructure (energy) improvement.

The study has not looked at other non-electricity energy requirements at health facilities such as energy for heating, hot water and cooking nor the potential for reduction in demands from energy efficient demand. In addition since the study focussed on the *health* impacts of providing electricity, the technical aspects, the operation and maintenance of any system and the cost benefits due to technology choice have not been reviewed.

1.1 Methodology

A broad range and combination of search terms were used based on the indicators listed above. An initial list of search terms was prepared which were then continually refined during the pilot search to ensure that the search picked up any document relating to the subject area. As far as possible, the terms allow for variants of word beginnings and endings. Some of the terms have meanings outside the energy sector. For example, the pilot test search revealed that the terms “light*” and “illuminat*” resulted in many irrelevant hits. The full set of database search terms are provided in Annex A.

The search terms were applied to titles and abstracts for all the academic literature databases used. For the grey literature each of the websites operated differently so specific sets of search terms were used for each. In each case the search was first carried out for titles and then for page content. The results for some of the grey literature searches are included in Annex B. A full set of search terms for each grey literature database is available on request. In addition to these searches, contact was made with staff at USAID, WHO and GIZ as well as local searches by staff in GVEP’s regional offices.

The limits to the search were set for all publications since 1996 and only English language publications. In addition the review was limited to studies reviewing data in developing countries.

Standard databases were used which include publications from most international health journals as well as papers from energy journals such as Energy Policy and xx. These included: Medline,

EMBASE, CINAHL, Web of Science, Scopus, Global Health and SIGLE. Grey literature was searched for from international organisations (World Bank, WHO, UNDP, ESMAP, REEEP, Oxfam), bilateral agencies including USAID and GIZ plus Google search which brought up a number of small NGO websites working in the area of energy and health.

The titles and abstracts of material meeting the criteria was entered into an internet based reference database; Mendeley. 1523 papers were identified from the databases, once duplications had been removed. Each of these papers were then screened for relevance based on the title and abstract. In the grey literature a further few thousand documents were identified which were screened by title and abstract where possible and by search result where not. This identified 80 relevant articles from the academic literature and 95 from grey sources for full text review. Following a detailed review of the quality and relevance of these articles only two papers link electricity and health outcomes but a number of papers provide some information on the role of electricity, or the lack of it, some provide information on health services, rather than outcomes, and many papers refer to the issue of electricity at health facilities without providing any further information. The following results provide an overview of the information found.

1.2 Results

The literature review has confirmed that few studies are available that provide empirical evidence of the links between electricity access at health facilities and key health indicators. There is a general consensus that electricity can improve health services provision and that the lack of power is impacting on health service provision.

Anecdotal evidence suggests that, where there is a lack, or inadequate electricity, then workaround solutions are found by the health care workers and this renders complications in attributing health outcomes to the provision of a more stable source of energy alone. . While a lack of energy may hinder health services or reduce health staff satisfaction, provision of health services, or the quality of services is dependent on many other factors, some of them critical, such as availability of trained staff, medicine and equipment. In addition the reasons for using or not using a health facility are linked to the presence of staff, medicines and supplies as well as culturally mediated and not necessarily linked to energy availability in a clinic. The following sections provide an overview of the findings from the literature review.

1) Little evidence

A number of reports found in the review confirm our finding that there is little, if any, evidence showing the causal effect between electricity provision and improvement of health outcomes in a community. These include the following quotations from the World Bank, WHO, and USAID:

- "there is very little peer-reviewed work on the causal effects of reliable power in health facilities… studies on the effects of electrification are needed to fill this gap in the literature.[1]"
- "Health facilities can benefit directly from renewable sources in two ways: by having longer opening hours and by having equipment that requires electricity. These links have not been subject to previous empirical investigation" [2]
- "The most commonly claimed benefit for health clinics for electrification is that it helps preserve the cold chain for vaccines; again, this claim has not been tested."[3]
- The WHO, in its Health in the Green Economy Series, identifies that a systematic review of impacts of energy poverty in health facilities and of health outcomes related to sustainable energy interventions in health clinics is needed[4].

There is one study underway by the Liberian Institute of Biomedical Research which is aiming to provide proof-of-concept that low cost renewable energy offers a significant, unexplored opportunity for reducing mortality and morbidity in developing countries and which aims to define requirements for

a large study providing definitive data on the impact of renewable energy on mortality and morbidity[5]. No results are available yet.

Although not unexpected it is surprising considering the number of projects providing energy to health facilities which have been funded by Government Health ministries, international and bilateral agencies and NGOs. Many of these **projects report positive health outcomes but the evidence behind them is not provided**. One such example from Cuba where photovoltaic (PV) systems were provided to 170 rural clinics in the remote mountain regions reportedly increased the quality of life and decreased the infant mortality rate in those areas[6]. All the systems included lights, a vaccine refrigerator, and other medical equipment, such as electrocardiographs and x-ray machines. This example is also quoted in another report on productive uses of energy for rural development[7].

As part of the World Bank's Energy for Rural Transformation project in Uganda solar energy packages were installed at medical buildings and health centres. The associated Implementation Completion and Results report[8] states that the project is deemed to be cost effective because: "Standard solar energy packages installed in medical buildings and Health Centers have resulted in offering improved health services, and positive impact on decreasing diseases such as Measles, Polio and Typhoid." However no evidence is provided in the report to back this up and there is an admission that further research and work is needed. In addition the report states that at the Paidha ERT site "Facilities with electricity are observed to offer improved services, where patients have light in wards, the hospital environment is relatively safe, and services are faster where record keeping is computerized. However, the impact remains somehow overshadowed by the many other challenges that health facilities face such as a lack of adequate and qualified staff, a lack of adequate drugs, lack of space / beds and other equipment and a lack of sufficient funds for capital and operational expenditure ".

An impact evaluation for GTZ of their PV programme, also in Uganda, is based on impressions rather than measured results of healthcare provision or improvement of health status of the communities served by the health centres provided with energy. In fact there is no mention of any health outcomes at all. That said, it reports that use of services did not increase but this was due to factors other than power in the centres such as HR deficit, lack of medication or supervision and lack of motivation. Comparison factors for health facilities other than the presence or absence of lighting are not mentioned. Quality of care is measured based on perception of users and providers rather than based on quantitative scores. There is also no mention how many of them were interviewed, if it was a random or a convenience sampling, and if they were interviewed before or after the service was provided. The methodology did not include these issues as limitations of the study.

A project in Colombia provided PV systems for four rural remote communities in the Province of Chocó to provide health care services by powering vaccine refrigeration, lighting, communications, and medical appliances. The case study states that services were improved, in particular that: vaccination coverage was increased; diagnosis of Malaria was more rapid; and lighting improved the quality of health clinic night visits. However no details are provided how this service improvement was measured [].

When USAID looked at carrying out an impact evaluation in Haiti they found that during a short-term evaluation it would not be possible to clearly measure outcomes since at facilities where power was unreliable or of poor quality, staff reported adaptations and workarounds, such as substituting manual procedures or not offering services which required powered equipment[9]. For example at one hospital the maternity nurses carry flashlights (and cell phones) to provide light during night time deliveries.

As part of their Liberia Energy Assistance Programme, USAID also provided a solar powered vaccine refrigerator and potable solar lantern for night births and other emergencies at the Sakonnedu Health Clinic in Liberia. A health worker at the clinic, which is run by the International Medical Corp, credits the solar powered refrigerator with saving lives: "Before a lot of newborns died, mostly from tetanus; since the refrigerator came, no more."[10]

In Liberia WeCareSolar have been disseminating 'solar suitcases' which provide power for lights and mobile phones. Feedback from the clinicians is that it is easier to see at night and repair lacerations, making obstetric care safer. In addition WecareSolar have been told that more women are having

skilled providers at their births since the overhead LED lights in the labour rooms are attracting more women to deliver in clinics at night[11] -.

Further anecdotal evidence is provided by a number of NGOs working in the field. We have requested further information from the NGOs. The one response to date confirms that they have only anecdotal evidence but they have started a monitoring and evaluation exercise. .

Anecdotal evidence - the difference electricity can make

"In the surgical ward we use the oxygen concentrator for patients who cannot breathe on their own. We need light to use the oxygen concentrator or the patients must be referred to another hospital. Sometimes the patients cannot afford to go, or sometimes they are too sick to make the journey. With electricity we can save the patients here. Before the solar panels went in, sometimes the generator would break down for one or two weeks, and we wouldn't have lights. We had to use candles, and it made our job difficult. Now with the solar we always have light. We are much safer and happier now."

Mari T Gomez - Surgical Ward, Sulayman Junkung General Hospital, The Gambia[12]. The hospital serves 100,000 people.

"When you have to deliver a baby using candle light it is terrible. You are helping the mother, and the candle may fall over or go out - the mother starts to scream, all of us are looking in the dark for the candle or matches whilst the mother needs our help. Solar power would help us so much here and in our homes as well."

Dianna Magapa is a nurse at Mazuru clinic, in Gutu, Zimbabwe, which serves 17,000 people across the district.[13]

"Hospital staff noted that the 24 hour supply of electricity had a significant role in reducing the mortality rate, improving the ability of the staff to deliver high quality life saving patient care during the difficult night time shifts"

Bansang hospital, The Gambia is in the remote east of the country and serves a catchment of nearly 600,000 people[14].

Prior to the solar lamps "the kerosene lamp made health problems both to me and mothers with their newborn babies. I have contracted respiratory infections on various occasions and also the use of moonlight is quite tricky as I have to conduct deliveries in the open air. I use moonlight only when kerosene is out of stock or when I contract respiratory sickness,'' she said.

Muktar is a Traditional Birth Attendant in Garissa in Northern Kenya. Not only is the solar lamp improving service she also said that it is bringing down the cost of her service since she no longer needs to pay for the kerosene. The cost has reduced from 425 Kenyan shillings ($5) for a delivery, including to 255 Kenyan shillings ($3) a delivery[15].

In Nigeria,staff from 'WeCareSolar' interviewed midwives and community health workers in advance of receiving a solar suitcase. In one clinic "a midwife told me about a breech delivery in the darkness. The baby's body delivered first, and the head was trapped. She searched for a light, but the only flashlight in the facility was broken. The midwife grabbed a cell phone to utilize its small light, but the phone fell in a pool of blood on the delivery table, and no longer could function. By the time the delivery could be completed, the baby was dead."

A clinic supervisor summed the problem up in this way. "If there is no light, anything can happen. [The health worker] cannot see the person she is delivering. You can try to clamp the cord and clamp the wrong thing. You can mistakenly cut the woman. Even the health worker can be wounded, and if the patient is HIV positive, this is especially dangerous." When I describe our plans for bringing Solar Suitcases to their clinics, they smile as they imagine a time when lighting will be assured. "The light you bring will help the health worker, it will help the patient…it will certainly help a lot." [16]

Conversely an unpublished Masters thesis studying the impact of electricity in Bhutan, could not establish strong links between electrification and any reduction in child mortality, improvement of maternal health or in combating some diseases. The researcher concluded that this was because the role of electricity appeared not as significant as other factors such as better drinking water and proper sanitation [17].

2) Difficulty in attribution

Attribution of changes in health status or health services uptake due to the provision of electricity is not clear in any of the studies reviewed since there are many factors that impact health services and outcomes. These include staff availability and pay, availability of basic equipment and medicines, transport and infrastructure. A study reviewing the impact of electrification, more generally, on gender also refers to the problem of attribution since it mentions that there is much literature that describes the potential impacts of electricity assuming no other behavioural responses to the intervention. However, the authors found that claims are largely based on qualitative analysis, and thus "do not rule out rival explanations such as systematic differences in the communities or households that receive the electricity or motive power[18]".

In Uganda the 'Rural Extended Services and Care for Ultimate Emergency Relief' (RESCUER) project was initiated in 1996 to try to reduce the high maternal mortality rate (MMR), estimated at 506/100,000. The project had three components: communication, transport and quality health services delivery. Communication, in this case VHF radio, required energy provision. After three years there was reduction in the MMR of about 50%[1] due to the increased number of deliveries under trained personnel and increased referrals to health units made possible from the communication and transport facilities. Note thta confidence levels are not provided for this study and since maternal deaths are a rare event, the figures may not be robust. "Before the project, there were problems of lack of communication facilities and transport, which made referrals slow and sometimes led to the death of the mother or baby or both". (Administrator). However it is important to note that the success of the communication component is only made possible due to the contribution of the other two project components – transportation and quality of service delivery[19].

3) Two studies with some evidence of outcomes

Two studies provided some quantification of health outcomes related to electricity provision (and telemedicine in one case). Again it is difficult to isolate the benefits due to electricity. The first was a study undertaken by Mbonye et al. in Uganda which reviewed the data on maternal deaths and level of emergency obstetric care in 54 districts and 553 health facilities (covering three levels of facility). The study collected information using a structured questionnaire that captured data on: the number of health workers; emergency obstetric care services (signal functions); maternal deaths and obstetric complications; status of health infrastructure like availability of running water, supply of electricity, telephone facilities, waste disposal facilities and accommodation for staff; furniture and linen facilities; availability of basic equipment and availability of essential drugs. One of the factors found to have a protective effect on maternal health was the availability of electricity at the facility (OR 0.39, P<0.000) ie. Women delivering in health facilities without electricity are 39 times more likely to die than the ones in facilities with electricity. . That said the availability of midwives had the highest protective effect on maternal deaths, reducing the case fatality rate by 80% (OR 0.20, P<0.0001) whilst other significant factors included a functional operating theatre (OR 0.56, P<0.0001) and laboratory (OR 0.71, P<0.0001). Despite this few health facilities had these features[20].

The second study involved 32 health posts in the rural Amazon region of Peru where each was provided both energy and communication technologies[2122]. Prior to the installation of the equipment a survey was carried out with 32 managers from 39 health sites who were interviewed using a questionnaire regarding their time travelling for administration, drug acquisition, training, trips relating

[1] "*A survey carried out recently in three districts of Arua, Iganga and Tororo, which all had their TBAs trained, showed that Iganga's MMR had reduced from 500/100,000 in 1996 to 271/100,000; whereas rates for Tororo and Arua had reduced, but both were above 350/100,000.*"

to doubts, transfers and costs. The first priority for 40.5% of those interviewed was an improvement in the infrastructure followed by communications and an increase in personnel. Subsequently e*ach of* the health posts was provided with a 160W PV system along with a VHF transceiver, laptop, internet, lighting system and batteries for 5 days autonomy plus a central server was installed in a hospital in Lima. The aim of the project was to provide distance training, electronic publications, exchange of epidemiological reports, access to experts and health information and to assist in patient transfer. The users were trained in preventive maintenance, operation of the communication system, and use of the computer (hardware and software).

Two impact evaluations at 9 and 24 months were then carried out reviewing the use of system plus the impact on the health of the community as well as the impact on the health personnel and overall health services. The communication system was found to be successful and used for 100% of emergency cases and in 64% of these reduced the time for referral by enabling the use of vehicles from other establishments (a 60% reduction). Health-care personnel reported that in 60 of the emergency cases (25.3%) the use of the system saved the life of the patient.

Obstetric emergencies, followed by cases of complicated malaria, were the two medical problems for which the communication system had the greatest benefit. In fact, the time to detection of cases of malaria was reduced by half, which, over the long term, will affect the morbidity and mortality associated with this disease. The epidemiological surveillance system in the area, one of the most isolated areas in Alto Amazonas, was improved by reducing by a quarter the number of trips made to send reports.

As with the Uganda RESCUER project it is not possible to attribute how many of the outcomes were primarily down to the provision of PV. Without the PV the outcomes would not have been possible but equally the communication equipment and training are needed to attain these results. In this sense, electricity can be viewed as enabling improved services, but not the cause of improved services.

4) Negative impact of inadequate energy access

There are numerous papers and anecdotal evidence suggesting that a lack of reliable electricity can negatively impact on the delivery of health services, equipment performance and in some cases patient outcomes. Similarly there is a body of work, particularly relating to the Millennium Development Goals (MDGs) which reflect on the role that energy can have in helping to reduce child mortality, improve maternal health and reduce (MDGs4,5 & 6).

A literature review undertaken by Brenneman et al. summarises the issues well[23]:

> "The lack of modern energy sources negatively impacts health centers. Without electricity for refrigeration, health clinics cannot safely administer vaccines or a number of other medicines. Without a constant source of good lighting, which is not achievable using candles or other non-electrified sources, doctors cannot safely perform operations or even adequately examine a patient at night. Many doctors and nurses simply won't serve at health clinics that don't have outdoor lighting to provide for their safety. Thus, it is difficult, if not impossible to establish a safe and efficient health clinic that provides quality health care services without electricity or more modern energy sources."

Essential health technologies, as defined by WHO[24], include technologies and medical devices to support emergency and surgical care, blood transfusion, vaccines and injections (e.g. refrigeration), diagnostics and laboratory technology and e-health.

The following examples are not comprehensive but illustrate where and how electricity can enable services. Studies which met the search criteria also showed the impact of services available due to electricity supply (eg telemedicine, fans, lighting). In addition new equipment and forms of diagnoses are always being developed. Yet in some cases low income countries are not able to avail themselves of the new developments. In addition to cost one of the reasons is the need for a stable and regular electricity supply. One such example includes a quick test for TB.[25]

Support for Emergency and Surgical care (Lighting, sterilization, anaesthesia, suction machines, incubators)

Good lighting is one of the most common services mentioned as lacking, particularly for night-time deliveries and emergency care. In fact almost all projects providing power to health facilities focus on lighting first.

There are a number of studies covering different countries that review the availability and use of emergency and surgical services or of emergency obstetric services and all state that the lack of electricity is one of the main obstacles to operating a 24-h service. [262728293031323334]

However these studies do not go as far as linking use specifically to the availability of electricity. For example Pearson et al states "Lack of basic infrastructure such as electricity, water, communication, means of referrals, adequate staff quarters, and poor security especially at night and for female staff were the main obstacles to running 24-h quality EmOC services." Of course infrastructure is just one of the obstacles along with lack of surgeons and midwives, lack of medicines and drugs and lack of essential equipment such as "as the oxygen tube of the anaesthesia machine, bulbs of the surgical light, or the plug of the autoclave". The same study also found that a higher coverage of EmOC does not automatically mean higher use since there are other limiting barriers such as cost of services, cultural barriers, ease of referral etc[35].

A study of a hospital in Nigeria reviewing emergency surgery over a 12 month period concluded the same, stating that although the lack of electricity was the commonest reason for the delay of operations other reasons were also given including a lack of theatre space, light, water, sterile gowns, anaesthetic drugs, investigation results and patients' inability to pay. Since it found that the majority (57.7%) of emergency surgery was performed after normal working hours, between 4pm and 8am lighting is particularly important[36].

One paper by Chao et al takes the role of electricity as only one of the limiting factors further by stating that "infrastructure limitations of electricity, water, oxygen, and blood banking do not prove to be significant barriers to surgical care.[37]" Rather than improvements in energy access the same paper notes that since much surgical mortality comes from late presentations, an improvement in accessibility through infrastructure development would likely provide a major improvement in surgical morbidity and mortality rates.

Support for Vaccination/Blood transfusion (Refrigeration)

Immunization programmes depend upon reliable refrigeration to preserve vaccines such as those administered to prevent infectious diseases such as Polio, Diptheria, Tetanus, Pertussis, , Measles, Yellow Fever, and Hepatitis-B among others. In addition refrigeration is a critical element in maintaining blood safety for transfusions and other procedures. A systematic review of the published literature by Hyde et al. to examine the impact of new vaccine introduction on countries' immunization and broader health systems frequently showed the need for increased cold chain capacity along with the importance of training and education for health care workers and social mobilization[38]. Reports also state that unreliable cold chain is due to undependable electricity supply. For example in a study in South Africa, out of nine rural clinics surveyed, seven had unreliable radio-communication, five reported unreliable vaccine storage and three reported non- functional lighting schemes which decreased staff safety, all due to unreliable energy sources[39].

A number of programmes have provided PV powered refrigerators to help with the development of cold chain for vaccinations and for blood storage. These projects have shown that the cold chain is more reliable with electricity (PV) but they have not reported changes on immunization levels, or where they are recorded they have shown that immunization levels have been maintained or not increased markedly. The Cold Chain Program in Africa provided PV to health clinics for their vaccine refrigerators and demonstrated an improvement in the reliability the cold chain. In Uganda and Ghana, which both participated in the study, the mean time between failures for PV refrigerators was 2.6 years and 4 years respectively both much lower than could have been achieved with better basic maintenance of gas refrigerators.[40].

WB analysis shows that refrigeration was significantly more available in clinics with electricity however the immunization rate did not vary widely implying that those clinics without electricity employ work-around solutions, including organising vaccination days, to overcome the lack of cold chain. The impact of access to electricity and refrigeration for the patients is that children can be vaccinated anytime rather than on predetermined days and therefore this reduces the number of times mothers have to come to the centre with their children for vaccination or could come at more convenient times. Similarly in electrified hospitals in Bhutan vaccines and medicines are now kept reliably refrigerated. The key difference was that people no longer need to go to other health facilities to receive vaccination and other basic treatment. As a result, they save time and money on transportation and lost wages[41]. However one case study mentioned that the lack of tetanus vaccines for new-borns had led to child deaths.

Table D.5: Electrification of Rural Health Clinics and the Cold Chain by Country

	Ghana (2003)		Egypt (2002)		Kenya (2004)	
	Electricity	No electricity	Electricity	No electricity	Electricity	No electricity
Electricity	72.8	27.2	98.6	1.4	77.5	22.5
Refrigerator	64.2	40.7***	51.3	0.0***	71.9	67.3
Ice	2.6	6.2*	0.6	0.0	0.6	0.0
No storage	21.9	37.2**	11.6	0.0***	3.3	7.1***
Immunization	88.7	84.1	63.4	0.0***	75.7	74.5

	Electrified (%)	Not electrified (%)
Bangladesh (2000)		
Cold chain equipment available and operational	55.9	10.0***
Nicaragua (2001)		
Electric refrigerator	65.5	10.2***
Solar refrigerator	15.2	20.7*
Any refrigerator	80.7	31.0***
Cold box	29.2	14.1*
Termo	92.6	65.9***
Rwanda (2001)		
Refrigerator	80.8	96.6***
Immunization	80.8	98.8***

Source: DHS data except Nicaragua, from Measure Evaluation Health Facility Survey.
*Significant difference at 10 percent.
**Significant difference at 5 percent.
***Significant difference at 1 percent.

Table 1 Electrification of Rural Health Clinics and the Cold Chain by Country (Source: World Bank IEG Report[42])

The provision of blood transfusions can save lives. In Haiti USAID describes a case where a young woman died due to the lack of blood refrigeration. Dr. Malhi Cho, a blood transfusion specialist and consultant with the Pan American Health Organization in Haiti says that the importance of stable and reliable electricity for blood banks cannot be overstated. “If blood transfusions are going to be part of the standard of care in developing countries, we have to think about ways to leverage cost-effective technologies to ensure the cold chain.”[43]

Support for Oxygen Concentrators

Oxygen treatment is important for pneumonia and influenza. One study by Belle et al concludes that in addition to efforts to secure vaccines and antivirals, future global influenza preparedness efforts should include investments in oxygen and associated equipment and infrastructure at first referral health facilities, to minimize morbidity and mortality from influenza in regions with limited medical resources[44]. To meet this requirement the use of oxygen concentrators in developing countries is

increasingly becoming an alternative to conventional compressed gas cylinders, which are expensive to refill and logistically challenging to transport. However one major obstacle to the effective use of oxygen concentrators is the need for a constant power supply. What's more, monitoring equipment and ventilators are at risk of damage from variable electricity and voltage surges. In The Gambia a report identifies that suboptimal electricity and maintenance made using concentrators difficult[45]. However the benefits of oxygen concentrator programmes, which need reliable electricity, are clear both in terms of outcomes and costs:

- In Malawi, childhood pneumonia case-fatality fell from 18.6% to 8.4% after the implementation of a national program involving the installation of oxygen concentrator treatment systems. In a study of 10 000 children in Papua New Guinea, a 35% reduction in case-fatality was reported after a system based on oxygen concentrators and hypoxia detection with pulse oximetry was installed.
- In a cost comparison study in The Gambia, estimated yearly operational costs of cylinders for all district hospitals was US$152,750, while costs to provide the same volume of oxygen from concentrators (with a reliable power source) were only US$18,750.[46]

As with other initiatives electricity is an enabler for improved services since the impacts seen also require a number of other simultaneous initiatives.

Support for Ultrasound

Pregnant women in developing countries frequently give birth at home, limiting their ability to receive adequate obstetrical care if needed. The use of ultrasound technology (needing electricity) has the potential to help reduce maternal death rates in rural developing regions by improving the accuracy of referrals[47]. However, due to a lack of power and because of limited numbers of highly trained medical personnel and high prices for ultrasound equipment it is not widely used. Portable ultrasound units are being explored by a variety of projects in developing regions to help combat maternal mortality

The potential impact is demonstrated by a study in Uganda where 58% of deliveries occur at home [33] and an estimated 6,300 women die each year from maternal-related complications [34]. The survey found that the obstetricians estimated substantial increases in survival rates if pregnant women with complications delivered in a health care facility, estimating on average that survival rates in a hospital (as opposed to a rural village) would increase from 43% to 97% for breech presentation, from 51% to 94% for multiple gestations, and from 17% to 86% for placenta previa [Personal communication: Babagamura J. and Nathan, R., Survey of Ugandan obstetric opinion makers on maternal mortality risk. 2009].[48]

Ultrasound is clearly only one factor that contributes to the improvement in maternal health demonstrated. Another paper confirms this by stating that introducing ultrasound technology alone is not enough to reduce the high maternal death rates in poor countries [49].

Support for Telemedicine

ICT-based services (e-health and telemedicine) can help to improve health through improved dissemination of public health information, by supporting rural health workers through enabling remote consultation, diagnosis and treatment, facilitate training, collaboration and cooperation among health workers, reducing inefficient expenditures of time and resources through improved administrative systems and referrals. In addition ICT provides a strengthened ability to monitor and respond to the incidence of public health threats such as pandemics and disease outbreaks as well as facilitating communication between health workers and patients for improving adherence to treatment. Use of these technologies requires access to electricity and communications. In fact in one study an implementer cited the lack of the necessary infrastructure to provide reliable electricity and internet access as a key reason for moving from one type of telemedicine to another; from computers to mobile phones, for which the necessary infrastructure is more readily available[50].

A number of different papers meeting the search criteria have reviewed the impacts of telemedicine, or tried to with mixed results. One systematic review of telemedicine assessments by Hailey et al. identified 66 scientifically credible studies that included comparison with a non-telemedicine

alternative and that reported administrative changes, patient outcomes, or results of economic assessment. Of these thirty-seven of the studies (56%) suggested that telemedicine had advantages[51]. Other reviews found that a gap exists between assumed and empirically demonstrated benefits of eHealth and that there was little information on the impacts of e-health programmes, particularly in low- and middle-income countries. Most of the reported work on telemedicine usage in developing countries concerns pilot trials or feasibility studies[52]. Good quality clinical studies are few and usually limited in scope. Stronger evidence is therefore needed to increase the appropriate use, scale and impact of telemedicine in resource-limited settings. This need for stronger evidence underscores that more and better evaluations need to be conducted. Given their size and relative success, long-running telemedicine networks should be the subject of controlled evaluations in future[53]. Nevertheless, eHealth was argued to increase the quality and efficiency of care, reduce erroneous treatments, and improve access to care in remotely populated areas. As with electricity provision more data exists regarding the efficiency and costs than on the system's potential impact on the outcomes of care.[545556]

One paper for Infodev which reviewed major constraints and challenges faced in using ICTs effectively in the health sector of developing countries, found a number of examples of improved health outcomes. For example in "Peru, Egypt and Uganda, effective use of ICTs has prevented avoidable maternal deaths. In South Africa, the use of mobile phones has enabled TB patients to receive timely reminders to take their medication. In Cambodia, Rwanda, South Africa and Nicaragua, multimedia communication programmes are increasing awareness of how to strengthen community responses to HIV and AIDS. In Bangladesh and India, global satellite technology is helping to track outbreaks of epidemics and ensure effective prevention and treatment can reach people in time."[57]

Another study has also shown that a low cost and reliable email/web messaging service can help clinicians in a very remote part of the world. Assistance can be provided with diagnosis and management of patients with many semi-urgent or non-urgent medical conditions. This is particularly important in those countries where the electricity supply, the telecommunications and computer resources may be limited and/or only sporadically available. The authors believe that the service only requires basic computer and Internet facilities and the fact that it is useful even when electricity supply and telecommunication is limited, it should be considered before more expensive, high-technology services are contemplated[58].

In Cuba rural health clinics benefit from radio-telephone communications capabilities. Following the earlier installation of PV at clinics and a recognition that owing to the remoteness of clinics, doctors still had no way to communicate with ambulances or hospitals radio communications were added to each clinic. The radiotelephones have already saved numerous lives and have been used for many purposes, including during hurricanes and floods to request ambulance or helicopter assistance; to inform relatives of the condition of a patient in a hospital; to inform hospitals about the status of vaccination campaigns; to ask for specific medicines needed by the clinic; and to solicit help from medical specialists. Importantly, the communications equipment adds only slightly to the cost of the total PV system[59].

In Cambodia a study concludes that telemedicine support for mobile non-physician health care workers is a feasible model for delivering care in the developing world. The project installed a computer, solar panel, and satellite dish allowing for Internet connectivity at a school in the village of Th'naut Malou in Rovieng, Cambodia allowing a previously unserved population of 4000 to receive a monthly telemedicine clinic[60]

Mobile phones can have an important role for patient interaction as well as with rural workers. In Kenya, text messages to health workers significantly improved their adherence to guidelines for malaria treatment. A trial carried out in Zanzibar by Lund et al. found that mobile phone intervention significantly increased skilled delivery attendance amongst women of urban residence. The authors suggest that mobile phone solutions may contribute to the saving of lives of women and their newborns and the achievement of Millennium Development Goals 4 and 5[61]. However another paper aiming to anaylse the potential of mobile phones to improve maternal heath in LMIC countries found that few projects exist in this field and little evidence is available as yet on the impact of mobile phones on the quality of maternal health services[62].

As with other services electricity alone will not ensure positive results from ICTs. In fact one paper concluded that ICTs play a marginal role in access to health information due to the health vulnerabilities and limited information resources of the poor more generally and that no ICTs will work in a resource-poor setting unless livelihood-based approach is intervened[63].

Air circulation

A review of the impact of electric fans for reducing adverse health impacts in heatwaves did not find any empirical evidence but only observational studies where some showed that fans were associated with better health outcomes (including fewer deaths), whilst others found the reverse. Fans do not cool but the aim is to increase heat loss by increasing the efficiency of normal methods of heat loss, but particularly by evaporation and convection methods. Therefore increased sweating can lead to dehydration and electrolyte imbalances if these fluids and electrolytes are not replaced quickly enough[64].

6) Workaround solutions

Lack of or inadequate electricity can result in coping solutions so that the impact of electricity on health outcomes is less clear. For instance in the WB study of vaccine refrigeration referred to earlier it was shown that immunization rates were not very different with and without reliable cold chain and this could be due to workaround solutions such as vaccination days.

One study of intensive care units concluded that an irregular supply of water and electricity to a hospital is not a complete bar to developing some ICU facility as long as staff are trained to deal with the local conditions such as dealing with ventilated patients if the power fails.[65]

As mentioned previously when USAID looked at carrying out an impact evaluation in Haiti they found that during a short-term evaluation it would not be possible to clearly measure outcomes since at facilities where power was unreliable or of poor quality, staff reported adaptations and workarounds, such as substituting manual procedures or not offering services which required powered equipment[66].

5) Reported impact on health services

Studies that do exist concentrate on impact of electricity on health services (hours of operation, available equipment, vaccine storage etc.) or perception of health service quality (e.g. that the health service is good), not health impacts (prevalence of disease, mortality rates). It is possible that these could be used for proxies for health impacts. The World Bank study concluded that renewable energy benefits the quality of health services and lowers costs by extending opening hours and significantly strengthening the cold chain for vaccines— though it does not increase the extent to which such services are offered. Opening hours were increased in Bangladeshi and Kenyan clinics with electricity[67].

Table D.6: Average Number of Hours Rural Clinics Are Open

	Electricity	No electricity
Bangladesh	7.1	6.1[a]
Kenya	15.1	11.0[a]

Source: DHS facility surveys.
a. Significant difference at 1 percent.

Table 2: Average number of hours that Rural Health Clinics are open (Source: World Bank IEG Report[68])

The GTZ funded impact study on the solar electrification of health centres in Uganda found that the quality of the night-time examinations and deliveries was enhanced[2] by the availability of electric light but there was no difference in the number of night-time emergency cases attended to between those health centres with and without electricity. 92% of patients interviewed did not choose to go to a health centre due to it having electricity access but they all felt more secure being treated at one with power. Their highest priority was availability of medication, the level of care followed by the health centre's proximity. The same study concluded that electricity for lighting should be targeted at those clinics with staff quarters since they are more likely to provide longer opening hours.

An unpublished Masters thesis which focused on the impact of electricity on the income, health and education in rural Bhutan found that the services provided in the hospitals of electrified villages was much better mainly because of the presence of electricity. The results are based on a with-without study from a survey carried out in four electrified villages and another four non-electrified villages in central Bhutan[69]. Refrigerators, electric sterilizers, suction machines were important electrical devices. The emergency operations and attending to first aid at night were quoted by health workers in non-electrified villages as a big difficulty. According to all the health workers, sterilization is better in electrified hospitals where they use electrical apparatuses, electrified suction machines enables safer and more efficient child delivery; and the electrified rural health units also reported their services being availed in the evenings during emergencies. At night, wound dressing, wound stitching and removal of foreign bodies from wounds was more convenient. The study also states that these village hospitals do not have any professionally qualified doctors so if possible many villagers go to larger hospitals to get treatment rather than attend local hospitals even where the services are available.

7) Retention of health workers

There is some evidence that a lack of good infrastructure impacts on attracting and retaining health workers in rural areas.

A study by WHO, which provides evidence based recommendations for attracting and retaining health workers to rural and remote areas, recommends good infrastructure and facilities (sanitation, electricity, telecommunications, schools, etc.) as these have a significant influence on a health work's decision to locate or to remain in the rural area[70]. The work followed a comprehensive review of all relevant and available evidence related to health workforce attractiveness, recruitment and retention in remote and rural areas. Note the evidence was found to be of low quality according WHO's GRADE system.

A study in Bangladesh found that there was less absenteeism of health workers at local health facilities for those living in electrified communities, although the study did not specify electricity supply at the health facility. The study does state that this may be due to electricity being a proxy for wealth, or it may be due to the direct benefits of living with access to electricity[71].

A report produced by VSO has documented the experiences and views of 122 health workers (medical doctors, clinical officers, nurses, midwives and nursing assistants) based at 18 hospitals and health centres in Uganda. The anecdotal evidence referring to a lack of limited electricity includes the lack of job satisfaction of health workers, for example "Doctors blamed the lack of opportunity to practise surgery for unwillingness to take up a medical doctor post at a health centre IV, and increased risks to health workers and their patients. Risks come from contaminated blood, inability to read patients records, difficulty in working in dim conditions, unlit compounds, and poor infection control due to lack of water and sterilization[72].

The health staff who had electricity access were satisfied with their level of lighting whereas those without electricity, including those with non-functioning solar, rated their light quality as insufficient or very bad[73].

[2] *Interviews with staff showed that inadequate lighting has led to accidents and difficulty in observing abnormalities, with locating equipment and preparing rooms.*

Previous studies of African health systems have also identified the most important human resources tools to manage job satisfaction as, in order of importance these were: materials, salary, training, working environment, supportive supervision, living conditions, and recognition. In Uganda field surveyors heard stories of (or witnessed) delivering babies by candle-light, dentists idled because their tools would not operate without electricity, hospitals without any x-ray facilities, non-functioning rest rooms and ambulances, and extreme staff shortages. Yet although working conditions were poor, living conditions were worse. Insufficient access to basic supplies and equipment, including water and electricity, were discouraging[74].

The Africa Rural and Renewable Energy Initiative (AFRREI) confirmed the same. A presentation included some 'poor voices' regarding energy to health centres. Not only did these restate the ability to undertake night time deliveries can save mothers lives they also mentioned the ability to retain staff. "Health workers do not want to stay in rural areas where facilities like water, electricity and schools for their children are not available. Without electricity, it is difficult to retain staff and the attrition rate is high." Administrator, Rukungiri district, Uganda[75].

8) Direct savings reported

Any quantitative assessments of electricity provision at health facilities seem to focus on the direct benefits, calculated by the avoided cost method (estimating benefits by the avoided costs of the various devices that are replaced by electrification) or avoided cost of referrals made possible due to telemedicine with electricity.

In Mozambique, it is estimated that use of telemedicine could save up to US$10,000 per year for the central hospitals based on transportation costs for inappropriate referrals[76].

The AFREI programme estimated that its energy-health component (providing energy plus sterilization, lighting, cold chain, lab equipment and telemedicine) would improve health care service for 4.2 million people in 10 districts of Uganda. This is less than USD 1/capita.

In the Peru study a cost-benefit study was carried out based on the direct benefits due to savings on travel (US$1718 monthly) and on patient evacuation (US$4230 monthly). The set up costs (USD4195) plus on-going communication costs, maintenance and repair (USD 704/month) gave a payback in 2.5 years. However this did not take into account the indirect benefits including the increased productivity of health staff due to reduction in travel and office task (estimated reduction in report writing from 20 to 13 hours per month (45% reduction)), and the productivity increase of patients and relatives due to the reduction in patient evacuation. The average time for patient evacuation was reduced from 8.61 hours to 5.17 hours (60% reduction) due to the more efficient use of vehicles made possible by the communication.

USAID's Powering Health programme has provided PV to a number of health facilities in Haiti, Guyana, Rwanda and Afghanistan. An information note for the installation of a 5 kW PV system at Deh Sabz District clinic in Afghanistan states that the operating costs are now negligible compared to the previous diesel costs of USD 30,000 a year. Previously nearly all the clinic's money was spent on diesel.[77]

10) Other findings - Household electricity

Other papers that met the search criteria linked electricity access in a household with greater use of health facilities and/or with impact on health outcomes.

In a study covering six countries in Central and West SSA, differences in infant mortality rates between rural and urban areas were found to mainly derive from the disadvantage in rural household characteristics. These characteristics include access to electricity as well as access to safe drinking water and the quality of housing material and were due to lack of infrastructure as well as the inability of some households to exploit the services[78] This could be that infrastructure services including electricity are a proxy for wealth. However another study looking at determinants of infant and under 5 mortality rates found that the electricity effect was largely independent of the income effect. L Wang

(2003) used cross-country DHS data and results from earlier studies looking at health outcomes cross 60 low-income countries. The results found that electricity access was one of the key determinants in child mortality rates. "The analysis on mortality determination shows that at the national level access to electricity, incomes, vaccination in the first year of birth, and public health expenditure significantly reduce child mortality. The electricity effect is largely independent of the income effect. While in urban areas, access to electricity is the only significant mortality determinant, in rural areas, vaccination in the first year of birth is the only significant factor."[79]

In Sindh, Pakistan the presence of electricity in the house was strongly associated with the utilisation of antenatal care[80]. However this may also be due to electricity access being a proxy for wealth.

- New technology development

Some of the literature reviewed deals with the development of new technologies specifically for resource poor settings. These are creating opportunities to improve health facilities and services and will have an impact on the future energy demands of health facilities. These include low energy and battery powered devices such as portable ultrasound, LED microscopes and solar powered cold chain. Further examples include:

- Sterilization and disinfection - For example solar energy seems to be a cheap method to autoclave medical instruments and treat biomedical waste[818283 84]
- Blood pressure measurement - The management of high blood pressure (BP) is currently inadequate in low-income countries. To address the challenges a new measurement device has been specifically designed for low resource settings which is inexpensive, semi-automated, robust and solar powered[85].
- Anaesthetic machines - New sophisticated anaesthetic machines are not appropriate for many parts of the developing world, as they are reliant on regular servicing by skilled engineers and need an uninterrupted supply of electricity and compressed gases. The Glostavent has been designed specifically for working in these countries. It is robust, simple to use, economical, easy to service and will continue to run during an interruption of the supply of oxygen or electricity[86].

Gender disaggregation

None of the papers reviewed disaggregated data for gender. One study from Uganda found that women were impacted more by the provision of electricity but that is partly because they are the majority users of the health centres.

1.3 Conclusions

There is little evidence that shows that electricity alone has an impact on health services or health outcomes. Further studies on the effects of electrification of health clinics (all other factors being equal) are needed. However it is clear from reviewing the literature that electricity is a key enabler for improvements in health services and outcomes and in the case of tertiary care is essential to provide the required care during surgical procedures or in intensive care units.

The following table outlines the potential impacts on health service provision from a variety of energy applications as well as identifying some of the frequently quoted health outcomes. The final column shows what evidence has been found in this literature review relating to these impacts or outcomes. The table is adapted from an EU funded study, ENABLE, which summarised how energy access can impact health provision plus WHO's SARA and USAID's Power Health tool.

	Energy Services/ Appliances	Potential Health Service Impact from Energy Provision	Potential health outputs of service provision	Potential Health Outcomes	Evidence found relating to energy provision/health services and outcomes
Medical services	• *Internal and external lighting* • *Mobile phone charging* • *Air circulation* • *Air conditioning* • *Space heating* • *Ultrasound* • *Incubator* • *Suction apparatus* • *Anesthesia machine* • *Oxygen concentrator* • *Blood refrigeration*	• *Prolonged opening hours with general lighting and security lights provided;* • *Wider range of services will be implemented, because more qualified staff are attracted to stay;* • *Improved emergency surgical services including blood transfusions;* • *Better obstetric emergency care;* • *Improved management of childhood illnesses;* • *Better management of chronic conditions;* • *Improved referral system (communication system between peripheral and referral units);* • *Improving planning and quality assurance* • *Increased medication services*	• *Increased utilization rate (all patients)* • *Increased utilization rate (Under five)* • *Increased ANC 1st and 4th visits* • *Increased no. of deliveries in the health facility* • *Increased no. of C-sections in the health facility* • *Increased no. of blood transfusions in the health facility* • *Increased number of surgical procedures in the health facility*	• *Reduced mortality and morbidity* • *Reduced maternal mortality* • *Reduced child mortality* • *Fewer complications* • *Reduced DALY*	• *1-4 hours extended opening hours [2]* • *Mixed evidence of increase in service use – none [73] to an increase [69]* • *61% reduction of likelihood of dying in centres with electricity [20]* • *25% of emergency patients saved with PV and tele [21]* • *Papers/Case studies increasing assisted delivery [11,47,48,49,51,57]* • *Anecdotal/case studies stating reduced maternal mortality and reduced mortality from surgical and emergency services (various)*
	• *Autoclave* • *Sterlization oven* • *Boiler or steamer*	• *Better sterilisation procedures;* • *Better waste management*		*Reduced infection*	• *Better sterilization [69]*

Disease prevention ,laboratory ,diagnostics and treatment	• *Vaccine refrigerator* • *Centrifuge* • *Haematology mixer* • *Microscope* • *ECG machine* • *Blood chemical analyser* • *Water bath* • *Haematology analyzer* • *CD4 machine* • *X-ray* • *HIV/TB testing equipment* • *Nebulizer*	• *Improved cold chain will give a lower immunisation failure rate and a better immunisation coverage and reduce waste of vaccines due to cold chain failure;* • *Facilitate diagnosis for infectious diseases including HIV and TB;* • *Evening awareness sessions with general lighting and a TV/VCR.* • *Improved diagnosis of certain diseases (lab techniques)*	*Increased number of children immunized in the health facility*	*Reduced mortality and morbidity* *Reduced child morbidity and mortality (polio, measles, meningitis, HiB)* *Reduced neonatal mortality due to Tetanus vaccination*	*Better cold chain but no evidence of clear impact on immunisation levels [22, 2,40]* *Case study of child mortality due to lack of tetanus availability[10]*
Health and Safety	• *Water pumping* • *Water purification* • *External lighting*	• *General cleanliness would improve with general lighting and water available;* • *In-patients would feel more comfortable and secure;* • *Staff feel more secure;* • *Security lights provided during evening open hours.*		*Reduced infection* *Reduced maternal mortality due to increased attended births at health centres*	*Patients feel more secure [73]* *Staff feel safer [70,71,72]*
Staff recruitment and retention	• *Lighting (internal and external)* • *Communication (internet/mobile)* • *Computing* • *Radio/TV/VCR/Projectors* • *Fans/air conditioning* • *Appliances*	• *Better job satisfaction for staff because of better living and working conditions;* • *Continuity since staff will want to stay longer in a place where there are better living and working conditions;* • *Electricity in staff houses means continued medical education is possible;* • *Easier recruitment and retention of staff to locations with electricity and water;* • *Easier to train staff because of improved lighting, equipment and*	• *Wider range of services will be implemented*	*Reduced mortality and morbidity*	*Better job satisfaction and retention [70,71,72]*

		TV/VCR.			
Administration and logistics	• *Computing and internet* • *Printing* • *VHF radio* • *Lighting*	• *Better administration and record keeping;* • *Better communication between health facilities and better planning of transport logistics*	*Better health records and epidemiological surveys*	*Reduced disease from early awareness of outbreaks*	*Reduction in costs and time ([21]* *Tracking of epidemics[57]*

Table 3: Energy Services at Health Facilities and the Potential Health Service Impacts, Health Outputs and Health Outcomes of Energy Services. Adapted from IT Power *2007*[lxxxvii]*, USAID Powering Health, and WHO's Service Readiness Indicators*

2 Field visits

To obtain clear evidence of impact due to the addition of electricity alone at health clinics, an intervention-control study would be needed in which the condition of ceteris paribus is maintained for all other elements influencing quality of care apart from energy provision. Alternatively these factors can be identified over time and their effects considered during the analysis so that the results of energy provision over health (and health care) can be isolated. This would need to collect data before and after the energy systems were installed at the health facility and at the community level and ideally the health facilities should cover one geographically delimited area or district so there is little contamination of effects due to other factors (new staff, better roads etc.) . At a community level it would then be possible to assess the difference in outcomes of services as a measurement of health impact. We are referring to services which will be made possible or improve due to the supply of constant energy and whose uptake decrease the likelihood of dying such as immunization, deliveries in health facilities or the attention to complicated deliveries including C-sections or blood transfusions or life saving surgery. Such a study is not possible within the timeframe of this project.

Within the timeframe available there are two possible methodologies for collecting further information. One is to survey electrified and non-electrified (or control) health facilities of similar sizes and similar catchment areas in each country. The key limitation to this approach is that it is difficult to find these similar conditions. Differences between health facilities may be due to a variety of reasons, some easier to identify than others. For example LSTM have recently finalized a baseline study for a case-control study on health financing modalities in Northern Uganda and finding comparable centres took over three months; after the completion of a health facility assessment, the quality of care made them more different than initially thought.

Another possibility is to visit clinics with (recent) electricity and assess new services and if possible some basic service uptake indicators before and after. The limitations to this approach are:

1. Reliance on the routine report and record keeping of the health facility which may prove unreliable/
2. There may have been other factors introduced after the supply of energy which may have influenced the uptake of services: new lab equipment; more medication; more staff; provision of supplies; better transportation to the centre etc. All these factors will introduce bias into the study which will be impossible to control for during the analysis
3. Perception of care by the consumers and community will have to be taken at face value and without a reference value before and after, in absence of community scorecard or similar performance measurement which should have been introduced long before the provision of energy.

Such a study, will provide evidence that is likely anecdotal and it is unlikely that a study in these circumstances will find hard core evidence of changes of health services which can be transformed into changes of health status due to energy provision. . As seen in the USAID report the researchers decided not to do a case-control study because of the problems of ceteris paribus and the fact that in most cases the energy supply was only another factor, but not a determinant for good services. In addition the fact that health care staff cope with alternative sources of energy means that at the limit, life saving services may be provided even in challenging circumstances.

Ideally, impact due to energy should be measured if this is an enabler for provision or a life saving service which could not be provided before the energy is provided, or be able to show an increase in the uptake of these services (for instance C-sections or blood transfusions). Although outside main towns workaround solutions may be used such as blood transfusions occurring from person to person and C-sections can be done with a torch if really necessary. However it is clear that the provision of energy enables better care and in case of tertiary care is essential to provide the required care during surgical procedures or in intensive care units. Therefore the issue with energy is that it is absolutely needed for secondary and mainly tertiary care but this care is usually the domain of hospitals and medical centres which have access to grid or generators even in less developed countries.

Even though confounding factors outlined above may render the results as anecdotal it may provide interesting information because a field study will focus *only* on the differences in health services uptake due to electricity. The literature review showed that no previous study has published on this area.

In summary, the field study may provide a more structured basis to carry out electricity-related health impact valuations but its potential value for money should be assessed in the expectation that it is unlikely to tell us any information that is not already known.

If DFID are interested in the results of a field study then possible terms of reference are outlined below.

Possible Terms of Reference for Field Work

1. In consultation with Health Ministries and development organisations identify x health care units in which:

- the only change has been that they have been provided with energy.
- there are all similar health care centres and cover for a geographical districts where (in principle) there have not been other service provision changes.
- The health facilities may be located in two or three countries although this is not entirely necessary.
- there is a routine information system in place which allows investigators to collect the monthly uptake of services before and after for a number of months (perhaps 6 and better 12 to avoid seasonal influences so that trends of service uptake can be identified .

2. Develop a questionnaire which covers the following questions relating to the clinic, its patients and health care provision before and after the energy intervention:

- general facility information: , operating hours, staffing, equipment (lighting, internet, cold chain, suction apparatus, incubators, oxygen concentrators, ultrasound), details about services/appliances in staff accommodation
- availability of services/procedures: obstetric care, , emergency, vaccinations, blood transfusions, lab services
- patient and utilization rates: utilization rates (all, under 5s), ANC visits, deliveries, C-sections, blood transfusions, surgical procedures, immunization numbers
- cost data: if possible relating to any new equipment/services
- open-ended qualitative data: acceptability by service users , security issues, reliability of power, job satisfaction, efficiency in time allocation, perception of power reliability

3. Data to be collected from information systems and via interviews with medical directors and clinical staff.

4. Assessment of quantitative and qualitative data. If there have been other changes in addition to the provision of energy this should be highlighted from the questionnaire responses and may allow some additional analysis on the cost benefit to additional equipment/training being added at the same time as electricity.

Annex A – Search terms used for database searches

Limits:
Dates: 1996 - current
Fields: Title and Abstract
Publication Types: ALL

	Search Terms	Results
Group 1	electricity	
	electrification	
	electrical	
	electrified	
	electrify	
	renewable energy	
	access adj3 energy	
	modern energy	
	improved energy	
	energy provision*	
	hydro power	
	energy suppl*	
	hydro-electric	
	hydro-power	
	solar energy	
	solar panel	
	power generation	
	rural power	
	rural energy	
	energy program	
	energy adj2 project	
	energy service*	
	wind power or	
	wind energy	
	wind turbine	
	wind generat*	
	diesel power	
	energy system	
	solar water heater	
	swh	
	grid?	
	telemedicine	
	cold chain	
	refrigeration	
	refrigerator	
	ICT*	
	information and communication* technolog*	
	eHealth	
	e-health	
	labratory	
	heat*	
	light	
	Illuminat*	
	freez*	
	cool	

	Group 1 Total	
AND		
Group 2	developing countr*	
	low* income countr*	
	middle income countr*	
	less* developed countr*	
	least developed countr*	
	low* and middle income countr*	
	developing nation*	
	low* income nation*	
	middle income nation*	
	less* developed nation*	
	least developed nation*	
	countr* less-developed	
	under developed nation*	
	under developed countr*	
	underdeveloped countr*	
	underdeveloped nation*	
	third world countr*	
	countr* developing	
	third world nation*	
	countr* under developed	
	developing region	
	developing econom*	
	poor count*	
	LDC*	
	LMIC*	
	Uganda	
	Rwanda	
	Mozambique	
	Cuba	
	Ghana	
	Group 2 Total	
AND		
Group 3	health facilit*	
	health centre*	
	health center*	
	medical centre*	
	medical center*	
	hospital*	
	emergency service*	
	emergency medical services*	
	health post*	
	clinic*	
	dispensar*	

	health service*	
	family practi?e	
	healthcare	
	health care	
	emoc	
	emergency care	
	public health	
	primary care	
	phc*	
	primary health	
	health sector	
	surgical care	
	surgical and anesthesia care	
	medical care	
	health system*	
	Group 3 Total	
OR		
Group 4	c section*	
	cesarean section*	
	caesarean section*	
	surgical procedure*	
	surgery	
	immuni?ation*	
	vaccination*	
	vaccine*	
	transfusion*	
	obstetric deliver*	
	emergency service*	
	staff retention	
	staff recruitment	
	utili?ation rate*	
	mortality rate*	
	DALY	
	under 5 mortality	
	infant mortality	
	child mortality	
	maternal mortality	
	((opening hour*) OR (24-h) OR (24 hour*) OR (24 hr)) adj5 ((service*))	
	Group 4 Total	
AND		
Group 5	outcome*	
	impact*	
	improv*	
	benefit*	
	influence*	
	increase*	
	better	
	greater	

	higher	
	availability	
	affect	
	effect*	
	enhance*	
	advanced	
	develop*	
	progess*	
	gain*	
	help*	
	quality	
	success*	
	result*	
	useful	
	use?	
	uptake	
	scale up	
	scaling up	
	Group 5 Total	

Annex B - Final Web Search Results

The following document details the results of the searches on some of the individual websites. The search terms used are available on request.

01 WHO
http://www.who.int/en/

The search was conducted using the WHO Advanced Search function.

Limits
Language: English
Occurrences: anywhere in the page

	Results
Search 1	1200
Search 2	2300
Search 3	259
Search 4	315
Search 5	67

02 World Bank
http://documents.worldbank.org/curated/en/docadvancesearch

This search was conducted using the World Bank Advanced Search function. Search terms were: electricity electrification electrical energy medical health hospital clinic vaccination vaccine surgical surgery immunisation immunization transfusion c-section caesarean cesarean

Limits
Region: Africa, East Asia and Pacific, The World Region
Topic: Energy
Language: English
Document Type: Publication and Research
Document Date: 01/01/1996 to 20/12/2012
Type of Search: Keyword

	Results
Search 1	1049

Limits
Region: Africa, East Asia and Pacific, The World Region
Topic: Energy
Language: English
Document Type: Publication and Research
Document Date: 01/01/1996 to 20/12/2012
Type of Search: Title

	Results
Search 1	234

03 ESMAP
http://www.esmap.org/search/

The search was conducted through Google Advance Search linking to esmap.org

Limits
Language: English
Document Date: 01/01/1996 to 20/12/2012
Occurrences: anywhere in the page

	Results

Search 1	170
Search 2	57
Search 3	91
Search 4	121
Search 5	16

04 Usaid

http://gsearch.info.usaid.gov/

This search was conducted using the USAID Advanced Search function.

Limits
Language: English
Occurrences: anywhere in the page

	Results
Search 1	2180
Search 2	1000
Search 3	639
Search 4	1230
Search 5	120

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