Energizing health: accelerating electricity access in health-care facilities

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Access to electricity is fundamental to the provision of health services – from lights to illuminate a midwife's work guiding childbirth, to enabling nurses and clinicians to correctly diagnose and respond to emergency conditions.

Yet this critical aspect of essential health care has remained almost invisible in the decades-long push to improve health service delivery and health outcomes. Among the dozens of global and national indicators used to track and monitor the performance of health services, access to electricity has been most glaringly absent from the list, at least until very recently.

This landmark report aims to change that, and give access to energy – particularly electricity – its rightful place in health services and systems planning, implementation and evaluation. Co-led by the World Health Organization, the World Bank, the International Renewable Energy Agency, and Sustainable Energy for All, this report represents the first official interagency mapping of electricity access in low- and middle-income countries worldwide – with reference to the sparse available data.

Those data reflect huge gaps in electricity access in the world's poorest countries. In South Asia and Sub-Saharan African countries reporting on electricity, 12%-15% of facilities respectively lack any access whatsoever. Only a little more than half of hospitals in sub-Saharan countries with data report that they have reliable electricity access.

Altogether, at least one billion people globally are served by health facilities that lack reliable access to electricity. It is simply unacceptable that tens of thousands of clinics in rural areas of Asia, Africa and Latin America are equipped with little more than kerosene lanterns and rapid diagnostic tests.

This report provides a much-needed baseline for electricity access and provides insights and recommendations on how to accelerate health facility electrification while supporting the transition to clean, sustainable energy systems that improve health and climate outcomes. To that end, this report provides guidance and tools to assess energy needs and options, including renewables; financing alternatives; policy requirements; overcoming barriers; and case studies.
But we need to do much more to put this issue on the map, first by monitoring energy access in health facilities more systematically; second, by dramatically increasing investments in electrifying health care facilities; third, by providing the necessary resources to design and implement clean energy plans, tailored to the needs of the health sector; and fourth, by developing policy and finance schemes to unlock the potential of sustainable energy solutions, and to address the health sector needs.

From national health ministries to field practitioners, providing reliable, affordable and clean electricity access to all health-care facilities must be considered a development priority.

In remote field locations, the image of health care providers bent over a patient’s bedside, hand-holding his or her pulse under a fading kerosene lamp – needs to be relegated once and for all to the annals of history.

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Reliable electricity in health-care facilities is essential to save lives.

Electricity is critical to effective health-care provision, from managing childbirth and emergencies to immunization – without reliable electricity in all health-care facilities, universal health coverage cannot be reached.

Yet this aspect of health infrastructure is still neglected, and urgently needs more attention by all, from governments to donors and development partners, from philanthropic institutions to international organizations.

This collaborative report, based on thorough analysis, is intended to catalyse action to accelerate electricity access in health-care facilities, and highlight some key priority actions and figures, including the following.
It is estimated that close to 1 billion people in low- and lower-middle-income countries are served by health-care facilities without reliable electricity access or with no electricity access at all.

- The assessment is based on representative findings from 27 low-income and lower-middle-income countries that have national survey data on electrification status of health-care facilities, for any year between 2015 and 2022.
- There is a sharp urban–rural divide: urban health-care facilities often report more access to any electricity and more reliable electricity access than rural facilities in the same country.

In low- and lower-middle-income countries of South Asia and sub-Saharan Africa, approximately 12% and 15% of health-care facilities, respectively, have no access to electricity whatsoever.

- At least 25,000 health-care facilities in sub-Saharan Africa have no electricity access, and 68,350 health-care facilities only have access to unreliable electricity.
- Only half of hospitals in sub-Saharan Africa have access to reliable electricity.

Reliable energy provision – particularly electricity – is a major enabler of universal health coverage. Conversely, lack of electricity and an unreliable supply of electricity are major barriers to attainment of universal health coverage.

- Electricity is needed to power the most basic services – from lighting and communications to clean water supply. Reliable power is also crucial for the medical equipment necessary to safely manage childbirth or to ensure immunization as well as for undertaking most of the routine and emergency procedures.
- Access to reliable electricity can make the difference between life and death.

Electrification of health-care facilities must be considered a development priority. Support, financing and investments must be scaled up accordingly.

Health is a human right and a public good. Increased support, financing and investments from governments, philanthropic institutions, and financing and development organizations are necessary to accelerate health-care facility electrification.

- The included World Bank analysis shows that almost two thirds (64%) of health-care facilities in 63 low- and middle-income countries require some form of urgent intervention, in the form of either a new connection or a backup power system to improve faulty energy infrastructures that impede effective health-care delivery.
- The analysis estimates approximately US$ 4.9 billion is urgently needed to bring health-care facilities in the assessed 63 low- and middle-income countries up to a minimal or intermediate level of electrification to ensure that all the essential health services are covered.
- This required amount is much lower than the social cost of inaction.

Delaying electrification means denying access to life saving health services. There is no time - and no need - to “wait for the grid.”

- Today, a myriad of energy solutions exists to electrify health-care facilities that were not available, or were more expensive, a few years ago. For example, decentralized sustainable energy solutions based on solar photovoltaics (PVs) are not only cost-effective and clean but rapidly deployable on site, without the need to wait for the arrival of the central grid.
- We have no excuse for delaying. Solutions are available and rapidly deployable. The impact on saving lives and improving health of vulnerable populations would be huge.
Powering health-care facilities through decentralized renewable energy is a concrete action to build climate resilience.

- Health-care systems and facilities are increasingly affected by the accelerating impacts of climate change. Building climate-resilient health-care systems means building facilities and services that can meet the challenges of a changing climate, such as extreme weather events, while improving environmental sustainability.
- This includes leveraging the opportunities provided by decentralized renewable energy generation – which make health-care facilities independent from the diesel supply needed for generators – and by energy efficiency, from infrastructure to medical devices.

The “install and forget” approach to electrification needs to be transformed into “install and maintain.”

- Long-term operation and maintenance of energy systems must be ensured, along with replacement of batteries and spare parts.
- The necessary funding for long-term operation and maintenance of a facility’s energy systems, including costs of battery replacement and waste management, should be an integral part of budget planning for health-care facility electrification, and dedicated funds should be allocated accordingly.
- Funding procedures and disbursement time frames of governments and development partners should be adapted to cover these long-term maintenance costs.
- Functionality of installed energy systems in the medium and long term should be monitored (including through remote monitoring), and accountability mechanisms should be put in place.

Building the capacity of local stakeholders is key to the long-term functionality of energy systems.

- Programmes should be designed to support the development of local skills and markets.
- Strengthening the technical knowledge and capacities of health sector staff at different levels increases the ability of the health sector to identify energy needs, select the best electrification options, design and implement programmes, and properly use the energy systems most appropriate for the local context and needs.
- Strengthening the capacity of local energy technicians (including in rural areas) is critical to ensuring sustainability, and providing timely operation and maintenance to guarantee continued service delivery. It also creates flow-on benefits for local communities and economies.

Precise and holistic health–energy needs assessments are critical for effective electrification plans.

- Comprehensive health–energy needs assessments provide a robust evaluation of the energy requirements needed to deliver quality health services. These assessments aim to provide understanding of energy needs in relation to the health services provided, the availability of trained staff and the medical equipment used at a facility type (with the identification of critical and non-critical loads).
- Online tools and geospatial data can be helpful in a pre-screening phase, but a detailed on-site health–energy audit developed in partnership with local health stakeholders is still essential for the correct design and implementation of any health-care facility electrification programme.
Electricity access initiatives need to be complemented by investments in medical devices and equipment.

- Electricity supply is only one part of the equation and can only have an impact if coordinated with other key elements, such as the provision of medical devices and training of staff.
- Health-care facility electrification programmes should coordinate with efforts focused on the provision of medical devices and appliances. This is necessary to avoid situations in which a health-care facility becomes electrified but does not have devices and appliances to use the electricity. The converse situation must also be avoided: where an unelectrified or barely electrified facility is provided with energy-intensive medical devices whose operation would be incompatible with, or would exhaust, all the available energy supply.
- In addition to the support tailored to electrification programmes, facilities may need further support to acquire new equipment and appliances. Relevant stakeholders and development partners should coordinate accordingly.
- Energy efficiency should be encouraged from infrastructure design to equipment selection. Energy efficient medical devices and appliances significantly reduce the energy demand, and therefore the size (and cost) of the decentralized energy systems to be installed.
- Medical devices and appliances need to be suitable to the specific contexts in which they will be installed. In harsh conditions, devices need to be not only energy-efficient but also resilient to factors such as high temperatures and dusty environments.
Improved coordination is needed between relevant stakeholders at the global and local levels.

- Addressing the energy needs of health-care facilities requires better cooperation between the energy and health sectors. This should involve ministries of health and energy and other relevant stakeholders, and should happen at all levels, from strategy and planning to policies, budgeting, procurement and implementation.
- Strong collaboration between public, private and nongovernmental institutions needs to be facilitated, to leverage synergies and unlock resources.
- Donors and development partners need to increase dialogue and collaboration at country level, to maximize impact and avoid duplication of efforts.

Data collection, analysis, accessibility and sharing need to be improved.

- Data on simple, but critical, energy access indicators should be collected routinely at the national level, building on national health information systems already in place. This would dramatically help with tracking of progress and gaps.
- Countries, and bilateral and multilateral institutions should ensure that energy access questions are incorporated in health-care facility surveys, systematically and in a harmonized way.
- Development partners and other actors that collect such data need to make the data more readily and transparently available to researchers, policy-makers and other development partners, as well as the public, to avoid inefficiencies and duplication of efforts.

Political commitment, awareness and advocacy are critical to generating local action.

- Increasing awareness and advocacy for the political prioritization of health-care facility electrification will help to ensure that it is a priority in both national and subnational plans – establishing a clear mandate across a country or a region.
- Dialogue and engagement with all relevant stakeholders, from the energy and health sectors and beyond, is crucial from the national to the local level.
Access to affordable, reliable, sustainable and modern energy, particularly electricity, is a critical but under-recognized enabler of health services. Without access to reliable electricity in all health-care facilities, the aspiration for universal health coverage under the United Nations Sustainable Development Goal 3 simply cannot be achieved.

This report provides a comprehensive update on the status of electricity access, and proposes a way forward and guidance for:

- assessment of the energy requirements of health-care facilities;
- technical and economic considerations for electrification approaches tailored to health-care facilities;
- assessment of investments required to provide reliable electricity access to all health-care facilities;
- enabling frameworks to accelerate electrification; and
- priority actions, taking into account lessons learned and analysis of country-level case studies.

The report concludes by identifying suggested way forward and key actions for governments, development partners and other stakeholders, articulated in terms of data, system planning and programme implementation.

**Electricity access as an enabler of health services and better health outcomes**

Electricity is required for operation and use of a wide variety of vital medical equipment and appliances. Electricity plays a crucial role in availability and reliability of essential health services, as well as better health outcomes, including safe childbirth and newborn care, prenatal and antenatal care, childhood vaccinations, diagnostic capacity, and emergency response.

When health-care facilities have sufficient and reliable electricity, women can more safely give birth at night and during emergencies, medical equipment can be powered and better sterilized, and clinics can safely store life-saving vaccines and medicines for newborns, children and adults. Electricity is also important for supply of clean and hot water, communication, lighting and other basic amenities. Access to reliable electricity in health-care facilities can make the difference between life and death.

**Role of sustainable energy in the health–energy nexus**

Health-care facilities that serve the poorest and most underserved populations have the highest levels of energy poverty. Providing reliable, affordable and sustainable energy to these facilities is essential to protect the most vulnerable populations.

As well as ensuring that people are provided with health services, access to sustainable energy by all health-care facilities, including those in rural and remote areas, contributes to achieving multiple social, economic and environmental benefits, such as increased sense of security of staff and patients, and easier health worker recruitment and retention. Decentralized sustainable energy
systems save costs of fuel for generators, as well as costs of often expensive grid-supplied electricity. They reduce the harmful pollution from on-site diesel generation in health-care facilities, leading to wider community health benefits. Reliable electricity also reduces the damage to medical devices caused by low-quality electricity supply.

**Fig. 1. Sustainable energy and health nexus**

- **ECONOMIC, SOCIAL AND ENVIRONMENTAL BENEFITS**
  - SDG3, SDG7, SDG13
  - Reduced operational expenses
  - Reduced long-term costs for country
  - Increased climate resilience
  - Avoided CO₂ and polluting emissions

- **GENDER CONSIDERATIONS**
  - Enhanced safety and hygiene
  - Increased confidence in access to health care
  - Reduced risk for women accessing maternal care

- **HEALTH WORKERS RETENTION**
  - Enhanced safety and hygiene
  - Greater comfort in providing health care
  - Improved accommodation and well-being (in staff quarters adjacent to the facility)
  - Functional systems -> increased motivation and better morale among health-care workers

- **TYPES OF SERVICES**
  - Immunization and cold chain facilities
  - Maternal care and safer deliveries
  - Neonatal care
  - Laboratory and diagnostics
  - Digitization and better administration etc

- **SERVICE DELIVERY**
  - Prolonged hours of operation
  - Reduced “out of pocket” expenses for patients
  - Wider range of services
  - Better utilization of medical devices
  - Telemedicine and remote care

- **REDUCED OPERATIONAL EXPENSES**
  - Independence from fuel supply for generators
  - Reduced downtime on energy systems in disaster contexts (flood/cyclones) – ability to repair and maintain locally
  - Increased use of active and passive cooling to reduce health complications due to heat stress

- **AVOIDED CO₂ AND POLLUTING EMISSIONS**
  - Offset the use of fossil fuel based generators
  - Reduced energy consumption and increased energy efficiency
  - Avoided need for future fossil fuels as health services grow

- **INCREASED CLIMATE RESILIENCE**
  - Reduced electricity bills (efficiency + renewable energy sources)
  - Avoided costs of diesel fuel and generator
  - Reduced damage to equipment due to voltage fluctuations

- **REDUCED LONG-TERM COSTS FOR COUNTRY**
  - Avoided diesel use bringing reduction to the health/energy system costs as a whole in the long run
  - Improved health outcomes and well-being of population

- **JOB CREATION AND LOCAL ENTREPRENEURSHIP**
  - Involvement of local individuals, technicians and enterprises in design, installation, operation and maintenance
  - Opportunity to strengthen local manufacturing and entrepreneurship on energy-health nexus needs
Decentralized electrification to expand access and increase climate resilience

In many rural and remote areas of the world, grid extensions are both costly and technically difficult. Today, with falling costs of renewable energy technologies, myriad solutions exist that were not available, or were more expensive, a decade ago. For example, decentralized renewable energy systems based on solar PV panels and batteries are often the most cost-effective and readily deployable solution for electrification of health-care facilities not reached by the central grid.

Decentralized renewable energy systems can also play a key role in providing backup or supplementary electricity in grid-connected health-care facilities where the electricity supply is unreliable or too expensive.

Energy systems based on decentralized and sustainable energy sources, being independent from the diesel supply chain, increase the climate resilience of health-care facilities, and make them less vulnerable to the impacts of climate change, including extreme weather events. Furthermore, they reduce air pollution and deliver climate mitigation benefits, creating a pathway to a low-carbon future. Sustainability and climate change impacts should therefore be central to efforts to close the energy gaps in health-care facilities across the world.

Convergence between health and energy sectors

Health and energy actors have often worked in silos. Increased collaboration is needed to leverage synergies and maximize impact. A more integrated approach, and a comprehensive process to assess, design, implement and manage energy solutions for health care is necessary. This requires both health and energy stakeholders to contribute to a more nuanced understanding of the needs, working more closely together to bridge knowledge and skill gaps, and to identify and implement joint solutions. Increased cooperation is needed at all governance levels, from national ministries to local stakeholders, and in all phases, from strategy and planning to policies, budgeting, procurement and implementation.

Status of electricity access in health-care facilities

Overview

This report undertakes a systematic stocktake of available national survey data on electricity access in health-care facilities to produce comparable cross-country and cross-regional estimates of electricity access and reliability at health-care facilities in underserved areas around the world.

The data were extracted from available national health-care facility surveys, including by the World Health Organization (WHO) (Service Availability and Readiness Assessment – SARA), the World Bank (Service Delivery Indicators – SDI) and the United States Agency for International Development (Service Provision Assessment – SPA). Available data were collected for low-income and lower-middle-income countries worldwide (based on the World Bank income group classification in 2022).

As a key outcome of this report, WHO established a database on electricity access in health-care facilities on its Global Health Observatory. The data and methods described here can inform and guide countries in similar assessments, as a first step towards understanding and addressing electricity gaps.
Indicators
The indicators used were access to any form of electricity; reliable access to electricity; and primary source, operationality and uses of electricity. Data were mapped and analysed with reference to a standard set of indicators for electricity access in health-care facilities disaggregated by health-care facility type (hospitals versus non-hospital facilities) and geographic location (urban versus rural), when available.

In the case of the first two indicators, national survey data on access to any form of electricity and reliability were used to benchmark electricity access at national and regional levels, based on 27 countries with available data. For other indicators, there were insufficient data to draw regional conclusions. A closer look based on selected country examples is provided for indicative insights.

Key figures
The proportion of health-care facilities lacking any access or reliable access to electricity was determined as follows.

- **Access to any electricity**: 12% of health-care facilities in the low- and lower-middle-income countries of South Asia, and 15% of facilities in the low- and lower-middle-income countries of sub-Saharan Africa lacked any access to electricity whatsoever. Health-care facilities in the Latin American and the Caribbean region fared somewhat better, reporting 8% of facilities with no electricity access.

- **Access to reliable electricity supply**: In the low- and lower-middle-income countries of the sub-Saharan Africa region, only 40% of facilities had reliable electricity, and in the Latin America and the Caribbean region, an average of 72% of facilities had reliable electricity. In other regions, data were insufficient to make average estimations.

![Fig. 2. Percentage of health-care facilities reporting no access to any electricity in national surveys, 2015–2022](map.png)
Among the estimated 166,720 health-care facilities situated across the 41 low- and lower-middle-income countries of sub-Saharan Africa, this report estimates that at least 25,000 health-care facilities lack any electricity access, and at least 68,350 health-care facilities lack reliable electricity, illustrating the high level of energy insecurity in health-care facilities of this region.

Similar inequities are evident when looking at access by countries’ income levels, facility type and geography. Rates of reliable electricity access are lower in health-care facilities of low-income countries than in lower-middle-income countries. Non-hospital health-care facilities, such as primary health centres, tend to fare worse than hospitals in access to any electricity supply or reliable electricity supply. Additionally, there is an urban–rural divide. Urban health-care facilities often report greater access to any electricity and reliable electricity than rural facilities in the same country.

A more global snapshot of the population served by health-care facilities lacking electricity access

Weighted by 2022 population figures, across the Latin America and the Caribbean, Middle East and North Africa, South Asia, and sub-Saharan Africa regions where data on energy access in health-care facilities are available and sufficient, the population in these regions served by hospitals and clinics lacking adequate energy services was estimated as follows.

- 433 million people rely on facilities without any electricity.
- 478 million people are served by facilities lacking a reliable supply of electricity.

At least 912 million people across these four regions are served by facilities with no electricity access or with unreliable supply of electricity (Fig. 4).

This is approximately the size of the entire populations of the United States of America, Indonesia, Pakistan and Germany combined. Globally, the lack of any electricity and of reliable electricity in health-care facilities is likely to be even greater, considering that the estimates presented here focus on countries representing only three quarters of the population living in low- and lower-middle-income countries.
A closer look at energy access

Data on the availability of any access and reliable access to electricity provide a basic snapshot of the energy access situation in a country’s health-care settings. However, this fails to give policymakers much insight into the primary source of electricity, the operationality of the systems, the uses of the electricity supply, and other key indicators useful for policy and programmatic decision-making.

In subsets of countries, more detailed information on such indicators was available (e.g. primary source of electricity, adequacy of supply). A closer look at these indicators provides more nuanced insights into what works and what does not in terms of health-care facility electrification for quality health service delivery. For example, the data show that generators are often not operational, and that facilities are often underserved, with energy supply being insufficient to cover all the needs of the facility.

*Improving data collection, processing and accessibility is a key challenge to overcoming gaps.*

Although a basic set of health service indicators are routinely reported at national and global levels, energy (and electricity) access is a notable exception. Data on access are not routinely collected at a national level. Even the widely used questionnaires such as the SPA, SARA and SDI surveys differ in how (and whether) they collect certain electrification data.

There is an urgent need to standardize data collection using harmonized indicators and methodologies that reflect current trends and needs, and provide georeferenced data where feasible. It is also essential to increase resources and support for collecting and analysing data to properly assess the situation and track progress.

*Public access to data and metadata on health-care facility electrification should be ensured.*

There are critical challenges in accessing health-care facility data sources, including a lack of clear mechanisms for making data requests and an often complex bureaucracy associated with soliciting microdata – and even summary reports – from responsible agencies.
Future efforts to gather data to facilitate planning and prioritization would benefit from the establishment of publicly accessible online platforms, including by multilateral institutions collecting electrification data, allowing survey data to be obtained by researchers upon request. The entities that hold health-care facility data may not always have the resources to compile an entire programme website to make data publicly accessible. Solutions such as the WHO Global Health Observatory or the World Bank Microdata Catalog can help by providing a centralized infrastructure for housing and providing public access to data.

A more holistic approach to health-care facility infrastructure services is needed. The paucity of energy and WASH (water, sanitation and hygiene) services in health-care facilities of low- and lower-middle-income countries highlights the need to prioritize basic infrastructure on the pathway to universal health coverage. Furthermore, programmatic synergies and efficiencies will occur with a more holistic approach to building a coordinated tracking framework and monitoring progress in health-care facility infrastructure for water, sanitation and energy together.

A coordinated effort is needed to advance a framework to measure uniformly and fully the diverse dimensions of energy access in health-care facilities. Key institutions managing facility surveys, as well as ministries of health, ministries of energy and related actors, need to work together to identify and harmonize the most suitable electricity access indicators, survey questions and methodologies relevant to delivery of health services and health outcomes. Such a framework could contribute to the development of more comprehensive, routine, global energy assessments of health-care facilities by national ministries, as well as by multilateral organizations and other development partners in the health and energy sectors, to support joint monitoring and reporting of energy access in health-care facilities.

Chapter 3 provides insights on how facility administrators, planners and other stakeholders can estimate the electricity and overall energy requirements of health-care facilities. The chapter also examines energy load considerations, and provides guidance for conducting a health–energy needs assessments as well as references to key technical standards and tools.

Determinants of energy requirements
Energy needs span a wide range, including medical equipment, lighting, information technology and communications, refrigerators for vaccines and preservation of medicines, supply of clean and hot water, ventilation, cooking, sterilization and, depending on the setting, space heating and cooling. For maternal and newborn care, for example, a suite of life-saving, essential devices require electricity, including fetal heart monitors and ultrasounds, baby warmers, oxygen concentrators, suction units and phototherapy. From emergencies to internal medicine, almost every area of care has unique energy requirements. Other factors include the following.

- **Facility type and population served.** Needs vary widely by the type or tier of health facility (e.g. health post, clinic, hospital); demands are much higher for higher-tier facilities. Within the same tier, the energy requirements of a facility can be influenced by multiple factors, such as the sociodemographic profile (in terms of the population it caters for) and the diseases prevailing in the served community.
• **Load variability and operational hours.** In many clinics, the electricity load may vary widely depending on the time of day and the season, and the combination of demands that might be imposed at any one time (e.g. during a childbirth emergency). Other important aspects include the load characterization (critical/priority devices and non-critical ones), the time of use of high-power demand appliances (with opportunities for load shifting/shaving), and assessment of potential future load growth.

**Conducting a health–energy needs assessment**

Health-care facilities, even within the same tier of a public health system, vary in the type and amount of daily health services they deliver. This variation could be a function of the demand in the region, accessibility, affordability, and availability of doctors and other staff, among other factors. As a result, a “one size fits all” approach to determining the energy requirements of a health-care facility and installing a standardized energy system would fail to note nuances in equipment efficiency, equipment use or special needs reflecting the health conditions in different regions.

Energy assessment for health-care facilities should integrate health and energy needs simultaneously for better design, local sense of ownership and use. This includes aspects from the health side (i.e. health services and facility profile), the nexus between health and energy (i.e. infrastructure, equipment, accessibility and environment) and the energy side (i.e. energy scenario, related impacts and systems). Benefits of an integrated health-energy assessment will accrue to patients, who will gain both increased access to health services and improved quality of services, and to facility managers and staff, who will experience improved well-being and productivity, as well as reduced equipment damage and financial savings.

Since energy is only one part of the equation, a combined health–energy needs assessment can also help identify other critical and related needs, such as the need for additional staff or for appropriate equipment. A basic energy assessment focusing only on the existing energy situation would not provide these insights, which are critical in improving health-care delivery on the ground.

A variety of tools and methodologies exist to help planners characterize the health–energy needs of a facility through bottom-up assessments. Chapter 3 describes basic features to consider, while Chapter 4 includes more details about available online tools.

**Toolkits for health–energy needs assessments** may include checklists for interviews with staff at the health-care facility; collection of data on health-care appliances, and their power consumption and usage patterns using energy meters, data loggers and registers; observations about built environment structures; and assessments to enable design of energy systems.

**Seasonal variations that affect basic services** such as lighting and space heating or cooling need to be considered, as well as seasonally variable disease burdens such as a high growth in malaria cases at the onset of the rainy season in some countries. Reliability of the energy supply can also vary daily, seasonally and from year to year – for instance, due to changes in grid power reliability, generation capacity of hydropower due to climate change, and the variability of solar or wind power.

**Geospatial data** can help planners by combining facility-level information with satellite imagery showing demographic data and existing power infrastructure, to build representative demand estimates at both facility and community levels. Geospatial tools allow data to be scaled up from current facility-level surveys to estimate ranges of requirements for unserved and underserved health-care facilities of similar type, size, location and catchment population. The estimated electricity requirements can then be inputs to least-cost electrification modelling tools to ensure...
that health-care facility needs are fully considered in estimates of optimal supply configurations and investment needs for the community as a whole. Although geospatial data and related models can provide important support, the energy needs evaluation must always include an on-the-ground health–energy assessment at the facility level.

Assessing the power requirements of medical devices
The steps involved in assessing power demand include listing all medical equipment required in the facility, the estimated hours of operation (including which hours or periods of the day the equipment would be powered, which is necessary for estimating peak load), and the critical nature of certain equipment that always needs to be powered.

Power requirements should also be assessed to identify critical and non-critical loads; critical loads require greater reliability and availability of the service. For example, fans, mobile charging points, laptops and printers are considered as non-critical and consumptive loads, whereas baby warmers, oxygen concentrators and refrigerators are considered as critical loads. Usage patterns of one should not disrupt the functioning of the other. For example, overuse of lights and fans (non-critical loads) should not drain the power required for refrigerators and baby warmers (critical loads) when required. These aspects should be considered in the electricity system design of the facility.

Key role of energy efficiency
Energy efficiency in medical devices and appliances needs to be encouraged at a wider scale and a more rapid time frame, to truly take advantage of the opportunities that different power solutions can bring to health service delivery. Studies focusing on several types of commonly used medical equipment in health-care facilities and their energy-efficient alternatives found that energy savings of nearly 55% in blood bank refrigerators, 53% in baby warmers and 75% in oxygen concentrators could be made by switching to available energy-efficient medical appliances. These energy savings directly translate to reduced energy bills from lower energy consumption, as well as a considerable reduction in the size of the decentralized energy system (e.g. solar panels, batteries, inverters) needed to power health-care facilities.

Suitability of medical devices for harsh conditions
A major challenge for health-care facilities in resource-constrained settings is a lack of appropriately sized and designed medical equipment for health service delivery. Manufacturers of medical equipment typically focus on safety and reliability, and take for granted that a consistent, reliable electricity supply is guaranteed. Very few medical devices are suitable for performance in settings with harsh conditions (e.g. hot and/or humid climate, dusty environment) or intermittent power supply. In 2010, WHO highlighted that over 50% of the medical equipment in low-income countries was not functioning, not used correctly or not maintained, with some being entirely unnecessary or inappropriate to fulfil its intended purpose. Nearly a third of failures of medical devices globally was estimated to be caused by unreliable electricity supply. Furthermore, in sub-Saharan Africa, almost 70% of equipment was found to lie idle due to mismanagement of the acquisition process, absence of user training and lack of effective technical support.

Procurement guidelines should encourage the purchase of medical equipment suitable for the specific conditions where it will be used. At the same time, innovation in medical devices is needed to support the development of devices that are suitable for use in harsh conditions and rural settings.
Chapter 4 documents key technical and economic aspects of the electrification options for health-care facilities, including grid extension, mini-grid and stand-alone on-site solutions.

The chapter builds on the insights from Chapter 3 on analysis of energy requirements, and highlights how these insights play a key role on the choice of the electrification solutions for different contexts and needs.

**Key energy supply options**
After evaluating the overall electricity demand – and the demand for uninterruptible and reliable power supplies for critical services – planners should weigh alternative least-cost technology solutions that could be used to provide power for delivering quality health services.

The right energy system configuration for a given health-care facility depends on a combination of **techno-economic factors**, including:

- site characteristics;
- size and characteristics of the electrical load;
- local availability of energy resources;
- environmental and climate factors;
- affordability and financial resources;
- public policies and incentives; and
- financing sources.

**Centralized grid extension** has served as the main electrification approach for decades. If grid electricity is available, a grid connection is typically the most logical primary source of power. However, in several low-income countries, grid extension is often slow. This is particularly the case for rural and remote regions due to the distance between the user and the existing grid, challenging local terrain for infrastructure expansion, and a low population density and size of the load to be served, including other nearby loads. Furthermore, grid power interruptions and irregularities in voltage and frequency have a dramatic impact on the health services available and can damage sensitive medical equipment, especially if the equipment is not engineered to operate in harsh environments.

**Decentralized sustainable energy solutions** are often the most technically and economically viable solution to provide reliable energy to health-care facilities that are in remote locations not connected to the central grid, or that are supplied by unreliable and expensive energy sources. In facilities that are not connected to the central grid, off-grid solutions (stand-alone systems or mini-grids) based on sustainable energy can be deployed in a timely manner. Decentralized sustainable energy solutions can also be installed in grid-connected facilities as backup options, to ensure reliability, adequacy and affordability of electricity supply.

**Mini-grids** are a form of decentralized generation and distribution that provides power to several users and buildings in one or more local communities. They use electricity produced from on-site generators using fossil fuels, renewable energy or a combination of the two. Mini-grids require significant high upfront infrastructure investment (unlike stand-alone solar systems), which is usually recovered through high rates of use and regular tariff collection over several years. Policies and regulatory frameworks (e.g. legal and licensing provisions, cost recovery, tariff regulation) play a critical role in influencing (or delaying) mini-grid implementation.
A **stand-alone solar PV based system** is a decentralized solution based on solar panels not connected to the central grid or a mini-grid. The energy generated is used to power the appliances of a facility and to charge a battery bank used for energy storage. The average price of solar PV modules declined by as much as 93% between 2010 and 2020. In the long run, stand-alone solar-based systems are more competitive than fuel-based generators, and are more resilient because they are independent from the fuel supply chain (e.g. diesel). A stand-alone solar PV system is a versatile, modular system that can be customized to meet specific electricity demand.

Although solar PV–based systems have been the most common form of decentralized renewable energy generation in rural areas, other forms of renewable energy sources have played – and will continue to play – a key role in some locations, such as small (run-of-river) hydro, wind and biomass-based systems.

**Fuel-based generators**, using diesel or other fuels, remain a widespread backup solution for many hospitals and health-care facilities across the world. They are available in a wide range of sizes, from portable to large stationary systems. Along with their reliance on fossil fuels, generators emit considerable pollution, which can be damaging to health, as well as noise. Despite a lower upfront cost, portable generators are typically more expensive in the long run than solar systems, as a result of continued fuel and maintenance costs – for which a stable supply chain of fuel and spare parts is necessary. "Hybrid” solutions – generators paired with other solutions – are often used to provide a more reliable backup burst of power.

**Batteries** form an integral part of decentralized (both stand-alone and mini-grids) energy systems, which provide continuous and reliable electricity to health-care facilities in off-grid settings. Batteries are often also used in grid-connected facilities with frequent power outages, to store electricity for use when the grid is down.

The most common battery storage technologies are lead-acid and lithium-ion batteries. Batteries require regular operation and maintenance, including cleaning and topping up with distilled water (in the case of certain types of lead-acid batteries). Disposal of batteries is a growing environmental concern; discarded lead-acid batteries pose a particular risk to the environment and health if their disposal is not properly managed. Funding needs to be secured for battery maintenance, replacement, recycling and disposal. Accordingly, local capacity must be built to operate and maintain batteries to achieve long-term operational sustainability.

**Building climate-resilient health-care infrastructure**

Climate change and the need to strengthen the health system against its impacts mean that planners should incorporate principles of resilience into health system planning. The increased frequency and intensity of extreme events (e.g. floods) associated with climate change can disrupt the existing electricity supply, leading to the need for alternative or backup electricity sources. Health-care facilities are not necessarily designed to withstand physical climate risks, which can include droughts, floods, lightning, extreme temperatures and wildfires. In addition, unpredictability of water supply and water scarcity can affect the availability of water for drinking, washing, sanitation and hygiene.

Designing solutions that are climate-resilient and sufficiently flexible to adapt to evolving risks is important for all facilities. In this context, decentralized renewable energy solutions represent a key opportunity to guarantee the energy supply. Decentralized renewable energy solutions, unlike diesel-based generators, also allow health-care facilities to avoid the risk of disruption to the fuel supply and of fuel price variability. Reliability of electricity supply is key, particularly for the operation of sensitive medical equipment in areas that are remote and vulnerable to extreme weather events or other climate-related physical risks. This also implies the need for appropriately designed medical equipment that is energy-efficient, requires low maintenance and is robust to the harsh conditions.
(e.g. dust, heat) found in many areas. Adoption of technical standards, government incentives and regulatory policies are needed to support the increase of climate resilience in the health sector.

**Design and costs of solar systems for decentralized health-care facility electrification**

A wide range of issues need to be considered in the design of a decentralized solar system for a health-care facility, including:

- sunshine hours/peak sun hours, which will vary between locations and climatic conditions;
- days of autonomy (the number of days the load can operate from the energy stored in the batteries without any charging from the sun);
- battery charge and discharge capacity;
- equipment load requirements and load profile throughout the facility’s operating hours, including load peaks that could be shifted with manual or automatic demand-side management; and
- equipment efficiency, which can significantly change the sizing of PV panels and battery capacity of a decentralized solar energy system.

The costs of procuring, installing and maintaining decentralized solar systems vary from country to country, depending on several factors. Examples of costs associated with solar energy systems in health-care facilities are shown in Table 1.

<table>
<thead>
<tr>
<th>Capital costs</th>
<th>Operating costs</th>
<th>Soft costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply of solar equipment</td>
<td>Operation and maintenance</td>
<td>Health-energy assessments</td>
</tr>
<tr>
<td>Installation costs</td>
<td>Battery replacement costs</td>
<td>Stakeholder engagement and meetings</td>
</tr>
<tr>
<td>Transport of materials to site</td>
<td>Remote monitoring</td>
<td></td>
</tr>
</tbody>
</table>

A wide range of other factors also shape the investment and running costs of the system. They include decisions made about ownership of the system (e.g. health-care facility, energy provider), and the manner in which operation and maintenance costs are integrated into the long-term plan. Long-term operation and maintenance, as well as replacement of batteries, play a key role in the sustainability of electrification programmes, and adequate funding must be considered from the design phase. Advantages and challenges of different technology, ownership and financing models are described in detail in the chapter.

**Tools for planning and system design**

Geospatial data and technology can narrow the existing data gap in electricity access in health-care facilities – for example, by allowing estimation of ranges of electricity requirements for unserved and underserved facilities. Demand estimates can be made by combining available facility-level information (e.g. facility type, health services provided, ownership of equipment, population served, number of beds) with satellite imagery and geospatial data on demographics (e.g. population density, catchment population), facility location, disease rates, weather and climate patterns, and power infrastructure (grid and off-grid). Geospatial data and tools can be useful for initial valuation, screening and planning, however, they can provide only a partial view of the situation, and need to be complemented and verified through proper on-site assessments before moving forward with design and implementation. Geospatial tools and methodologies that relate to health-care facility electrification and are open source include the Global Electrification Platform (GEP), the Energy Access Explorer (EAE), the Multi-sectoral Latent Electricity Demand Assessment (M-LED) and the Clean Energy Access Tool (CEAT).

Online tools can also be useful for an initial estimate of costs and system sizing. An example is the HOMER Powering Health Tool. This tool combines energy demand data related to specific equipment with combinations of power supply, and helps calculate the lowest cost per unit of electricity generated over a project lifetime.
Solar system design for different facility types and tiers
Each country has a different way of organizing its public health system, depending on its needs, resources and historical context. From village-level clinics to specialty hospitals, the tiers of the public health infrastructure typically include first points of care, primary care facilities, first referral units, secondary care facilities and higher-level tertiary care hospitals. The health services delivered at each of these tiers, combined with the operational hours and the size of the populations that use their services, determine the facility’s energy requirements.

Indicative loads and design for stand-alone solar PV systems for different tiers of health-care facilities are included in the chapter. For each tier, an indicative system design is mentioned for low-sunshine (3 hours per day) and high-sunshine (5 hours per day) scenarios, along with a comparison of powering traditional equipment (based on an estimated demand) versus powering efficient equipment (based on an estimated demand). These comparisons show that using efficient equipment significantly reduces the required capacity of solar panels, batteries and inverters, and therefore dramatically reduces the cost of the overall energy system.

As an example, Table 2 illustrates loads and solar PV system design for a possible primary health-care facility, which is usually the cornerstone of rural health services – a first port of call to a qualified doctor of the public sector in rural areas for the sick, and those who directly report or are referred from first points of care for curative, preventive and promotive health care.

Table 2. Examples of loads for a possible primary health-care facility

<table>
<thead>
<tr>
<th>Type of room</th>
<th>Examples of loads</th>
</tr>
</thead>
<tbody>
<tr>
<td>OFFICE</td>
<td>Lights, fans, laptop, printer</td>
</tr>
<tr>
<td>REGISTRATION</td>
<td>Lights, fans, laptop, printer</td>
</tr>
<tr>
<td>LABOUR ROOM</td>
<td>Lights, fans, radiant warmer, suction machine, spotlight, phototherapy</td>
</tr>
<tr>
<td>MEN’S AND WOMEN’S WARDS</td>
<td>Lights, fans</td>
</tr>
<tr>
<td>NURSES ROOM</td>
<td>Lights, fans</td>
</tr>
<tr>
<td>LABORATORY</td>
<td>Lights, fans, microscope, centrifuge</td>
</tr>
<tr>
<td>MINOR OPERATING THEATRE</td>
<td>Lights, fans, nebulizer, needle cutter</td>
</tr>
<tr>
<td>OUTPATIENT DEPARTMENT</td>
<td>Lights, fans</td>
</tr>
<tr>
<td>COLD CHAIN ROOM AND PHARMACY</td>
<td>Lights, fans</td>
</tr>
<tr>
<td>IMMUNIZATION ROOM</td>
<td>Lights, fans</td>
</tr>
<tr>
<td>DRESSING ROOM</td>
<td>Lights, fans</td>
</tr>
<tr>
<td>COLD CHAIN EQUIPMENT IN COLD CHAIN ROOM, PHARMACY, IMMUNIZATION ROOMS</td>
<td>Cold chain room and pharmacy – ice-lined refrigerator, deep freezer Immunization – refrigerator</td>
</tr>
<tr>
<td>EMERGENCY ROOM</td>
<td>Lights, fans, mobile light, oxygen concentrator, ECG machine</td>
</tr>
<tr>
<td>STOREROOM</td>
<td>Lights</td>
</tr>
<tr>
<td>WAITING AREA</td>
<td>Lights, fans</td>
</tr>
<tr>
<td>WASHROOM/BATHROOM/TOILET</td>
<td>Lights</td>
</tr>
<tr>
<td>ENTRANCE</td>
<td>Lights</td>
</tr>
<tr>
<td>CORRIDOR</td>
<td>Lights</td>
</tr>
</tbody>
</table>

Table 3. Example of solar PV–based system design for a possible primary health-care facility

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Powering traditional equipment</th>
<th>Powering efficient equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum load that can be connected</td>
<td>7 870 W</td>
<td>4 620 W</td>
</tr>
<tr>
<td>Maximum units that can be used per day</td>
<td>18.4 kWh</td>
<td>10 kWh</td>
</tr>
<tr>
<td>Peak sun hours per day</td>
<td>Low-sunshine hours</td>
<td>High-sunshine hours</td>
</tr>
<tr>
<td></td>
<td>10.11 kW</td>
<td>6.6 kW</td>
</tr>
<tr>
<td></td>
<td>High-sunshine hours</td>
<td>Low-sunshine hours</td>
</tr>
<tr>
<td></td>
<td>6 kW</td>
<td>3.6 kW</td>
</tr>
<tr>
<td>Solar system capacity required</td>
<td>10.11 kW</td>
<td>6.6 kW</td>
</tr>
<tr>
<td>Battery capacity</td>
<td>6 100 Ah 12V</td>
<td>3 300 Ah 12V</td>
</tr>
<tr>
<td>Inverter capacity equivalent to</td>
<td>20 kVA</td>
<td>12.5 kVA</td>
</tr>
<tr>
<td></td>
<td>7.5 kVA</td>
<td>7.5 kVA</td>
</tr>
</tbody>
</table>
Chapter 5 presents World Bank estimates of the investment required to improve the electrification status of health-care facilities in 63 low- and middle-income countries. The countries included in this analysis were selected based on data availability, and compatibility between the stocktaking exercise presented in Chapter 2 and an analysis undertaken by the World Bank as part of the Global Electrification Platform (GEP) initiative.

While Chapter 2 assessed the current national electricity access situation of health-care facilities based on recent (2015–2022) national survey data from 27 low- and lower-middle-income countries, Chapter 5 estimates the total monetary cost required to improve the electrification status via new connections and/or backup systems for 63 low- and middle-income countries.

This investment analysis is not exhaustive, but rather provides high-level estimates based on a series of assumptions that may differ between countries and between health-care facilities.

Summary of methods
To assess the level of investment required to improve the electrification status of health-care facilities in each country, data were gathered for both hospital and non-hospital facilities from an array of resources, mainly the World Bank GEP database, on four key parameters: total number of health-care facilities, health-care facility electricity access rate, proportion of facilities experiencing frequent interruptions, and proportion of grid versus off-grid electrified facilities.

The GEP database contains information related to the least-cost electrification option for millions of unserved settlements in the developing world. Based on these parameters, the required level of intervention per country was estimated. Two levels of intervention were defined:

- new connection – installation of a new electricity connection for health-care facilities that do not have any access to electricity; and
- backup system – installation of a backup system in health-care facilities with access to grid electricity with low reliability of supply (frequent outages or interruptions).

After identifying the level of intervention required for each country, this information was paired with additional data to derive the total number of new connections for grid and off-grid powered systems in each country and the total number of health-care facilities that require an additional off-grid backup system.

Proxy technology costs for each country were calculated, with reference to the assessed needs at different tiers of health-care facility. These proxy costs are based on:

- the average cost per kW of grid connection; and
- the average net present cost per kW of off-grid PV–battery–diesel connection (hybrid array).

The estimated daily electricity requirements were assumed as 500 kWh/day for hospitals and 15 kWh/day for non-hospitals.

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1 For five of the 63 countries considered – for which GEP results were not available – these proxies were estimated based on regional averages from the GEP database. These countries were Afghanistan, Nepal, Sri Lanka and India (South Asia region), and Viet Nam (East Asia and Pacific region).
The load factor was set at 21% for referral-level facilities, 15% for primary-level facilities and 16% for community-level facilities. However, different types of health-care facilities might be subject to different load factors depending on their equipment, services and operation status.

The backup to peak load ratio was set at 50%.

**Results – quantifying investments for electrification of health-care facilities**

The total net present cost of electrifying health-care facilities in 63 low- and middle-income countries is estimated as about US$ 4.9 billion. Regionally, the costs break down as shown in Table 4.

**Table 4. Investment requirements for electrification of the 459,206 health-care facilities in 63 countries, by region, type and intervention level required**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>LAC</td>
<td>Hospital</td>
<td>2.7</td>
<td>-</td>
<td>-</td>
<td>13.8</td>
<td>8.0</td>
<td>24.6</td>
</tr>
<tr>
<td></td>
<td>Non-hospital</td>
<td>1.5</td>
<td>1.2</td>
<td>0.1</td>
<td>3.9</td>
<td>2.0</td>
<td>8.7</td>
</tr>
<tr>
<td>SAR</td>
<td>Hospital</td>
<td>46.9</td>
<td>-</td>
<td>-</td>
<td>89.5</td>
<td>60.0</td>
<td>196.5</td>
</tr>
<tr>
<td></td>
<td>Non-hospital</td>
<td>277.9</td>
<td>32.6</td>
<td>17.4</td>
<td>928.0</td>
<td>508.9</td>
<td>1,764.8</td>
</tr>
<tr>
<td>EAP</td>
<td>Hospital</td>
<td>47.2</td>
<td>16.5</td>
<td>7.7</td>
<td>113.6</td>
<td>55.4</td>
<td>240.4</td>
</tr>
<tr>
<td></td>
<td>Non-hospital</td>
<td>28.7</td>
<td>20.7</td>
<td>2.6</td>
<td>56.7</td>
<td>25.8</td>
<td>134.4</td>
</tr>
<tr>
<td>SSA</td>
<td>Hospital</td>
<td>327.5</td>
<td>44.3</td>
<td>2.5</td>
<td>530.6</td>
<td>40.6</td>
<td>945.4</td>
</tr>
<tr>
<td></td>
<td>Non-hospital</td>
<td>812.2</td>
<td>360.7</td>
<td>29.2</td>
<td>349.4</td>
<td>40.5</td>
<td>1,592.0</td>
</tr>
<tr>
<td>Total</td>
<td>-</td>
<td>1,544.7</td>
<td>475.9</td>
<td>59.5</td>
<td>2,085.5</td>
<td>741.2</td>
<td>4,906.8</td>
</tr>
</tbody>
</table>

CAPEX: capital expenditure; EAP: East Asia and Pacific region; LAC: Latin America and the Caribbean region; NPC: net present costs; OPEX: operating expenditure; SAR: South Asia region; SSA: Sub-Saharan Africa region.

Note: Estimates are in US$ for 2022.

In terms of infrastructure outlays, the cost breakdown estimate is:

- US$ 2.8 billion for supporting the deployment of backup off-grid generation in already connected health-care facilities; and
- US$ 2.1 billion for new connections, comprising about $1.5 billion for new grid-based connections and about $476 million for off-grid-based new connections.

About 64% of the health-care facilities in 63 low- and middle-income countries require an intervention – in the form of either a new connection or a backup power system. In absolute terms, this amounts to 100,926 facilities requiring a new connection and 223,506 health-care facilities requiring a backup energy system.

The highest rates of intervention needed were found in the South Asia and sub-Saharan Africa regions, followed by the East Asia and Pacific region; the rate is significantly lower in countries in the Latin America and the Caribbean region.

**Limitations – granularity of data and electricity requirement assumptions**

The current analysis only estimates the costs of the most basic interventions required to power currently unserved facilities, and provide backup generation to unreliably connected facilities, bringing them up to a basic or intermediate level of electrification. This means that daily electricity requirements were assumed at 15 kWh for the category “non-hospitals” and at 500 kWh for the category “hospitals.” In reality, the daily requirements vary, depending on equipment and services available, and operation status. Clearly, changing the demand assumptions can have a considerable
impact on the estimated investment requirements.

For example, increasing non-hospitals’ electricity access to 32 kWh/day could increase the total net present cost of electrification to US$ 8.9 billion (Table 5). This comprises $5 billion for backup off-grid generation in already connected health-care facilities and about $3.8 billion for new connections.

Table 5. Estimated investment costs in relation to daily electricity load requirement assumptions

<table>
<thead>
<tr>
<th>Type of facility</th>
<th>Daily electricity requirements (kWh/day)</th>
<th>Estimated investment (US$ million)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hospital 500</td>
<td>New connections CAPEX – grid 1 544.7</td>
</tr>
<tr>
<td></td>
<td>Non-hospital 15</td>
<td>New connections CAPEX – off-grid 475.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>New connections OPEX – off-grid 59.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Backup system CAPEX – off-grid 2 985.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Backup system OPEX – off-grid 741.2</td>
</tr>
<tr>
<td></td>
<td><strong>Total NPC</strong></td>
<td></td>
</tr>
</tbody>
</table>

|                  | 500                                     | 1 000                              | 1 000                              | 3 238.8 |
|                  | 15                                      | 32                                 | 15                                 | 1 007.1 |
|                  |                                         | 115.3                              | 69.6                               | 125.5   |
|                  |                                         | 3 601.8                            | 2 833.1                            | 4 349.4 |
|                  |                                         | 1 395.4                            | 905.3                              | 1 559.4 |
|                  |                                         | 8 873.4                            | 6 313.7                            | 10 280.3 |

CAPEX: capital expenditure; NPC: net present costs; OPEX: operating expenditure.

Note: Estimates are in US$ for 2022.

Although the targeted electricity requirement aims to capture latent demand by being at the higher end of the range of typical values (e.g. greater population, higher catchment area, additional equipment), the analysis does not include new facilities that might be built in coming years.

The sizing of the power system for each health facility was based on assumed load factors and a selected backup system deployment strategy. A change in those assumptions will have an impact on the estimated investment. Similarly, selecting a different electrification scenario from the GEP database may lead to different least-cost mix (grid vs. off-grid) for health facilities, and thus to different investment requirements.

Finally, the costs reflect only the intervention required for power generation, distribution, and operation and maintenance associated with new connections and backup generation; the costs of acquiring the medical equipment in the facilities were not included.
Chapter 6 provides an overview of policies, regulations, financing approaches and institutional frameworks to accelerate electrification of health-care facilities, as well as lessons learned, across different scales of governance.

**Barriers to electrification**

A range of technical, capacity, policy and financing barriers can slow the pace of electrification.

- **Technical** issues include the unreliability of electricity supply, lack of supply of appropriately designed medical equipment, poor coordination between planning of electrification and procurement of medical equipment, poor access to solar vendors and spare parts in remote and rural areas, and poorly maintained systems that affect reliability of electricity supply, especially in off-grid systems. Lack of finance for appropriate maintenance of energy equipment and for battery replacement is a critical gap.

- **Policy and governance** barriers include a lack of understanding of the linkages between electricity access and health-care delivery; a disconnect between agencies/departments responsible for health-care services and energy services; siloed policy-making; a lack of supportive policies and regulations; a lack of clear standards and procedures for the design, procurement, installation and servicing of energy systems; and a scarcity of data on electricity gaps, as well as a lack of harmonized data.

- **Institutional capacity** barriers mean that mechanisms are lacking to build local institutional capacity to design and manage electrification programmes tailored to health-care facilities. At the same time, local knowledge to properly operate and maintain energy systems is essential to avoid failure of health-care facility electrification programmes.

- **Financial** challenges include a lack of adequate funding to support electrification of health-care facilities. This includes not only capital costs but also funds for operation and maintenance, and for replacement batteries throughout the lifetime of the system. Supporting policies, such as subsidies and fiscal incentives for renewable energy products to be installed in health-care facilities, and appropriate monitoring and accountability mechanisms to measure the impacts of investment are often lacking.

**Building the enabling environment for acceleration of electrification**

Taking into consideration the key role of electricity in health-care facilities to ensure quality health services, this should be considered a development priority. Creating an enabling environment that overcomes barriers and facilitates improvements in access involves developing fair and transparent policy and planning frameworks; solid data infrastructure; and increased and dedicated financing, including for ongoing maintenance. Institutionally, coordination between the energy and health sectors is critical. Equally important is the fostering of champions who can articulate and advocate for electrification in the health sector context. Key priority actions covered in the chapter include the following.

- **Integrate electrification of health-care facilities into energy sector planning.** Energy demand of health-care facilities need to be integrated into broader national and community electrification plans. Integrating energy planning with health policy planning supports win–win outcomes.

- **Improve financing models to cover long-term operation and maintenance.** There is a need to scale up investments and to move from a short-term approach to capital investments to a time frame of at least 10–15 years, with operation and maintenance costs and replacement of parts adequately covered. This change in approach also requires an adaptation of the traditional model of funds disbursement by governments and development partners.
instance, whereas funds for diesel fuel are often an established line item in ministry budgets, operation and maintenance of solar PV systems is unfamiliar and requires focused advocacy for inclusion. Blending diverse sources of finance and enhancing public–private partnerships, when possible, can help unlock new resources.

- **Develop supporting policies and accountability mechanisms.** A broad range of support measures, from import tax exemptions for sustainable energy equipment to be installed in health-care facilities to renewable energy subsidies tailored to the health sector, can be used to support sustainable electrification of health-care facilities. The most suitable policy instrument needs to be identified, taking into consideration the specific country context.

- **Build capacity at local level.** Capacity-building should be encouraged among all actors involved in health-care facility electrification programmes, from health sector staff to local energy enterprises. Institutional capacity must be strengthened to enable the public sector to design and manage health-care facility electrification programmes. Health sector stakeholders play a key role in supporting the accurate assessment of the electricity demands of a facility, as well as the necessary operation and maintenance of the electricity system (especially for decentralized electricity systems) and medical devices. Local sustainable energy providers can promptly and efficiently support operation and maintenance of energy systems in a sustainable way. Health-care facility electrification programmes can play a crucial role in creating a skilled workforce; they can also support local electrification more broadly in homes, farms and businesses. This, in turn, lowers the transaction costs of doing business, and channels profits to local communities rather than to actors outside the community or even overseas.

- **Ensure that development is needs driven, not supply driven.** One-size-fits-all energy systems may be underdesigned or overdesigned for the current and future needs of the health-care facility. And heavy reliance on external actors, along with insufficient leadership by local stakeholders, tends to create an ownership vacuum, jeopardizing the long-term sustainability of the electrification programme. A demand-driven approach, with the active involvement of local stakeholders, including frontline health-care workers, is critical from the local to the national level.

Chapter 7 analyses case studies of health-care facility electrification – in India, Uganda, and Nepal – that may provide valuable insights on programme design and implementation. The chapter closes with a synthesis of lessons learned that can be important for other countries.

**INDIA – building local ownership**

SELCO Foundation, an India-based not-for-profit organization, uses an innovative approach to scale up the electrification of health-care facilities in rural communities of India. To better ensure the long-term sustainability and use of a health-care facility electricity system, SELCO Foundation found that working directly within the local community, specifically with the health facility staff who rely on the system, to complete the energy needs assessment was an important way to ensure that the facility’s most important electrical needs were accounted for in the system design and rollout. SELCO Foundation also trained local health-care facility staff in the maintenance and operation of the electricity system to ensure its long-term sustainability.
In the SELCO Foundation model, public health-care facilities own the solar system, with 60–80% of capital expenditure paid by state government health infrastructure funding and the remainder supplied by SELCO Foundation through the philanthropic capital provided by its funders. The decentralized approach used by SELCO Foundation also applies to operation and maintenance of the energy systems, which are the responsibility of the health-care facilities.

**UGANDA – learning from the past to inform the future**

Much work has taken place to electrify the health-care facilities of Uganda, providing important experiences on the role of government and development partners, and the need for greater coordination and staff retention to maximize long-term impacts of electrification efforts.

Over the past decade, the World Bank's Energy for Rural Transformation (ERT) programme has played a key role in health-care facility electrification in Uganda. As this programme has evolved, it has provided some important lessons on financing, government ownership and data sharing.

The initial ERT programme used a 1+4 operation and maintenance contract approach, in which the World Bank financed the capital expenditure and the first year of maintenance, while the Ministry of Health was responsible for the following 4 years of maintenance contracts. After 5 years, the responsibility for renewing the maintenance contract was transferred to the district local governments. However, in many cases, the districts preferred to fund repairs on an ad hoc basis, rather than to tender full operation and maintenance contracts. In some cases, the lack of regular maintenance has led to systems falling into disrepair.

To help mitigate such a risk in future work of the ERT programme, the subsequent phases, ERT-2 and ERT-3, aimed to better ensure system longevity. A commitment was made by the Ministry of Health to increase the budget to ensure regular maintenance and repair, as well as battery replacement and disposal.

Another key actor working on health-care facility electrification in Uganda has been the UN Foundation. Keeping in mind the importance of staff retention and morale, the UN Foundation's Powering Healthcare initiative expanded the scope of electrification to include staff quarters. This project, launched in 2016, aimed to electrify 36 health-care facilities with solar PV systems to account for future growth. The 2–6 kilowatt-peak (kWp) capacity included power for staff quarters, to improve staff satisfaction and retention by allowing the use of televisions and radios in addition to standard lighting and phone charging.

Although electrification of Uganda’s health-care facilities remains a challenge, there has been an increase in the number of health-care facility electrification programmes supported by donors. The proliferation of initiatives increasingly demands more efficient coordination mechanisms to maximize impact, ensure efficiency and avoid duplication of efforts. Stakeholders describe concerns that solar technologies may be installed in facilities that have already been electrified under another programme, instead of repairing the systems previously installed in the facilities, some of which are no longer functional.

**NEPAL – key role of policy and governance**

Under Nepal’s Renewable Energy Subsidy Policy of 2016, public health-care facilities in rural areas are eligible for a subsidy of up to 65% (up to US$ 6500) for solar PV. The subsidies are managed by Nepal’s Alternative Energy Promotion Centre (AEPC) under the Ministry of Energy, Water Resources and Irrigation. In the design phase of the programme, the AEPC undertook a review of health-care facility needs, and identified two standard systems sized at 1 kWp and 2 kWp. The 1 kWp system is for community health subposts, village-level health posts and birthing centres. The 2 kWp system was designed for community or government (district-level) health posts, snakebite centres, primary health centres or hospitals.
To support those facilities in need, the AEPC puts out an annual public call through daily newspapers asking institutions in need of support for electrification to apply for the subsidy. At this stage, if there is insufficient budget to cover all the needs of the requesting facilities, a selection process takes place using criteria based on the facility’s current level of electricity access, the size of the facility’s catchment population and whether there is already electricity-reliant equipment present in the facility. Facilities with equipment and medical devices already in place, or that have a commitment letter from donors or other institutions to support them with equipment supply in the short term, are then prioritized for government support.

After installation of the solar system by a local supplier, the AEPC pays the energy system supplier the first 90% of the total subsidy. The remaining 10% is held back to ensure after-sales service for 2 years. After the 2-year warranty with after-sales service expires, it understood that all operation and maintenance is the responsibility of the health-care facility.

This subsidy model has been effective in providing rural health-care facilities with solar systems. However, integration of long-term maintenance costs into health-care facility budgets remains a challenge for some facilities.
LESSONS LEARNED

Lesson 1: The cases in this chapter highlighted that financial support, through either national budget and government subsidies, development partners, philanthropic institutions or bilateral and multilateral organizations, is necessary for any electrification programmes targeting public health-care facilities. The private sector can play a role as an energy service provider, or to unlock some financing sources. However, as health is a public good, the public sector is responsible for leading and making adequate financial resources available for health-care facility electrification as an essential element for the delivery of quality health services for all, particularly the most vulnerable.

Lesson 2: Correct system sizing plays a key role in the success of any health-care facility electrification programme. System sizing is a trade-off between standardization and customization, and diverse approaches can be used to build standardization into an electrification programme. Great attention needs to be given to the energy needs assessment in the initial design stage. Engagement with health staff at facility level in this phase is crucial to properly identify current and future energy–health needs.

Lesson 3: Operation and maintenance of energy systems can be institutionalized at the government or at the health clinic level – but it does need to be institutionalized. Most programmes fail to include operation and maintenance budgets for more than 5 years, when warranties typically expire and batteries need replacement. In some cases, the operation and maintenance situation is even more dire, covering only 2 years. It is critical that maintenance funds, including for troubleshooting and replacement of batteries and other system components, are earmarked in budgets to ensure long-term sustainability (e.g. 10–15 years). Monitoring and accountability mechanisms should also be put in place.

Lesson 4: Programmes should be designed to support local market development and capacities, to improve the ability of local actors to supply equipment, replace parts and provide maintenance services. This will contribute to the longevity and functionality of energy systems in health-care facilities, and will have cascading economic benefits for local communities. In the case of international contracts, programmes should encourage international companies to partner with local companies (e.g. to ensure that a local service provider is available).

Lesson 5: Data on the success of existing electrification programmes are severely lacking, which hinders decision-making. Most programmes evaluate success on the basis of number of installations, not long-term functionality. Remote monitoring can facilitate and automate collection of these data. Remote monitoring data could also be connected to other facility-specific information to help prioritize resources. It is also important to monitor health outcomes as part of these programmes.

Lesson 6: Coordination of actors and development partners working on different health-care facility electrification programmes at country level is needed. This is essential to maximize impact, ensure efficiency and avoid duplication of efforts. In this context, the potential to repair systems already installed in facilities that are no longer functional should be considered before installing new systems to facilities that have already been electrified under another programme.

Lesson 7: It is essential that programmes focusing on electrification of health-care facilities coordinate with programmes focusing on providing medical devices and appliances. Electricity is only one side of the equation; to really generate impact, it must be provided along with all other components, including suitable medical devices and staff training. Government actors and development partners need to increase coordination efforts in this direction.
Some dominant themes of this report are the need for closer cooperation between the health and energy sectors, and the need for improved collection of data to enable monitoring, evaluation and building the evidence base to identify what works best for sustainable health-care facility electrification.

Climate change and the need to make health systems more resilient against its impacts, including extreme weather events, make the case for accelerating electrification all the more urgent. The COVID-19 pandemic further highlighted the need for reliable electricity to enable essential services, such as oxygen production, vaccine cold chain, and rapid two-way communication between outlying clinics and central authorities.

Designing solutions that are resilient and sufficiently flexible to adapt to evolving risks is important for all facilities. In this context, decentralized renewable energy solutions represent a key opportunity to guarantee the energy supply.

Decentralized renewable energy solutions also allow health-care facilities to be energy independent, thus avoiding the risk of fuel shortages and price variability which can affect facilities relying on fuel-based generators. Reliability of electricity supply is key to the functionality of sensitive, lifesaving medical equipment, as well as provision of clean water, in areas that are remote and vulnerable to water stress, extreme weather events or other climate-related risks.

Hand in hand with these requirements is the need for design and procurement of more robust, energy-efficient, low-maintenance medical equipment. National-level guidance and standards across the tiers of health care are crucial to identify priority and suitable medical equipment. Such guidance, along with data and knowledge of the quality of electricity supply, helps build essential knowledge flow between health-care decision-makers and equipment providers.
Health sector actors are essential to co-lead the electrification process, by identifying priority needs. Encouraging multisector coordination groups at different levels, involving both energy and health stakeholders, is key to advocating for health and electricity interests in the decision-making process. Mechanisms that encourage integration and interaction between the health and electricity sectors, involving both public and private stakeholders, are important building blocks for translating policy intent into action.

Training and capacity-building for the technical and financial requirements of electrification in health-care facilities are critical, and must involve both health sector and energy actors. Strengthening institutional capacity is key for the public sector to design and manage health-care facility electrification programmes. Similarly, capacity should be built at the central and local level to ensure the integration of electricity into national and local development plans, and sustainability of initiatives.

Increasing awareness of, and advocacy for, the political prioritization of health-care facility electrification will help to ensure that it is a priority in both national and subnational plans – establishing a clear mandate across a country or a region. Identifying and engaging with champions of health-care facility electrification, from national officials and inspirational cultural figures to frontline health-care workers, is critical to creating momentum that will push this lifesaving aspect of health care higher on political agendas.

The conclusions chapter of this report summarizes some of the actions that governments, development partners, academic institutions and other stakeholders could take to accelerate electrification of health-care facilities, and the provision of reliable electricity in the short and long terms. The proposed actions are based on the review of data on, investment in, and case studies of, electrification programmes, including successes and shortcomings, and are articulated in terms of I) data, II) system planning and III) programme implementation. This final chapter proposes a way forward to change pace and consider electrification of health-care facilities as a development priority, calling all relevant actors to action.