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EXPERT NOTE

An approach to powering unelectrified and under-electrified healthcare facilities

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Summary

About one billion people across low- and middle-income countries access healthcare facilities without electricity or with unreliable power (WHO et al. 2023). The COVID-19 pandemic revealed significant gaps in electricity access across healthcare facilities, underscoring the difficulty of powering essential medical equipment and services. This can be more significant in resource-constrained and hard-to-reach rural settings where grid electricity is unavailable or unreliable. Often, the alternative is polluting and expensive diesel generators. A viable option for reliable and sustainable healthcare facility electrification (HFE)— complementary to the grid—is decentralized renewable energy (DRE).

DRE, particularly solar photovoltaic (PV) and batteries, can be customized to specific energy needs and made adaptable and resilient to climate vulnerable regions (Ginoya et al. 2021). In areas far from the national grid, DRE solutions have proven to be readily deployable (IEA et al. 2024). Rising diesel prices coupled with advancements in battery storage and solar PV technologies make DRE solutions cost-effective, with a payback period of 3–5 years (SEforALL 2024). Apart from its economic benefits, there can be significant social and environmental outcomes. These include enhanced patient care, reliable operation of medical equipment, and improved healthcare service delivery. They also extend to environmental gains, such as reduced carbon emissions and lower pollution levels, all of which contribute to the overall well-being of the wider community. Several stakeholders have rallied support for the deployment of DRE solutions, primarily powered by solar, including global commitments to solarize 98,000 healthcare facilities before 2030 (SEforALL, CrossBoundary Advisory, and Odyssey 2023).

World Resources Institute has researched, developed tools and platforms, supported implementation, and convened global, national, and subnational stakeholders on HFE. While the significance of DRE for healthcare facilities in rural and remote settings has been established (IRENA and SELCO Foundation 2022; Concessao et al. 2023; WHO et al. 2023; IEA et al. 2024), there is need to streamline development and implementation of sustainable energy systems at scale, especially in terms of tools and processes. This is critical in mobilizing investments estimated at US$ 3.6–4.9 billion (WHO et al. 2023; SEforALL, CrossBoundary Advisory, and Odyssey 2023).

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Suggested Citation: Ireri, B., L. Concessao, and S. Sinclair-Lecaros. 2025. "An approach to powering unelectrified and under-electrified healthcare facilities." Expert Note. Washington, DC: World Resources Institute. Available online at doi.org/10.46830/wrien.24.00046.

Expert notes provide timely, focused, and concise information for urgent challenges, based on expert perspectives.

We recognize that knowledge gaps exist in implementing HFE at scale. This expert note presents a lifecycle approach to identifying priority facilities, designing, building, and operating sustainable electricity systems for new and existing healthcare institutions. It is based on the authors' experiences working with partners to support healthcare electrification and energy planning in India and Africa at local, subnational, and national levels.

Approaches to health electrification

The following three frameworks address challenges of providing healthcare facilities with reliable access to power and propose approaches to tackling them. The first, IRENA and SELCO Foundation (2022) recommends the following steps for better planning, designing, and implementation of 'energy-health nexus' solutions: energy-health assessment, system design and costing, procurement and installation, ownership and maintenance, and capacity building. They also recommend an ecosystem-based approach to enhance understanding of enablers and barriers to adoption, functioning quality, and the sustainability of DRE systems (IRENA and SELCO Foundation 2024).

The USAID Powering Health Toolkit adopts a five-step approach to powering health: analyze energy demand and supply; account for changes based on future equipment replacement or addition; investigate electrification options; design, procure and install; and ensure sustainability of investment. The toolkit also includes guidance on international standards, tools for energy demand assessment and energy audits (USAID 2023), including the HOMER Powering Health Tool – an online platform that provides cost estimation and system sizing for solarization of individual healthcare facilities (USAID et al. 2020).

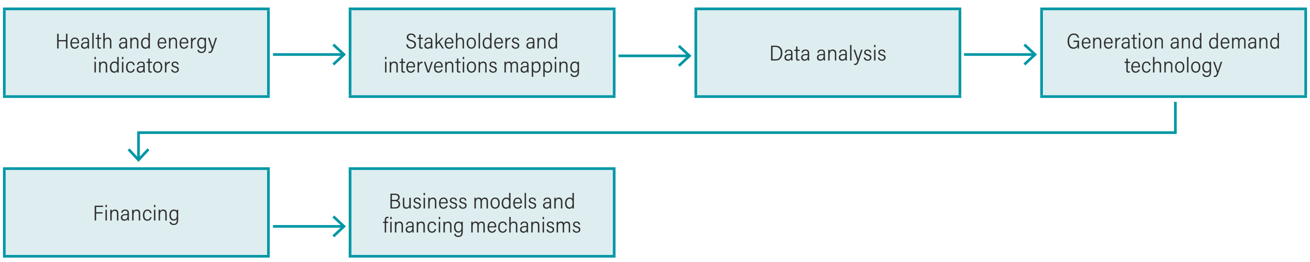
SEforALL proposes an approach that includes mapping stakeholders and interventions; health facility data analysis; technology assessment; funding and financing mechanisms; delivery models; and a roadmap for health electrification as shown in Figure 2 (SEforALL 2022; 2023a; 2023b; 2024).

A review of these frameworks, complemented with our "on-the-ground" experiences has informed our thinking about adopting a holistic, lifecycle approach to HFE programs using DRE, which is defined in the next section.

FIGURE 1 | Key components of an ecosystem approach on designing DRE solutions in the health context

Source: IRENA and SELCO Foundation (2024).

FIGURE 2 | SEforALL's market assessment and roadmap for HFE



Source: SEforALL (2023a).

WRI's project lifecycle approach to healthcare facility electrification

Figure 3 highlights our holistic approach to HFE. It breaks down a program or project lifecycle across different timelines. While the stages may appear linear, depending on the scale and stakeholders involved, some elements may overlap, be iterative, or begin at different stages.

Attention for some HFE initiatives tends to focus on **time-bound stages** of the project lifecycle, and less on long-term operations and maintenance (O&M) plus monitoring & evaluation (M&E) (SEforALL 2024). While information on **time-bound** stages exists, there is a gap around addressing ongoing needs for O&M and M&E, which must be **periodically scheduled and carried out.** Moreover, financing, stakeholder engagement, and capacity building are required across all stages, so they must be **continuously evaluated**. Below, we describe stages of the project lifecycle grouped under three categories: **time-bound**, **periodic,** and **continuous activities**.

A: Time-bound activities include the following actions:

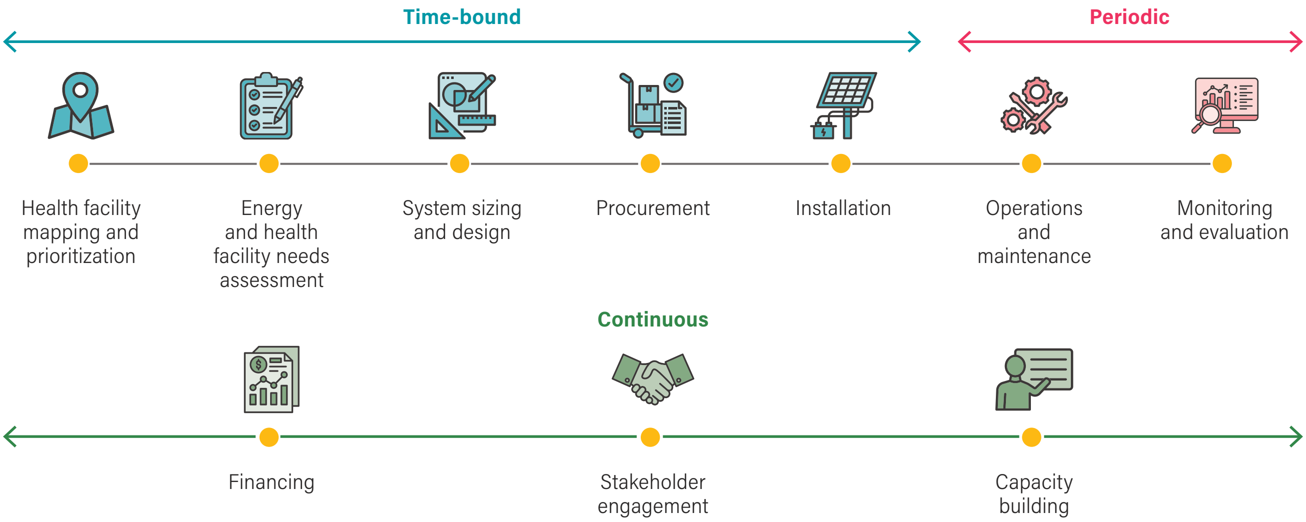
1. **Mapping and prioritization of unelectrified[1] and under-electrified[2] healthcare facilities:**

   A data-informed approach utilizing geospatial analysis, representing current or potential energy-demand and supply options allows government agencies, financial institutions, and development organizations to identify and prioritize locations of healthcare facilities for electrification. These stakeholders can conduct high-resolution pre-screening in potential intervention areas before investing in feasibility studies or on-site assessments (WHO et al. 2023). Geospatial technologies can also help identify and plan for DRE interventions at scale by capturing the location and characteristics of health and energy assets plus facility-level data, thus assisting governments to allocate resources in designing policies, programs and roadmaps for electrification (Sinclair-Lecaros et al. 2023).

   Incorporating data on the location, services, and electrification status of healthcare facilities, along with population density and social and productive use infrastructure, can present a comprehensive snapshot of an area's potential energy needs. Combined with available datasets on potential energy supply, this can facilitate multicriteria analysis (MCA) scenarios to identify and prioritize intervention areas. Energy Access Explorer (EAE) is an online and interactive geospatial platform that provides analytical outputs while enabling visualization and interaction with geospatial data.

   Mapping healthcare facilities and their electrification status requires regular data collection and validation. Governments must invest in building robust data in health, energy, and related sectors. This would benefit from more enabling policies that encourage coordination among government departments and stakeholder inputs in the health-energy ecosystem (Sinclair-Lecaros et al. 2023).

FIGURE 3 | Project lifecycle of deploying DRE solutions for HFE programs



Notes: Time-bound = activities that take place withing a defined time-period; Periodic = activities that need to be periodically scheduled, at defined intervals (e.g., monthly, quarterly, annually); Continuous = activities that need to be continuously evaluated and undertaken as the need arises.
Source: Authors.

2. **Energy and health needs assessment is essential to designing right-sized solutions.** This involves combining energy supply systems with appropriate medical equipment. Healthcare systems can vary widely, including country-specific system structure, ownership, size, medical services, medical and non-medical equipment, etc. This requires an energy needs assessment that considers existing power supply solutions, met and unmet energy demand of medical and non-medical equipment, and future energy needs. We approached the energy needs assessment using two complementary methods: facility-level energy audits and a GIS-supported energy demand model.

   The facility-level approach assesses an institution's energy needs based on its location and energy consumption for its medical and non-medical equipment. It analyzes current and future energy usage for different end-use equipment requiring uninterrupted power supply and identifies opportunities to reduce energy consumption and integrate energy supply solutions.

   The GIS-supported energy demand model combines the bottom-up approach to estimate the electricity needs of different tiers of healthcare facilities, with GIS-based analysis to assess location and spatial characteristics of each facility. It enables high-resolution preliminary assessments, helping stakeholders quickly identify and address energy data gaps in healthcare facilities, especially in resource-constrained settings. While this approach does not replace the facility-level energy audit when designing an appropriate energy system, understanding average electricity requirements for different tiers and sizes of healthcare facilities can offer plausible options for electrifying various facilities across an area.

3. **Energy system size and design** are informed by energy and health needs assessments. This includes customizing the energy system configuration and sizing it to meet a healthcare facility's medical and non-medical needs. The size of the energy system will be influenced by its energy needs, available budget, and existing electricity supply options. This can range from a comprehensive system that covers all needs, to one that starts by focusing on critical loads, with gradual expansion (Concessao et al. 2023).
4. **Procurement and installation of DRE systems** relies on the outcome of energy needs assessment and system design. Documents like request for proposals (RfPs) should be designed to capture details, including energy system design configuration, components' technical specifications, and compliance with local and international standards. Procurement contracts should include milestone-based payment terms while accounting for activities that strengthen energy system resilience, including insurance, warranties, long-term maintenance, replacement contracts, and monitoring systems for troubleshooting. They should also promote the use of certified DRE system components, along with proper end-of-life handling, including refurbishment, recycling, and decommissioning for responsible waste management. A robust procurement framework allows for selecting the right energy enterprise to undertake installation and providing healthcare facilities with O&M and capacity building support. In remote areas, procuring from local enterprises can support system sustainability, provided the local technology ecosystem is mature or constantly improving. Otherwise, collaboration between established suppliers and local technicians can respond to timely O&M requirements.

B: Periodic activities, which encompass the following two actions:

1. **Establishing and implementing O&M protocols** are key as the project transitions to the post-installation phase. These should include processes for routinely monitoring energy generation and usage, as early detection of issues would enable prompt corrective actions, minimizing downtime and maximizing energy production. Periodic maintenance at regular intervals helps identify components needing immediate attention or replacement, as well as contributing to extending the lifespan of the energy system.

   Healthcare facilities or implementing agencies should institutionalize these processes by integrating O&M in the procurement for an agreed period. Any additional costs should be budgeted in the future, with clear communication and guidance provided to facility owners (IRENA and SELCO Foundation 2022; Concessao et al. 2023). A transition period that allows ample staff training at healthcare facilities would ensure a smooth handover of the O&M responsibilities. Accountability within the healthcare facility to manage and monitor energy system performance and upkeep should be established.

2. **Monitoring and evaluation (M&E):** The impacts of reliable electricity supply on healthcare service delivery can be manifold – an increase in the number of patients treated, expansion of medical services, and a comfortable environment for patients and staff. Assessing causal pathways which determine health outcomes of a population is challenging (Shastry and Rai 2021), particularly in measuring impacts of electricity access on health outcomes

(White and Raitzer 2017). The resultant changes of DRE interventions must be evaluated periodically, including the post-program funding cycle. This requires harmonizing data collection efforts to ensure information is regularly gathered to assess facility- and community-level impacts, as well as the socio-economic, and environmental benefits of the interventions.

While the role of electricity in enhancing healthcare service delivery outcomes is well recognized, more empirical evidence is needed to support this link. Measuring specific health outcomes—such as changes in service delivery or reductions in maternal and infant mortality—can take longer to observe. Evolving demographics and healthcare needs must be considered when evaluating the adaptability of the energy supply infrastructure to the changing healthcare landscape.

C: Continuous activities, which include financing and capacity building are required throughout the project's lifecycle.

1. **Financing needs** must go beyond investments required for procurement and installation, to cover for the time and effort in identifying priority healthcare facilities; assessing their energy needs; and the costs associated with O&M and M&E. Projects that incorporate the costs of M&E – by integrating monitoring systems – and O&M – through financial and human resource allocation – from the outset are more likely to be sustainable (WHO et al. 2023). This is even more critical for remote and under-resourced facilities. Depending on the financing model, the roles of stakeholders may vary in terms of risks and responsibilities. About 95 percent of current HFE financing comes through capital expenditure (capex), asset ownership models funded by donors (SEforALL, CrossBoundary Advisory, and Odyssey 2023), or a combination of donor, developer, and public budgets. Private financing has been limited to larger hospitals capable of covering upfront capital expenditures. Willingness and ability to pay for periodic O&M and M&E needs in an asset ownership model should be considered during project design. Coordination between energy, health and finance ministries or government-led working groups can help identify financing needs and secure capital for the installation, operation, maintenance and monitoring of HFE programs.

   Alternative models to asset ownership such as the energy-as-a-service (EaaS) or lease-to-own model can facilitate investments. Investment risks in these models, both for repayment and O&M, shift to developers who own the assets.

2. **Stakeholder engagement and capacity building:** Healthcare facilities assume responsibility for O&M plus regular monitoring in an asset ownership model. Regular training of staff can strengthen ownership of the energy system for optimal utilization, sustained performance, and longer asset life (IRENA and SELCO Foundation 2022). For public facilities, governments can consider meeting the cost of replacing components. In India for example, the National Programme on Climate Change and Human Health enables subnational governments to integrate O&M costs for solar and batteries as a line item within their annual health budgets (National Centre for Disease Control 2023).

   Stakeholder engagement and capacity building require more than one-way communication between energy enterprises and healthcare facilities; they involve mutual dialogue and collaboration. Continuous engagement and consultation amongst all stakeholders – including energy enterprises, healthcare facilities, financing organizations and government agencies – are essential to ensure long-term sustainability of existing projects. Moreover, lessons learnt from these pilot projects can help replicate and scale DRE solutions in areas that still lack reliable electrification options.

Discussion

Electrifying the estimated 98,000 facilities (SEforALL, CrossBoundary Advisory, and Odyssey 2023) requires multi-stakeholder collaboration. Through joint efforts, stakeholders can effectively support each stage of the project lifecycle. Though some of these stages appear linear, they could overlap. For example, facility prioritization could overlap with energy needs assessment and system sizing. The same agency can do this simultaneously rather than in separate phases. In addition, certain stages, like O&M, should not be seen as separate and could be managed by the developer, as in an EaaS model. Furthermore, certain aspects may be pre-defined, like fixed budgets for HFE, which can limit flexibility and adaptability. Therefore, depending on the project needs, stakeholders can modify their approach based on the timelines mentioned or apply the entire "holistic" approach. As demonstrated earlier in the paper, different approaches or tools are dedicated to each project lifecycle stage. They include EAE for identifying priority sites for health electrification, facility-level energy audits or demand assessment tools, selecting appropriate financing options, and processes for installation, O&M, and M&E.

This note outlines an approach for public and private healthcare facilities, energy developers, and financing stakeholders to rethink powering healthcare. It focuses on project timelines and key activities needed to ensure long-term sustainability of healthcare electrification programs. Considering the nature and timeline of different activities across the stages—time-bound, continuous, and periodic—allows stakeholders to structure HFE programs in a manner that enables energy service provisioning to play its role effectively.

List of abbreviations

Capex	Capital expenditure
COVID-19	Coronavirus Disease
DRE	Decentralized renewable energy
EaaS	Energy-as-a-service
EAE	Energy Access Explorer
ESMAP	Energy Sector Management Assistance Program
GIS	Geographic Information System
HFE	Healthcare facility electrification
IEA	The International Energy Agency
IRENA	The International Renewable Energy Agency
M&E	Monitoring and Evaluation
MCA	Multicriteria analysis scenarios
O&M	Operations and maintenance
PV	Photovoltaic
RfP	Request for Proposal
SDG	Sustainable Development Goal
SEforALL	Sustainable Energy for All
UNSD	The United Nations Statistics Division
US$	United States Dollar
USAID	U.S. Agency for International Development
WHO	World Health Organization
WRI	World Resources Institute

Endnotes

1. Unelectrified healthcare facilities are defined as those which have no access to any form of electricity, with the exclusion of stand-alone medical devices and applications.
2. Under-electrified healthcare facilities are defined as those which have some form of access to electricity, but suffer from frequent power supply outages i.e., a power outage lasting more than 2 hours at a time in the previous one week (WHO et al. 2023).

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Acknowledgments

We are pleased to acknowledge our institutional strategic partners that provide core funding to WRI: the Netherlands Ministry of Foreign Affairs, Royal Danish Ministry of Foreign Affairs, and Swedish International Development Cooperation Agency.

The authors are grateful to WRI colleagues Abdul Khalid, Amit Kumar, Akansha Saklani, Arundhita Bhanjdeo, Bharath Jairaj, Birouke Teferra, Carlos Muñoz, Dheeraj Gupta, Dimitrios Mentis, Harsha Meenawat, Masfick Hazarika, Meron Tesfamichael, and Sarah George, for their insights and suggestions on this expert note. We would also like to thank our external reviewers, Rahul Srinivasan (Sustainable Energy for All) and Kamran Siddiqui (International Renewable Energy Agency) for their valuable feedback. We express our gratitude to Renee Pineda, Romain Warnault, Betty Rabar, and Shannon Collins for the administrative, editorial, and design support.

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