

ENERGY POVERTY AND HOUSEHOLD WELL-BEING IN REMOTE VILLAGES

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Abstract

Energy poverty remains a persistent barrier to health, dignity, productive livelihoods, and social participation in remote villages. It is not limited to the absence of an electricity connection. Households can be energy poor when available energy is unreliable, unaffordable, unsafe, seasonal, or insufficient for cooking, lighting, communication, refrigeration, heating or cooling, and income-generating activity. In geographically isolated settlements, long supply chains, difficult terrain, dispersed homes, weak maintenance systems, and low purchasing capacity can deepen these limitations. The result is an uneven burden on households that may already face constrained access to markets, health care, education, and public services.

This paper examines the relationship between energy poverty and household well-being in remote villages through an evidence-informed conceptual and comparative approach. It considers five linked dimensions: availability and reliability of energy services, affordability and household expenditure pressure, cooking-related health and time burdens, productive and educational uses of energy, and local institutions for maintenance and support. Particular attention is given to the fact that energy deprivation is experienced differently within the same household. Women, girls, older persons, persons with disabilities, and families dependent on seasonal livelihoods may carry higher costs when energy services are inadequate or unpredictable.

The analysis indicates that improvements in household well-being depend on the quality of energy services rather than on infrastructure provision alone. Grid extension, solar home systems, mini-grids, clean cooking solutions, battery storage, and efficient appliances can contribute to better outcomes when they are reliable, affordable, locally maintainable, and aligned with everyday needs. The study concludes that remote-village energy planning should combine technical design with household affordability, gender-responsive participation, service standards, livelihood support, and accountable local governance. Such an approach can reduce avoidable hardship and strengthen the capability of rural households to live healthy, secure, and productive lives.

Keywords: Energy Poverty, Household Well-Being, Remote Villages, Rural Energy Access, Clean Cooking, Energy Reliability, Rural Livelihoods, Gender and Energy, Decentralised Renewable Energy, Sustainable Development

1. INTRODUCTION

Energy is central to the ordinary routines through which households cook food, preserve medicines, study after sunset, communicate with relatives, charge devices, operate small equipment, manage water, and respond to emergencies. In remote villages, however, these routines are often shaped by restricted or unreliable access to modern energy services. A household may have a nominal electricity connection while receiving only a few hours of supply, or it may use a solar device that is adequate for lighting but insufficient for refrigeration, irrigation, or productive work. Similarly, a family may rely on collected firewood for cooking despite having access to

electricity because cooking fuel is costly, unavailable, or poorly matched to local practices. These conditions show why energy poverty should be understood as a multidimensional form of deprivation rather than a simple connection gap.

Remote location can make energy deprivation especially difficult to address. Transporting poles, batteries, liquefied petroleum gas cylinders, spare parts, technicians, and fuels to isolated settlements is expensive and slow. Rainfall, floods, mountain terrain, forest routes, or seasonal road closures can interrupt supply and maintenance. Service providers may view small and dispersed communities as commercially unattractive, while households

may not be able to pay high upfront costs or regular tariffs. Energy systems therefore need to be assessed not only by whether equipment has been installed but also by whether services can be sustained over time under local social, economic, and environmental conditions.

Energy poverty is closely linked to household well-being. Inadequate lighting can limit study time and safe movement at night. Dependence on polluting fuels can expose family members to smoke and increase the time required for fuel collection and cooking. Unreliable electricity can interrupt small businesses, restrict digital access, and make it difficult to preserve perishable goods or operate water pumps. These effects are not separate problems: they interact with health, education, income, gender relations, safety, and the capacity of households to plan for the future. Energy access can therefore expand well-being, but only when the service is meaningful in daily life.

This study explores how energy poverty affects household well-being in remote villages and how energy interventions can be designed more responsively. It reviews the main concepts used to understand energy deprivation, identifies common pathways of household impact, compares representative village contexts, and develops a practical framework for evaluating the contribution of energy services to well-being. The study does not present survey results from a single village. Instead, it synthesises established dimensions of energy access and rural living conditions to support more inclusive and realistic energy planning.

2. LITERATURE REVIEW

Research on energy poverty has moved beyond the narrow question of whether a household is connected to an electricity network. Earlier approaches frequently used expenditure thresholds or connection status as proxies for deprivation. More recent work emphasises the quality, reliability, affordability, safety, and usefulness of energy services. This broader view recognises that a household can remain energy poor even after infrastructure reaches the village if supply is irregular, appliances are unaffordable, cooking needs are unmet, or repairs are not available. Energy poverty is therefore connected to the

practical capabilities that energy enables in a household context.

The literature also links energy services to multiple components of well-being. Clean and efficient cooking can reduce smoke exposure and time spent collecting biomass. Reliable lighting may support children's study routines and household safety. Electricity for communications, refrigeration, water pumping, or small machinery can contribute to access to information, health services, agriculture, and local enterprises. At the same time, the benefits are not automatic. An energy service that is too weak, too expensive, or poorly maintained may have limited effect on everyday welfare. The social value of energy is therefore influenced by the way people use it, the assets they own, the institutions that support them, and the wider availability of markets and public services.

A further theme in the literature is the unequal distribution of energy burdens within households and communities. Women and girls often undertake fuel collection, food preparation, and household care, which can make them especially exposed to the time, physical effort, and health effects associated with traditional fuels. Older persons, people with disabilities, and low-income households may also find it difficult to manage fuel collection, travel to recharge devices, or pay for energy in advance. Studies of rural electrification and decentralised renewable energy consequently underline the need for participation, affordability mechanisms, local maintenance capacity, and attention to gender and inclusion in energy programme design.

2.1 ENERGY POVERTY AS MULTIDIMENSIONAL DEPRIVATION

- Energy poverty concerns the inability to obtain sufficient, safe, reliable, affordable, and socially acceptable energy services for everyday life.
- A household with an electricity connection may still experience deprivation when supply is intermittent, voltage is poor, tariffs are unaffordable, or appliances cannot be used effectively.
- Cooking energy is a central part of energy poverty because the continued use of biomass, kerosene, or other polluting fuels can create health, labour, and environmental burdens.

- Remote-village energy assessment should consider lighting, cooking, mobility, communication, cooling, water access, and productive-use needs rather than treating one technology as a complete solution.

2.2 HOUSEHOLD WELL-BEING AND BASIC ENERGY SERVICES

- Well-being includes health, safety, time use, education, income opportunities, social connection, dignity, and the ability to manage routine household responsibilities.
- Reliable energy can reduce uncertainty by supporting food preservation, communication during emergencies, charging of devices, and continuity of household activities after dark.
- The value of an energy service depends on local priorities: a water pump, rice mill, sewing machine, refrigeration unit, or clinic refrigerator may be more consequential than additional household lighting alone.
- Energy improvements are stronger when complemented by usable appliances, financial access, technical support, and opportunities to convert saved time or energy into valued activities.

2.3 REMOTE VILLAGE CONTEXT AND STRUCTURAL BARRIERS

- Difficult terrain, dispersed settlement patterns, seasonal isolation, and limited road access can increase the cost of supplying and maintaining energy systems.
- Small consumer bases may discourage private providers unless programmes include service obligations, subsidies, local enterprises, or viable community-management arrangements.
- Weak supply chains can delay repair of inverters, batteries, pumps, wiring, cooking equipment, and other components, causing installed systems to become underused.
- Household cash incomes may be seasonal, making flat monthly charges difficult even where families value dependable energy services.

2.4 GENDER, TIME, AND INTRA-HOUSEHOLD IMPACTS

- Energy deprivation can intensify unpaid care work when cooking requires fuel

collection, water heating, long preparation times, or repeated travel to obtain fuel.

- Girls may lose study time or participate in fuel collection, while women may have fewer opportunities for paid work, training, or public participation.
- Women should be included in decisions about technology choice, tariff design, operating hours, appliance priorities, and repair arrangements because they often manage daily energy use.
- Inclusive energy planning should also consider the needs of older persons, persons with disabilities, and households with limited labour or mobility.

3. OBJECT OF STUDY

The present study focuses on energy poverty and household well-being in remote villages. Its central purpose is to examine how the availability, reliability, affordability, safety, and suitability of energy services shape everyday household conditions. The study treats energy poverty as a practical limitation on the ability of people to cook safely, use light and communications, protect health, manage time, support education, maintain livelihoods, and participate in community life. The analysis is conceptual and comparative. It does not claim to estimate the prevalence of energy poverty in a particular district or country. Instead, it organises recurring forms of energy deprivation and household response across representative remote-village contexts. The framework is intended to support researchers, local governments, energy planners, community organisations, and development practitioners in identifying priorities for energy services that are more closely connected to household well-being.

3.1 THEORETICAL BASIS AND HOUSEHOLD CONTEXTS CONSIDERED

From a capability and well-being perspective, energy matters because it enables activities that households have reason to value. The study compares representative household contexts to illustrate how energy deprivation can take different forms and why a single energy technology may not meet all local needs.

S. No.	Household Context	Typical Energy Constraint	Priority Energy / Support Response	Key Well-Being Contribution
1	Biomass-dependent household	Smoke exposure, fuel collection, and long cooking time	Clean cooking options, efficient stoves, and reliable fuel supply	Improves health and reduces time burden
2	Grid-connected but low-reliability household	Frequent outages, poor voltage, and limited evening use	Service-quality improvement, local repair, and suitable backup	Supports education, safety, and communications
3	Off-grid farm household	Limited power for irrigation, storage, or processing	Productive-use energy, finance, and maintenance support	Strengthens income resilience
4	Women-led or labour-constrained household	High cost of fuel collection and appliance access	Gender-responsive energy services and flexible payment options	Reduces unpaid work and vulnerability
5	Remote hamlet using decentralised solar	Battery decline, repair delays, and restricted appliance use	Local technicians, spare-parts systems, and realistic service tiers	Improves continuity and trust

3.2 STUDY OBJECTIVES

- To examine the relationship between energy poverty and household well-being in remote-village settings.
- To identify common constraints involving electricity reliability, clean cooking, affordability, maintenance, and productive use of energy.
- To analyse how energy deprivation affects health, time use, education, livelihoods, safety, and social participation.
- To compare household energy priorities across representative remote-village contexts.
- To develop an integrated framework for energy planning that is practical, inclusive, and responsive to local well-being needs.

4. RESEARCH METHODOLOGY

The study adopts a conceptual and comparative research methodology. It draws on energy-poverty scholarship, rural development research, clean-cooking literature, decentralised energy studies, and well-being frameworks to identify conditions that connect energy services with household outcomes. The methodology is designed to clarify how everyday energy needs are affected by service quality, affordability, technology choice, household roles, and local institutions rather than to generate statistical estimates for a particular settlement.

A qualitative framework is used to examine the interaction between energy supply, household practices, social inequality, and the enabling environment for sustained use. Remote villages are not treated as uniform. They differ in terrain, livelihood patterns, market distance, resource availability, seasonal risks, social composition, public-service access, and existing energy infrastructure. The research approach therefore combines common energy-poverty dimensions with context-sensitive questions about what households need, when they need it, who benefits, and what may prevent a service from remaining functional over time.

4.1 RESEARCH DESIGN

- The study follows an evidence-informed conceptual and comparative research design.
- Energy deprivation is examined through the linked dimensions of access, reliability, affordability, safety, usability, and institutional support.
- The framework compares representative household circumstances rather than producing village-specific prevalence estimates.
- The analysis gives particular attention to the difference between infrastructure installation and the sustained delivery of useful energy services.

4.2 ANALYTICAL FRAMEWORK

- Availability of electricity, clean cooking fuels, lighting, charging, refrigeration, and mechanical power suited to household needs.
- Reliability and quality of supply, including operating hours, voltage stability, fuel continuity, seasonal disruption, and repair response.
- Affordability of connections, appliances, fuel, maintenance, and tariff payments in relation to household income patterns.
- Health, time-use, education, livelihood, safety, communication, and social-participation outcomes associated with energy conditions.
- Roles of local institutions, women's groups, technicians, cooperatives, public agencies, and service providers in sustaining access.

4.3 HOUSEHOLD WELL-BEING INDICATORS

- Ability to cook daily meals with reduced smoke, lower fuel-collection burden, and predictable access to suitable cooking energy.
- Availability of adequate lighting for study, care work, household safety, and evening activities.
- Ability to charge phones, access information, communicate during emergencies, and use digital services where available.
- Continuity of energy for water supply, refrigeration, irrigation, small businesses, processing, or other productive activities.
- Distribution of energy-related labour, expenditure pressure, and decision-making power within the household.

4.4 PARAMETERS OF ANALYSIS

The analysis evaluates the following parameters of energy poverty and household well-being:

- Adequacy of energy services for cooking, lighting, communications, water, cooling, and livelihood-related requirements.
- Predictability of access across seasons, weather conditions, payment cycles, and periods of repair or replacement.
- Household affordability, including upfront costs, recurring charges, appliance finance, and the trade-offs families make between energy and other essentials.

- Exposure to indoor air pollution, physical labour, safety risks, and time loss associated with traditional or unreliable energy arrangements.
- Inclusion of women, marginalised households, older persons, and persons with disabilities in energy decisions and benefit distribution.
- Availability of trusted maintenance, grievance response, local technical capacity, and transparent service governance.

4.5 PROCEDURE OF STUDY

- Review key concepts and research on energy poverty, rural energy access, clean cooking, decentralised systems, and household well-being.
- Identify recurring constraints involving supply reliability, cost, fuel collection, technology suitability, appliance access, and maintenance.
- Organise energy outcomes into health, time, education, livelihood, safety, communication, and social-inclusion dimensions.
- Compare representative household contexts to identify context-specific priorities and likely implementation barriers.
- Interpret how household practices, local institutions, and service design can either strengthen or weaken the well-being value of energy access.
- Develop practical implications for village energy planning, programme monitoring, community participation, and service accountability.

4.6 ANALYTICAL APPROACH

- Qualitative comparison of common energy constraints and household responses in remote-village environments.
- Assessment of relationships between technical performance, affordability, social roles, environmental conditions, and institutional support.
- Identification of co-benefits and limitations associated with grid extension, mini-grids, solar systems, clean cooking initiatives, and productive-use interventions.
- Use of an illustrative energy-poverty and well-being matrix to demonstrate how

priority actions can be selected for different household needs.

5. DATA ANALYSIS

The data analysis is based on a structured qualitative synthesis of the energy-poverty dimensions identified in the literature. The purpose is not to suggest that every remote village experiences identical conditions. Instead, the analysis uses common questions to interpret household energy deprivation: Which energy services are missing or unreliable? What daily activities are constrained? Who bears the time, health, and financial burden? What technology and support arrangements are actually usable? Which local institutions can help sustain the service?

The synthesis indicates that household well-being improves most when energy services are available as a dependable package rather than as isolated equipment. A solar lantern can reduce darkness, but it may not meet cooking, water, refrigeration, or livelihood needs. A grid connection can facilitate appliance use, but its value is limited when supply is erratic or tariffs are unaffordable. A clean stove can reduce smoke, but adoption may falter when fuel is not consistently available or cooking practices are not considered. Energy interventions should therefore be judged by

their practical contribution to household routines, not solely by the number of connections or units distributed.

The comparative assessment also shows that household conditions and institutional arrangements matter greatly. Families with stable income, access to appliances, and nearby repair services are often better able to convert energy access into improved education and livelihoods. Low-income, women-led, labour-constrained, or seasonally isolated households may require additional support such as flexible payment schedules, targeted subsidies, local financing, training, and responsive maintenance. The overall implication is that energy poverty is reduced most effectively when energy planning is combined with measures that protect affordability, inclusion, and continuity of service.

5.1 ILLUSTRATIVE COMPARATIVE ENERGY-POVERTY ASSESSMENT

Table 2 presents an illustrative matrix for interpreting how selected energy-service measures may contribute to household well-being. The classifications are conceptual and indicate relative priority rather than numerical performance for a specific village or programme.

Energy Dimension	Typical Household Constraint	Priority Response	Expected Contribution
Clean cooking	Smoke, fuel collection, and unsafe or slow cooking	Reliable clean fuel, efficient appliances, and user support	High - improves health and time use
Electricity reliability	Outages, low voltage, and limited productive use	Service standards, repair systems, and appropriate storage	High - supports continuity of daily activities
Affordability	Upfront cost, irregular income, and payment stress	Flexible finance, targeted support, and transparent tariffs	High - reduces exclusion from services
Productive-use energy	Insufficient power for irrigation, processing, or storage	Appliance access, training, and local enterprise linkage	Medium to high - strengthens livelihoods
Local maintenance and governance	Repair delay, weak accountability, and declining trust	Village technicians, spare parts, and grievance mechanisms	High - sustains long-term service value

6. DISCUSSION

The analysis confirms that energy poverty in remote villages is best understood as a continuing condition of constrained capability. A connection, panel, stove, or battery may be important, but the decisive question is whether the household can use energy safely, regularly, and affordably for activities that matter. This requires attention to service level, maintenance, user knowledge, appliance availability, and the fit between technology and daily routines. Energy planning that focuses only on installation targets can overlook the lived experience of households whose systems are present but inadequate.

One of the most significant findings is the importance of reliability. In many remote settings, uncertainty can be as damaging as outright absence. Households may avoid purchasing appliances, curtail productive activities, or continue using traditional fuels when they cannot depend on electricity or clean cooking fuel. Reliable service supports planning: students can study when needed, farmers can schedule irrigation, small enterprises can accept orders, and families can maintain communication during adverse weather or health emergencies. Reliability therefore has a direct relationship with confidence, risk reduction, and household decision-making.

The discussion also highlights that clean cooking should not be treated as secondary to electrification. Cooking remains one of the most intensive household energy uses, and dependence on smoky fuels can affect health, time use, local environments, and gender equality. Programmes need to consider fuel supply, payment practices, cooking preferences, safety, and the role of women in technology selection. A technically efficient stove may not deliver lasting benefits if the household cannot obtain fuel, repair the equipment, or use it for staple foods and seasonal cooking practices.

Productive use is another key pathway through which energy can strengthen well-being. Electricity for irrigation, cold storage, food processing, tailoring, charging services, digital access, and village enterprises may create income opportunities and reduce losses. Yet productive-use outcomes are shaped by finance, skills, market access, water

availability, business demand, and local regulation. Energy providers and rural-development agencies should therefore coordinate their efforts. A household energy system becomes more valuable when it is linked with opportunities that help families use saved time and reliable power to improve livelihoods.

Finally, the analysis underlines the need for accountable local governance. Remote systems often fail not because technology is inherently unsuitable, but because maintenance is delayed, spare parts are unavailable, roles are unclear, or households have no accessible way to report problems. Community participation should go beyond initial consultation. Users need meaningful roles in selecting service priorities, understanding costs, monitoring quality, and shaping repair arrangements. With appropriate support from public agencies and service providers, local technicians, women's groups, cooperatives, and village committees can improve continuity and trust.

7. CONCLUSION

This study presented a conceptual and comparative examination of energy poverty and household well-being in remote villages. The analysis showed that energy deprivation is shaped by the combined effect of availability, reliability, affordability, safety, technology suitability, household roles, and institutional support. Remote households may remain energy poor even when electricity or energy devices are physically present if services are insufficient for cooking, lighting, communication, water, cooling, or livelihood needs.

The study emphasises that energy planning should assess the practical services households can sustain and use, rather than relying only on connection counts or equipment distribution. Clean cooking, reliable electricity, flexible payment arrangements, productive-use opportunities, local maintenance, and inclusive participation can jointly reduce hardship and improve health, time use, education, livelihood security, and social participation. These measures are particularly important for women, girls, older persons, persons with disabilities, and households with low or seasonal incomes.

The paper concludes that meaningful energy access is a foundation for rural well-being, but

it must be designed as a long-term service rather than a one-time infrastructure intervention. Future research can apply the proposed framework through village surveys, household time-use studies, service-quality monitoring, participatory technology

assessments, and longitudinal evaluations of clean-cooking and decentralised-energy programmes. Such work can help translate broad energy-access commitments into locally accountable and well-being-centred solutions for remote communities.

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