Clean household energy and health:

A synthesis of country findings using the Household Energy Assessment Rapid Tool

World Health Organization

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Contents

Background

Household air pollution (HAP) remains one of the leading environmental health risks worldwide. In 2023, around 2.1 billion people still cook and heat their homes using polluting fuels and technologies—such as wood, charcoal, dung, crop waste, coal, and kerosene—on open fires or inefficient stoves.[1] Exposure to HAP is estimated to be responsible for 2.9 million premature deaths per year in 2021, including about 309,000 deaths among children under five, and contributes substantially to the global burden of cardiovascular and respiratory diseases.[2] These exposures are heavily concentrated in low- and middle-income countries (LMICs) and fall disproportionately on women, young children, and other vulnerable groups who spend more time near household cooking and heating activities.

Household energy use is also a major driver of ambient (outdoor) air pollution, accounting for a significant share of fine particulate matter ($PM_{2.5}$) in many regions and contributes to climate change through emissions of carbon dioxide and short-lived climate pollutants such as black carbon. The continued reliance on traditional biomass and other polluting fuels is linked to deforestation, ecosystem degradation, and gendered time and safety burdens associated with fuel collection. Despite decades of effort, progress has been slow: recent SDG7 tracking shows that more than a quarter world's population still lack access to clean fuels and technologies for cooking, and global trends suggest that the world is not on track to achieve universal access by 2030.

Clean household energy (CHE)—fuels and technologies that are considered clean and safe for health at the point of use—offers a major public health and development opportunity. Fuels such as electricity, LPG, biogas, and ethanol, used with appropriate appliances, can reduce HAP exposures to levels consistent with WHO air quality guidelines when properly adopted and used. To clarify what "clean" means for health, WHO issued the Guidelines for indoor air quality: household fuel combustion in 2014, providing health-based recommendations on which fuels and technologies can be considered clean and how to plan transitions away from polluting options.[3] These are complemented by the 2021 WHO Global Air Quality Guidelines, which set more stringent targets for $PM_{2.5}$ and other pollutants and highlight the need to reduce emissions from both household and ambient sources. Together, this normative guidance supports countries to design policies that maximize health benefits while also advancing climate and environmental goals.

The efforts towards clean household energy transition have been reinforced in global health and sustainable development agendas.

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1 IEA, IRENA, UNSD, World Bank, WHO. 2025. Tracking SDG 7: The Energy Progress Report. World Bank, Washington DC. © World Bank. License: Creative Commons Attribution—Non-Commercial 3.0 IGO (CC BY-NC 3.0 IGO).
2 Household air pollution [fact sheet]. World Health Organization. (https://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health).
3 Defining clean fuels and technologies. World Health Organization. (https://www.who.int/tools/clean-household-energy-solutions-toolkit/module-7-defining-clean).

SDG3 on health includes an indicator on mortality attributable to household and ambient air pollution, while SDG7 commits countries to ensuring universal access to “affordable, reliable, sustainable and modern energy” by 2030. Achieving SDG3 will depend, in part, on accelerated progress under SDG7, particularly in the areas of clean cooking and heating. Recent tracking reports emphasize that without stronger policy action, targeted finance, and better coordination across sectors, progress on clean cooking will remain too slow to meet 2030 targets.

In response, WHO Member States have endorsed a series of global commitments on air pollution, health, and energy. The 2016 Road Map for an Enhanced Global Response to the Adverse Health Effects of Air Pollution and its subsequent updates in 2025 call for countries to achieve a 50% reduction in the population-attributable fraction of mortality from anthropogenic sources of air pollution by 2040, strengthening health sector leadership, and integrating air quality and energy considerations into national development planning. The First WHO Global Conference on Air Pollution and Health (Geneva, 2018) launched the “Clean Air for Health” Geneva Action Agenda and mobilized multi-sectoral commitments to reduce air pollution and protect health. Building on this, the Second WHO Global Conference on Air Pollution and Health (Cartagena, 2025) brought together over 700 participants from 100 countries and secured new commitments from governments, cities, and partners to accelerate action on clean air, clean household energy, and climate mitigation, with a strong focus on implementation and accountability.

In parallel, clean cooking has been elevated as a substantive global priority under UN-Energy. Following the UN High-level Dialogue on Energy in 2021 and the UN Secretary-General’s Global Roadmap for Accelerated SDG7 Action, UN-Energy and partners developed Achieving universal access by 2030 and net-zero emissions by 2050: A global roadmap for just and inclusive clean cooking transition. This roadmap sets out policy, financing, and technology pathways to reach universal access to clean cooking while aligning with net-zero trajectories, and explicitly links clean cooking to health, gender equality, and climate objectives. Recent UN-Energy policy briefs and related initiatives further underscore clean cooking as a core area of SDG7 implementation, including through voluntary Energy Compacts and coordinated action by UN agencies and development partners.

Countries are seeking practical tools to translate global commitments into national strategies that deliver tangible health and equity gains. The Household Energy Assessment Rapid Tool (HEART), developed by WHO, responds to this need by providing a structured approach to rapidly assess household energy use, exposure to HAP, health impacts, and the policy and institutional landscape, and to identify opportunities for coordinated action. Initial HEART scoping studies were conducted in four countries (Ethiopia, Ghana, India, and Kenya), focusing on the role of the health sector in accelerating clean household energy transitions. Building on this foundation, the current series expands the assessments to nine countries—Ethiopia, Ghana, India, Kenya,

Nepal, Rwanda, Panama, Honduras, and Burkina Faso—spanning South Asia, sub-Saharan Africa, and Latin America.

This synthesis report brings together findings from these nine HEART country assessments. It summarizes national contexts and household energy landscapes; reviews policy, institutional, and health-sector responses; and examines the main barriers and opportunities for scaling clean household energy. The report then discusses common policy directions and regional patterns and articulates the HEART results within the broader global agenda on clean air, climate, and sustainable energy—including recent WHO roadmaps and global conferences, and UN-Energy's substantive priority on clean cooking. In doing so, it aims to support countries, health authorities, and partners to develop and implement integrated strategies that reduce exposure to household air pollution, improve health, and advance progress towards SDG3 and SDG7.

Policy Recommendations & Implications

The country-specific reports applying the Household Energy Assessment Rapid Tool (HEART) highlight consistent, multi-layered challenges across diverse income levels and regions. The transition to clean household energy is constrained less by the availability of technology and more by governance, financing, and institutional capacity. Policy choices on how responsibilities are shared across sectors, how subsidies are designed and targeted, how energy infrastructure is planned and regulated, and how health is integrated into energy and development strategies will determine whether countries can achieve universal access to clean household energy and reduce exposure to household air pollution. Across the nine assessments, recommendations cluster around three broad domains: 1) policy, governance, and implementation; 2) access, affordability, and infrastructure; and 3) health, communication, and research. The specific actions of these domains vary by country based on their current household energy mix, institutional, economic, and sociocultural contexts.

High-level national policy directions

Table 1 summarizes the primary policy priorities and the main clean fuel focus in each HEART country.

Table 1. High level national recommendations and primary clean fuel focus

Country	Key policy priority	Primary clean fuel focus
India	Enhancing existing mega-programmes (e.g., PMUY), securing refill affordability, strengthening inter-ministerial coordination	LPG, electricity (longer term)
Nepal	Institutional coordination across federal, provincial and local levels, formalizing health targets, updating electricity grid infrastructure	Electricity, LPG, biogas
Kenya	Shifting attention from “intermediate measures” (improved biomass stoves) to clean fuels, establishing coordinated, integrated action plans (WASH, social protection)	Clean fuels (LPG, ethanol)
Ghana	Making LPG cost-competitive with charcoal through subsidies; regulatory reform for safer, smaller LPG cylinders, expanding electricity where biomass dominates	LPG, renewable electricity
Rwanda	Formalizing the LPG supply chain (master plan, branded cylinders), leveraging community health mechanisms for uptake and finance	LPG, electricity
Ethiopia	Integrating household air pollution (HAP) into cross-cutting agendas (Health, Agriculture, Housing), using institutional kitchens and social programmes for adoption	Biogas, ethanol, electricity
Panama	Focusing subsidies and electrification on remote indigenous communities, planning urban transition from LPG to electric cooking	LPG, electricity, photovoltaic systems
Honduras	Ensuring reliability of electricity supply, stringent LPG safety regulation, targeted high subsidies for very poor households	LPG, electricity, stoves with chimneys in rural areas
Burkina Faso	Strengthening legal and institutional frameworks for indoor air pollution, reducing financial barriers for LPG and renewables	LPG, renewable energies

This pattern confirms that most countries are not starting from zero, but rather need to adjust and deepen existing policy and programme frameworks so that modern fuels become accessible, affordable, and reliably supplied, particularly for poor and rural households.

Cross-cutting policy directions

1. Strengthen governance and intersectoral coordination

All nine countries recommend clearer institutional mandates and stronger mechanisms for coordination across sectors. This includes:

- establishing or reforming intersectoral working groups that include the health sector, often under the Ministry of Health, to oversee household energy and health monitoring (Nepal, Ghana, Kenya, India, Ethiopia)
- converting broad biomass or energy strategies into explicit clean cooking strategies that prioritize clean fuels and

technologies (Rwanda)

- reviewing and updating energy, housing, and environmental policies so that indoor and household air pollution, WHO air quality guidelines, and specific health targets are systematically reflected (Nepal, Rwanda, Burkina Faso, India, Ethiopia, Ghana)

These measures are intended to reduce fragmented decision-making, clarify roles across central and local governments, and ensure that health and environment perspectives inform energy choices.

2. Improve access, affordability, and financial targeting

Affordability, particularly for sustained use of LPG and electricity, is a central barrier in all settings. Policy responses focus on:

- targeted subsidies for poor and marginalized groups, including reallocation of general LPG subsidies and more precise use of social protection systems and conditional cash transfers to reach vulnerable households (India, Nepal, Ghana, Panama, Honduras, Burkina Faso)
- fiscal incentives, such as exemptions from customs duties and value-added tax on clean stoves and fuels, to reduce upfront costs (Nepal, Rwanda)
- flexible financing mechanisms for low-income users, including microfinance, savings schemes, pay-as-you-go models, and village savings and loan associations for appliances and ongoing fuel purchases (India, Honduras, Rwanda, Ethiopia, Kenya)

The common implication is that universal access will require a shift from broad and sometimes regressive subsidies to more targeted instruments that support sustained use among the poorest households while allowing market development.

3. Develop and regulate energy infrastructure and markets for cooking

Several countries stress the need to build or formalize markets for LPG and other fuels and to ensure that electricity systems are able to support cooking:

- planning and regulating LPG supply chains through national master plans, branded cylinder recirculation models, safety standards, and rules allowing smaller, lighter cylinders (Rwanda, Ghana, Honduras, Burkina Faso)
- expanding and improving electricity distribution with explicit consideration of cooking demand, including off-grid solutions such as photovoltaic and small hydroelectric systems for remote communities (Nepal, Panama, Honduras, Ethiopia)
- coordinating clean household energy programmes with national electrification and housing strategies, and integrating

clean energy into slum upgrading initiatives (Ethiopia, Rwanda, Nepal)

Where electricity supply is unreliable, or LPG distribution is weak or perceived as unsafe, households remain reliant on biomass and kerosene even when nominal access has increased.

4. Institutionalize health, communication, and evidence

The reports consistently frame clean household energy as a public health intervention. Policy implications include:

- integrating HAP into health sector plans, including maternal and child health, noncommunicable diseases, and injury prevention, and creating care pathways that link diagnosis and counselling with access to clean energy solutions (India, Ethiopia, Kenya, Honduras, Nepal)
- training health workers and other frontline staff to communicate health risks, incorporate HAP in curricula, and use tools to "prescribe" clean household energy (Nepal, Ghana, Rwanda, Ethiopia, Honduras, Burkina Faso)
- using existing community and social platforms, such as Community Health Clubs, Umuganda, and social programmes, to promote adoption, support savings schemes, and reinforce behavior change (Rwanda, Kenya, Ethiopia, Panama)
- strengthening surveillance, registries, and research on energy use, injuries, exposure, and health outcomes, including links to biomass and fossil fuel use and equity dimensions (Ghana, Honduras, Nepal, Burkina Faso, India)

Systematically embedding household energy in health information systems and routine services is central to capturing health benefits and sustaining political attention.

5. Promote equity and inclusion

Even where national access to electricity and LPG is relatively high, deep spatial and social inequalities remain. Countries recommend:

- concentrating subsidies and programmes on remote rural, indigenous, and extremely poor communities that continue to rely on biomass despite national progress (Panama, Honduras, Nepal, Burkina Faso)
- designing differentiated approaches for urban and rural areas, with greater emphasis on LPG and electricity in urban settings and combinations of LPG, biogas, ethanol and improved electricity access in rural regions (India, Kenya, Ethiopia, Rwanda, Ghana, Honduras, Panama)

These measures respond to the evidence that transition pathways differ markedly within countries and that one-size-fits-all approaches are unlikely to close remaining gaps.

Regional policy implications

While implementation is nationally specific, the HEART assessments reveal distinct regional patterns that are useful for regional dialogue, technical cooperation, and financing strategies.

Table 2. Regional patterns in policy focus

Region and countries	Main policy focus	Example action
Sub-Saharan Africa (Rwanda, Kenya, Ghana, Ethiopia, Burkina Faso)	Building and formalizing supply chains and markets, reducing charcoal and firewood use	LPG master plans and branded cylinders, grid expansion aligned with cooking needs, community platforms
South Asia (India, Nepal)	Refining and financing large scale programmes, strengthening institutions and data	Targeted LPG subsidies and refill support, intersectoral coordination, large survey and surveillance systems
Latin America (Panama, Honduras)	Deep equity interventions and system reliability	Targeted subsidies for indigenous and poor households, rural photovoltaics (PV) and mini hydro, electricity reliability and LPG safety regulation

Sub-Saharan Africa

In Rwanda, Kenya, Ghana, Ethiopia, and Burkina Faso, the core policy task is to establish and mature markets for clean fuels while managing persistent dependence on charcoal and firewood. Key features include:

- strong emphasis on enabling and regulating LPG supply chains, including branded cylinder recirculation models, safety standards, and measures to reduce financial barriers to LPG and renewables (Rwanda, Ghana, Burkina Faso)
- explicit recommendations to move away from intermediate options, such as improved biomass stoves, and to prioritize genuinely clean fuels wherever feasible (Kenya)
- leveraging community structures and existing programmes, such as Community Health Clubs, Umuganda, WASH, and agricultural safety net programmes, to support adoption, awareness, and financing (Rwanda, Ethiopia, Kenya)

These findings point to the importance of combining regulatory reforms and infrastructure investments with investments in local social and institutional capacity.

South Asia

In India and Nepal, the main infrastructure and programmes for LPG and electricity already operate a large scale. Policy priorities,

therefore, shift to:

- ensuring that subsidy schemes and social protection instruments support sustained LPG use through refill affordability, while phasing out general middle-class subsidies and refining targeting to the poorest households and hard-to-reach areas
- strengthening intersectoral coordination across ministries and levels of government and aligning energy, health, and social protection objectives to reduce fragmentation
- expanding data systems, large-scale survey tools, and integrated health surveillance to monitor adoption, refill patterns, accidents, and health outcomes in order to adapt programmes over time and to plan a gradual transition to electric cooking where grid conditions permit

The regional implication is that attention now needs to focus on quality, equity, and sustainability of high-volume programmes, rather than on basic access alone.

Latin America

In Panama and Honduras, national levels of access to electricity and LPG are relatively high, but large disparities persist for remote, indigenous, and very poor populations. Policy implications include:

- implementing targeted equity interventions that concentrate LPG subsidies on the poorest households and facilitate access in indigenous regions, while expanding electrification with photovoltaic and small hydroelectric systems in low-income rural communities (Panama)
- comprehensively strengthening electricity distribution systems to guarantee continuous service, combined with clear communication on tariffs and meter functioning to build trust and reduce reliance on kerosene and other backup fuels (Honduras)
- strengthening institutional frameworks and market conditions for LPG, including safety regulation, regular checks, and sanctions for noncompliance, while promoting smaller cylinders for ease of purchase and transport (Honduras)

These experiences highlight that equity and reliability are central policy concerns even where headline access indicators are strong.

Global implications and conclusion

Taken together, the nine HEART country assessments point to a set of global policy imperatives that are relevant across regions and income levels.

Institutionalize health in energy and development policy. The widespread recommendation to establish intersectoral coordinating bodies involving the health sector, integrate HAP into national health

strategies, and embed care pathways that link health services to access to clean energy reflects a broad consensus that clean household energy is a core public health intervention.

At the global level, this implies that energy access targets should be aligned with health objectives, that health ministries should be supported to participate in national and international energy and climate processes, and that health evidence should inform investment decisions in household energy.

Prioritize financial targeting and sustained affordability. Across all regions, the reports stress that blanket or poorly targeted subsidies are unlikely to deliver universal access in a fiscally sustainable way. Instead, innovative but practical financial mechanisms are needed that:

- address both the upfront costs of appliances and the recurring costs of fuels
- leverage social protection and poverty targeting systems to reach the poorest groups
- support market development while limiting the risk of displacing private investment

Development partners and international financial institutions can play a role by supporting the design, implementation, and evaluation of such targeted schemes and by providing predictable, longer-term funding for clean household energy.

Harness climate and environmental finance for household energy. Several country reports recommend incorporating greenhouse gas and short-lived climate pollutant emissions from cooking and heating fuels into national climate mitigation goals and using evidence on co-benefits to mobilize additional finance. Nepal and Honduras explicitly propose linking household energy actions to climate commitments.

At the global level, integrating household energy measures into nationally determined contributions and air quality strategies, and seeking access to climate and carbon finance where appropriate, can help scale up clean household energy while delivering local health and equity gains.

Toward an integrated development approach. Finally, the assessments underline that achieving Sustainable Development Goal 7 on modern energy access is closely interconnected with progress on health, poverty reduction, and climate resilience. Ethiopia's promotion of biogas and ethanol in specific regions and Panama's urban electric transition strategy differ in technological choice but share a common logic of matching solutions to local capacity and household purchasing power.
From a global perspective, the transition to clean household energy should not be treated only as an infrastructure expansion effort. It should be managed as an integrated development strategy in

which success is assessed by sustained reductions in exposure to household air pollution, measurable improvements in health outcomes, more equitable access to clean and modern energy services, and contributions to national climate and environmental goals. This integrated approach is essential if national and international ambitions on clean household energy are to translate into durable, population-wide adoption.

India

1. Country Context

India is a vast country with a population of 1.2 billion (2011 census) and a steadily urbanizing demographic (31.14% in 2011). As an agrarian economy, about 60% of the land is used for agriculture, while forests cover 21.3% of the geographical area and provide an important source of biomass. Despite ongoing efforts to transition away from fossil fuels, clean household energy access remains challenging, particularly in rural and remote areas. Continued reliance on inefficient fuels contributes to the degradation of local tree cover and emissions of short-lived climate pollutants, including black carbon.

2. Household Energy Landscape

Access to Electricity

In 2011, 67.3% of households used electricity for lighting, though only 0.1% used it for cooking. Large-scale efforts resulted in the electrification of 99% of unserved census villages by 2015, supported by a generation capacity exceeding 350,000 MW (2016–2017) and the lowest recorded national power deficit. However, reliability concerns remain, and rural distribution networks often require upgrading to support higher loads needed for electric cooking. Many below-the-poverty-line (BPL) households receive low-capacity connections (<1 kW), limiting the use of induction stoves. Decentralized renewable systems continue to expand in difficult and inaccessible terrains.

Household Energy Mix

Solid biomass fuels remain the dominant cooking energy source, particularly in rural areas where stove-stacking is common. In 2011, 67.4% of households primarily used solid biomass for cooking, with significant rural–urban disparities (86.5% vs. 26.1%). LPG penetration was 28.6% in 2011, but usage patterns vary widely, with LPG often used only for limited tasks due to affordability and access constraints. Women spend substantial time collecting firewood—up to 374 hours annually in mountainous regions—highlighting the significant gender implications of household energy choices.

3. Policy and Institutional Context

National Policies

The Government of India has implemented several large-scale initiatives to increase access to clean household energy:

- Pradhan Mantri Ujjwala Yojana (PMUY) (2016), which aims to provide LPG connections to 50 million women in BPL families over three years, with a budgetary commitment of over US$1.5 billion (2016–2017).
- DDUGJY and Saubhagya, which target rural electrification and

free electricity connections for BPL households.

- The 2017 National Health Policy, which lists exposure to air pollution as a priority for action.
- National performance standards for subsidized biomass cookstoves, though these remain less stringent than WHO indoor air quality guidelines.

Institutional and Governance

Key agencies include the Ministry of New and Renewable Energy (MNRE), Ministry of Power, Ministry of Petroleum and Natural Gas (MoPNG), and Ministry of Health and Family Welfare (MoHFW). MoHFW established an expert committee on air pollution and health in 2015. Despite shared objectives, there is limited institutional coordination between MoHFW, MoPNG, and the Ministry of Environment, Forest and Climate Change, which constrains the integration of health considerations into energy policymaking.

4. Health Sector Overview

Burden of Disease from Household Air Pollution

Household air pollution is the fourth most important risk factor for mortality and morbidity in India, according to the Global Burden of Disease 2016. Exposure to HAP caused an estimated one million deaths annually in 2012, primarily due to COPD (33%), ischaemic heart disease (32%), and stroke (25%), with ALRI accounting for 8% of deaths. While morbidity attributable to HAP declined from over 5,000 per 100,000 population in 1990 to 1,730 in 2016, women and children remain disproportionately exposed to particulate concentrations far exceeding WHO guidelines.

Health System Capacity and Engagement

The National Health Mission implements major health programs, including those targeting non-communicable diseases (NCDs) such as COPD. Opportunities exist to integrate HAP risk communication into existing platforms, including:

- Front-line workers, particularly accredited social health activists (ASHAs), who have strong community credibility.
- Conditional cash transfer programs, such as the Pradhan Mantri Matritva Vandana Yojana, which can link clean cooking benefits to maternal and child health services.

However, awareness of HAP as a significant COPD risk factor remains limited among medical professionals, and patient counseling on mitigation strategies is uncommon.

5. Barriers to Adoption of Clean Household Energy

- **Affordability:** High upfront LPG connection costs (~Rs 3,000) and recurring refill costs (~Rs 450, even with subsidy).
- **Infrastructure constraints:** Limited LPG delivery in

remote areas; unreliable electricity supply; low-capacity BPL connections that restrict electric cooking use.

- **Behavioral factors:** Limited awareness of HAP risks; fear of LPG explosions; preference for traditional cooking practices and food preparation methods.
- **Institutional challenges:** Fragmented coordination between energy, environment, and health ministries.
- **Data limitations:** Gaps in high-quality data needed for epidemiological studies, cost–benefit analyses, and policy evaluation.

6. Opportunities for Advancing Clean Household Energy

India's strong policy commitment provides a foundation for scaling access to clean household energy. Opportunities include:

- Strengthening and expanding PMUY and the "Give It Up" subsidy redirection scheme to support fuel affordability.
- Leveraging improvements in electricity reliability and distribution to support long-term transitions toward electric cooking.
- Utilizing social welfare programs (e.g., MGNREGA, cash transfers) to enhance households' ability to afford clean fuels and appliances.
- Mobilizing ASHAs and health workers as trusted sources of information to increase awareness of HAP risks and the health benefits of clean cooking.
- Scaling biogas where strong technical servicing networks exist to ensure long-term functionality.

Nepal

1. Country Context

Nepal is a small, mountainous, low- to middle-income country of 147,516 km^2 with diverse geography across the Terai (17%), hills (68%), and mountains (15%). The population was 29.1 million in 2020, and the country is urbanizing rapidly. Poverty has declined to 18.7% (2018), though inequality remains high. Despite a 95.5% national electrification rate, 66% of households still rely on solid fuels for cooking. Nepal contributes only 0.06% of global greenhouse gas emissions but is highly vulnerable to climate change impacts.

2. Household Energy Landscape

Access to Electricity

Electrification is widespread (95.5% nationwide; 99% urban, 95% rural), but reliability and quality remain major challenges:

- 70% of grid-connected households report unreliable supply;
- 17% experience serious voltage problems;
- Only 47.4% receive 24-hour service.

Off-grid solutions—micro/mini hydropower and solar mini-grids—remain essential in remote regions but typically provide only 200–250 W per household and are not designed to support electric cooking. The Government targets 5,000 MW generation by 2023 and 15,000 MW by 2033.

Household Energy Mix

Firewood remains the dominant cooking fuel (52.4%), followed by LPG (33.1%), cow dung (8.5%), and biogas (3.1%). Cookstove stacking is common: 16.3% use two stove types, and 7.3% combine LPG with traditional stoves. Traditional stove use varies substantially by province, with traditional cookstove use being highest in Sudurpashchim (80.1%) and Province 2 (74.1%). Female-headed households, though generally have lower socioeconomic status and wealth, show similar access to clean energy once infrastructure is available.

3. Policy and Institutional Context

National Policies

Nepal aims to achieve universal clean energy access by 2030. Key national commitments include:

- 25% of households using electric stoves by 2030 (NDC, 2020);
- 500,000 improved cook stoves and 200,000 household biogas plants installed by 2025 (NDC, 2020);
- Promotion of clean household energy as part of the National Environment Policy (2019) to reduce pollution.

Air quality regulations include the national $PM_{2.5}$ standard of 40 µg/m^3 (24-hour average) and indoor guidelines of 100 µg/m^3 (1-hour average $PM_{2.5}$).

Institutions and Governance

Energy-sector leadership includes the Ministry of Energy, Water Resources and Irrigation, the Nepal Electricity Authority (with authority over transmission and distribution), and the Alternative Energy Promotion Centre (AEPC), which manages renewable energy programs and subsidies. Health-sector oversight lies with the Ministry of Health and Population.

Under the federal structure, local governments hold increasing responsibilities for energy planning, but coordination across ministries and sectors—particularly energy and health—remains limited, constraining coherent action on air quality and clean household energy.

4. Health Sector Overview

Burden of Disease from Household Air Pollution

Household air pollution is a leading risk factor for death in Nepal. In 2016, exposure to HAP resulted in:

- 23,397 deaths (rate of 119.9 per 100,000);
- 710,929 DALYs (rate of 2,453 per 100,000).

Leading causes include Chronic Obstructive Pulmonary Disease (COPD), ischemic heart disease, stroke, and lower respiratory infections. Mortality and DALY burdens have increased over the past decade.

Health System Capacity and Engagement

Primary care is delivered through community health centers and health posts under the MoHP. Female community health volunteers and mothers' groups already engage households on energy, health, and behavior change. The health sector is implementing a "Health National Adaptation Plan" to address climate change impacts. Health workers have high community trust and could be more intentionally mobilized to advance clean household energy translation.

5. Barriers to Clean Household Energy Adoption

- **Affordability:** Clean fuels and technologies require high upfront costs. For example, under current tariffs, electric cooking can be more expensive than LPG for households consuming >400 kWh/month.
- **Infrastructure:** Unreliable electricity supply affects 70% of grid-connected households; 61% of households in Kathmandu have only 5-amp connections, limiting electric stove use. Off-grid systems are not designed for cooking loads.
- **Awareness and Behavior:** Limited understanding of health risks associated with HAP and benefits of clean energy; male household members often make energy decisions.
- **Institutional and Data/Evidence Gaps:** Limited coordination between health and energy sectors; lack of updated data and

scientific evidence on cooking practices, HAP exposure, and its health consequences hinders planning.

6. Opportunities to Advance Clean Household Energy

- **Political Commitment:** 2018–2028 designated as the Decade of Energy and Hydropower; large-scale hydropower expansion is expected to improve electricity coverage and reliability.
- **Financial Incentives:** Customs duty on induction stoves is reduced to 1%, and households receive a 25% discount on electricity use up to 150 kWh/month. Targeted subsidies exist for solar, biogas, and improved cook stoves, with higher incentives for remote and vulnerable groups.
- **Social Protection Integration:** Platforms such as the school food programme and social security allowances could support conditional incentives for clean energy adoption.
- **Health Sector Engagement:** Health workers and volunteers represent a trusted entry point for HAP and health awareness and behavior change.
- **Market Potential:** Private sector activity is increasing, with approximately 50,000 induction stoves sold in the past three years.

Panama

1. Country Context

Panama is a Central American nation of 75,420 km^2, comprising 10 provinces and five Indigenous Comarcas. The population was 4.16 million in 2018, with high urbanization (66.9%) and a Human Development Index of 0.8. Despite a high GNI per capita (US$21,890 in 2017), social inequality persists (Gini 49.2), and poverty remains heavily concentrated in the Indigenous Comarcas, where multidimensional poverty levels are four to six times the national average.

2. Household Energy Landscape

Access to Electricity

Panama has achieved high national electrification coverage, reaching 93.35% of the population in 2018. Panama's electricity generation relies predominantly on renewable sources (77.7% of capacity in 2018), including 43.8% hydropower. Although national coverage is high, access remains deeply unequal: in Indigenous Comarcas such as Ngäbe-Buglé, Emberá, and Kuna Yala, electrification ranges from only 3.8% to 34.9%. Government programs such as Proyecto kioscos solares aim to expand photovoltaic access in remote communities. Electricity is heavily subsidized for low-volume consumers, 98% of customers receive support, yet affordability remains a challenge. For the poorest rural households, basic electricity consumption can represent 23–63% of monthly income.

Household Energy Mix

LPG is the main cooking fuel nationally (89%), supported by a long-standing subsidy for 25-pound cylinders. Firewood continues to be used by 10% of households, with a sharp rural–urban divide: 25% of rural households use wood, compared to 1% in urban areas. Usage is highest in Indigenous Comarcas, where reliance on firewood reaches 92.6% (Ngäbe-Buglé). Electricity for cooking is nearly negligible (0.5%). For lighting, most households use electricity, while those without access depend on kerosene and candles.

3. Policy and Institutional Context

National Policies Related to Household Energy

Panama is committed to achieving universal access to affordable, safe, and modern energy by 2030 (SDG 7). It is also a member of the Clean Air and Climate Coalition (CCAC), with residential biomass use responsible for 28% of national black carbon emissions. A key long-standing policy is the subsidy on LPG cylinders, in place since 1992. Initiatives such as Termosolar Panamá aim to expand solar water heater use, reduce electricity and LPG subsidies, and cut an estimated 162,325 tons of CO_2 annually. The country continues to promote energy matrix diversification and expanded renewable electricity generation.

Institutions and Governance

The National Energy Secretariat (SNE) leads energy policy, while the Authority of Public Services (ASEP) sets tariffs and regulates electricity services. The Ministry of Health (MINSA) and its Environmental Health Subdirectorate address health impacts linked to air pollution. Effective progress requires coordinated action across energy, health, and environmental sectors, particularly given Panama's decentralized structure.

4. Health Sector Overview

Burden of Disease from Household Air Pollution

Household air pollution from solid fuel use remains a significant health risk, contributing to cardiopulmonary diseases and acute and chronic respiratory illnesses. In 2016, HAP exposure caused an estimated 420 premature deaths, including 21 deaths among children under five, and 8,714 DALYs in adults over 25. An additional 1,907 DALYs occurred in children aged 0–4. Accelerating clean energy adoption could prevent more than 85,000 DALYs in a 10-year period.

Health System Capacity & Engagement

Health services are concentrated in urban centers, leaving Indigenous Comarcas with limited access to specialized care and low social security coverage (<10%, versus a national average of 52.6%). However, health professionals are trusted within communities and represent a promising channel for clean cooking awareness and behavior change. Strengthening primary care engagement, particularly through training on the health risks of firewood use, offers an important opportunity.

5. Barriers to Clean Household Energy Adoption

- **Affordability:** Even with subsidies, the recurring costs of LPG and electricity exceed the disposable income of many low-income rural and Indigenous households, preventing consistent use.
- **Cost of appliances:** High upfront prices for induction stoves and the need to purchase compatible cookware hinder adoption of electric cooking, especially in poorer households.
- **Infrastructure:** Electricity access and reliability remain limited in Indigenous Comarcas, and LPG distribution networks are weak or nearly absent in remote regions.
- **Geographic and Socioeconomic Inequities:** Poverty, limited access to health and social services, and longstanding inequalities in Indigenous territories make fuel transitions more difficult.
- **Policy and Evidence/Data Gaps:** No national policy or incentives supporting biogas production/use and limited local research on cooking practices, solid fuel usage patterns, or

barriers to adoption, making targeted policymaking more challenging.

6. Opportunities for Advancing Clean Household Energy

- Strong government commitment to renewable energy expansion provides a foundation for promoting electric cooking in urban areas with reliable infrastructure.
- Maintaining and better targeting the LPG subsidy can help sustain the major gains already achieved in reducing firewood dependence.
- Social protection programs (e.g., *Red de Oportunidades*) offer platforms to integrate support for clean fuel and appliance purchases among low-income families.
- The clear geographic concentration of firewood users enables targeted, context-specific interventions.
- Trusted primary care providers present an effective channel to integrate health messaging and promote clean household energy uptake.

Honduras

1. Country Context

Honduras is a Central American nation covering 112,492 km^2, with a tropical climate and extensive forest and agricultural lands. The population was estimated at 9.1 million in 2016, with 56% living in urban areas and an average household size of 4.4 persons. Despite steady economic growth (GDP 4.8% in 2017) and a medium Human Development Index (0.634 in 2019), poverty remains widespread, affecting 60% of the population. While electricity access is relatively high (over 80%), nearly half of households (47%—about 1.1 million) still rely on firewood and organic residues for cooking. Heavy dependence on traditional fuels contributes to an annual deforestation rate of approximately 42,000 hectares.

2. Household Energy Landscape

Access to Electricity

Electricity access reached 80.9% nationally in 2019, with coverage indices ranging from 85–87%. However, disparities are large: access is only 6% in the remote Gracias a Dios department. Supply is often unreliable, with outages lasting up to 24 hours, leading households to keep backup options such as wood or kerosene. The national utility (ENEE) is expanding generation capacity, including six planned hydroelectric projects (951 MW total) by 2026. Off-grid households—especially in low-access regions—use solar panels, ocote (pinewood), or candles for lighting.

Household Energy Mix

The national energy matrix is dominated by biomass, which accounts for 82% of primary energy. Firewood remains the dominant cooking fuel for 55% of households, including 87% of rural and 26% of urban homes. Other primary fuels include LPG (23%), electricity (17%), and kerosene (5%). More than 75% of households collecting wood obtain all their firewood themselves, usually spending 2–6 hours per week. Kerosene is still widely used for lighting in southern areas such as Choluteca (21% of households). Stove stacking is common, and cultural food practices—especially the preparation of corn tortillas—support continued use of wood-fired stoves even where cleaner fuels are available.

3. Policy and Institutional Context

National Policies Related to Household Energy

Honduras has integrated energy access into poverty reduction goals. Key initiatives include:

- National Strategy for the Sustainable Production and Use of Firewood and Charcoal (2015–2022) to improve sustainable resource use.

- Vida Mejor (Better Life) Program, which distributed more than 277,030 efficient biomass cookstoves ("Ecofogones") by 2019.
- A voluntary national standard for improved cookstoves (OHN 97001:2017) defining performance and emissions requirements.
- A Fund for the Renewal of the LPG Cylinder Fleet to strengthen safety and facilitate LPG use.

Institutions and Governance

Key institutions include the Secretariat of Health, the Secretariat of Energy (SEN), the Secretariat of Natural Resources and Environment (MIAMBIENTE), and the National Electric Energy Company (ENEE). NGOs such as AHDESA and Project Mirador play major roles in stove dissemination. However, reliance on short-term government or NGO programs limits long-term maintenance and access to spare parts. Additional regulatory support is needed for LPG distributors and to improve cylinder quality control.

4. Health Sector Overview

Burden of Disease from Household Air Pollution

Household air pollution from solid fuel use is the fifth leading risk factor for ill health. In 2016, WHO estimated 2,269 deaths attributable to solid fuel use, including 158 deaths among children under five. Long-term exposure contributes significantly to cardiovascular disease, stroke, COPD, and acute respiratory infections—conditions accounting for about 31% of premature deaths. Acute respiratory infections (ARIs) are the fourth leading cause of death in children under five.

Health System Capacity and Engagement

The public health system includes 1,503 primary care centers and a range of hospitals. Programs such as *Mejores Familias* (Better Families) engage women of reproductive age in health and nutrition education. Given the high public trust in health workers, the sector is well-positioned to support risk communication and behavior-change initiatives. However, improvements are needed in national health statistics—particularly for burns, kerosene poisoning, and other HAP-related outcomes—and in staff capacity to assess household exposure.

5. Barriers to Adoption of Clean Household Energy

- **Affordability:** Low-income households struggle with fixed electricity payments. Although monthly LPG costs are comparable to wood or kerosene, upfront investments for cylinders and refills remain prohibitive.
- **Infrastructure and Reliability:** Frequent electricity interruptions and incomplete rural grid coverage reinforce dependence on backup polluting fuels. LPG distribution is inconsistent, and transport of cylinders is often a burden for

consumers.

- **Awareness and Behavior:** Limited awareness of HAP health risks, fear of LPG accidents due to past incidents, and strong culinary traditions—especially tortilla-making—slow adoption of clean fuels.
- **Institutional Constraints:** Weak regulation of the LPG market reduces confidence in safety. Sustainability of improved stoves is undermined by limited maintenance options once project-based programs end.

6. Opportunities for Advancing Clean Household Energy

- **Government commitments:** The National Program for Rural and Social Electrification aims to expand rural electrification to 75%, supported by upcoming hydroelectric projects.
- **Targeted subsidies and safety measures:** Initiatives such as the LPG cylinder renewal fund help lower barriers to clean fuel access.
- **Large-scale dissemination platforms:** The distribution of efficient biomass cookstoves (the Ecofogones program) provides a strong foundation for reaching rural areas with efficient biomass stoves and eventually transitioning to cleaner fuels.
- **Health and climate co-benefits:** Reducing wood combustion cuts black carbon emissions, supporting both public health and climate objectives.
- **Leveraging existing social welfare programs:** *Bono Vida Mejor* and *Vivienda Saludable* can provide financial support for clean fuels among vulnerable groups.
- **Health sector engagement:** Trusted health workers can effectively communicate risks and benefits, supporting sustained behavioral change.

Kenya

1. Country Context

Kenya is an East African country straddling the equator and covering 582,646 km^2. The population was an estimated 45.56 million in 2014 and is exceptionally young, with 78% under the age of 35. Kenya reached middle-income status in 2015 with a GDP of US$ 61 billion, yet wealth disparities remain high: 90% of Kenyans in the bottom 40% of the income distribution live in rural areas. Urbanization is growing at 4.3%, though only 27% of the population currently resides in urban areas. Access to reliable and modern energy forms a core pillar of Kenya's national development blueprint, Vision 2030. The national energy profile is dominated by renewable energy sources (mainly biomass), which account for 69% of total energy use, while electricity represents only 9%.

2. Household Energy Landscape

Access to Electricity

Kenya has made significant progress, increasing electrification from 23% in 2009 to roughly 50% in 2016, with a national goal of universal access by 2022 through both grid and off-grid solutions. However, major disparities persist: electrification reaches 51% in urban areas but only 5% in rural areas. Nine of the 47 counties, including Marsabit, Turkana, and Wajir, remain largely off-grid. While 23% of households use electricity for lighting, a household in Nairobi is 36 times more likely to have electricity than one in Turkana or Tana River. The current grid remains concentrated in the central corridor, limiting nationwide expansion.

Household Energy Mix

Biomass (firewood and charcoal) and kerosene dominate household fuel use. Among rural households, where 73% of the population resides, 96% rely primarily on solid fuels or kerosene for cooking; in urban areas, this falls to 45%. LPG adoption is growing, particularly in urban and western regions. About half of all households cook inside the home—77% in urban areas and especially in informal settlements. For lighting, kerosene is the most widely used fuel (69% nationally; 84% in rural areas). Fuel stacking is common, with 54% of households using multiple fuels to manage price fluctuations, accessibility, and supply issues.

3. Policy and Institutional Context

National Policies Related to Household Energy

Access to modern energy services is central to Vision 2030 and Kenya's SE4All Action Plan, which targets universal modern energy access. The draft National Energy and Petroleum Policy (2015) projected that by 2022:

- 22% of households would transition to clean non-solid fuels

(including 18.6% LPG), and

- 52.7% would adopt improved cookstoves.

Kenya also issued Air Quality Guidelines in 2014 addressing household air pollution, and the National Climate Change Action Plan identifies distributed clean energy technologies as having a mitigation potential exceeding 10 Mt CO_2e annually by 2030.

Institutions and Governance

Key agencies include:

- Ministry of Energy and Petroleum: leading electrification (Last Mile Project) and LPG promotion;
- Ministry of Environment and Natural Resources: overseeing environmental standards and climate policies; and
- Ministry of Health (MOH): guiding health sector responses, including capacity building and HAP awareness.

Health services were devolved to county governments in 2013. Weak interagency coordination remains a major barrier, highlighting the need for a more cohesive national strategy led by strong interministerial partnerships.

4. Health Sector Overview

Burden of Disease from Household Air Pollution

Air pollution is the second most important environmental risk factor in Kenya. Household air pollution is estimated to cause 15,140 premature deaths annually—five times the national road accident death toll. Acute respiratory infections, frequently linked to HAP, are among the top five causes of death, with children disproportionately affected through lower respiratory infections.

Health System Capacity and Engagement

Kenya's six-tier healthcare system is overseen by the MOH, which integrates HAP concerns into broader strategies such as the Noncommunicable Diseases Strategic Plan 2017–2020, though no dedicated HAP policy currently exists. A major asset is the strong Community Health Extension Service and its network of CHWs. Existing platforms—particularly maternal and child health services—provide opportunities to integrate HAP risk assessment, health messaging, and mitigation strategies at the community level.

5. Barriers to Adoption of Clean Household Energy

- **Cost and affordability:** High upfront costs for LPG cylinders and electrical installation limit uptake. Low-income households often purchase small daily quantities of charcoal or kerosene despite higher unit costs.
- **Infrastructure limitations:** Poor road conditions impede "last-mile" distribution of clean fuels, especially in remote

counties.

- **Awareness and behavioral factors:** Perceptions that clean fuels are expensive, cultural preferences for traditional cooking, and limited awareness of HAP health impacts reduce adoption.
- **Policy and institutional constraints:** Weak interagency coordination and policies that continue to enable charcoal production and use.
- **Data gaps:** Limited local evidence on the performance and health benefits of clean technologies hinders effective policy planning and modelling.

6. Opportunities for Advancing Clean Household Energy

- **Strong political commitment** to universal electricity access and modern energy expansion.
- **Rapid electrification and growth of decentralized energy systems**, including mini-grids and stand-alone systems.
- **Innovative financing models**, such as “pay-as-you-go” systems successful in the solar sector, which could support clean cooking transitions.
- **Financial incentives**, including subsidized electricity connections via the Last Mile Connectivity Project.
- **Extensive mobile penetration (90.4%) and widespread mobile money use**, enabling digital financing and broad consumer awareness campaigns.
- **Social protection systems**, such as the National Safety Net Program, which could support transitions for more than 800,000 vulnerable households.
- **Strong CHW networks and integration into maternal and child health programs**, providing trusted platforms to promote the health benefits of clean household energy.

Ghana

1. Country Context

Ghana is a lower middle-income country on the west coast of Africa, covering 238,540 km^2, with an estimated population of 27.41 million in 2015 and an annual growth rate of 2.3%. Urbanization stands at roughly 50%, though the northern regions remain predominantly rural. Ghana is the second-largest economy in West Africa and attained lower middle-income status in 2011, with a per capita income of USD 1,367.70 in 2015.

2. Household Energy Landscape

Access to Electricity

Approximately 65% of Ghanaian households are connected to the national grid, with marked disparities: 84% in urban areas versus 40% in rural areas. As of 2012, around 7 million people still lacked electricity access. Frequent outages pose economic challenges, reducing business sales by over 5% in 2014. For lighting, kerosene and other polluting fuels remain common, used by nearly 18% of the population—especially in northern and eastern areas. The National Electrification Scheme and Self-Help Electrification Programme aim to achieve universal access.

Household Energy Mix

Solid fuels dominate cooking practices. About 76% of households use polluting fuels, primarily firewood (41.3%) and charcoal (31.5%). Rural reliance is almost universal at 94%. LPG use is growing but remains at 22% nationally, with much higher uptake in urban areas—over half of households in Accra. Cooking practices vary by region, from separate cooking spaces in coastal areas to open-air cooking in the north. Stove stacking is widespread. Kerosene remains commonly used for lighting.

3. Policy and Institutional Context

National Policies Related to Household Energy

Ghana's Sustainable Energy for All (SE4ALL) Action Plan (2013) emphasizes modern energy access for cooking. Key initiatives include:

- The Rural LPG Programme (2014), providing free cylinders to stimulate LPG adoption in targeted districts.
- Earlier improved stove dissemination efforts such as the "Ahibenso Coalpot Programme" (late 1980s).
- Ongoing development of cookstove standards and labelling systems by the Ghana Standards Authority.

Institutions and Governance

Household energy policy is led by the Ministry of Energy, with implementation by the Energy Commission (technical regulator) and

regulation of LPG by the National Petroleum Authority. The Ministry of Health engages through the Occupational and Environmental Health Unit. However, intersectoral coordination remains limited, and efforts to operationalize a multi-sectoral Health and Environment Strategic Alliance (HESA) committee has stalled due to lack of funding.

4. Health Sector Overview

Burden of Disease from Air Pollution

Air pollution ranks among Ghana's leading risk factors for premature death. Household air pollution causes an estimated 14,000 premature deaths annually. In 2012, HAP contributed to 7,796 stroke deaths and 4,238 acute lower respiratory infections among children under five. Diseases linked to HAP—lower respiratory infections, stroke, and ischaemic heart disease—are all among the top national causes of mortality. Health burdens are likely underestimated due to gaps in reporting other related outcomes like burns and injuries.

Health System Capacity and Engagement

The Ministry of Health recognizes HAP as a major public health issue and collaborates with energy and environment institutions on awareness and risk assessments. Opportunities for engagement include:

- The Free Maternal Health Services Initiative, reaching over 80% of pregnant women.
- The Ghana School Feeding Programme, which can support clean fuel adoption in institutional kitchens.
- Training programs for health personnel on HAP health impacts.

5. Barriers to Adoption of Clean Household Energy

- **Affordability:** High upfront cost of cylinders and recurring LPG expenditures, leading many households, especially rural, to revert to polluting fuels.
- **Infrastructure constraints:** Limited LPG distribution networks, long travel distances for refilling, and low local LPG production capacity.
- **Awareness and behavioral factors:** Misconceptions about LPG safety, low perception of HAP health risks even among health professionals, and economic dependence on charcoal production.
- **Institutional limitations:** Weak intersectoral coordination and absence of systematic monitoring and evaluation for the rural LPG programme.

6. Opportunities for Advancing Clean Household Energy

Ghana's policy environment provides strong entry points for scaling clean household energy:

- Government commitment to universal electricity access and clean cooking under the SE4ALL Action Plan.
- Expansion of innovative LPG delivery models (e.g., tricycle distribution) to improve rural access.
- Implementation of the cylinder recirculation model by the National Petroleum Authority to address safety concerns.
- Leveraging social protection schemes, such as Livelihood Empowerment Against Poverty (LEAP), to target vulnerable households.
- Aligning clean cooking transitions with Ghana's climate commitments by reducing black carbon and methane emissions.

Ethiopia

1. Country Context

Ethiopia is the second most populous country in sub-Saharan Africa, with over 100 million people, more than 80 million of whom live in rural areas. Its geography ranges from 100 meters below sea level to over 4,000 meters, creating diverse agro-ecological zones that influence cooking and housing styles. The country achieved rapid economic growth between 2004 and 2016 (10.6% annually), but 34% of the population remains below the poverty line and significant rural–urban inequality persists. The majority of households still rely on polluting biomass fuels for cooking, contributing to growing pressure on forests; logging for fuel is the second leading cause of forest degradation. Electricity generation is almost entirely renewable, mainly from hydropower.

2. Household Energy Landscape

Access to Electricity

Geographical electricity coverage is around 56%, yet only about 25% of households are actually connected. Urban–rural gaps are large: 95% coverage in cities versus 9% in rural areas. The national "integrated electrification road map" targets 100% access by 2025 (65% on-grid, 35% off-grid). However, reliability remains a major challenge—over 85% of households reported weekly outages—and the current grid infrastructure is insufficient to support widespread electric cooking.

Household Energy Mix

Polluting fuels and technologies are used in over 95% of households. Firewood dominates cooking (76%), followed by charcoal (8%) and dung cake (7%). Rural reliance on biomass is nearly universal; in urban areas, biomass remains common (38% firewood, 30% charcoal). Only 5% of households cook with electricity and 1% with LPG. Stove stacking is widespread. The traditional coffee ceremony in urban areas, a major source of high particulate matter (PM) and carbon monoxide (CO) exposure, drives daily charcoal use across all income levels. Firewood is also used for heating in high-altitude rural areas. For lighting, although many households use clean sources, about 30% still rely on kerosene or wood, with kerosene particularly prevalent in rural areas (31%).

3. Policy and Institutional Context

National Policies Related to Household Energy

Ethiopia's Constitution guarantees the right to a clean and healthy environment. The Government's "climate-resilient green economy" strategy prioritizes reducing greenhouse gas emissions and lowering demand for firewood through fuel-efficient and alternative fuel stoves (electric, LPG, biogas). The National Hygiene and Environmental Health Strategy identifies HAP as an emerging health concern. The "integrated electrification road map" sets a

universal access target for 2025. Cooking stove standards are under development, though indoor air pollution parameters are not yet included.

Institutions and Governance

The Ministry of Water, Irrigation and Electricity leads the energy sector and oversees utilities and alternative energy promotion. The Ministry of Environment, Forestry and Climate Change manages environmental policies and the national improved cooking stove program. The Ministry of Health addresses HAP within its Hygiene and Environmental Health Directorate. However, coordination remains limited due to overlapping mandates and fragmented implementation. The successful One WASH national programme provides a model for strengthening multisectoral collaboration in the clean household energy space.

4. Health Sector Overview

Burden of Disease from Air Pollution

Air pollution is the largest environmental risk factor for premature death in Ethiopia. Household Air Pollution contributes to more than 65,000 premature deaths and over 3.1 million DALYs annually. Lower respiratory infections (LRI) among children account for the largest share, with 36,144 deaths recorded in 2016. HAP also contributes to COPD, lung cancer, and cardiovascular disease among adults.

Health System Capacity and Engagement

Ethiopia's three-tier health system is anchored by primary care units and supported by the Health Extension Programme (HEP), a major institutional asset for reaching rural households. Health extension workers provide community outreach and household-level education. The Ministry of Health recognizes HAP as a multisectoral issue and integrates clean cooking messages into maternal and child health platforms, including antenatal care and maternity services, providing opportunities to reach pregnant women and families.

5. Barriers to Adoption of Clean Household Energy

- **Affordability constraints:** high upfront costs of clean stoves and biogas systems, combined with the perception that firewood is "free."
- **Infrastructure limitations:** dispersed rural settlements make electricity transmission expensive, and the grid remains unreliable.
- **Cultural and behavioral factors:** strong attachment to traditional practices such as the daily coffee ceremony; limited awareness of HAP-related health risks.
- **Institutional challenges:** weak interministerial coordination and unclear mandates hinder cohesive planning and implementation.

6. Opportunities for Advancing Clean Household Energy

- Strong political commitment through the climate-resilient green economy strategy, which identifies clean cooking as the largest mitigation opportunity.
- Progress toward universal electricity access under the 2025 electrification road map.
- Emerging financial mechanisms, including microfinance loans, installment payments, and carbon financing through housing programs.
- Leverage of the extensive Health Extension Programme for risk communication, household engagement, and clean energy promotion.
- Targeted solutions offer high potential:
    - Ethanol from surplus sugar production as a viable and competitive fuel.
    - Biogas systems, feasible for millions of livestock-owning rural households and supported by subsidies.
    - Institutional kitchens (schools, hospitals) as demonstration sites and entry points for scaling clean cooking practices.

Rwanda

1. Country Context

Rwanda is a small, landlocked, and mountainous East African country (26,338 km^2; altitude 950–4500 m) with a population of about 14 million and a median age of 19.2 years. Urbanization is increasing (17.6%), though regional poverty varies sharply (1% extreme poverty in Kigali vs. 32% in the Southern Province). Per capita income was US$ 797.9 in 2020. Despite national goals for universal electricity access by 2024, nearly all households (98.5%) continue to rely on polluting fuels—mainly firewood and charcoal—for cooking, contributing to deforestation and other social, health, and environmental concerns.

2. Household Energy Landscape

Access to Electricity

Rwanda has made substantial progress in expanding electricity access, yet important gaps remain.

- 70% of the population lives in areas with electricity (49% grid, 21% off-grid).
- Only 47% of households are actually connected.
- Access is highly uneven (93% in urban areas vs. 26% in rural areas).
- Reliability is a major concern: 91.7% of connected households experience more than four disruptions per week.
- Average household consumption is low (20.8 kWh/month), suggesting that the grid is not yet ready for widespread electric cooking.

Household Energy Mix

Biomass (firewood and charcoal) dominates Rwanda's energy system, accounting for about 85% of primary energy supply; the residential sector consume 82% of total national energy. Most households use traditional three-stone stoves (53%), primarily burning firewood, or other traditional biomass stoves (16%). Charcoal is the primary cooking fuel in urban areas (67%), while LPG use remains low (5%). Stove stacking is common even among improved cookstove users. Fuel collection is time-intensive and gendered: 76.5% of households spend over 7 hours per week collecting or preparing fuel, often relying on children in rural areas. In homes without electricity, lighting relies on dry-cell batteries, candles, and kerosene.

3. Policy and Institutional Context

National Policies

Rwanda has articulated strong national commitments to clean energy and environmental protection. Key goals include:

- Achieving 100% electricity access by 2024.
- Scaling LPG access to 38.5% of the population by 2030 through

the national LPG master plan.

- Reducing household dependence on wood for cooking to 42% by 2024.
- Advancing the National Strategy for Transformation, which prioritizes reducing particulate-emitting technologies.

National air quality standards are under development, and programmes such as the National Domestic Biogas Programme provide subsidies for biogas adoption.

Institutions and Governance

The energy sector is governed by the Ministry of Infrastructure (responsible for policy and strategy), with operations managed by the Rwanda Energy Group. Environmental oversight and air pollution monitoring fall under the Ministry of the Environment and Rwanda Environment Management Authority (REMA), while the Ministry of Health leads awareness-raising on the health impacts of household air pollution. Although cooperation exists, multisectoral coordination remains limited, with no clear national mechanism to integrate clean household energy actions across sectors.

4. Health Sector Overview

Burden of Disease from Household Air Pollution

Household air pollution remains a leading health risk factor in Rwanda. In 2019, it accounted for an estimated 6,932 deaths and 237,855 DALYs, primarily due to lower respiratory infections and ischaemic heart disease. Acute respiratory infections were the leading cause of morbidity in 2019–2020, representing 24.2% of all admitted patients.

Health System Capacity and Engagement

Rwanda's health system has made strong progress toward universal health coverage, supported by a network of more than 45,000 Community Health Workers (CHWs). The health sector recognizes HAP as a multisectoral issue and collaborates with energy and environmental institutions on health risk assessments and awareness campaigns. Platforms such as the CHW network and the Community-based environmental health promotion programme provide strong entry points for community-level clean energy outreach.

5. Barriers to Adoption of Clean Household Energy

- **Affordability:** High upfront costs for LPG cylinders, biogas systems, and clean stoves; limited and unattractive micro-finance options.
- **Infrastructure & Reliability:** Inadequate electricity capacity for high-load appliances and frequent power disruptions.
- **Market & Supply Constraints:** Fragmented LPG market with

unstandardized branded cylinders. Market concerns about the quality of some locally manufactured products.

- **Awareness & Behavior:** Low perception of HAP risks and persistent misconceptions about LPG safety.
- **Institutional:** Weak multisectoral coordination that limits effective implementation across institutions.

6. Opportunities for Advancing Clean Household Energy

- Strong government commitments to universal electrification, LPG scale-up, and biomass reduction targets create enabling policy momentum.
- Financial incentive programmes—including subsidies for low-income household electricity connections and Clean Cooking Results-Based Financing—may help address affordability constraints.
- Planned expansion of hydro, solar, and methane-based generation (e.g., Lake Kivu) offers opportunities to improve electricity reliability needed for electric cooking.
- Rwanda's network of more than 45,000 Community Health Workers and the national Umuganda social mobilization practice provide ready platforms for household air pollution awareness and community-level clean energy promotion.

Existing initiatives such as the national LPG master plan and improved cookstove programmes reflect strong strategic planning capacity that can be accelerated through strengthened cross-sectoral coordination.

Burkina Faso

1. Country Context

Burkina Faso is a landlocked West African nation covering 273,187 km^2. The population reached approximately 20.3 million in 2019, driven by a high annual growth rate of 3.1%. The country has a Sudanese climate with a long dry season (October–April) dominated by the dust-raising Harmattan winds. Life expectancy at birth is about 60 years. The economic context remains challenging, with poverty estimated at 40.1% and an adult illiteracy rate of 65.5%. Burkina Faso relies heavily on biomass and has weak and inequitable access to modern energy services. Nearly the entire household population depends on wood for cooking and indoor heating, contributing to significant environmental and public health pressures.

2. Household Energy Landscape

Access to Electricity

Electricity access remains low and highly unequal. As of December 2015, national access stood at 18.8%, with stark disparities between urban (59.9%) and rural (3.1%) areas. The power system faces an annual supply deficit of roughly 25 GWh, contributing to recurrent power shedding of up to 110 MW. National policy priorities include expanding production capacity for both conventional and renewable energy and operationalizing the National Agency for Renewable Energy and Energy Efficiency. To encourage clean technology adoption, the government exempted taxes and customs duties on solar equipment imports for five years beginning in 2013.

Household Energy Mix

Biomass dominates household energy use. In 2016, wood represented 77% of Burkina Faso's primary energy supply, with 88% of households in 2014 using wood or charcoal as their primary cooking fuel. Rising demand for biomass energy exceeds the sustainable forest resource base, accelerating overexploitation. Other household energy sources include LPG (butane), electricity, and solar energy. Efforts to promote improved cookstoves have been ongoing since the 1970s, with more than 204,000 distributed between 2006 and 2011, offering fuel savings of 35–80% compared with traditional three-stone fires. The National Biodigester Program has supported the construction of 1,232 biodigesters as of August 2018. Other practices that significantly contribute to indoor air pollution include burning plastics to start fires (45% of households), and daily burning of incense or religious products (32% of households).

3. Policy and Institutional Context

National Policies Related to Household Energy

Air pollution control is guided by the Environmental Code, Public Health Code, and Urbanism Code. The national energy policy (under

validation) aims to reinforce production capacity, promote renewable energy, and expand access to modern energy services. A central clean cooking target is the installation of 40,000 biodigesters by 2020. Although national decrees set concentration limits for ambient air pollutants, there are no regulatory texts specifically addressing indoor air pollution. The strategic framework lacks an overarching plan to combat air pollution, and international guidance—such as WHO recommendations on $PM_{2.5}$ and CO, and fuel restrictions—has yet to be fully integrated.

Institutions and Governance

The Ministry of Environment, Green Economy, and Climate Change leads national efforts to address air pollution, coordinating with ministries responsible for transport, trade, and health. The Ministry of Energy oversees energy strategy, renewable energy promotion, and efficiency measures. The Ministry of Health—through the Directorate for the Protection of Population Health (DPSP)—manages environmental public health functions and epidemiological surveillance, including for severe acute respiratory infections (ARIs). Despite the involvement of many actors, collaboration and coordination remain weak, contributing to the absence of a specific strategy or surveillance mechanism for indoor air quality.

4. Health Sector Overview

Burden of Disease from Air Pollution

Household air pollution poses a substantial health burden. In 2016, respiratory diseases linked to air pollution accounted for 1,168,304 DALYs, and the WHO estimated that indoor air pollution caused 16,500 deaths in 2004—around one-tenth of all deaths in the country. Biomass smoke exposure is strongly associated with respiratory and ocular diseases. Among children under five, 26% of severe ARI cases were linked to exposure to biomass pollutants from cooking. Studies from Ouagadougou found that even the use of wood in improved stoves was associated with markedly elevated respiratory risks (OR = 14.703). Monitoring shows consistently high exposure levels: $PM_{2.5}$, PM_{10}, and CO concentrations in homes using biomass consistently exceed WHO standards. Mean 24-hour CO concentrations of 17 ppm were documented in such households, surpassing recommended limits. Cooking outdoors in enclosed spaces also retained high CO levels, emphasizing the importance of ventilation and cooking location.

Health System Capacity & Engagement

The DPSP leads environmental health functions and oversees surveillance for 52 diseases, including severe ARIs. However, the health sector lacks a dedicated strategy to address HAP, and limited awareness exists among staff regarding the links between indoor air pollution and disease. Health promotion services currently do not run targeted communication activities on this issue.

5. Barriers to Adoption of Clean Household Energy

- **Institutional and policy gaps:** Lack of regulatory texts addressing indoor air pollution; no coordinated national strategy; weak cross-sectoral collaboration.
- **Affordability constraints:** High costs of LPG (butane) and renewable energy technologies limit adoption for low-income households.
- **Awareness and behavioral challenges:** Limited public understanding of pollution sources (e.g., incense, burning plastics) and associated health risks contributes to harmful practices.
- **Data and monitoring limitations:** Few studies and no indoor air quality surveillance system hinder effective policy planning and enforcement.

6. Opportunities for Advancing Clean Household Energy

There are several strengths and opportunities to build on:

- **Policy commitments** to renewable energy expansion and the establishment of the National Agency for Renewable Energy and Energy Efficiency.
- **Supportive financing environment**, including interest from international partners and ongoing public programs for improved cookstoves and biodigesters.
- **Growing research and training capacity** at national universities and institutes to strengthen the evidence base for clean energy solutions.
- **Health and social platforms**, such as the Directorate for Health Promotion and Education, which can support public communication efforts.
- **Existing ventilation practices**, with 91% of households regularly opening windows, an important behavioral asset for reducing pollutant concentrations.

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