

Breathing Room: Cleaner Fuels for Home Cooking in LMICs

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<https://doi.org/10.1289/EHP12232>

Cooking with solid fuels is risky, not just for the estimated 2.4–2.8 billion people^{1–3} who rely on these fuels at home, but also for the future of the planet. Household air pollution—which includes the noxious fumes from incomplete combustion of wood, charcoal, coal, crop residues, dung, and others—is considered one of the leading environmental causes of disease.⁴ The World Health Organization (WHO) estimates household air pollution is responsible for around 3.2 million premature deaths each year.¹ In addition, collecting solid fuels contributes to land degradation and deforestation⁵ and imposes an inordinate burden on women and children.^{4,6,7} Finally, burning these fuels produces at least 2% of global carbon-equivalent emissions.⁸

In many low- and middle-income countries (LMICs), cleaner-burning natural gas—often in the form of liquid petroleum gas (LPG)—has long been pursued as a feasible solution to reducing household air pollution and other impacts from solid cooking fuels. The recently completed Household Air Pollution Intervention Network (HAPIN) trial⁹ offers robust evidence that in a best-case scenario, with LPG stoves and cylinders provided free of charge, residents' exposures to fine particulate matter (PM_{2.5}) can be brought below interim guidelines established by the WHO.¹⁰

LPG cookstoves are far from a perfect solution, however. Fossil fuels—including natural gas—must be rapidly phased out to avoid the worst impacts of climate change, according to the Intergovernmental Panel on Climate Change.¹¹ Gas stoves emit pollutants that are harmful to human health.¹² Finally, provision of gas relies on distribution networks that are subject to interruption¹³ and a global market with fluctuating prices,¹⁴ so low-income, rural communities cannot rely on a steady and affordable supply.

As a result, some in the clean-cooking field have begun to advocate leapfrogging past LPG and prioritizing a shift from the dirtiest fuels to electric cooking devices. Access to electricity is expanding in LMICs,¹⁵ and such a switch would not only drastically reduce air pollution inside homes, they argue, but also help pave the way for a decarbonized global energy sector.

Could it be that easy?

Electrification May Not Mean Clean Cooking

Perhaps the biggest bet yet on electric cooking has come from the British government's UK Aid Direct program, which in 2019 committed approximately \$50 million toward an initiative called Modern Energy Cooking Services, or MECS. Led by England's



Traditional solid fuels such as wood, charcoal, crop residues, and dried dung are used for home cooking by billions of people, contributing to adverse health outcomes, climate change, and environmental degradation. On Russia's Yamal Peninsula (shown here), as in many places around the world, women maintain cooking fires and prepare meals, exposing themselves and others to indoor air pollutants. Image: © Elena Chernyshova/Panos Pictures.

Loughborough University and the World Bank's Energy Sector Management Assistance Program (ESMAP), the 7-year program aims to rapidly accelerate the transition from biomass-based cooking to, as its name states, modern energy cooking services—a term that encompasses not just clean energy but also efficiency, convenience, safety, reliability, and affordability.¹⁶

Three years in, MECS continues to advocate for electric cooking as a multi-benefit solution to the climate, health, and social problems caused by widespread use of solid fuels. In August 2022, at a webinar hosted by the Colorado State University–based consortium Advancing Sustainable Household Energy Solutions (ASHES), MECS research director Ed Brown stated that after two to three decades of effort, the provision of cleaner cooking fuels is barely keeping up with population growth. “Over these years,” he said, “we’ve come to the conclusion that the really big potential game changer—indeed, we think it is far more than ‘potential’—is electricity.”¹⁷

A key element undergirding this logic is that global access to electricity has been expanding dramatically. Over the last decade, tens of billions of dollars have been invested annually in building and maintaining new connections, and an estimated 1.3 billion people globally gained electricity access between 2010 and 2020.¹⁵ In Asia overall, connectivity approaches 90%, up from 66% in 2000;^{15,18} in sub-Saharan Africa, the regional average is now above 50%, although large populations lack access, especially in Nigeria, the Democratic Republic of Congo, and Ethiopia.^{15,18}

However, progress in electricity access has not always been accompanied by adoption of clean electric cooking, Brown says. For example, in Kampala, Uganda, a city of 1.7 million people, nearly all households are connected to a reliable electrical grid,¹⁹ yet only 8% used electric stoves as of 2014—over three-fourths still cooked with charcoal, and most of the rest used firewood, LPG, or kerosene. Similar situations exist in Southeast Asia. Globally, at least 1.8 billion people who have access to electricity continue to cook with highly polluting traditional fuels.²⁰

One reason for this, Brown suggests, is that energy access and clean cooking have been siloed into separate campaigns, with electricity often being advanced primarily as a means to achieve better lighting and “productive use” (including powering and charging electronic devices), to the exclusion of cooking.

For example, Colorado State University professor of mechanical engineering John Volckens, who co-leads the ASHES consortium, is running the Sustainable Household Energy Adoption in Rwanda (SHEAR) study alongside Maggie Clark of the University of Colorado. This study will bring solar-powered electricity into remote rural households for the first time—but not for cooking. The electricity is mainly for lighting, because the trial's low-voltage power supply is not sufficient to support cooking appliances.

“We could have created a more powerful grid if we wanted to, but that still wouldn't have worked for cooking,” Volckens says. He explains that batteries to store electrical energy from solar power are still prohibitively expensive in LMICs. “Solar power is



Households with access to electricity may continue to cook with charcoal (shown here) and other solid fuels for many reasons, including inadequate or inconsistent power supply. Charcoal stoves, for example, are cheap and widely available, and charcoal is less bulky to transport and cook with than wood.²¹ Image: MECS, *The Kenya eCookbook* (CC BY 4.0).

only cost effective when the sun is shining, so participants cannot cook at night or early in the morning,” he says, pointing out that instead, households in the SHEAR study will be provided with LPG stoves. Researchers will investigate the combined health benefits of simultaneously switching both lighting and cooking to cleaner fuels.

Still, Volckens agrees that electricity is the future of clean cooking. “It’s absolutely critical, both for health and for climate, to move away from fossil fuels,” he says. “We know that although burning natural gas is cleaner than wood, it’s not clean. Natural gas creates nitrogen oxides, it creates ultrafine particles, and these are things that we know can do harm. Moving to electric cooking is the direction we want to go.”

A related reason for the slower adoption of electric cooking is infrastructure, says Jennifer Peel, a professor of epidemiology at Colorado State University and one of three principal investigators for HAPIN (along with William Checkley of The Johns Hopkins University and Thomas Clasen of Emory University). Although great progress is being made in electrification, grids in some rural or poorer communities are not up to the task of handling an electric stove or pressure cooker in every home, she explains. Such grids may not be stable or reliable enough to support everyone cooking at the same time, or, as with SHEAR’s grid, they may not run on the necessary current. In such cases, LPG likely remains the best available clean-cooking option—for now.

“It’s not as easy a choice as it may seem when you have to deal with the realities in low-resource settings,” she says. “I think we have to continue to be both dynamic and aspirational. Everybody has the right to clean cooking and clean air.”

Natural Gas—Cleaner Indoor Air in the Interim

HAPIN investigator Kalpana Balakrishnan, of India’s Sri Ramachandra Institute of Higher Education and Research, acknowledges the proven benefits of electric cooking for both health and climate. But, like Peel, she is wary of singling out electric cooking as the solution of choice when so many people are still using solid fuels, and electricity is either out of reach, unreliable, or too expensive for many of them.

“Nobody is arguing the benefits of [renewables], but the perfect can’t be the enemy of the good,” Balakrishnan says. “We shouldn’t throw out everything we know about LPG stoves just because we’re looking forward to electricity.”

Rather, she says, LPG remains positioned to serve as a valuable bridge fuel in India and elsewhere. “LPG is the most scalable near-term proposition to achieve health and climate benefits,” she emphasizes. “If you don’t enable the biomass-using households to scale the energy ladder and transition to LPG and [instead,] keep waiting for the perfect solution to emerge, then the energy inequities are just going to widen beyond repair.” Indeed, a national campaign in India to promote LPG for home cooking has already demonstrated that the fuel can be brought to scale rapidly given the right setting and investment, Balakrishnan states. As recently as 10 years ago, roughly 75% of the population cooked primarily with solid fuel, she says; today, that figure is down to 45%–50%. Much of this progress is attributable to general economic growth in combination with the government’s campaign, which has included infrastructure development, public messaging and campaigning, cost subsidies, and free connections to households below the poverty line.



Balakrishnan and others see LPG stoves, such as this one in Uttar Pradesh, India, as a bridge toward cleaner cooking, helping reduce use of solid fuels as electrification efforts are under way. Image: © Bloomberg/Getty Images.

Meanwhile, the HAPIN study has demonstrated more conclusively than ever that meaningful reductions in household air pollution can be achieved through consistent use of LPG stoves.²² “We were really pleased to see the proportion of the intervention measurements, about 70%, that were below the WHO Interim 1 standard for fine particulate matter of 35 $\mu\text{g}/\text{m}^3$,” says Peel. “That’s pretty remarkable, especially compared to previous similar trials that were trying to reduce exposure.”

In homes that switched from solid fuels to LPG, HAPIN researchers found associations between lower exposures to both $\text{PM}_{2.5}$ and black carbon and higher birthweight and weight-for-gestational-age among babies born to mothers living in those homes, suggesting that using the new stoves may have also meaningfully improved health outcomes.²² As of February 2023, these results had not yet been peer-reviewed but were available as a preprint.

Still, $\text{PM}_{2.5}$ concentrations inside homes that received the intervention were not as low as the WHO’s ambitious new guideline of 5 $\mu\text{g}/\text{m}^3$.²³ “If a community can bypass LPG and get to electric cooking—induction stoves—that’s probably the way to go,” Peel suggests. “The question is, how many communities can get there, and when?”

Scaling Up Electricity for the Long Term

MECS sees a solution in grouping cooking together with other household needs supported by electrification. To achieve its goals, the program publishes original research and other resources, such as case studies, country-specific market assessments, factsheets on the viability of electric cooking, and cuisine-specific cookbooks

tailored for the use of electric appliances (<https://meecs.org.uk/publications/>). In one oft-cited albeit non-peer-reviewed finding from MECS research, published in *The Kenya eCookbook* in 2018,²¹ cooking beans with an efficient electric pressure cooker cost seven times less than cooking with charcoal and took half as long. It was also far cheaper than three alternatives: kerosene, LPG, and a traditional electric-coil hotplate.²¹

Another tool employed by the program is a challenge fund to support research projects geared toward safe and efficient modern energy cooking systems. Competitions, each with their own focus and objectives,²⁴ are open to companies and organizations of all sizes, as well as participants from academia.

MECS has launched a global call to action dubbed “40,60 by 2030.”²⁵ It proposes that by 2030, 40% of all households connected to grid or off-grid electricity should use it for cooking, and 60% of households cooking with electricity should use power generated from low-carbon sources, which include wind, solar, nuclear, or hydropower.

Sheila Oparaocha, director of Energia, a Netherlands-based nonprofit that supports gender equality in energy access throughout Africa and Asia, has partnered with MECS to promote 40,60 by 2030. In announcing the program during a 2022 webinar, she said electricity will provide the long-term solution to decarbonizing cooking as the international community embraces the greening of power generation.¹⁷

“Electric cooking offers the opportunity for rapid scaling through its incorporation into existing electrification programs [that have] the kind of large budgets that dwarf the amounts available for separate clean cooking programs,” Oparaocha said.



Exposure to $\text{PM}_{2.5}$ is associated with birth outcomes that can predispose a child to future health problems. Reducing household air pollution through effective cooking interventions promises some relief from these challenges to children’s growth and healthy development. Image: © Aubrey Wade/Panos Pictures.



To encourage adoption of electric cooking, MECS has developed a series of eCookbooks with recipes and advice tailored to specific countries. For example, the *Myanmar eCookbook*²⁷ suggests that in off-grid areas or where the electrical grid is weak, lower power devices be used, including electric fryers, rice cookers, and pressure cookers. Images, clockwise from top left: © iStock.com/undefined, © Muhammad Wafa/Shutterstock.com, © Arina P Habich/Shutterstock.com.

Another of MECS's committed partners, ESMAP, collaborated on a key 2020 report²⁶ that found the rate of access to modern energy cooking services for cooking (including electricity, LPG, and other cleaner-burning fuels) stands at only 10% in sub-

Saharan Africa, 36% in East Asia, and 56% in Latin America and the Caribbean. The report also estimated that \$150 billion will be needed annually to reach universal access to modern energy cooking services by 2030.



Renewable energy sources such as biogas, wind, solar, and micro hydropower are helping bring electricity to rural parts of Nepal, left. The Nepal-based non-governmental organization People, Energy & Environment Development Association says that women and girls here play vital roles in spreading awareness about the dangers of indoor air pollution and introducing new technologies to mitigate them.³⁰ A Nepalese woman, right, in the district of Rukum, cooks on an electric induction stovetop. Images, left to right: © iStock.com/LSP1982; Courtesy of People, Energy and Environment Development Association (PEEDA), Nepal.

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