TRACKING SDG7

THE ENERGY PROGRESS REPORT 2021

A joint report of the custodian agencies

IEA International Energy Agency

IRENA International Renewable Energy Agency

United Nations Statistics Division

THE WORLD BANK IBRD • IDA | WORLD BANK GROUP

World Health Organization

Report designed by: Duina Reyes
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CHAPTER 2

ACCESS TO CLEAN FUELS AND TECHNOLOGIES FOR COOKING

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MAIN MESSAGES

- **Global trends:** Current trends suggest that unless rapid action is taken to scale up clean cooking, the world will fall well short of the SDG 7 target of universal access to clean cooking fuels and technologies—by almost 30 percent. The result? Only 72 percent of the population will have access to clean cooking in 2030.[24] Annual increases of more than 3 percentage points will be required between now and 2030 to achieve the goal. In 2019, the share of the global population with access was 66 percent (59–71 percent),[25] leaving a third of the population—some 2.6 billion people (2.2–3.1 billion)—without access. Compared with 2010, access to clean fuels and technologies has risen to date by only 9 percentage points, from 57 percent (52–62 percent). Unless we accelerate action, the environmental, social, and health toll will continue, falling disproportionately on women and children, who bear primary responsibility for gathering fuel and preparing meals on polluting stoves.
- **Access and the 2030 target:** From 2010 to 2019, the global rate of access to clean cooking fuels and technologies increased annually by a percentage point (0.2–1.8). The acceleration in the rate was driven overwhelmingly by large, populous countries in Asia (from Central and Southern Asia to Eastern Asia and South-eastern Asia). In Sub-Saharan Africa, by contrast, population growth outpaced gains in access. In 2019, for the first time, more people without access to clean cooking fuels and technologies resided in Sub-Saharan Africa than in any other region, surpassing Central Asia and Southern Asia.
- **Regional highlights:** The regions of Central Asia and Southern Asia—along with Eastern Asia and South-eastern Asia—account for most of the access gains for the period 2010–19; each region saw annualized increases in access to clean cooking of 2.5 percentage points (0.3–4.5) and 1.4 percentage points (-0.6–3.4), respectively. The Latin America and Caribbean region has remained stable, with access at 88 percent (85–91) and an average annual increase of 0.3 percentage points (-0.2–0.8) for the period 2010–19. Marginal increases in access were seen in Sub-Saharan Africa, with annualized increases of 0.47 percentage points over the same time period.
- **Closer look at Sub-Saharan Africa:** Urgent progress is needed in Sub-Saharan Africa. In 2019, for the first time, more people without access to clean fuels and technologies reside in Sub-Saharan Africa than anywhere else, surpassing Central Asia and Southern Asia, which in 2018 housed the highest access deficit. The region's population grew by 26 million people per year between 2010 and 2019, while the population with access to clean fuels and technologies grew by only 8 million per year, resulting in an access-deficit population in this region of 910 million (880–930). In fact, the access deficit in Sub-Saharan Africa has risen by more than 50 percent since 2000.
- **Global and regional fuel trends:** Globally, the use of cleaner gaseous fuels increased consistently in the period 2010–19, reaching 51 percent (45–58) in low- and middle-income countries in 2019 and overtaking biomass as the dominant cooking fuel. Use of electricity for cooking also increased in that period, reaching 7 percent (4–12) in low- and middle-income countries. Globally, the use of kerosene declined. But its use remains notable in urban areas of low- and middle-income countries in Oceania, excluding Australia and New Zealand (10 percent [6–18]) and Sub-Saharan Africa (8 percent [6–11]).
- **Urban-rural divide:** The worldwide discrepancy between urban and rural areas in access to clean cooking fuels and technologies dropped over the past decade. In 2019, the difference in access was 42 percentage points (31–51), with 85 percent (77–88) of urban dwellers having access to clean fuels and technologies, compared with 42 percent (35–50) of rural dwellers. The access gap between urban and rural areas has decreased since 2010 owing, first, to improvements in rural access and, second, to urban population growth that is beginning to outpace the rate of growth in access to clean cooking. Differences in fuel trends suggest a steady rise in the uptake of gaseous fuels in rural areas, while use

24 SDG Goal 7.1—Ensure universal access to modern energy services; indicator 7.1.2—proportion of population with primary reliance on clean fuels and technology (https://sdgs.un.org/goals/goal7).

25 Parenthetical figures appearing after estimates throughout the chapter are 95 percent uncertainty intervals, as defined in methodology section at the end of this chapter.

of gaseous fuel has plateaued in cities. Reliance on electricity for cooking is growing in both urban and rural areas of low- and middle-income countries; however, it is rising at a much greater rate in urban areas, where growth is estimated at 0.44 percentage points per year, compared with 0.13 percentage points per year in rural areas.

- **The top 20 countries with access deficits:** Of the top 20 access-deficit countries, 10 are in Sub-Saharan Africa, 6 in Eastern Asia and South-eastern Asia, and 4 in Central Asia and Southern Asia. In total, they accounted for 81 percent of the global population without access to clean fuels and technologies in the period 2015–19. Of these countries, 7 have proportions of their respective populations with access at or below 5 percent, including Democratic Republic of the Congo, Ethiopia, Madagascar, Mozambique, Niger, Uganda, and Tanzania. Sixteen of the 20 countries have access rates of less than 50 percent. Meanwhile, Indonesia, Cambodia, and Myanmar achieved annual gains in access exceeding 2 percentage points in the period 2015–19.
- **Top 5 most populous countries:** During the period 2010–19, the top 5 most populous low- and middle-income countries (China, India, Indonesia, Brazil, and Pakistan) increased their combined access rate by 2.1 percentage points. During the same period, the average global access rate for all other low- and middle-income countries remained unchanged or stagnant. To ensure no one is left behind, political commitment and financial incentives must be prioritized in all access-deficit countries to achieve the universal target of SDG 7.
- **Investment needs scaling up:** Public and private finance for clean cooking remains far below the level of investment needed to achieve universal access to clean cooking by 2030. Estimates from various institutions, including Sustainable Energy for All, and the International Energy Agency (IEA) have reported that an annual investment of USD 4.5 billion is required to achieve clean cooking for all—or around USD 2 for every person without access in 2019. But the current level of investment is only a fraction of this—estimated at about USD 131 million in 2018 (SEforAll 2020), or around USD 0.05 for every person without access.
- **What are the costs?** In addition to the heavy environmental and health toll exacted by polluting cooking fuels and stove combinations, the economic costs of household reliance on these fuels and technologies are estimated to be on the order of USD 2 trillion per year (USD 1.4 trillion for health care costs, USD 0.8 trillion from lost productivity of women, and USD 0.2 trillion for environmental degradation)[26]—translating in 2019 to USD 1,000 for every person lacking access. In view of the monumental cost savings compared with the level of investment, an overwhelming economic case can be made for countries to invest in transitions to clean cooking.
- **Clean cooking in post-COVID-19 recovery:** Strategic policies and financial incentives will be key to recovering from setbacks in access to clean cooking and pollution exposure resulting from the COVID-19 pandemic. National governments will play a vital role in expanding targeted policies and subsidies so progress toward universal access to clean cooking can accelerate—particularly in Sub-Saharan Africa, where rapid progress is urgently needed.
- **Progress in policy:** The World Bank's annual Regulatory Indicators for Sustainable Energy (RISE) provides a snapshot of a country's policies and regulations. The 2020 edition (ESMAP 2020a) indicates that, of the 55 access-deficit countries included in the analysis, the number with advanced policy frameworks rose from none in 2010 to a total of eight in 2019, ultimately shifting about a quarter of access-deficit countries into the green zone on the RISE index.

26 ESMAP 2020b.

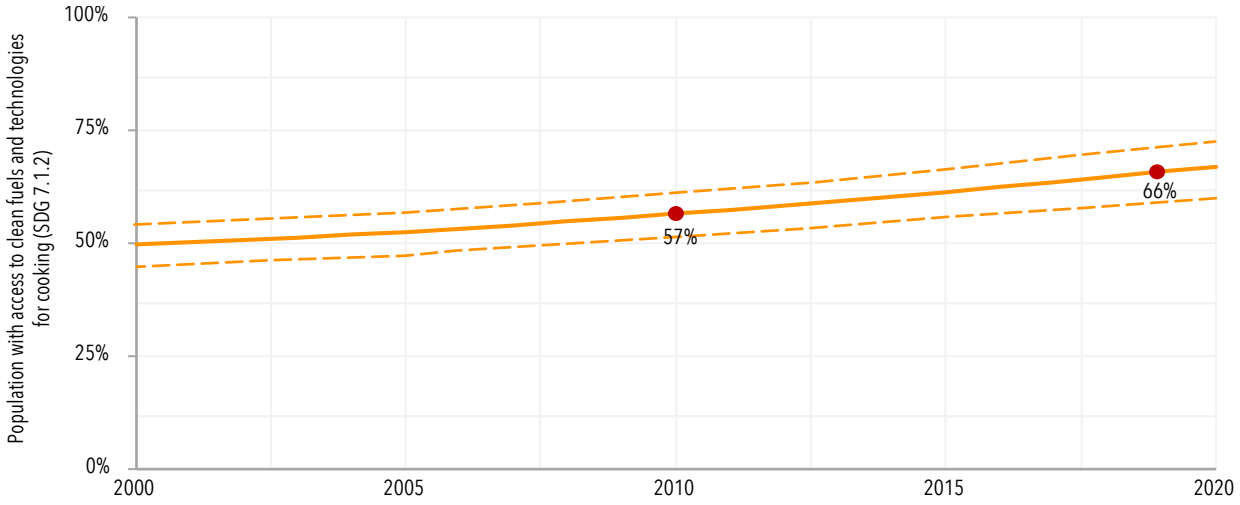
ARE WE ON TRACK?

Clean cooking must be prioritized and progress accelerated. In 2019, 66 percent (59–71) of the global population had access to clean cooking fuels and technologies—comprising electric, liquefied petroleum gas (LPG), natural gas, biogas, solar, and alcohol-fuel stoves. Technical recommendations defining "clean" fuels and technologies are set out in "WHO Guidelines for indoor air quality: household fuel combustion". (WHO 2014). Yet there remain some 2.6 billion (2.2–3.1) people who cook mainly with polluting fuels and technologies, using traditional stoves fueled by charcoal, coal, crop waste, dung, kerosene, and wood. Due to limitations in the underlying data, analyses use types of cooking fuel rather than cookstove-and-fuel combinations. The methodology section at the end of the chapter provides additional details.

Global access is tracked by surveying proportions of the population that rely mainly or primarily on clean cooking fuels and technologies. The global access rate has improved over the past few decades, albeit at an alarmingly slow pace (figure 2.1). By 2030, if states adopt only policies presently stated, only 72 percent of the population worldwide will have access to clean cooking fuels and technologies (IEA 2020).[27] This means that nearly a third of the global population will still not have transitioned to clean cooking by 2030; therefore the adverse health, environmental, and developmental impacts of polluting cooking solutions will persist among these vulnerable populations.

Furthermore, even 72 percent access fails to account for energy issues—like stove stacking, a practice involving the use of multiple fuels and technologies for cooking and other end uses, like space heating or lighting. When households stack a mix of cooking solutions, some polluting and others clean, the health and environmental co-benefits of the clean solutions are minimized (or negated altogether) because even one polluting fuel source can be a major source of smoke in and around the home. One common example of fuel stacking is the use of LPG for short cooking tasks like boiling water, while relying on biomass for longer tasks such as cooking beans. *The State of Access to Modern Energy Cooking Service* (ESMAP 2020b) assesses access in light of aspects of the cooking system beyond main fuel and technology, including affordability, convenience, stove stacking, and others. From the set of countries included in the report, it estimates that more than 4 billion people are thought to lack access to cooking services using modern energy. This information is necessary if appropriate policies are to be designed and can be provided as evidence to decision-makers.

FIGURE 2.1 • Percentage of the global population with access to clean cooking fuels and technologies

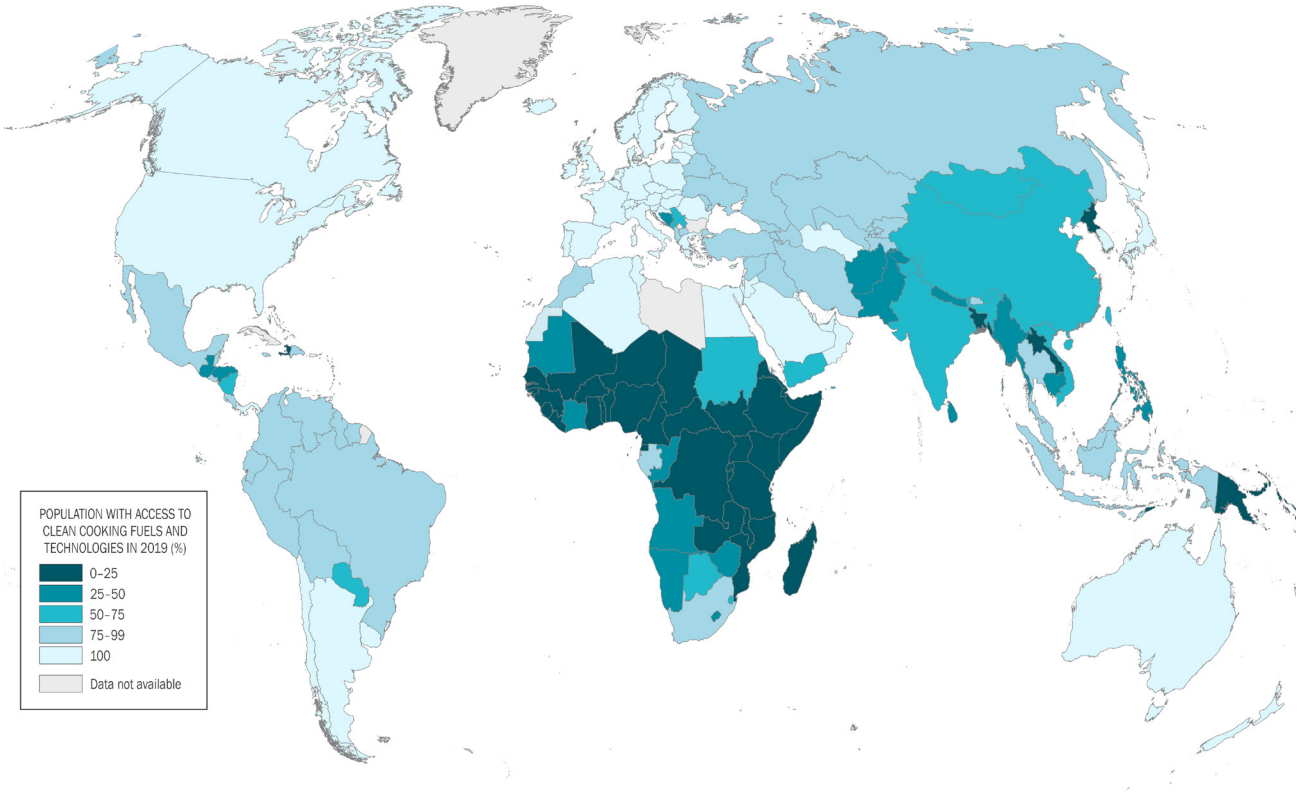


Source: WHO 2021.

27 IEA's Stated Policies Scenario takes into account policies and measures affecting energy markets that had been adopted as of mid-2020, together with relevant policy proposals. This scenario assumes only cautious implementation of current commitments and plans. The Stated Policies Scenario is contrasted in IEA's *World Energy Outlook* (2020) with the more ambitious Sustainable Development Scenario.

From 2000 to 2019, the proportion of people without access to clean fuels and technologies grew in Sub-Saharan Africa. As a result, for the first time more people without access to clean fuels and technologies resided in Sub-Saharan Africa in 2019 than in any other region. Indeed, when examining the geographic distribution of countries with low access rates, a large, continuous cluster is immediately visible in Sub-Saharan Africa (figure 2.2).

FIGURE 2.2 • Percent of population with access to clean cooking fuels and technologies by country, 2019



Source: WHO 2021.

Note/disclaimer: This map was produced by the Geospatial Operations Support Team of the World Bank based on the Cartography Unit of the World Bank. The boundaries, colors, denominations, and other information shown on any map in this work do not imply any judgment on the part of the custodian agencies concerning the legal status of or sovereignty over any territory or the endorsement or acceptance of such boundaries.

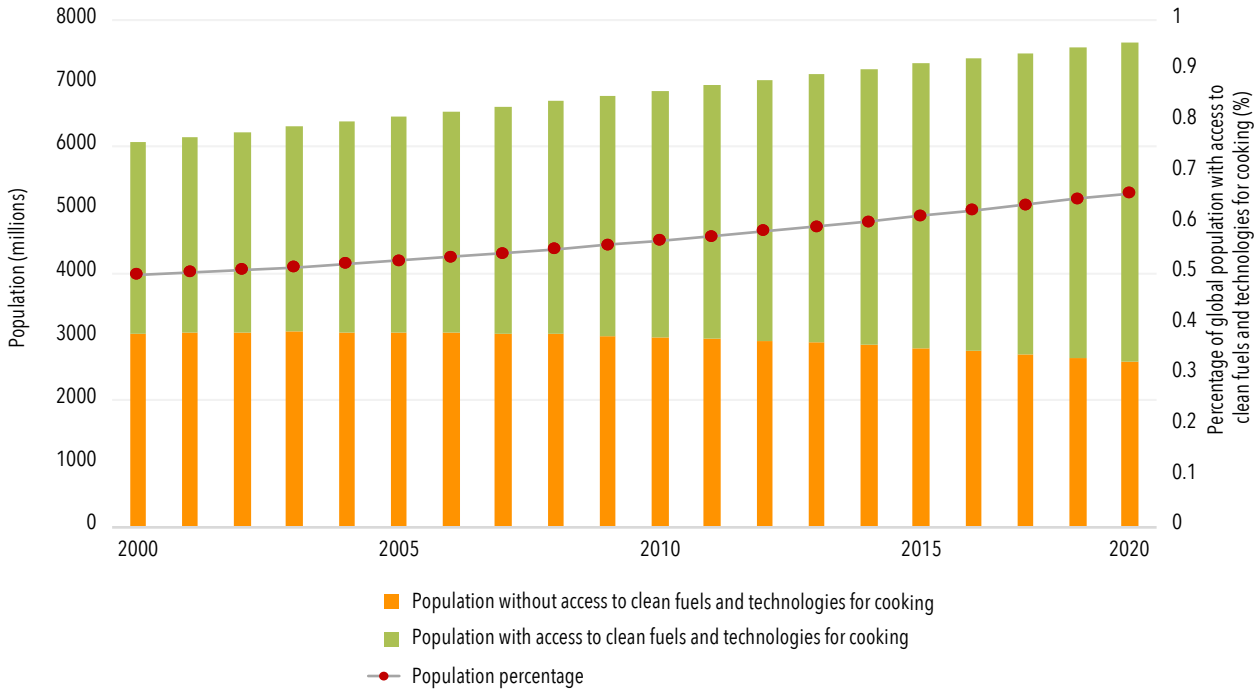
LOOKING BEYOND THE MAIN INDICATORS

ACCESS AND POPULATION

The global access rate to clean cooking fuels and technologies was 66 percent (59–71) in 2019. As seen in figure 2.3, the rate rose steadily between 2000 and 2019, with an annualized increase in access of 1.0 percentage points (0.2–1.8) between 2010 and 2019. Global values are dominated, however, by the most populous countries, several of which have seen recent and notable increases in the use of clean fuels and technologies. Figure 2.4 compares the global access rate for all countries, first, for the 5 most populous low- and middle-income countries, Brazil, China, India, Indonesia, and Pakistan, and, second, for the remaining low- and middle-income countries. While the top 5 most populous countries made steady progress, the global access rate for the others remained virtually unchanged between 2010 and 2019. To ensure that no one is left behind in the energy transition, clean cooking must be made a political priority in all access-deficit countries, accompanied by adequate financial and regulatory incentives and infrastructure.

In 2010, it was estimated that average annual increases of 2 percentage points would be necessary to achieve universal access to clean cooking. To make up for insufficient progress over the period 2010–19, however, the necessary annual increase in access rate now exceeds 3 percentage points, three times higher than the rate of progress seen in 2010–19. Meanwhile, the lack of improvement in the global access rate between 2010 and 2019 (when excluding the five most populous countries) identifies areas requiring urgent action to meet the global goal. If countries continue to make only marginal improvements, the farther the global community falls behind the goal of universal access by 2030. Again, transformative action is urgently needed.

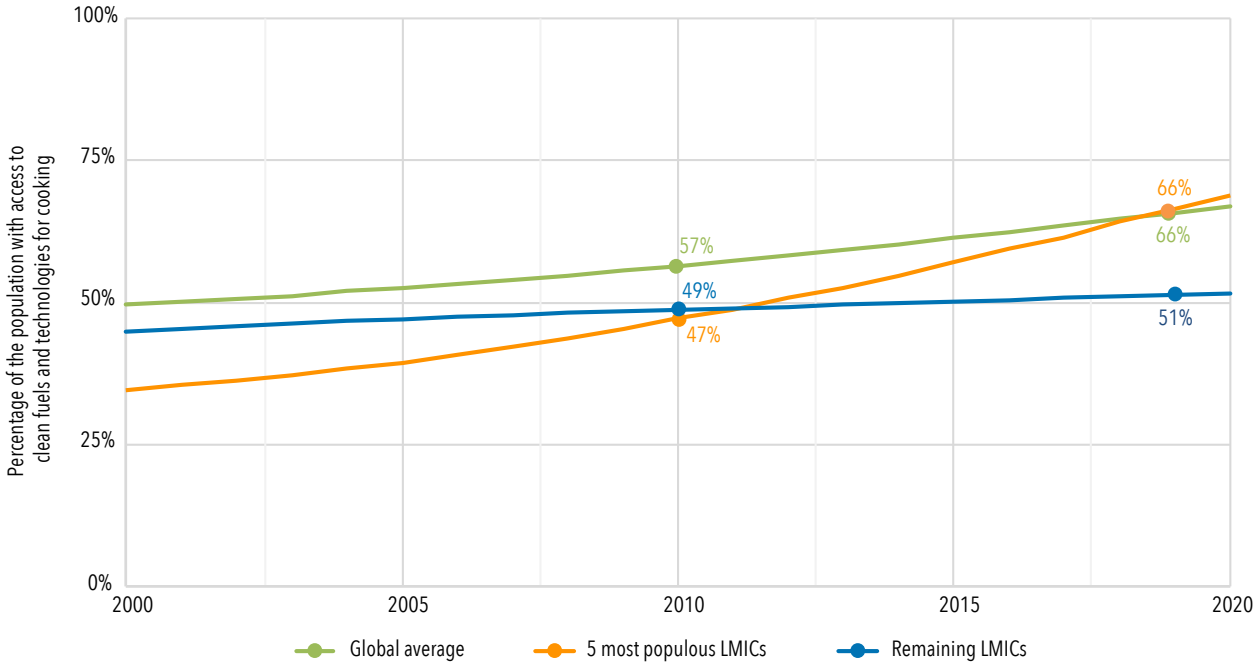
FIGURE 2.3 • Change over time in the absolute number of people (left axis) and percentage of the global population (right axis) with access to clean cooking



Source: WHO 2021.

FIGURE 2.4 • Percentage of the global population with access to clean cooking

Global average, 5 most populous low- and middle-income countries (China, India, Indonesia, Brazil, Pakistan), and low- and middle-income countries, excluding the 5 most populous



Source: Stoner and others 2021.

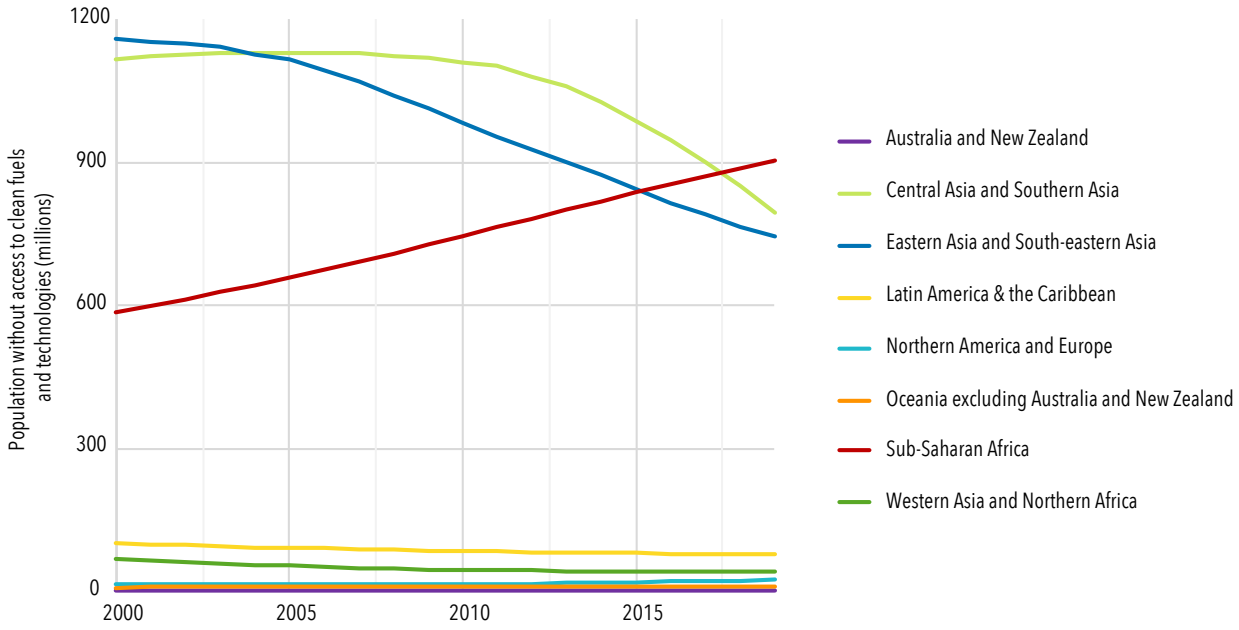
If trends continue without policy changes, the access deficit will shrink from 2.6 billion (2.2–3.1) to 2.3 billion people by 2030, about half of them residing in Sub-Saharan Africa and a quarter in Eastern Asia and South-eastern Asia. This is comparable to estimates derived under IEA's Stated Policies Scenario, which suggests that under current and planned policies 2.36 billion people will still lack access in 2030 (IEA 2020). As seen in previous years, however, population growth in Sub-Saharan Africa continues to outpace annual increases in the number of people having access to clean fuel and technologies. Over the period 2015–19, growth in the overall population of Sub-Saharan Africa outstripped growth in the number of people with access to clean cooking by around 18 million people each year. Thus, in this region, 894 million (874–911) people, or around 85 percent of the population, lack access to clean fuels and technologies for cooking. Unless action is taken to boost annual increases in access to clean cooking in Sub-Saharan Africa above population growth, global universal access will never be achieved.

THE ACCESS DEFICIT

On a global scale, the majority of gains (approximately 60 percent) among populations with access to clean cooking has been matched by population growth, causing a decades-long stagnation in the number of people lacking access to clean cooking—referred to here as the "access deficit." Estimates suggest this number hardly deviated from 3 billion people in any year between 2000 and 2010. Some progress was made in recent years, however, with the deficit dropping to 2.6 billion people [2.2–3.1] in 2019.

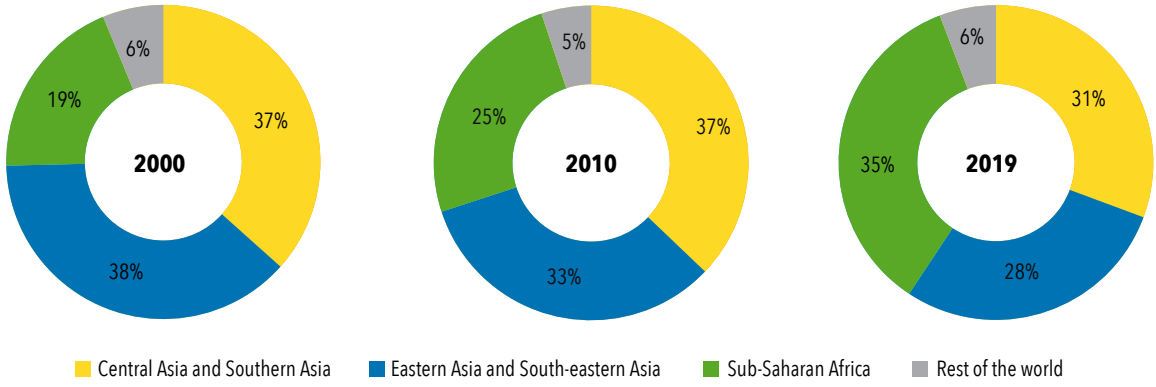
Stagnation in the global access deficit disguises key regional trends. As illustrated in figure 2.5, the access deficit has decreased consistently in Eastern Asia and South-eastern Asia since 2000 and in Central Asia and Southern Asia since 2010. In Sub-Saharan Africa, meanwhile, progress in the percentage of the population with access to clean fuels and technologies has failed to keep pace with population growth. Indeed, the access deficit in Sub-Saharan Africa has risen by more than 50 percent since 2000, reaching a total of 910 million [880–930] people in 2019.

FIGURE 2.5 • Access deficits by region (population without access to clean fuels and technologies), 2000 to 2019



Source: WHO 2021.

FIGURE 2.6 • Proportion of the total global access-deficit in the three largest access-deficit regions and the rest of the world, 2000, 2010, 2019



Source: WHO 2021.

As illustrated in figure 2.6, from 2000 to 2019, the proportion of the global population living in Sub-Saharan Africa that have no access to clean fuels and technologies rose from approximately one-fifth to one-third of the total. Meanwhile, the proportion residing in Eastern Asia and South-eastern Asia fell by 9 percentage points, and the proportion residing in Central Asia and Southern Asia dropped 6 points. As a result, in 2019 more people without access to clean fuels and technologies lived in Sub-Saharan Africa than in any other region. If observed trends in access and population continue, by 2030 Sub-Saharan Africans will be the dominant population with an access deficit—accounting for some 49 percent of the total deficit in 2030. This represents a substantial geographic redistribution of the global access deficit and associated health, economic, and societal burdens. Future policies should take these trends into account.

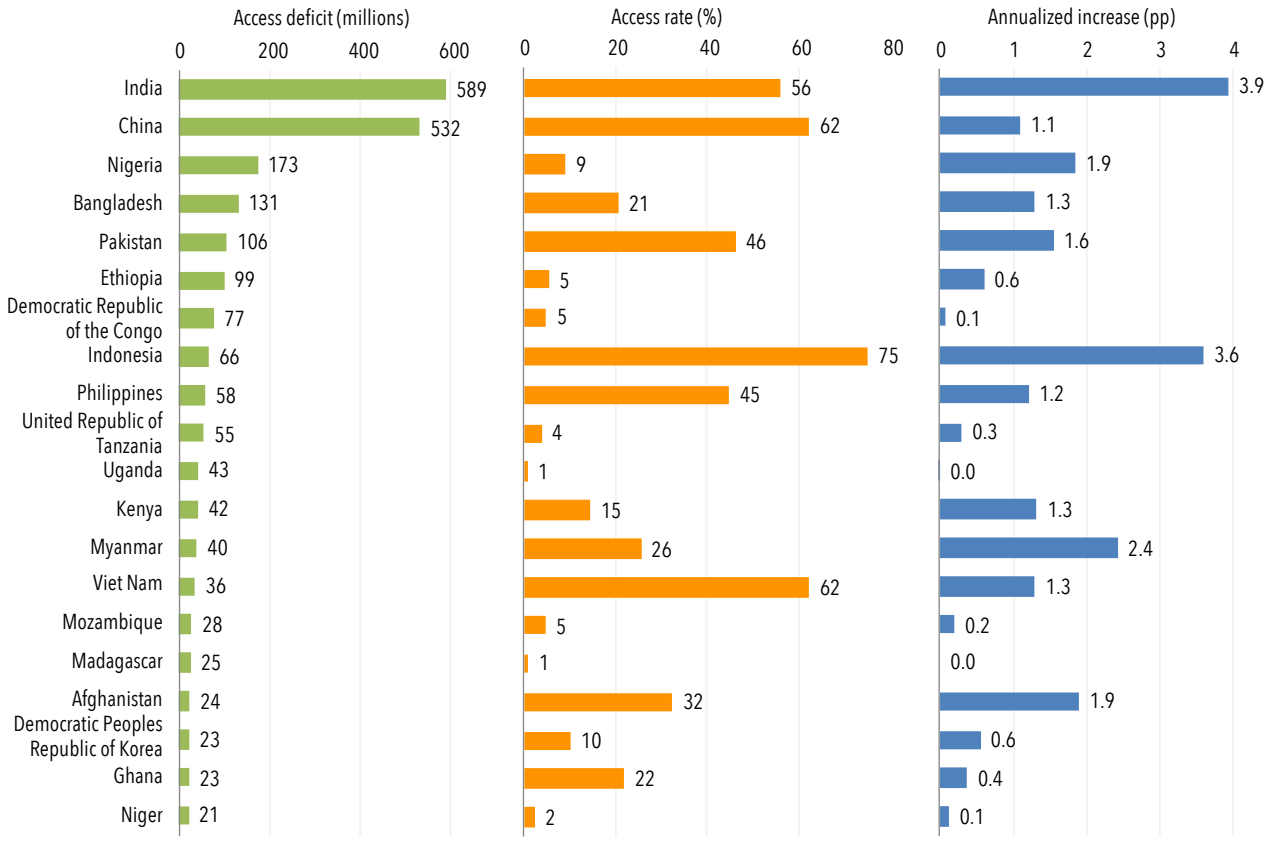
ANALYSIS OF THE TOP 20 ACCESS-DEFICIT COUNTRIES

The top 20 access-deficit countries (figure 2.7) accounted for 81 percent of the global population (2015–19 average) without access to clean cooking.[28] At 22 percent (589 million people), India alone still accounts for the largest single share of the access deficit, followed by China, at 20 percent (532 million people). At the same time, of these 20 countries, India and Indonesia alone achieved annualized increases above the 3 percentage points needed to achieve universal access by 2030.

In 7 of the 20 countries the proportion of the population with access to clean fuels is less than or equal to 5 percent (2015–19 average): Democratic Republic of Congo, Ethiopia, Madagascar, Mozambique, Niger, Uganda, and Tanzania. Sixteen of the 20 countries have access rates under 50 percent (figure 2.8).

FIGURE 2.7 • The 20 countries with the largest populations lacking access to clean cooking fuels and technologies, 2015–19 average

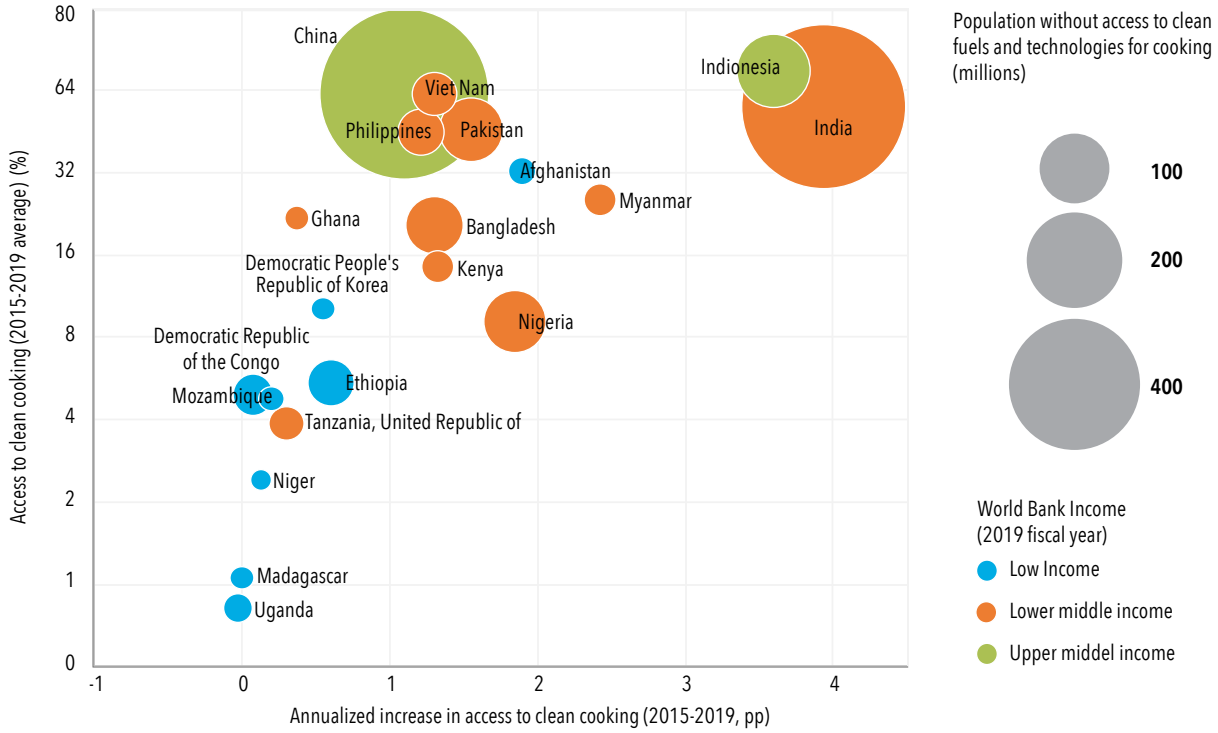
Left: the number of people without access to clean cooking. *Center*: the percentage of those with access to clean cooking. *Right:* the annualized increase in access to clean cooking.



Source: WHO 2021.

28 The top 20 access-deficit countries are those with the largest access-deficit populations (2015–19 average). These are Afghanistan, Bangladesh, China, Democratic People's Republic of Korea, Democratic Republic of Congo, Ethiopia, Ghana, India, Indonesia, Kenya, Madagascar, Mozambique, Myanmar, Niger, Nigeria, Pakistan, Philippines, Uganda, United Republic of Tanzania, and Vietnam.

FIGURE 2.8 • The 20 countries with the largest access deficits to clean cooking fuels, 2015–19



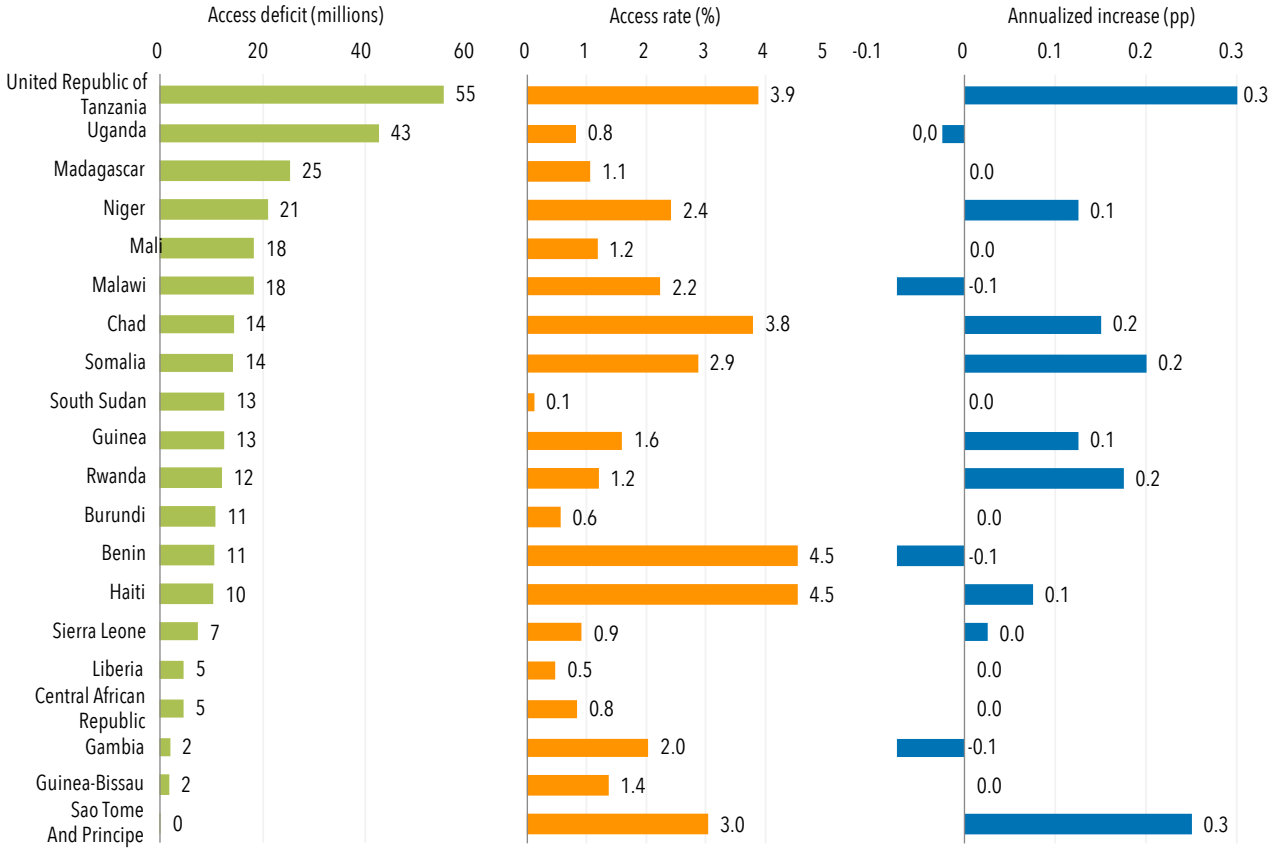
Source: WHO 2021.

Meanwhile, the 20 countries with the lowest access rates[29] show little to no sign of improvement, represented by near-zero annualized increases between 2015–19 (figure 2.9). While India has the largest population without access to clean cooking, access rose most rapidly there between 2015 and 2019, with an annualized increase of 3.9 percentage points. Rapid annual gains in access (more than 2 percentage points) were also seen in several countries between 2015 and 2019 (figure 2.10), notably Indonesia (3.6 points), Cambodia (2.9 points), and Myanmar (2.4 points).

29 The 20 countries with the lowest percentage of the population primarily using clean fuels and technologies (2015–19 average) were Benin, Burundi, Central African Republic, Chad, Gambia, Guinea, Guinea-Bissau, Haiti, Liberia, Madagascar, Malawi, Mali, Niger, Rwanda, Sao Tome and Principe, Sierra Leone, Somalia, South Sudan, Tanzania, and Uganda.

FIGURE 2.9 • The 20 countries with lowest percentage of the population with access to clean cooking fuels and technologies, 2015–19 average

Left: the number of people without access to clean cooking. *Center*: the percentage of people with access to clean cooking. *Right*: the annualized increase in access to clean cooking.



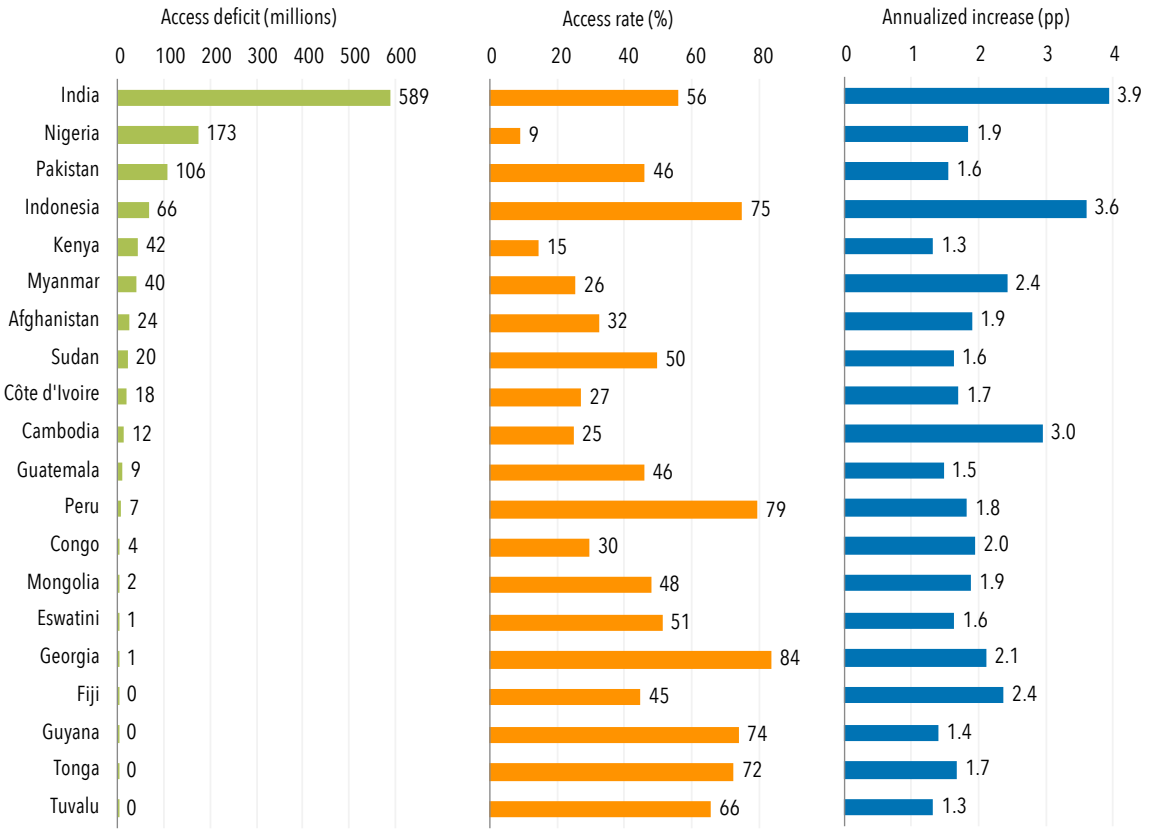
Source: WHO 2021.

Overall, in the 20 countries with the lowest population shares having access to clean fuels and technologies (figure 2.9), the annualized access gains between 2015 and 2019 were small (always less than 0.4 percent). Indeed, estimates suggest that a few countries may have seen declines in access during the same period. All of these 20 countries are among the least-developed countries and, with the exception of Haiti, are in Africa, further highlighting the urgent need to address access deficits in Africa. Figure 2.10 shows the 20 countries with the fastest annualized increases[30] (2015–19) in access to clean cooking. Despite relatively steep increases in access, the population without access remains notable in some of the larger countries. Those with the largest deficits also received limited financing in 2018—for example, Nigeria, Pakistan, and Myanmar —and thus face challenges for scaling up clean fuels and technologies, while a few countries attracted the bulk of the financing – for example, Bangladesh, Kenya, and India (SEforAll 2020).

30 The 20 countries with the highest annualized increases in access to clean fuels and technologies (2015–19) were Afghanistan, Cambodia, Congo (Democratic Republic of), Côte d'Ivoire, Eswatini, Fiji, Georgia, Guatemala, Guyana, India, Indonesia, Kenya, Mongolia, Myanmar, Nigeria, Pakistan, Peru, Sudan, Tonga, Tuvalu.

FIGURE 2.10 • The 20 countries with the fastest-growing population shares with access to clean cooking fuels and technologies, 2015–19 average

Left: the number of people without access to clean cooking. *Center*: the percentage of people with access to clean cooking. *Right*: the annualized increase in access to clean cooking.



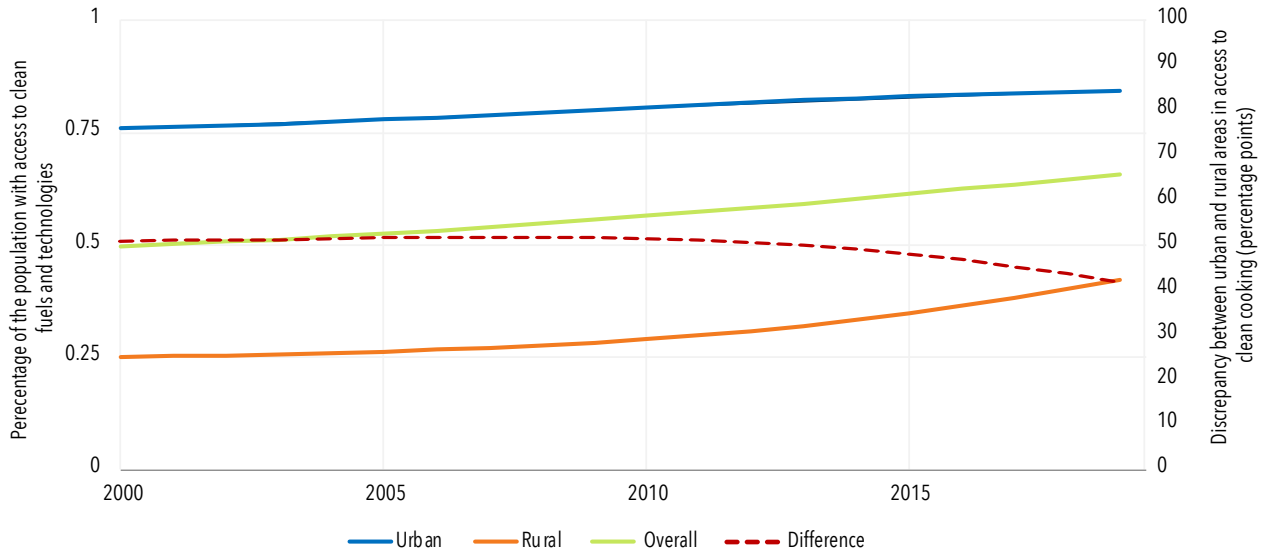
Source: WHO 2021.

THE URBAN-RURAL DIVIDE

A vast urban-rural disparity persists in access to clean cooking solutions. Urban areas enjoy greater access for various reasons, including better infrastructure for distribution of clean fuel and technology, greater availability of clean fuels, and higher household incomes. Figure 2.11 shows the percentage of the global population with access to clean fuels and technologies in urban areas, rural areas, and overall, from 2000 to 2019. In 2019, the urban access rate was 85 percent (77–88); rural access stood at 42 percent (35–50).

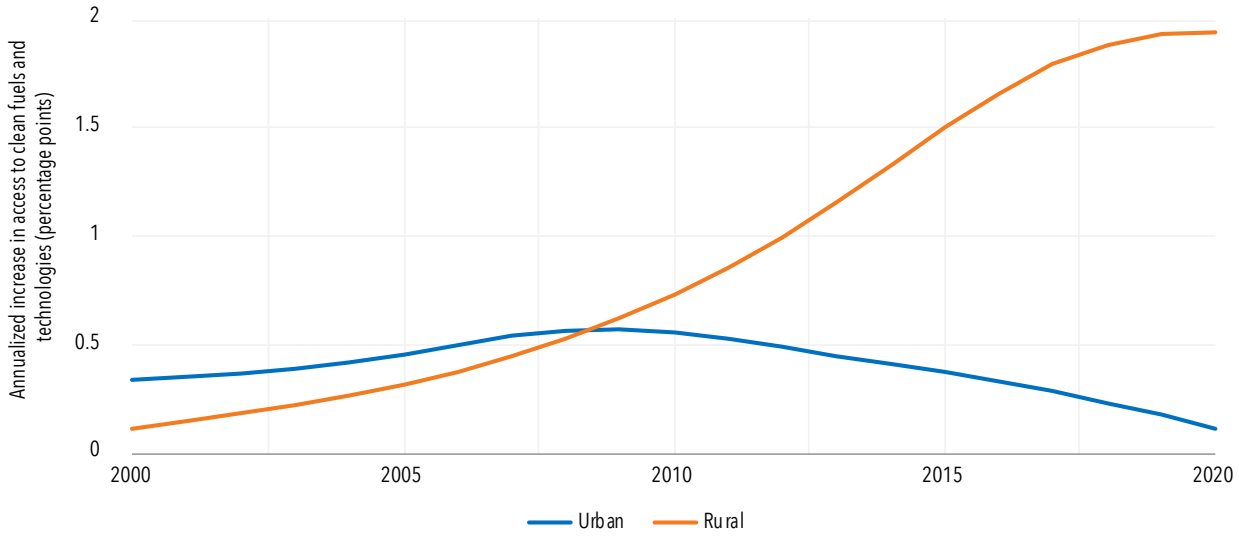
Between 2000 and 2010 the global disparity between urban and rural areas in access to clean cooking was fairly constant at just over 50 percentage points (52 percentage points [45–57] in 2010). But by 2019 this had fallen to 42 percentage points (31–51). The drop is explained by trend changes in the annual increase in access to clean fuels and technologies for urban and rural areas (figure 2.12). In rural areas, the annual increase rose consistently, from only 0.1 percentage point between 2000 and 2001 to 2.1 percentage points between 2018 and 2019. In contrast, the annual increase in cities fell consistently over the past decade, from a high of 0.6 percentage points in 2007–08 to only 0.2 percentage points in 2018–19. This means that, while access has accelerated in the more rural areas, it has been decelerating in urban areas. In fact, if trends continue—and if population growth continues to outpace access to clean fuels—the proportion with access to clean cooking is projected to fall in urban areas as the new decade begins. Meanwhile, some countries with rapid access growth will reach near-universal access, limiting their significant influence over the current rate of progress in the global access rate.

FIGURE 2.11 Percentage of people with clean cooking access in urban areas, rural areas, and overall (solid lines), and urban-rural discrepancy in access (dashed line)



Source: WHO 2021.

FIGURE 2.12 • Annual increase in access to clean fuels and technologies for urban and rural areas



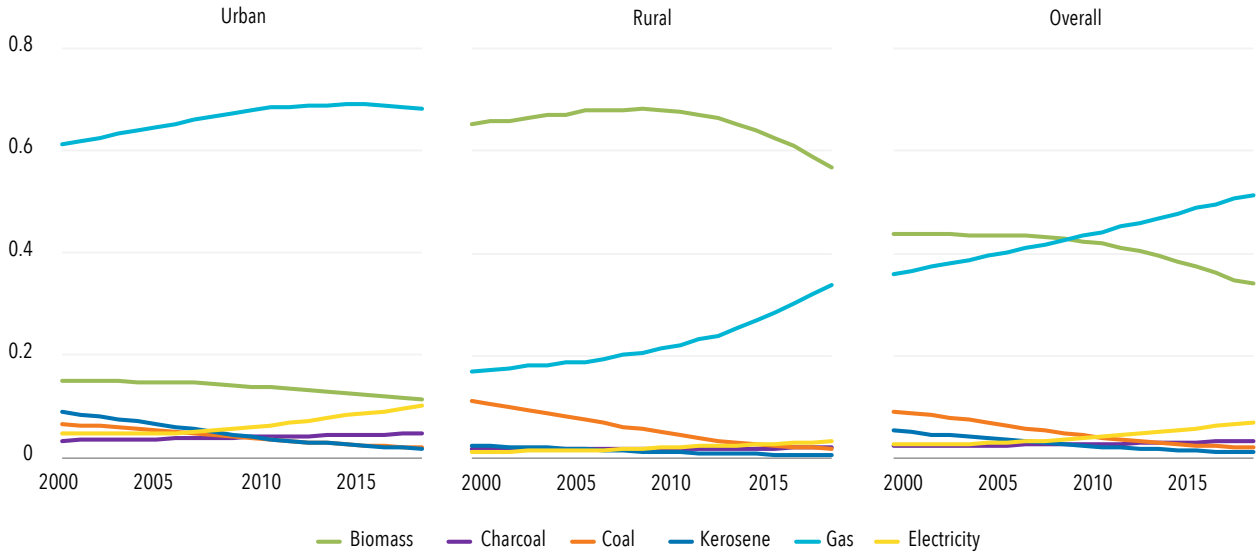
Source: Stoner and others 2021.

In 2019, Central Asia and Southern Asia, at 45 percentage points (32–58), had the greatest urban-rural disparity in access to clean fuels and technologies. In both this region and in Eastern Asia and South-eastern Asia, the discrepancies were growing prior to 2010—when it was 57 percentage points (46–66) in Central Asia and Southern Asia and 47 points (26–65) in Eastern Asia and South-eastern Asia—before falling sharply in recent years. At the same time, the disparity has fallen consistently since 2000 in both the Latin America and the Caribbean and in Western Asia and North Africa. It is growing in Sub-Saharan Africa, however, expanding from 23 percentage points (20–25) in 2010 to 29 points (25–33) in 2019. A virtually stagnant access rate in rural areas of Sub-Saharan Africa is to blame, showing up in annualized increases of 0.1 percentage points per year, with uncertainty intervals that overlap 0 percentage points per year (-0.05–0.24), compared with 0.8 percentage points (0.35–1.26) per year in urban areas.

CHANGES IN THE FUEL MIX

Trends in the use of cooking fuels can inform important policy discussions, which can in turn be harnessed to make and review policies so they produce the intended outcomes. In low- and middle-income countries, the use of gaseous fuels[31] increased consistently from 36 percent (31–41) in 2000 (1.8 billion people) to 51 percent (45–58) in 2019 (3.3 billion people), overtaking unprocessed biomass fuels[32] as the dominant cooking fuel over the past decade (figures 2.13 and 2.14). Use of electricity for cooking has also risen, from 3 percent (2–4) in 2000 (140 million people) to 7 percent (4–12) in 2019 (450 million people), though the increase was far more notable in urban areas (figure 2.13). Between 2000 and 2010, increases in the use of clean fuels were accompanied by steep declines in the use of coal, particularly in rural areas where the use of coal dropped from 11 percent (6–17) in 2000 to 2 percent (1–6) in 2019, and kerosene, particularly in urban areas, where its use dropped from 9 percent (7–10) in 2000 to 2 percent (1–3) in 2019. But from around 2010 onwards, the use of unprocessed biomass fuels (wood, crop waste, and dung) has shown persistent declines, primarily in rural areas, where use of unprocessed biomass fuels dropped from 68 percent (63–73) in 2010 to 57 percent (49–65) in 2019.

FIGURE 2.13 • Percentage of people using each type of cooking fuel in low- and middle-income countries, in urban areas, rural areas, and overall



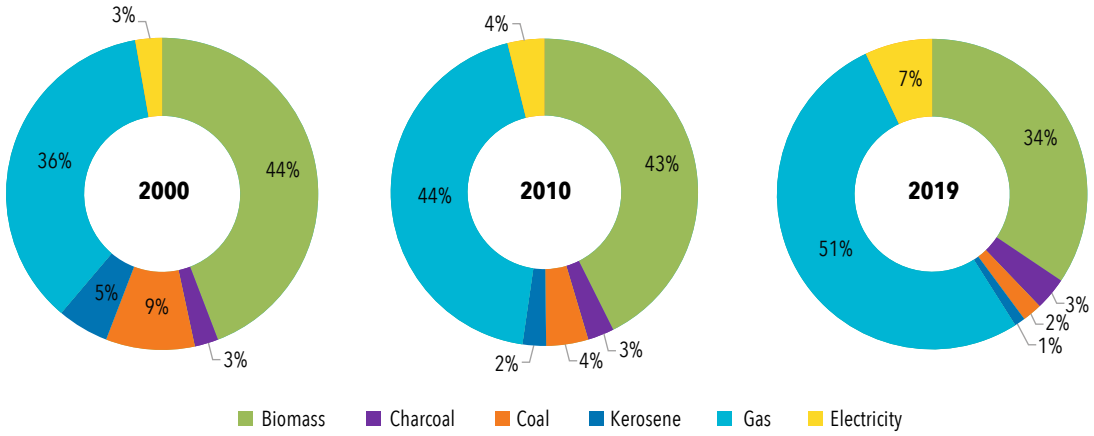
Source: Stoner and others 2021.

Although the use of kerosene has dwindled worldwide (figures 2.13 and 2.14), it remains prominent in urban areas of low- and middle-income countries in Oceania (16 percent [8–35] in 2018) and Sub-Saharan Africa (9 percent [6–11] in 2018). In 2018, globally, the proportion using charcoal was low (4 percent [3–4]), but in Sub-Saharan cities, charcoal has overtaken unprocessed biomass (29 percent [26–33]).

31 Gaseous fuels, or simply "gas," refer to liquefied petroleum gas (LPG), natural gas, and biogas.

32 Biomass fuels consist of raw/unprocessed biomass (wood, crop waste, and dung), but not charcoal, which is presented separately.

FIGURE 2.14 • Comparison of the percentage of people using each fuel type in low- and middle-income countries in 2000, 2010, and 2019



Source: Stoner and others 2021.

BOX 2.1 • RENEWABLE FUELS: BIOGAS AND SOLAR

Modern energy solutions for cooking are an important mechanism to achieve climate goals and zero net emissions. According to data from the WHO Household Energy Database, renewable energy cooking solutions are gradually being adopted by populations in some regions. From the database, surveys that report use of renewable fuels like solar and biogas are not yet available in sufficient numbers to derive globally representative estimates, but the available surveys can still inform more descriptive analyses of the current status of these energy sources, as well as how their use has changed over time.

A descriptive analysis of surveys in the WHO Household Energy database suggests that the use of biogas and solar for cooking purposes is increasing. Biogas is a viable alternative for households with livestock, which in some places can supply energy not only for cooking but also home lighting and heating. Because biogas has a carbon-neutral footprint, it contributes no greenhouse gas emissions, transforms organic waste into a high-quality fertilizer, and ultimately reduces the volume of disposed waste and improves sanitary conditions. Based on an

analysis of survey data, biogas as the primary energy source for cooking has grown over the past decade, with some countries in Asia, Latin America, and Sub-Saharan Africa reporting as much as 4 percent of the population mainly using biogas for cooking—a notable increase compared with survey values reported prior to 2010, where the minimum and median values for these regions were 0 percent.

TABLE B2.1.1 • Analysis of survey data on the percentage of the population relying mainly on biogas for cooking

		BEFORE 2010	2010–19
Central Asia and Southern Asia	Countries reporting	11	8
	Minimum (%)	0	0.05
	Median (%)	0	0.32
	Maximum (%)	3.1	3.2
Eastern Asia and South-eastern Asia	Countries reporting	10	8
	Minimum (%)	0	0.02
	Median (%)	0	0.26
	Maximum (%)	0.3	1.28
Latin America and the Caribbean	Countries reporting	21	10
	Minimum (%)	0	0
	Median (%)	0	0.09
	Maximum (%)	1	2.8
Sub-Saharan Africa	Countries reporting	37	33
	Minimum (%)	0	0
	Median (%)	0	0.12
	Maximum (%)	2	4.23

Source: WHO Household Energy Database (2021).

Solar cookers are another carbon-neutral solution reported in household surveys. Solar cookers are an important complement to a clean cooking system. Some factors—like the time required for cooking, sunshine availability, etc.—will restrain the adoption of solar cookers as primary equipment; most countries report less than 0.05 percent of the population using them. The past decade has seen a marginal increase of less than half a percentage point in the population using them. Between 2015 and 2019, around 5 percent of surveys reported use of solar cookers above 0.5 percent, or approximately 6 in 1,000 people. Another renewable clean cooking solutions with promise of scalability are ethanol stoves and renewable electric cooking. Ethanol and other alcohol stoves are clean cooking solutions that have shown to be socially acceptable and growing in popularity in some regions. More efficient electric cooking devices (e.g., induction stoves and pressure cookers), expanded mini-grid systems, and more battery storage from solar home systems are all making renewable electric cooking a reality in some places. Such scalable clean and renewable cooking solutions are critical to expanding access, particularly in rural or remote areas where development of infrastructure may not be as readily available or planned in an environmentally sustainable way. They also offer the benefit of stimulating demand for off-grid installations, which are key to their viability and sustainability.

POLICY INSIGHTS

In 2019, the global population with access to clean cooking fuels and technologies stood at 66 percent (59–71). The remaining 34 percent rely on polluting fuels and technologies that produce high levels of household air pollution having a range of damaging effects. In addition to exacerbating gender inequities, household air pollution damages health, well-being, and the environment. Most of those affected by severe household air pollution are the poor, who also lack access to adequate health care. The inequitable distribution and burden of disease from polluting fuels and technologies make primary prevention via clean household energy interventions even more vital. This is because one consequence of polluting fuels and technologies is the copious emission of fine particulate matter and gases (mainly carbon monoxide) generated both in the home and throughout a neighborhood. Fine particulate matter is a leading risk factor for noncommunicable diseases[33] and increased co-morbidity with COVID-19 (van der Valk 2021). It has been shown that the effects of acute as well as long-term exposure to household air pollution are substantial, with long-term exposure exacerbating disease and its progression. According to pre-COVID-19 estimates (WHO 2021), the lack of access to clean fuels and technologies for cooking contributes to 3.8 million deaths each year in low- and middle-income countries.

Lack of access to clean fuels and technologies has been shown to be a greater health and development risk for women and children. In energy-poor households, it is usually the women and children who are responsible for collecting the fuels used for household activities like cooking, heating, and lighting, putting them at greater risk for injury and violence. Compared with men, they are also typically the household members exposed to the most pollution owing to greater time spent around the stove. Indeed, achieving universal clean cooking access would positively affect other SDGs, including better health and well-being (SDG 3), education (SDG 4), reduced gender inequalities (SDG 5), economic growth (SDG 8), sustainable cities and communities (SDG 11), and climate action (SDG 13).

An integral piece of the policies and strategies under implementation is the setting of clear benchmarks for achievement. WHO's guidelines for indoor air quality: household fuel combustion (WHO 2014) provide benchmarks, which are considered by most countries when setting goals for clean household air and for clean cooking fuels and technologies. The guidelines provide evidence of fuel use, emissions, and human exposure levels, as well as health risks. As part of the interventions and tools provided by WHO, the Clean Household Energy Solutions Toolkit is intended to help sector professionals and policy makers implement the recommendations found in the WHO Guidelines. In addition to a clear roadmap, this tool provides intermediate targets and transition stages and opening opportunities for assessment and regulation.

In order to achieve universal access to clean fuels and technologies, greater political will at the national level is essential, along with coordination among different actors. All household energy needs, including cooking energy and electricity access, should be integrated in a national energy plan. Integrated energy planning can help governments decide where to direct available resources, what solutions to support or leverage, and which communities to target. Governments should also promote policies that enable an environment conducive to widening access to clean cooking fuels and technologies. Given the status of such access presented in previous sections, it is not possible to overstate the urgency of action. This is particularly the case for the Sub-Saharan African region, where access is particularly low and where the population exposed to polluting cooking is growing rapidly.

33 Noncommunicable diseases including ischemic heart disease, stroke, chronic obstructive pulmonary disease, and cancers. Household air pollution is a cause of pneumonia in children and has been reported to have significant associations with lung function development, respiratory infections, and asthma in young children.

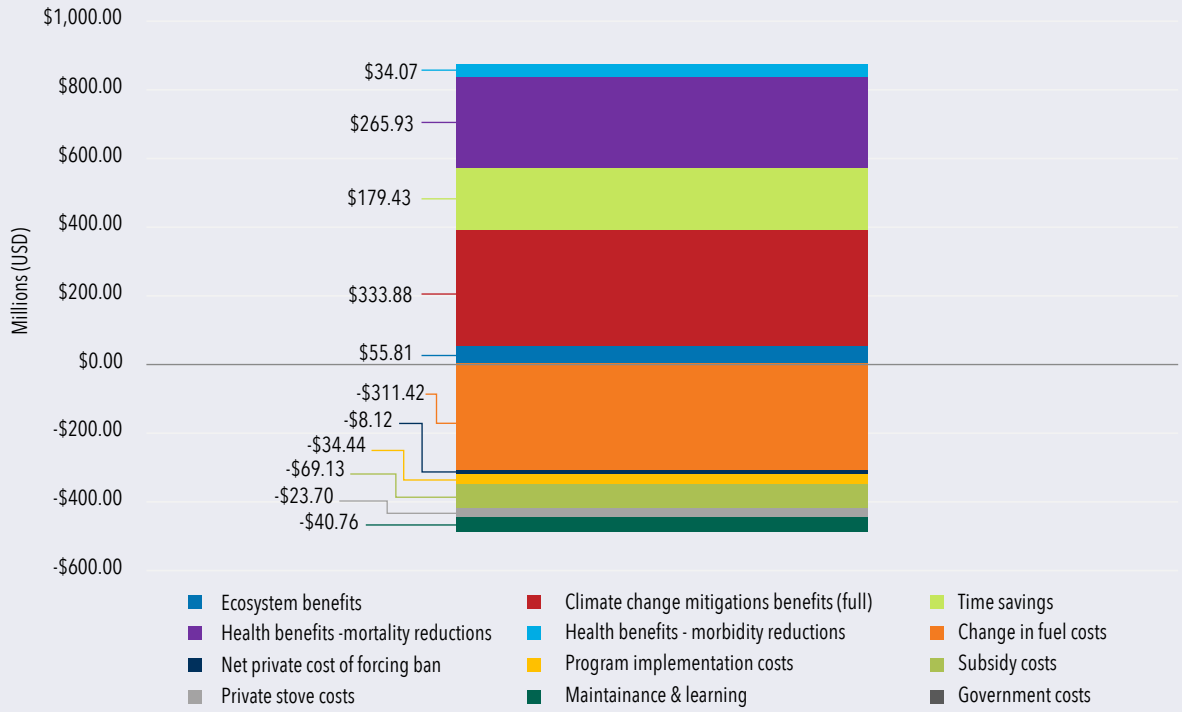
BOX 2.2 • WHO'S BAR-HAP TOOL FOR ANALYZING COSTS AND BENEFITS OF HOUSEHOLD ENERGY TRANSITIONS

Understanding the economic, health, and climate costs and benefits of different household energy interventions are critical elements that decision-makers must consider when designing and implementing household energy policies.

To better support evidence-based decision-making, WHO and researchers at Duke University developed a tool to inform policymakers about the costs and benefits of transitioning to cleaner fuels and technologies. The tool, Benefits of Action to Reduce Household Air Pollution (BAR-HAP), quantifies the net health and economic benefits of various policy actions and specific technology transitions. It contains 16 fuel and technology transitions from more polluting options (biomass, kerosene) to clean or transitional fuels and technologies including improved biomass, improved charcoal, biogas, LPG, ethanol, and electric stoves. Users can select from five policy instruments that could facilitate a transition to cleaner cooking: a subsidy for stoves, a subsidy for fuel (e.g., biomass pellets, LPG, electricity, and ethanol), stove financing (spreading payments for the new technology over time), a behavior change campaign, and a ban on polluting technology. Scenarios can be run to shift a portion of the population to various cleaner fuels and technologies, with different policy scenarios applied for each transition pathway. BAR-HAP calculates government and private costs, as well as mortality and morbidity reductions, accounting for health spillovers, time savings, climate-mitigation value, and other environmental benefits related to the sustainability of biomass harvesting. BAR-HAP is one of the critical elements of the WHO's Clean Household Energy Solutions Toolkit, which contains tools and resources that enable countries to develop policies for expanding clean household energy use.

The costs and benefits of transitioning all traditional firewood stoves to LPG stoves in Nepal provide a sample application of the tool. As seen in the figure below, climate mitigation is the largest category of benefits from this transition, followed by avoided mortality, household time savings, other ecosystem benefits, and avoided morbidity. The largest costs are stoves (borne by government and users), program implementation for stove distribution, and technology maintenance.

FIGURE B2.2.1 • Breakdown of total present value of costs and benefits with 70 percent stove subsidy for shift from traditional biomass stoves to LPG stoves in Nepal



Source: Das and others 2021.

OUTLOOK

The slow pace toward universal access to clean cooking fuels and technologies must not be overlooked. A continuation of business as usual is not sufficient or acceptable. Accelerating access must become a top political priority, accompanied by targeted policies. Moreover, the COVID-19 pandemic has exacerbated the vulnerability of people who lack access to clean fuels and technologies. The economic crisis caused by the pandemic will undoubtedly have consequences for household energy use; in some countries it threatens to reverse the progress made thus far (Shupler and others 2020). The same crisis provides an opportunity, however, to set new priorities; promote innovative policies, institutions, and businesses; and establish measures that guarantee universal clean cooking by 2030.

A household's choice of fuels and technology depends on multiple factors, including initial and recurrent costs, accessibility, household preferences for cooking practices (Shankar and others 2020), and the number of tasks (e.g., space heating and lighting in addition to supplemental cooking) that can be achieved with a given fuel and stove combination. Due to the lack of sufficient and comparable data on all household energy technologies, the clean cooking figures for SDG 7 reported here capture only the progress in transitioning households' primary fuel and technology for cooking and do not account for the full suite of fuels and technologies employed in the home for all cooking activities and related end uses like space heating and lighting.

Shankar and others (2020) confirm that the parallel use of multiple fuels and technologies, referred to as stove stacking, was observed in all 11 case study countries where fuel and cookstove programs had taken place. The case studies followed up on the clean cooking solution of LPG in Cameroon, Indonesia, Peru, and Ecuador; ethanol/methanol in Ethiopia and Nigeria; biogas in Cambodia, Kenya, Tanzania, and Uganda; and compressed biomass pellets and briquettes in Rwanda and China. The study reveals that everyone stacks. Even in places where programs are more established, as in Jakarta (Indonesia) and Carchi (Ecuador), reported rates of exclusive use of clean fuel are as low as 10 percent and 19 percent, respectively. Stacking information obtained through improved surveys, like WHO's core household energy survey questions or the World Bank's Multi-Tier Framework (MTF) surveys, are essential to better design and policy implementation that adapt to the reality of clean household energy transitions and the ubiquitous practice of stacking. A suggested approach to the problem of stacking is to implement policies to promote clean stacking of stoves and fuels—for example, the use of electricity from mini-grid or off-grid systems paired with LPG to meet household energy needs. Clean stacking is a critical practice that ensures healthy home and community environments for the most vulnerable populations.

In light of the acknowledged challenges of securing a rapid adoption of clean fuels and technologies, particularly in more rural and poorer areas where affordability and the lack of infrastructure are major obstacles, the switch to clean cooking may be more gradual, and intermediate solutions required. In these cases, transitional fuels and technologies—like low-emission biomass cookstoves that are more energy efficient and substantially reduce emissions, yielding benefits for health, climate, and the environment—should be prioritized (Anenberg 2013). In identifying such transitional technologies, policy and programmatic decision-makers should use available evidence of performance (e.g., emissions rates), health risks, safety, and user acceptability) to secure the widespread and sustained use of such improved technologies (Rehfuess 2014; Puzzolo 2013). Advanced cookstoves can also be the instrument that facilitates the exploration of cleaner fuel and stove stacking. Over time, users realize the benefits of the cleaner options, which can influence their decision-making.

The low rate of access to clean cooking fuels and technologies, along with the common practice of stove stacking, call for an innovative approach by policy makers to find solutions to current challenges. So far, public

investments have focused on "improved" cooking stoves, while little private investment has been made in alternate solutions like biogas, ethanol, solar, or electric cooking (SEforAll 2020). Both private investments and use of renewable energy for cooking show a promising trend (box 2.1). Establishing partnerships and cooperation platforms, such as the West and Central Africa Alliance for the Promotion of Biodigesters, can also play a catalytic role in aligning government, development funding, and the private sector behind alternative clean cooking solutions and should be leveraged to scale up such solutions where viable. It has been shown (Couture and Jacobs 2019) that the cost of cooking with electricity in mini-grid contexts or via solar energy is competitive with the costs of other cooking fuels. Overcoming cost challenges, however, is only part of the problem; adapting to the way of life of users is key for a lasting integration (Goodwin 2015).

Strategic policies and financial incentives will be essential in recovering from setbacks to clean cooking caused by COVID-19. The participation of national governments—in the form of targeted policies and subsidy support for both demand and supply— will be necessary to accelerate progress toward universal access, in particular in Sub-Saharan Africa. Policy solutions should include results-based incentives to finance scale-ups of proven business models and behavioral-change campaigns. Policy solutions should also leverage grid expansion and modernization, as well as decentralized electric solutions to address clean cooking gaps. Although some advancement has been made in Sub-Saharan Africa, it is limited to a few countries. Countries with small populations, the majority of which are without access, have not benefited from the programs and support that large countries have received, and as a consequence struggle to capture the attention of investors.

BOX 2.3 • COVID-19 AND ENERGY ACCESS: PROTECTING THE MOST VULNERABLE THROUGH CLEAN COOKING

Lockdowns imposed as a result of the pandemic have likely affected household fuel use. A full picture of the impact of the pandemic will not be available until further down the line, but preliminary studies and reports show the danger it presents to the progress achieved so far in expanding access to clean cooking.

Households that were able to afford clean fuels are affected by the financial backlash caused by lockdowns. With lost wages, poor households are being forced to make spending choices; in looking to cut costs, they often revert to polluting cooking solutions as cheaper alternatives. That is the case in areas of Kenya where studies have shown that households that were relying on LPG before the pandemic have returned to kerosene or wood for household activities (Shupler and others 2020).

Switching back to polluting alternatives puts the health of household members at greater risk of disease from household air pollution, particularly during a pandemic, when people are spending more time indoors breathing in the high levels of health-damaging pollutants. Air pollution is also known to weaken the immune system, compromising the ability to fight off infections including COVID-19 (van der Valk 2021). Poor communities are also likely to have unreliable or inadequate health-care infrastructure, making disease prevention even more critical to fighting the pandemic.

The impact of the pandemic on clean cooking progress extends beyond its effects on household members. An early assessment by the Clean Cooking Alliance of the outcomes of lockdowns on the clean cooking market suggests severe disruptions in the value chain, with nearly one-third of business respondents temporarily ceasing all operations early in the lockdown, and two-thirds expecting long-term consequences.

By contrast, another study also carried out in Kenya (Shupler and others 2021) showed the benefits of access to LPG in combination with payment flexibility and fuel delivery. The study showed that people with access to the pay-as-you-go LPG program (whereby consumers purchase LPG credits in small increments) were less likely to stop using LPG during the COVID-19 lockdowns. The study reports that 95 percent of pay-as-you-go LPG users continued to use the clean fuel during lockdown, despite a complete cessation of income in 88 percent of the community members. The same study points out that users of traditional LPG cylinders had a "drop rate" (that is, the rate of reverting to kerosene or fuel wood) between 22 percent and 67 percent, depending on changes in the number of household members during lockdown.

In light of the many challenges brought about by the pandemic, a green recovery presents an opportunity for clean cooking, as long as it is given full consideration as an essential element of the post-COVID-19 recovery. Sector policies and programs should be ambitious, forward-looking, and smart in design, integrating long-term financial assistance and resources.

HIGH-LEVEL FINANCIAL COMMITMENTS TO DATE

As previously noted, the lack of access to clean cooking costs on the order of USD 2 trillion per year—USD 1.4 trillion for negative health effects, USD 0.8 for lost productivity among women, and USD 0.2 trillion for environmental degradation (ESMAP 2020b).[34]

Finance for clean cooking remains far below the amount needed to achieve SDG 7 by 2030. To estimate the investments needed, different organizations report various figures, based on the scenario chosen. IEA (2020) reported that an annual investment of USD 4.5 billion would be needed to achieve universal access for cooking. Of that, USD 2.4 billion is needed in Sub-Saharan Africa, while South Asia and South-eastern Asia need USD 2.1 billion. Under the ESMAP-MECS scenario, the amount needed to transition to improved cooking solutions (Tier 2) rises to USD 10 billion annually, and it rises further to USD 156 billion annually for the Modern Energy Cooking Services scenario (Tier 4).[35] In 2018, USD 131 million of annual investment was made, accounting for less than 3 percent of the annual investment required in the IEA scenario. Of the amount invested, 60 percent is public finance. Although meager, this figure is still three times the USD 48 million allocated to clean cooking in the previous year. Nonetheless, both amounts remain much less than the amount needed (SEforAll 2020).

Furthermore, although many financial commitments have been made, resources are not reaching the countries that need it the most. A total of 18 countries are home to 2.2 billion people without access to clean cooking attracted only 25 percent of the investment tracked. Countries like Ethiopia or Democratic Republic of the Congo received less than 1 percent of the annual investment needed (SEforAll 2020).

The RISE report (ESMAP 2020a) provides an analysis of financial incentives for universal access to clean cooking for the period 2010–19 (box 2.4). For consumers, the incentives take the form of financing; for suppliers, the incentives include subsidies, tax benefits, and duty exemptions. Among the 55 economies surveyed, China, India, Nigeria, and South Africa implemented all 4 financial incentives. Thirteen economies (Bangladesh, Cambodia, Cameroon, Ethiopia, Lao PDR, Mauritania, Mongolia, Nepal, Niger, Rwanda, Togo, Uganda, Zimbabwe) had implemented 3 of the 4 financial incentives. Of these, India, Nigeria, Cambodia, and Mongolia are among the 20 countries with the fastest-rising population shares enjoying access to clean cooking fuels and technologies for the period 2015–19 (see figure 2.10).

BOX 2.4 • CLEAN COOKING POLICY FROM RISE 2020

Out of the four target areas for SDG 7 (access, efficiency, renewables, international cooperation), access to clean cooking is the most often overlooked by policy makers. In the latest edition of the World Bank's Regulatory Indicators for Sustainable Energy index (RISE), policy frameworks for SDG 7.1.2—universal access to clean fuels and technologies for cooking by 2030—were evaluated. The review of clean cooking in the RISE report included information on 55 countries that account for more than 93 percent of the world's population with low access scores. Four indicators measure the clean cooking pillar's policy frameworks: planning, inclusiveness, standards and labeling, and incentives to increase uptake.

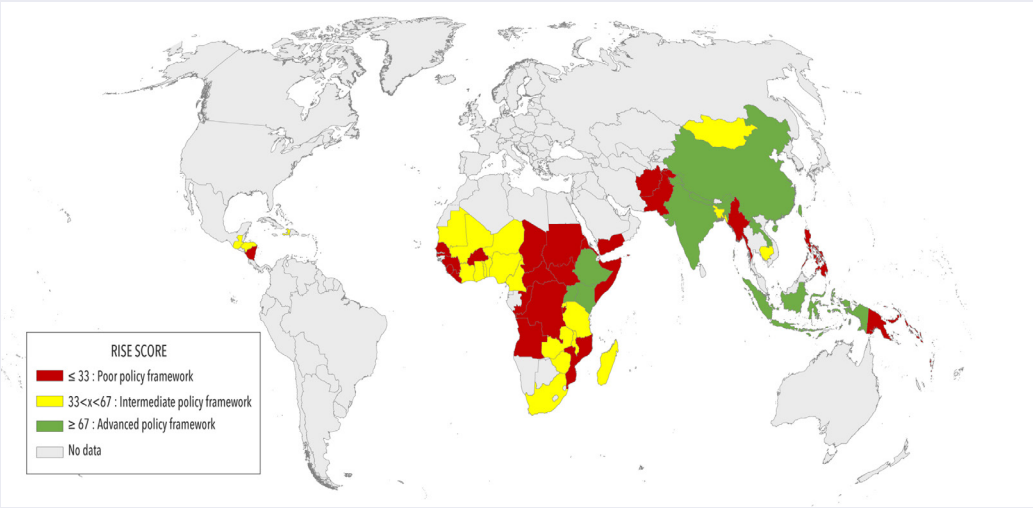
When evaluating policy frameworks for clean cooking dating back to 2010, RISE scores across all 55 access-deficit countries have improved consistently. The number of countries with advanced policy frameworks (RISE scores in the green zone on the map in figure B2.4.1) rose from none in 2010 to eight in 2019. Among these green zone countries, China, Ethiopia, India, Indonesia, and Kenya made great strides toward better access—especially India, which was the only country to score above 90 on a scale of 1 to 100. Of the remaining 47 countries that did not reach the green zone (scores below 67/100), 22 made moderate progress; in 25, the policy apparatus remains in its early stages. Yet looking at sheer numbers, the current situation is more encouraging (figure B2.4.2).

Although less than a quarter of the access-deficit countries have advanced policy frameworks, these countries are home to 1.4 billion people who still lack access, accounting for close to half the population lacking access.

34 When the costs of death and disability (measured in adjusted life years) are combined with the hours women spend on fuel collection, cooking, and stove cleaning, and with the costs of climate change and environmental degradation the economic impact is severe indeed.

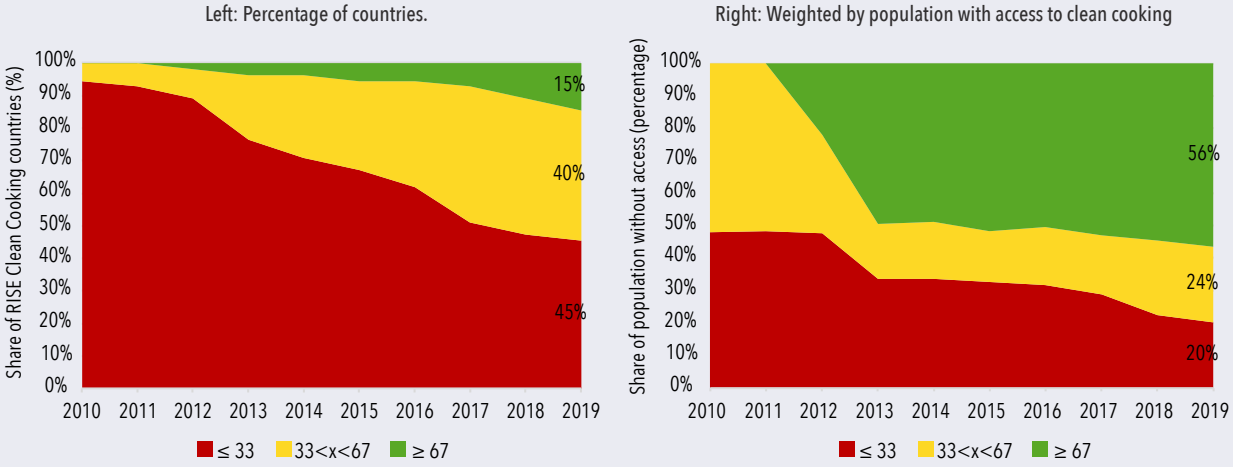
35 MECS is more stringent than the binary clean cooking indicator. The investment estimated by MECS includes, in addition to household spending for a two-burner stove and fuel, fuel and stove subsidies to fill in the affordability gap, as well as downstream infrastructure essential to the functioning of clean cooking market. The ESMAP-MECS Multi-Tier Framework considers scores (0–5) for convenience, fuel availability, safety, affordability, efficiency, and exposure.

FIGURE B2.4.1 • Placement on RISE index of 55 access-deficit countries, 2019



Note/disclaimer: This map was produced by the Geospatial Operations Support Team of the World Bank based on the Cartography Unit of the World Bank. *The boundaries, colors, denominations, and other information shown on any map in this work do not imply any judgment on the part of the custodian agencies concerning the legal status of or sovereignty over any territory or the endorsement or acceptance of such boundaries.*

FIGURE B2.4.2 • RISE Clean Cooking pillar score, 2010–19



Source: ESMAP 2020a.

Several trends can be discerned from the RISE report. Overall, although this trend is not universal, performance on the clean cooking index soars as income rises. Most lower-income countries are in the red zone, suggesting that they have not yet developed policy frameworks for clean cooking. Some low-income nations (like Ethiopia, Malawi, and Uganda) have robust policy frameworks that have boosted them into the green zone. The 2010–17 period was notable for pushing several countries out of the red zone. This was particularly true for upper- and lower-middle-income countries in Asia (most notably India) and Latin America (most notably Guatemala). The period between 2017 and 2019 saw large gains for poorer Sub-Saharan countries like Benin, Kenya, Nigeria, and Tanzania.

But the presence of low-access countries among top RISE performers shows that a focus on the policy agenda is not enough. Scaling up access on the ground depends on the finer aspects of allocating resources and planning implementation. In low-income countries like Uganda and Ethiopia, scale-up will require stepping away from artisanal production of biomass stoves toward clean solutions (LPG, biogas, and electricity). As this transition will occur over a longer period of time, interim solutions (such as quality-assured biomass stoves) will mitigate the worst health and environmental outcomes caused by the use of charcoal and firewood.

Source: ESMAP 2020a.

MONITORING THE TRANSITION TO CLEAN FUEL AND CLEAN TECHNOLOGIES

A key component to accelerating global action on household air pollution is to raise awareness of the benefits of clean fuels for household activities. Action plans should rely on data and estimates that quantify progress in the transition to clean fuels. Information on major cooking fuels is collected at the urban, rural, and national levels whenever available. The information obtained includes the principal fuel households use for cooking, which has a decisive effect on the air quality in the home and in the community. The progress reported in this chapter relies on this information, which enables projections that quantify progress made toward the SDG 7.1.2 goal. As access expands and pilot programs are implemented, a fuller, more nuanced picture of successful transitions to clean fuels will become possible.

In 2020, a collaboration between WHO and the World Bank produced new household survey questions for national surveys and censuses. These questions complement the information presently gathered on the principal cooking fuel, expanding it to include information on secondary fuel use and cooking technologies. Detailed new questions will enable surveys to gather information on all household fuel uses (for cooking, heating, and lighting), as well as technology and stacking practices. This information, which has just begun to be gathered, will also permit more reliable projections of the burden of disease.

POLICY RECOMMENDATIONS

Universal access to clean fuels and technologies must be prioritized, and action is most urgently needed in Sub-Saharan Africa, which is dominated by low access rates. Progress must be achieved through a just and equitable energy transition that leaves no one behind. Affordable solutions must be offered to poor and vulnerable populations.

Greater political will at the national level, along with cooperation among actors, is essential to coordinate and align policies (ESMAP 2020b). To strengthen policies and create an enabling environment, governments are encouraged to establish intergovernmental clean cooking "delivery teams" to work across government agencies (ESMAP 2020b).

Governments should consider embedding policies in stimulus packages to support energy service providers and minimize market disruptions (ESMAP 2020a). Possible financial incentives include favorable and stable taxes and duties to sustain business growth—for example, a five-year VAT exemption on all clean cooking fuels and technologies. Incentives and policies focusing on clean fuels and efficient technologies should also embed gender strategies at national levels. Placing women in the clean cooking energy value chain, from production to consumption, ensures that local cooking practices, affordability, and end-user preferences will be honored (Energia 2020).

Major initiatives are needed to drive progress. Key actions needed for large-scale public and private investment include the following:

- Increase investment in public infrastructure to reduce the transactional costs and make the ecosystem more credible for financing mechanisms, such as results-based financing and carbon finance.
- A "results-based financing accelerator" to standardize methodologies and create aggregate or warehouse structures would allow for investment in many small projects at once.
- Smart and equitable strategies for reform of fossil fuel subsidies to help reallocate funding and boost sustainable energy access.
- A subsidy toolkit that profiles effective programs and structures and provides guidance on how to design subsidies could be a first step toward quantifying the benefits of transitions to clean cooking fuels. For example, WHO's Clean Household Energy Solutions Toolkit describes the costs and benefits of various household energy interventions.

A strong market for clean cooking would benefit from the following key actions:

- Creating an open-platform "user insight lab" to generate and integrate insights on the user experience into innovative business models, technologies, and policies.
- Supporting international standards for clean cooking and building national implementation capacity.
- Supporting technology-specific innovation accelerators to drive rapid, evidence-based, market-ready research and development of clean cooking fuels and practices, related to ethanol and biomass, in particular.
- Providing gender-focused technical assistance to enterprises to ensure that gender equity is mainstreamed across the clean cooking ecosystem.
- Fostering mechanisms for knowledge exchange among peers.

METHODOLOGY

DATA SOURCES

The WHO Household Energy Database[36] contains regularly updated, nationally representative household survey data. It relies on a number of sources (table 2.1) and serves in this report as the basis for all modeling efforts (Bonjour and others 2014; Stoner and others 2020). The database is built from 1,440 surveys taken in 170 countries (including high-income countries) between 1960 and 2020; 21 percent of the surveys cover the years 2014–19; 88 new surveys cover 2017–19. Modeled estimates for low- and middle-income countries are provided only if there is underlying survey data on cooking fuels, so there are no estimates for Bulgaria, Cuba, Lebanon, or Libya.

Population data are from the United Nations Population Division.

MODEL

As household surveys are conducted irregularly and reported heterogeneously, the WHO Global Household Energy Model (GHEM) (developed in collaboration with the University of Exeter in the United Kingdom) is employed to estimate trends in household use of six fuel types:

- Unprocessed biomass (e.g., fuel wood, dung, crop waste)
- Charcoal
- Coal
- Kerosene
- Gaseous fuels (e.g., LPG)
- Electricity

Trends in the proportion of the population using each fuel type draw on country-level survey data and are estimated using a Bayesian hierarchical model, with urban and rural disaggregation. Smooth functions of time were the only covariate. Estimates for overall "polluting" fuels (unprocessed biomass, charcoal, coal, and kerosene) and "clean" fuels (gaseous fuels, electricity, as well as an aggregation of any other clean fuels, such as alcohol) are produced by aggregating estimates of relevant fuel types. Estimates produced by the model automatically respect the constraint that the total fuel use equals 100 percent.

GHEM is implemented using the *R* programming language and the NIMBLE software package for Bayesian

36 https://www.who.int/airpollution/data/household-energy-database/en/.

modeling with Markov Chain Monte Carlo Summaries can be taken to provide both point estimates (e.g., means) and measures of uncertainty (e.g., 95 percent credible and 95 percent prediction intervals). The GHEM is applied to the WHO household-energy database to produce a comprehensive set of estimates, together with associated measures of uncertainty, of the use of four specific polluting fuels and two specific clean fuels for cooking, by country, for each year from 1990 to 2019. Further details on the modeling methodology and validation can be found in Stoner and others (2020); and more detailed analysis of individual fuel use can be found in Stoner and others (2021).

Only surveys with less than 15 percent of the population reporting "missing" and "no cooking" and "other fuels" were included in the analysis. Surveys were also discarded if the sum of all mutually exclusive categories reported was not within 98–102 percent. Fuel use values were uniformly scaled (divided) by the sum of all mutually exclusive categories, excluding "missing," "no cooking," and "other fuels." Countries classified by the World Bank as high-income (60 countries) in the 2019 fiscal year were assumed to have transitioned to clean household energy. They are therefore reported as having 100 percent access to clean fuel and technologies; no fuel-specific estimates were reported for high-income countries. In addition, no estimates were reported for low- and middle-income countries without data suitable for modeling (Bulgaria, Cuba, Lebanon, and Libya). Modeled specific-fuel estimates were reported for 132 low- and middle-income countries, plus 2 countries with no World Bank income classification (Niue and Cook Islands); estimates of overall clean fuel use were reported for 190 countries.

UNCERTAINTY INTERVALS

Many of the point estimates provided here are accompanied by 95 percent uncertainty intervals, which imply a 95 percent chance that the true value lies within the given range. Small annual changes in the point estimate may be statistical noise arising from either the modeling process or survey variability and may therefore not reflect a real variation in the number of households relying on different fuels between years. The uncertainty intervals should therefore be taken into account when assessing changes in the access rate, or in the use of specific fuels, year to year.

GLOBAL AND REGIONAL AGGREGATIONS

Population data from the United Nations Population Division (2018 revision) were used to derive the population-weighted regional and global aggregates. Low- and middle-income countries without data were excluded from all aggregate calculations; high-income countries were excluded from aggregate calculation for specific fuels.

ANNUALIZED GROWTH RATES AND FUTURE PROJECTIONS

The annualized increase in the access rate is calculated as the difference between the access rate in year 2 and that in year 1, divided by the number of years to annualize the value:

(Access Rate Year 2–Access Rate Year 1) / (Year 2–Year 1)

This approach takes population growth into account by working with the final national access rate.

Projected access rates, access deficits, and fuel use can be estimated using the GHEM, where uncertainty increases the farther into the future estimates are calculated, reflecting how country trends may shift based on how unsettled they were during the data period.

Projections are hypothetical scenarios in which no new policies or interventions (positive or otherwise) take

place, and as such are useful as baseline scenarios for comparing the effect of interventions.

Data sources are summarized in table 2.1.

TABLE 2.1 • Overview of data sources for clean fuels and technology

NAME	ENTITY	NUMBER OF UNIQUE COUNTRIES	DISTRIBUTION OF DATA SOURCES (IN %)	QUESTION
Census	National statistical agencies	109	17.8	What is the main source of cooking fuel in your household?
Demographic and Health Survey (DHS)	Funded by USAID; implemented by ICF International	81	16.7	What type of fuel does your household mainly use for cooking?
Living Standard Measurement Survey, income expenditure survey, or other national surveys	National statistical agencies, supported by the World Bank	48	6.8	Which is the main source of energy for cooking?
Multi-indicator cluster survey	UNICEF	87	11.3	What type of fuel does your household mainly use for cooking?
Survey on global AGEING (SAGE)	WHO	7	0.6	
World Health Survey	WHO	50	3.5	
National survey		107	33.6	
Other		80	9.7	

REFERENCES

Anenberg, S. C., K. Balakrishnan, J. Jetter, O. Masera, S. Mehta, J. Moss, and V. Ramanathan. 2013. "Cleaner Cooking Solutions to Achieve Health, Climate, and Economic Cobenefits." *Environmental Science and Technology* 47 (9): 3944–52. doi: 10.1021/es304942e.

Bonjour, S., H. Adair-Rohani, J. Wolf, N. G. Bruce, S. Mehta, A. Prüss-Ustün, M. Lahiff, E. A. Rehfuess, V. Mishra, and K. R. Smith. 2013. "Solid Fuel Use for Household Cooking: Country and Regional Estimates for 1980–2010." *Environmental Health Perspectives* 121(7):784.

Couture, T. D., and D. D. Jacobs. 2019. *Beyond Fire: How to Achieve Electric Cooking*. World Future Council, The Hague.

Das, I., J. J. Lewis, R. Ludolph, M. Bertram, H. Adair-Rohani, and M. Jeuland. 2021. "The Benefits of Action to Reduce Household Air Pollution (BAR-HAP) Model: A New Decision Support Tool." *PLoS ONE*, 1–22. https://doi.org/10.1371/journal.pone.0245729.

Energia. 2020. "Policy Brief: The Benefits of Involving Women in Energy System Supply Chains." The Hague. https://www.energia.org/document/policy-brief-the-benefits-of-involving-women-in-energy-system-supply-chains/.

ESMAP (Energy Sector Management Assistance Program). 2020a. *Regulatory Indicators for Sustainable Energy (RISE) Sustaining the Momentum.* Washington, DC: World Bank.

ESMAP. 2020b. *The State of Access to Modern Energy Cooking Services*. Washington, DC: World Bank.

Goodwin NJ, O'Farrell SE, Jagoe K, Rouse J, Roma E, Biran A, Finkelstein EA. "Use of behavior change techniques in clean cooking interventions: a review of the evidence and scorecard of effectiveness". J Health Commun. 2015;20 Suppl 1:43-54. doi: 10.1080/10810730.2014.1002958. PMID: 25839202.

IEA (International Energy Agency). 2020. *World Energy Outlook 2020.* Paris: International Energy Agency, https://www.iea.org/reports/world-energy-outlook-2020.

Puzzolo, E., D. Stanistreet, D. Pope, N. Bruce, and E. A. Rehfuess. 2013. "Factors Influencing the Large-Scale Uptake by Households of Cleaner and More Efficient Household Energy Technologies." London: EPPI-Centre, Social Science Research Unit, Institute of Education, University of London.

Rehfuess, E. A., E. Puzzolo, D. Stanistreet, D. Pope, and N. G. Bruce. 2014. "Enablers and Barriers to Large-Scale Uptake of Improved Solid Fuel Stoves: A Systematic Review." *Environmental Health Perspectives* 122:2 doi.org/10.1289/ehp.1306639.

SEforAll (Sustainable Energy for All). 2020. "Energizing Finance: Understanding the Landscape." https://www.seforall.org/events/seforall-at-cop24-official-side-event-energizing-finance-understanding-the-landscape-2018.

Shankar, A. V., A. K. Quinn, K. L. Dickinson, and many others. 2020. "Everybody Stacks: Lessons from Household Energy Case Studies to Inform Design Principles for Clean Energy Transitions." *Energy Policy* 141: 111468.

Shupler, M., J. Mwitari, A, Gohole, R. Anderson de Cuevas, E. Puzzolo, I. Cukic, E. Nix, and D. Pope. 2020. COVID-19 *Lockdown in a Kenyan Informal Settlement: Impact on Household Energy and Food Security*. Renewable and Sustainable Energy Reviews, Volume 144, 2021.

Shupler, M., M. O'Keefe, E. Puzzolo, and many others. 2021. "Pay-as-You-Go Liquefied Petroleum Gas Supports Sustainable Clean Cooking in Kenyan Informal Urban Settlement during COVID-19 Lockdown." *Applied Energy,* doi.org/10.1016/j-apenrgy.2021.116769

Stoner, O., G. Shaddick, T. Economou, S. Gumy, J. Lewis, I. Lucio, G. Ruggeri, and H. Adair Rohani. 2020.

"Global Household Energy Model: A Multivariate Hierarchical Approach to Estimating Trends in the Use of Polluting and Clean Fuels for Cooking." *Journal of the Royal Statistical Society* 69: 815–39. https://doi.org/10.1111/rssc.12428

Stoner, O., J. Lewis, I. Martínez, S. Gumy, T, Economou, and H. Adair-Rohani. 2021. "What Fuels the Fire? Cooking Fuel Estimates at Global, Regional and Country Level for 1990–2030," Research Square. https://www.researchsquare.com/article/rs-251806/v1.

van der Valk, Joanna P. M., and J. In 't Veen. 2021. "The Interplay Between Air Pollution and Coronavirus Disease (COVID-19)." *Journal of Occupational and Environmental Medicine* 63(3): e163–67.

WHO (World Health Organization). 2021. "Global Health Observatory." World Health Organization, Geneva. https://www.who.int/data/gho/data/themes/air-pollution/household-air-pollution.

WHO. 2014. "WHO Guidelines for indoor air quality: household fuel combustion." World Health Organization, Geneva.