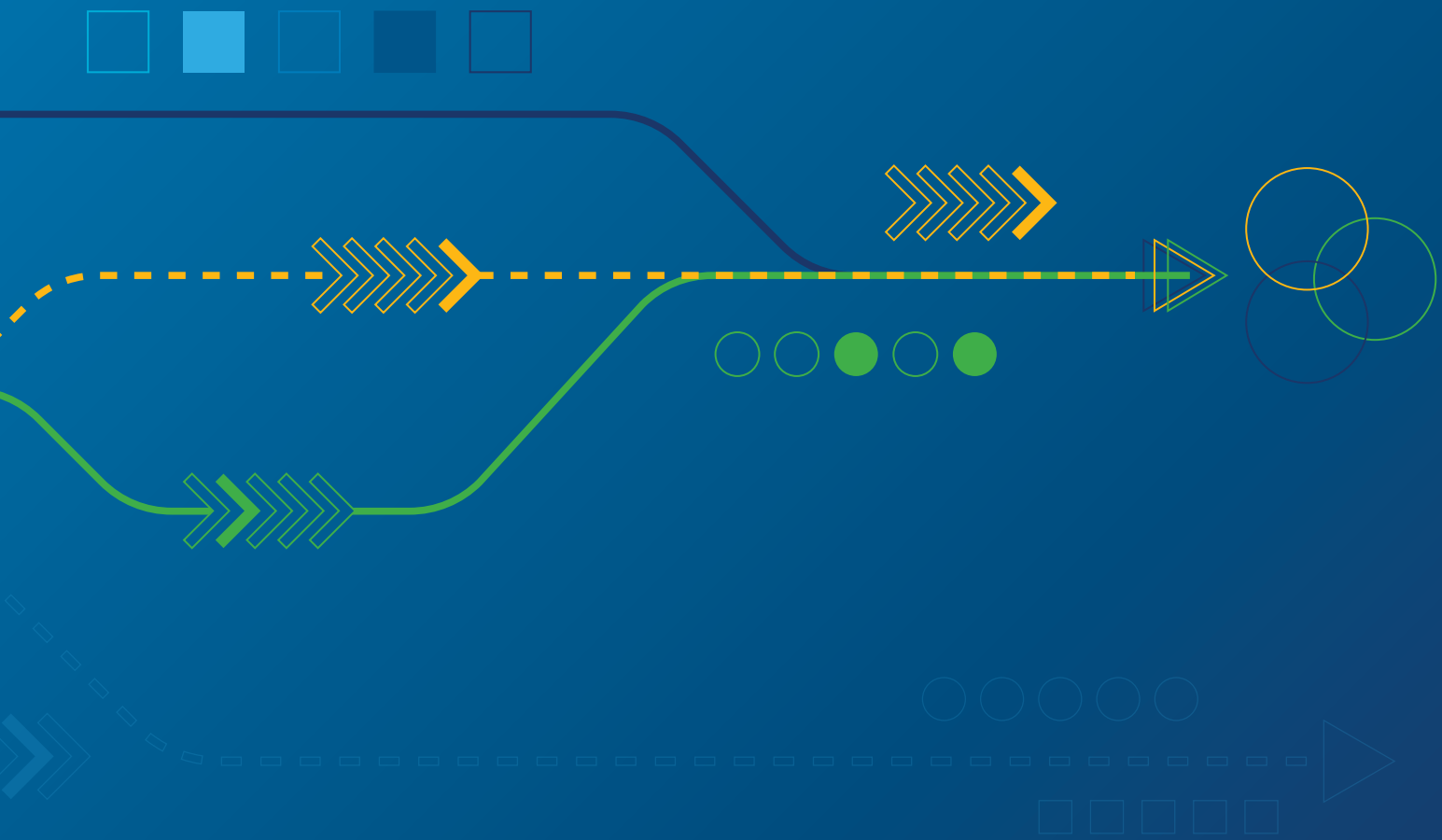
United Nations | UN ENERGY

ACHIEVING UNIVERSAL ACCESS BY 2030 AND NET-ZERO EMISSIONS BY 2050:

A Global Roadmap for Just and Inclusive Clean Cooking Transition



ABOUT UN-ENERGY POLICY BRIEF

The drafting of this UN-Energy Policy Brief was led by the the World Bank and the World Health Organization (WHO) in collaboration with the United Nations Department of Economic and Social Affairs (UNDESA) as members of UN-Energy. It builds on discussions at a UN-Energy meeting at technical level held on 10 May 2023 in New York, and on additional technical inputs from many other UN-Energy organisations.

This UN-Energy Policy Brief was prepared in support of the SDG7 review at the High-level Political Forum 2023 in line with the UN-Energy Plan of Action Towards 2025. The Plan outlines UN-Energy's contributions towards the implementation of the Global Action Plan for Accelerated SDG 7 Action presented by the UN Secretary-General as an outcome of the UN High-level Dialogue on Energy in 2021. The HLPF 2023 will inform the SDG Summit to be held during the UN General Assembly High-level Week in September 2023.

This work is a joint product of staff of various UN-Energy members and partners. The findings, interpretations, and conclusions expressed in this publication do not necessarily represent those of UN-Energy or any of its members or partners.

ABOUT UN-ENERGY

UN-Energy is the United Nations' mechanism for inter-agency collaboration in the field of energy established by the UN System Chief Executives Board for Coordination. It aims to promote coherence in the UN system´s multi-disciplinary response to achieve Sustainable Development Goal 7 (SDG 7) in support of the 2030 Agenda for Sustainable Development and the Paris Agreement on climate change. The member organizations of UN-Energy are: FAO, IAEA, IFAD, UNCDF, UNCTAD, UN DESA, UNDP, UN ECA, UN ECE, UN ECLAC, UN ESCAP, UN ESCWA, UNESCO, UNEP, UNFCCC, UNFPA, UN-Habitat, UNICEF, UNIDO, UNITAR, UN-OHRLLS, UN Women, World Bank, WHO, WMO, and partner organizations IRENA and SEforAll.

UN-Energy is co-chaired by Achim Steiner, Administrator of UNDP, and Damilola Ogunbiyi, Special Representative of the UN Secretary-General for Sustainable Energy for All. The UN-Energy secretariat is provided by UN DESA under the leadership of Li Junhua, UN Under-Secretary-General for Economic and Social Affairs.

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Introduction

Enabling the world's poor to cook with modern fuels and technologies and lifting them from cooking poverty is an urgent development issue, with enormous potential benefits for human health, climate, the environment, and advancement toward gender equity. However, the world is not on track to achieve clean cooking for all by 2030—the ambition of Sustainable Development Goal (SDG) indicator 7.1.2. The stark reality is that 2.3 billion people rely on polluting traditional fuels and technologies to cook their meals. Globally, the number of people gaining access to clean cooking has increased significantly in recent decades. However, population growth has outpaced these improvements, particularly in Sub-Saharan Africa where the number of people without access reached 0.9 billion in 2021.[1] Without accelerated action, 1.9 billion people can be expected to remain in cooking poverty in 2030, at a staggering annual cost of US$2.4 trillion due to the impacts on health, gender, and the global climate.

Advancing clean cooking access and delivering on the Paris Climate Agreement are inextricably linked. Universal access to clean cooking is an integral part of transitioning to a just net-zero-emissions energy system. In 2020, total emissions from the cooking sector were estimated at 1.69 gigatons (Gt) of carbon dioxide equivalent ($GtCO_2e$), of which 1.30 Gt (77%) were from non-renewable biomass, 0.33 Gt from liquefied petroleum gas (LPG) and liquefied natural gas (LNG), and 0.06 Gt from electricity.[2] Cooking-sector emissions account for about 3 percent of global greenhouse gas (GHG) emissions and 56 percent of emissions from buildings.[3] Promoting access to clean cooking can also advance gender equity for women and children, who are often primarily responsible for cooking and fuel collection tasks, through time savings, improvements in health and well-being, and empowerment and livelihood opportunities.

The SDG 2030 universal access clean cooking and 2050 net-zero goals will be missed unless current efforts to expand energy access are drastically accelerated Reducing the cooking sector's CO_2 emissions to net zero by 2050 is viewed as one of the most immediate and cost-effective solutions available for achieving the 2050 net-zero-emissions goal of the global energy sector and limiting the long-term increase in average global temperatures to 1.5 °C.[4]

A global roadmap including key milestone and priority actions for a just and inclusive transition in the cooking sector to reach net-zero CO_2 emissions by 2050 is presented here. By adapting this global roadmap to their local context, countries can develop their national-level roadmaps. The top priority action for low- and middle-income countries is to achieve universal access to clean cooking by 2030, while making sure vulnerable populations, including those who are displaced or in fragile settings, are integrated

[1] International Energy Agency, International Renewable Energy Agency, United Nations Statistics Division, World Bank, and World Health Organization (IEA, IRENA, UNSD, WB, and WHO), *Tracking SDG 7: The Energy Progress Report* (Washington, DC: World Bank, 2022).

[2] Food and Agriculture Organization (FAO) statistics

[3] International Energy Agency (IEA), *Net Zero by 2050: A Roadmap for the Global Energy Sector* (Paris: IEA, 2022).

[4] Gunther Bensch, Marc Jeuland, and Jörg Peters, "Efficient Biomass Cooking in Africa for Climate Change Mitigation and Development," *One Earth*, 4 (6): 879–90. https://doi.org/10.1016/j.oneear.2021.05.015.

in an inclusive manner. High-income countries should support those efforts while also working to decarbonize their own cooking and heating sectors to align with the net-zero-emissions goal by 2050.

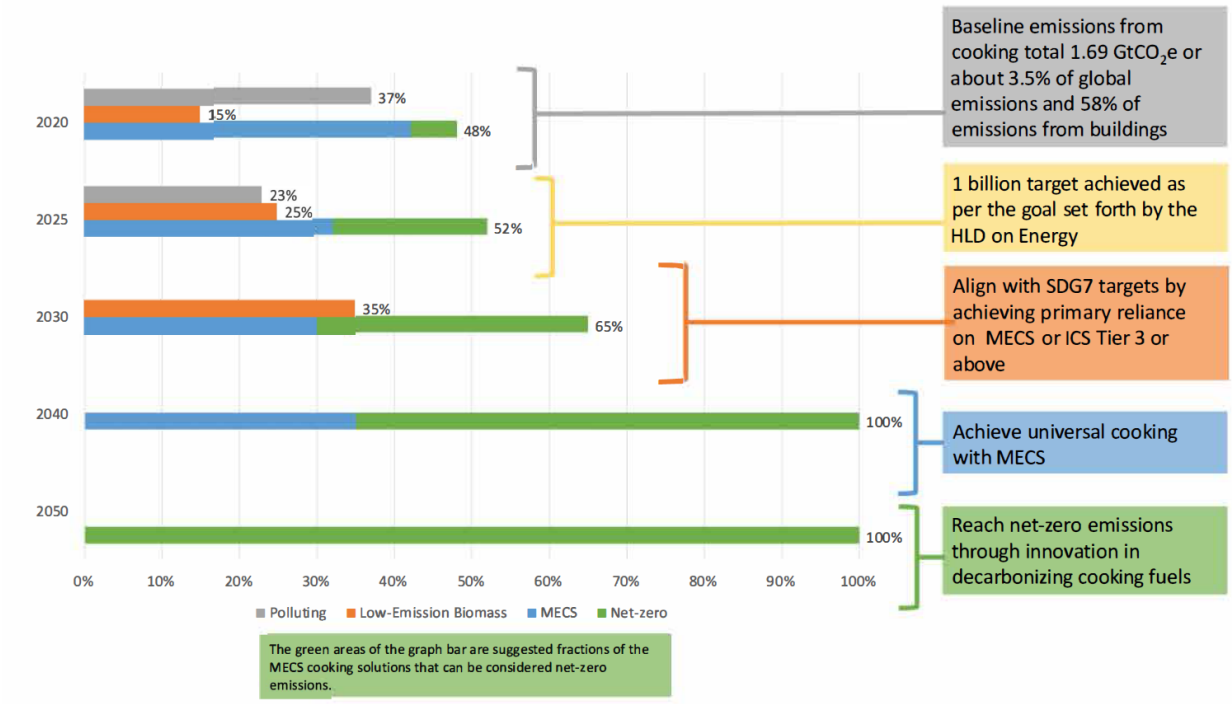
Global Pathways to Reach the 2030 and 2050 Goals

Following people-centered, energy-access approaches and addressing the common practice of fuel-and-stove stacking, this global roadmap uses the Multi-Tier Framework (MTF) for cooking (see Annex for description of the MTF). Households are considered to have gained access to clean cooking as per the SDG 7 target when they *primarily* or mainly cook with clean fuels such as LPG, natural gas, electricity, biogas, ethanol, or very low-emission biomass stoves meeting at least tier 3 or above the MTF[5][6]. Households are considered to have gained access to Modern Energy Cooking Services (MECS) when all fuels and technologies in the home are all MTF Tier-4 or above; while those that rely on Traditional (polluting) or transitional cooking fuels and technologies (tiers 0-2 of the MTF) lack access to clean cooking. Figure 1 provides critical reference points for the transition to net-zero emissions

[5] https://www.who.int/tools/clean-household-energy-solutions-toolkit/module-7-defining-clean

[6] Energy Sector Management Assistance Program (ESMAP), *The State of Access to Modern Energy Cooking Services* (Washington, DC: World Bank, 2020).

Figure 1. Targets for the share of population gaining access to tiered cooking solutions between 2020–50 to achieve the 2030 universal access and 2050 net-zero clean cooking goals



Polluting Cooking– Open fires and traditional inefficient stoves that burn wood, charcoal, coal, crop waste, dung or kerosene. These stoves are classified as Tiers 0-2 in the Multi-Tier Framework.

Clean Cooking—SDG 7 target of primary reliance on electricity, LPG, natural gas, biogas, alcohol fuels, solar and low-emission biomass stoves that meet Tier 3 or higher across the Multi–Tier Framework and provide some health and climate benefits.

Modern Energy Cooking Services (MECS)—LPG, electricity, alcohol fuels, biogas, natural gas, solar and low-emission biomass stoves (such as pellet stoves) that meet Tier 4 or higher across the Multi-Tier Framework.

Net-Zero Emission Cooking—Electricity from renewable resources, biogas, sustainably harvested alcohol fuels and bio-LPG.

Source: ESMAP, World Bank.

The 2050 Net-Zero-Emissions Scenario

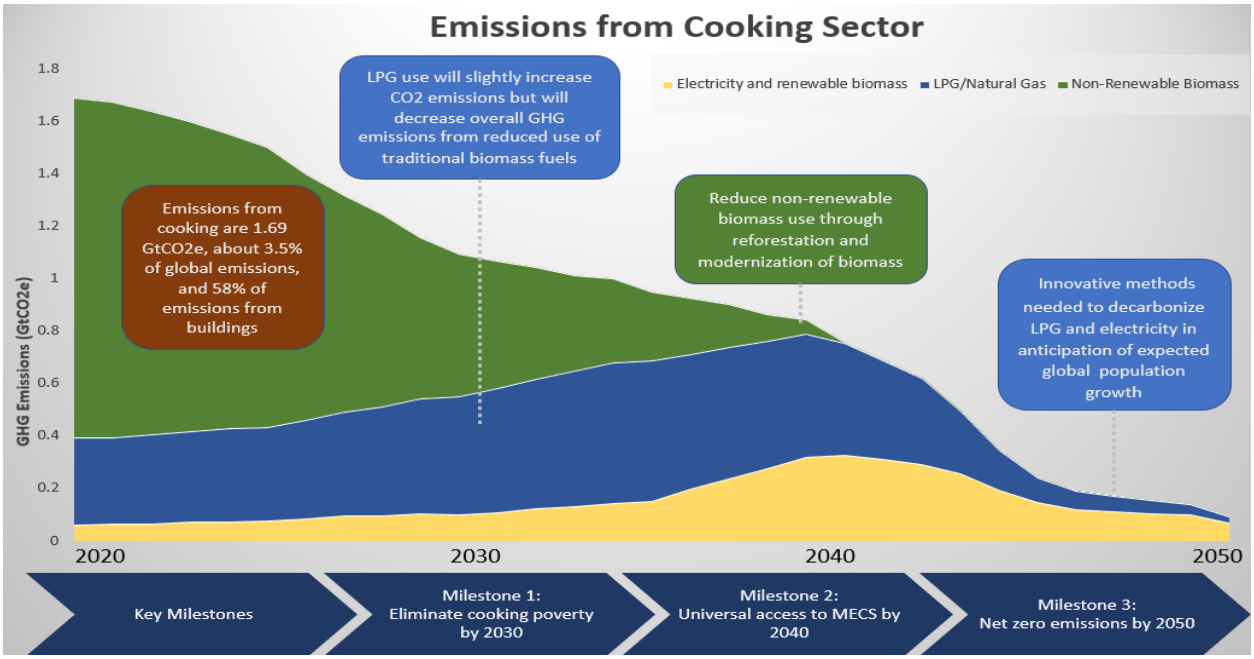
Emission Trends and Transition Requirements

The transition to net-zero emissions in the cooking sector by 2050 requires a substantial ramp-up in the decarbonization of electricity, power grids and other network infrastructure, and cooking fuels. Following the roadmap as outlined in this document would result in a net reduction of $CO_{2\text{-eq}}$ emission eventually falling to almost zero overall emissions by 2050.

Achievement of this goal can be accomplished through completion of the key milestones described below. By 2035, the use of LPG, although a fossil fuel, will have resulted in a small increase in CO_2 emissions but

a net reduction in overall GHG emissions due to the reduction in emissions of other climate forcing pollutants resulting from traditional biomass use (figure 2). The development of sustainable bioenergy will be able to utilize existing infrastructure; for example, BioLPG (i.e., LPG derived from renewable feedstocks) can be blended and distributed in the same way as conventional LPG. By 2050, the goal is that about 90 percent of electricity generation will come from renewable sources[7], accompanied by a sharp reduction in global generation from fossil fuels. As a result, nearly 70 percent of the population will cook with electricity from sustainable sources, with the remaining 30 percent cooking with renewable clean cooking fuels such as biogas, ethanol, bioLPG, solar and others.

Figure 2. Envisioned just and inclusive clean-cooking transition pathway toward net zero, 2020–50



Source: ESMAP, World Bank.

Key Milestones

No. 1: Eliminating cooking poverty and achieving universal access to clean cooking by 2030 in alignment with the SDG 7 target

To achieve the 2030 target, the share of the population mainly cooking with electricity, LPG/NG, biogas, ethanol, solar or other clean fuels or improved cooking solutions needs to increase from 48 percent (2020 base year) to 65 percent (2030), with an intermediate benchmark of 52 percent reached by 2025. Additionally, the share of the population mainly using improved cooking solutions like low-emission biomass stoves reaching Tier 3 or better needs to increase from 15 percent (2020 base year) to 35 percent (2030), with 25 percent reached by 2025. This means that, between 2020 and 2030, the pace of clean

[7] International Energy Agency (IEA), *Net Zero by 2050: A Roadmap for the Global Energy Sector* (Paris: IEA, 2022).

cooking expansion needs to increase from an annual growth rate of less than 2 percentage points to 4.7 percentage points.

No. 2: Achieve universal cooking with MECS and accelerate decarbonization of cooking fuels by 2040

Achieving these targets means that the population *primarily* using improved cooking solutions in 2030 must fully transition to the *exclusive* use of MECS by 2040. Concurrently, stepped-up efforts will be needed to replace LPG/natural gas with renewable electricity, bio-LPG, green hydrogen, or other renewable cooking fuels such as ethanol.

No. 3: Achieve net-zero clean cooking by 2050

Meeting the 2050 net-zero emission target will require significant efforts to decarbonize the entire energy value chain (e.g., production distribution) for both electricity and LPG/natural gas. Between the 2020 base year and 2050, emissions of $CO2\text{-}_{eq}$ produced through the generation of electricity, LPG, and natural gas will need to be reduced by upwards of 90% to a net-zero cooking footprint (Table 1).

Table 1. Reductions in household cooking emissions required to achieve net zero by 2050

Average annual household carbon emissions (tCO_2e)	2020	2025	2030	2035	2040	2050
Electric cooking	0.49	0.47	0.44	0.42	0.40	0.05
Liquefied petroleum gas (LPG)/natural gas	0.54	0.53	0.52	0.50	0.46	0.05

Source: ESMAP, World Bank.

Required Investment and Expected Benefits

Annual public investments to achieve universal access to clean cooking and eliminating cooking poverty (2020–30) and universal access to MECS (2030–40) are estimated at US$7.4 billion and US$13 billion, respectively. The public sector costs, borne by governments and development partners, will ensure that households do not spend more than 5 percent of their income on their monthly energy expenditure. The public sector will increase affordability for households through price support for stoves using targeted subsidies, conditional cash transfers for fuel payment or incentives, and supplementary costs (e.g., behavior-change programs, awareness-raising campaigns, and technical assistance). The costs assume that on the pathway from 2020 to 2030, households will replace traditional, low-efficiency stoves and fuels with two-burner low-emission efficient biomass cooking technologies and/or clean cooking solutions. Between 2030 and 2040, the analysis assumes a transition from improved cooking solutions to cleaner fuels such as LPG, electricity, biogas, and ethanol, at an average cost of US$80–225 per household, depending on the type of fuel-and-technology combination and locality (i.e., urban or rural).

The annual health, gender, and climate co-benefits from achieving universal access to a clean cooking, and eliminating cooking poverty by 2030 totals US$192.3 billion—more than 25 times the estimated public-sector investment. Moreover, the annual benefit of transitioning to exclusive use of to MECS by 2040 totals US$232.3 billion--about 17 times the estimated public financing. By 2040, the health co-benefit from avoided deaths and avoided disability-adjusted life years (DALYs) resulting from reduced

exposure to household air pollution (HAP) is estimated at US$178.7 billion per year. The gender co-benefit, associated with time savings in performing cooking-related tasks (e.g., collecting fuels and cooking), is estimated at US$20 billion per year. Finally, the climate co-benefit from switching targeted populations to cleaner cooking solutions is estimated at US$33.6 billion per year due to reductions in GHG and black carbon (BC) emissions (Annex 2).

Recommended Priority Actions

Achieving a just and inclusive global transition to ensure clean cooking for all requires mobilization of political commitment at the highest levels. The proposed global roadmap can be effectively used for advocacy, with a view to nurturing a political coalition in time for the 2023 SDG Summit and beyond. National governments should elevate their political ambitions and ramp up development aid and financing. Low- and middle-income countries should prioritize achieving clean cooking by 2030, while ensuring the most vulnerable populations, including those who are displaced or in fragile, conflict-prone and violence-prone areas, are not forgotten. High-income countries should support those efforts while also working to decarbonize their own cooking and heating sectors to align with the net-zero-emissions goal by 2050 (see Box 3).

Global pathways to clean cooking solutions for all by 2030 and net-zero sector emissions by 2050 require all governments to strengthen and achieve the clean cooking targets in their energy and climate policies. The Clean Cooking Alliance reports that, as of March 2023, 98 low and middle-income countries (LMIC) had included household energy or clean cooking–related goals in their Nationally Determined Contributions (NDCs) under the Paris Agreement on climate change and national clean cooking strategies and commitments; of those, 72 included specific clean cooking targets while the remaining 26 had established climate targets for adjacent sectors (e.g., energy efficiency, forest conservation, and air quality) that could be partially met through clean cooking activities. Twelve countries, most of them in sub-Saharan Africa, have also pledged to accelerate access to clean cooking in their energy compacts, mobilized since the United Nations High-Level Dialogue on Energy in September 2021. This is a huge step forward; however, commitments made to date fall short of what is required to achieve the 2050 Net-Zero target, and most pledges are not yet underpinned by near-term policies and measures.

National governments should integrate cooking energy demand into their energy planning and strategy development and then translate it into near-term trajectories and action plans. This requires a strong institutional champion that can coordinate with other relevant sectors. Raising the sector's visibility requires strategy, targets, budget, and a monitoring and evaluation mechanism. Public investment that takes global public goods into account is essential for crowding in private investment, while knowledge and innovation are key to lowering the costs of interventions. If clean cooking is not yet on a country's energy policy agenda, practitioners, including champions in government, must make the case for it. New measurement and planning tools for visualizing transition pathways can be used to facilitate identification and engagement. For example, the Clean Cooking Planning Tool developed by the Energy Sector Management Assistance Program (ESMAP), which covers 71 LMICs where a significant portion of the population lack access to clean cooking, can be used to facilitate integration of clean cooking analysis into development planning (box 1). The World Health Organization's Clean Household Energy Solutions Toolkit (CHEST) also contains various tools and resources that countries can use to develop or adapt policies and programmes for expanding access to and use of clean household energy for public health protection,

including the Benefits of Action to Reduce Household Air Pollution (BAR-HAP) tool to estimate costs and benefits of clean cooking policy interventions (box 2).

Country-specific pathways and roadmaps are needed to guide the transition to universal access to clean cooking by 2030 and net-zero emissions by 2050. Since cooking is a contextualized system with no one-size-fits-all solution, each country will need to design its own approach to the clean cooking transition, taking into account its specific stage of economic development and status of clean cooking access.[8] H igh-income countries are expected to make the transition to net zero at a more ambitious pace than low and middle-income countries (box 3). A whole-system approach is needed, whereby responses are mobilized at the national level and supported by a global or regional network of partners across the clean cooking ecosystem (e.g., national governments, multilateral development banks, dedicated impact investment funds, high-integrity carbon finance actors, and clean cooking enterprises).

Box 1. The World Bank's Country Climate and Development Report

In 2022, the World Bank Group launched the Country Climate and Development Report (CCDR), a core diagnostic tool designed to analyze the connection between climate and development policies. The aim is to help countries identify and prioritize actions that support the delivery of their development goals and objectives as they improve their climate resilience and reduce greenhouse gas (GHG) emissions. The first set of CCDRs covers 24 countries; in Sub-Saharan Africa, clean cooking is prominently featured in G5 Sahel countries (Burkina Faso, Chad, Mali, Mauritania, and Niger), Ghana, Malawi, Mozambique, and Rwanda.

The 2021–22 CCDR synthesis report, *Climate and Development: An Agenda for Action*, lists clean cooking as one of the main policy issues related to climate mitigation and adaptation. The report highlights that universal access to clean cooking is a development priority compatible with low-emissions development, especially for countries with energy-access deficits. Clean cooking can reduce deforestation by replacing traditional biomass use, as well as improve the health and well-being of people living in or close to poverty. The second batch of CCDRs, currently under preparation, will feature clean cooking in the following countries where population growth is outpacing gains in clean cooking access: Côte d'Ivoire, Democratic Republic of Congo, Guinea Bissau, Kenya, and Liberia.

Source: ESMAP, World Bank.

Box 2: The World Health Organization's Benefits of Action to Reduce Household Air Pollution (BAR-HAP) Tool

[8] ESMAP (Energy Sector Management Assistance Program), *Unlocking Clean Cooking Pathways: A Practitioner's Guide to Progress* (Washington, DC: World Bank, 2023).

The WHO's Benefits of Action to Reduce Household Air Pollution (BAR-HAP) tool can be used to estimate costs and benefits of different policy interventions that aim to promote cleaner household cooking, using country-specific data. Users can determine the costs and benefits associated with five different potential policy interventions, and sixteen different stove and fuel transitions for 120 different LMICs. Using current evidence, the tool breaks down the potential costs to governments and households, including stove and fuel purchase and subsidy costs, program implementation costs, as well as time, maintenance, and learning costs for households adopting a new stove. It also provides the value of the benefits of implementing the policy related to health (including avoided morbidity and mortality), time savings, climate, and the environment.

Policy makers can use the BAR-HAP tool to compare the costs and benefits of different policy interventions and select the solutions that will be the most beneficial for their specific country context. Tools such as BAR-HAP can help governments create their own country-specific roadmaps to achieve universal access to clean cooking by 2030 and net-zero emissions by 2050.

A dramatic scale-up in public financing is needed to leverage private financing for clean cooking. To achieve universal access to clean cooking and eliminate cooking poverty by 2030 and exclusive cooking with MECS by 2040, public investment needs to be scaled up from the tens of millions to tens of billions, along with dedicated policies. Such investment includes not only the initial capital costs of stoves and deposit/connection fees, but also the energy infrastructure and additional subsidies required to make the recurring clean-fuel costs affordable to the poorest consumers. Large-scale grant resources for MECS are particularly needed to scale up the availability, diversity, and volume of capital in the sector, as well as stimulate product and business-model innovations. Integrating the envisioned progress toward universal access to MECS with that of electrification as part of energy-access efforts is also critical to bolstering the scale and impact of allocated public resources and private-sector capital.[9]

Box 3. Transiting from Natural Gas to Electricity for Cooking in high-income countries and the United States

Even though most high-income countries have generally transitioned to clean cooking fuels and technologies, reliance on fossil fuels for cooking is still not fully eliminated. Around one third of households across European Union (EU) countries rely on gaseous fossil fuels, ranging from 0.2 up to 70 percent. Furthermore , an average of 38 percent (ranging between 0.3 in Sweden and 84.2 in Hungary) of households across EU rely on fossil fuels for space heating (Eurostat, 2021)[10] , resulting in additional emissions from high income countries.

When looking at the household use of cooking in the US, New York has become the first U.S. state to pass legislation banning the use of natural gas for heating and cooking in most new buildings,

[9] Energy Sector Management Assistance Program (ESMAP), *The State of Access to Modern Energy Cooking Services* (Washington, DC: World Bank, 2020).

[10] Eurostat (2021) Energy Consumption in households: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Energy_consumption_in_households&oldid=437946#Use_of_energy_products_in_households_by_purpose

with a US$229 billion state budget containing the provision approved in May 2023. The law bans gas-powered stoves, furnaces, and propane heating and effectively encourages the use of heat pumps and induction stoves in most new residential buildings across the state. It requires all electric heating and cooking in new buildings shorter than seven stories by 2026, and for taller buildings by 2029. It allows exemptions for large commercial and industrial buildings, such as manufacturing facilities, restaurants, hospitals, and stores.

In 2020, New York was the sixth-largest natural gas consumer in the U.S., with natural gas fueling 46 percent of the state's electricity generation. A landmark climate law passed in 2019 calls for a transition to renewable, emissions-free sources (e.g., solar, wind, and hydropower). It requires the state to achieve a carbon-free electricity system by 2040 and reduce greenhouse gas (GHG) emissions 40 percent below 1990 levels by 2030 and 85 percent by 2050, setting a new standard for states and the nation to expedite the transition to a net-zero-emissions economy.

In Massachusetts, a law adopted last year has allowed 10 cities and towns to participate in a pilot program banning gas-burning stoves and furnaces from new construction. California has also been at the forefront of the effort. In 2022, the California Air Resources Board (CARB) voted to ban the sale of new gas furnaces and water heaters beginning in 2030. Homes will be required to install zero-emissions alternatives, such as electric heaters. The state targets 100 percent clean electricity by 2045, with Los Angeles aiming to achieve it by 2035.

Sources: https://www.eia.gov/state/analysis.php?sid=NY; https://www.dec.ny.gov/press/126882.html#:~:text=The%20Climate%20Act%20requires%20the,to%20a%20clean%20energy%20economy; https://www.washingtonpost.com/climate-environment/2023/05/03/newyork-gas-ban-climate-change/; https://www.npr.org/2022/09/23/1124511549/california-plans-to-phase-out-new-gas-heaters-by-2030; https://www.latimes.com/california/story/2023-04-17/natural-gas-debate-heats-up-as-federal-appeals-court-strikes-down-berkeley-ban

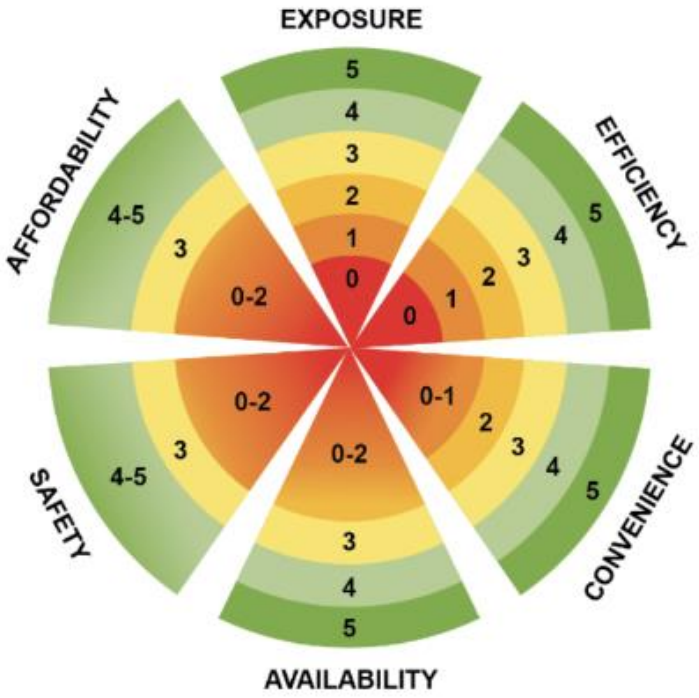
Climate finance can play a key role in making clean cooking investments financially viable if the downside risks are carefully managed. Carbon finance should be leveraged to support the hardest-to-reach market segment through improving the affordability of grid connections and higher-tier cooking solutions for the poorest customers in the form of Results-Based Financing (RBF) grants. At the national level, carbon finance can support the building of institutional capacity for Measurement, Reporting, and Verification (MRV)/transparency to collect and analyze data from the clean cooking sector to assess the impact of NDC implementation. Traditionally, carbon finance has been an attractive source of financing for clean cooking projects; and, with the recent surge in carbon prices, more carbon finance is finding its way to the clean cooking sector. Building on the carbon market infrastructure, it is possible to monetize the additional verified social impacts of interventions using recently developed methods that quantify and measure the public co-benefits (Annex 2). However, the associated risks of carbon finance (e.g., possible over-crediting and the free-stove distribution business model that relies fully on carbon revenue) need to be carefully managed. Governments, certification agencies, development partners, and private companies all have a role to play in mitigating risks.

Annex 1. Clarification of Key Terms

Clean Cooking— For this road map, clean cooking refers to a household that primarily relies on 'clean' cooking solutions where 'clean' is defined as those technology and fuel combination that meet the recommendations of WHO guidelines for indoor air quality: household fuel combustion[11]. Common fuels and technologies considered 'clean' at point-of-use include electricity, natural gas, liquified petroleum gas, biogas, alcohol fuels, solar cookers, and low-emission biomass stoves meeting the multi-tier tracking framework Tier 3).

Cooking Poverty—A household context reliant on traditional, polluting cooking fuels and technologies, synonymous with "lack of access to clean cooking fuels and technologies" in Sustainable Development Goal (SDG) 7 tracking.

Multi-Tier Framework (MTF) for cooking—Multidimensional, tiered approach to measuring household access to cooking solutions across six technical and contextual attributes with detailed indicators and six thresholds of access, ranging from Tier 0 (no access) to Tier 5 (full access). The aggregate MTF tier is the lowest tier rating across the six attributes: convenience, (fuel) availability (a proxy for reliability), safety, affordability, efficiency, and exposure (a proxy for health related to exposure to pollutants from cooking activities).



Modern Energy Cooking Services (MECS)—Refers to a household context that has met the standards of Tier 4 or higher across all six measurement attributes of the Multi-Tier Framework.

Improved cooking solutions — Refers to a household "in Transition," meaning it has met cooking solutions that meet the standards of Tier 3 across all six measurement attributes of the Multi-Tier Framework, but not all of those for Tier 4 or higher.[12] Typical improved cooking solution technologies include advanced biomass stoves that can achieve some health and climate benefits.

[11] https://www.who.int/publications/i/item/9789241548885

[12] Previously, biomass stoves were considered to be improved if they met MTF Tiers 2 and 3; however, given the significant difference in $PM_{2.5}$ emissions and health impacts between these tier technologies and the greater local availability of Tier 3 cooking solutions in countries lacking clean cooking access, only MTF Tier 3 is now considered to meet the standards for low emission biomass stoves.

Annex 2. Methodology

The modeling exercise for the 2050 Net-Zero Emissions Scenario takes a top-down approach to estimate the GHG emissions pathways of achieving universal access to clean cooking for the global population in the 2020–50 time frame. This note describes the methodology used to (1) model the 2020–50 transition pathways to universal clean cooking and exclusive use of MECS and (2) estimate the associated GHG emissions trajectory. The modeling work follows the analytic framework developed under ESMAP's Clean Cooking Planning Tool,[13] and uses the World Bank's country database developed for the ESMAP report, *The State of Access to Modern Energy Cooking Services*, for the 2020 baseline values of people without access to clean cooking. The exercise first sizes the number of households/people to transition by 2050, using estimates of the United Nations Department of Economic and Social Affairs (UNDESA), which account for population growth and urbanization at the global level. By 2050, it is expected that the global population will have reached 9.7 billion, with 68 percent living in urban areas.

Next, the graph models the pathways from the 2020 baseline to the 2050 transition scenario in terms of percentage of the global population with access to improved cooking solutions, MECS, and traditional cookstoves . By 2030, it is expected that access to cooking poverty will have been eliminated through the promoted use of ICS (MTF Tier 3) and MECS (MTF Tier 4 or higher),with exclusive cooking with MECS reached by 2040. The modeling results show that, in order to reach universal access to MECS by 2040, a projected population of 352 million per year will need to have transitioned by 2030, with 357 million per year gaining access to MECS between 2030 and 2040.

The model then estimates GHG emissions from various cooking fuels and technologies (traditional biomass, biofuels [ethanol and biogas], LNG and LPG, and electricity) for respective segments of the global population with access to traditional, low-emission biomass, and modern-energy cooking solutions. The annual emission factors for these cooking fuels and technologies, in terms of tCO2e per urban or rural household, are estimated, based on ESMAP's MECS model. A weighted average value for each cooking fuel is then calculated, based on the evolving rural-and-urban-household ratios over the 2020–50 period. In the Net-Zero Emissions Scenario, a diverse portfolio of technologies is deployed to reach full access to MECS by 2040, while continuing to reduce GHG emissions until 2050. The model views electric cooking and LPG/LNG as key to the rapid scale-up and achievement of universal access to MECS and continued efforts on decarbonizing electricity, power grids and other network infrastructure, and cooking fuels (e.g., LPG). The decarbonization effects are reflected in the annual emission factors of cooking fuels and technologies over the period.

Under the Net-Zero Emissions Scenario, ESMAP's Clean Cooking Planning Tool is used to estimate the annual investment needed and benefits of the transition to cooking poverty elimination by 2030 and full MECS access by 2040.

[13] https://energydata.info/cleancooking/planningtool/

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