



TECHNICAL REPORT 015/21

WHAT DRIVES THE TRANSITION TO MODERN ENERGY COOKING SERVICES?

A Systematic Review of the Evidence



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ABBREVIATIONS

CSV	comma-separated values
ESMAP	Energy Sector Management Assistance Program
FGD	focus group discussion
FISE	Social Energy Inclusion Fund (<i>Fondo de Inclusión Social Energético</i>)
HAP	household air pollution
ICS	improved cookstoves
LMIC	low- and middle-income countries
LPG	liquefied petroleum gas
MECS	modern energy cooking services
NGO	nongovernmental organization
PICO	Population, Intervention, Counterfactual, and Outcomes
RCT	randomized controlled trial
SDG	Sustainable Development Goal
SES	socioeconomic status
USB	universal serial bus

All currency in United States dollars (US\$, USD), unless otherwise indicated.

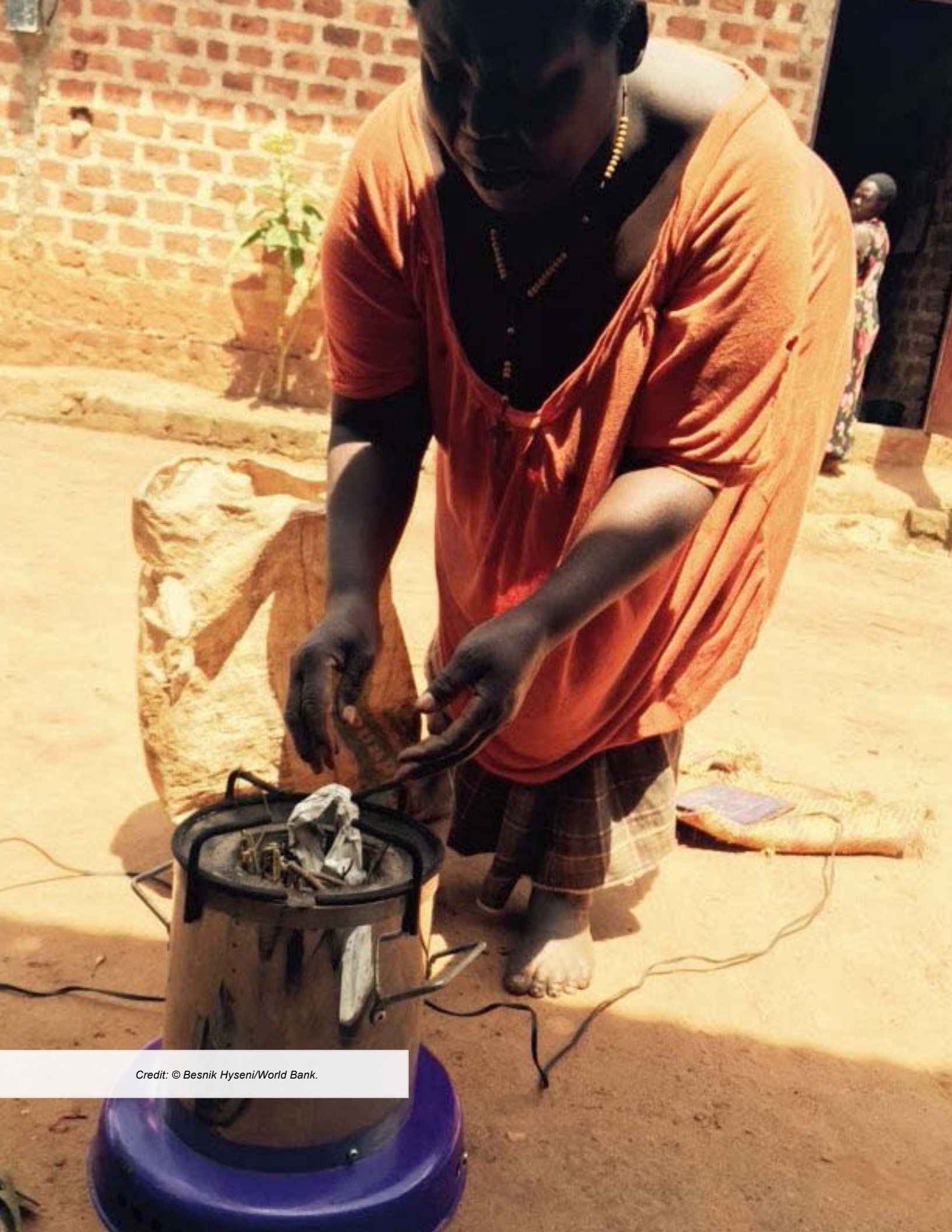
ACKNOWLEDGMENTS

This report summarizes findings from the systematic review of the published evidence on drivers of and barriers to transitioning populations to modern energy cooking services (MECS). It is a product of the research efforts implemented under the MECS Program, a five-year initiative funded by UK Aid of the Foreign, Commonwealth and Development Office (FCDO) and led by Loughborough University and the World Bank's Energy Sector Management Assistance Program (ESMAP). The MECS Program aims to accelerate the global transition from traditional biomass based cooking to modern energy cooking solutions.

This report was prepared by an ESMAP team led by Caroline Adongo Ochieng with inputs from Yabei Zhang and overall guidance provided by Rohit Khanna, Practice Manager. The systematic review was led by Gillian Petrokofsky of University of Oxford and Oxford Systematic Reviews LLP (OXSREV). The systematic evidence evaluation and development of the evidence map were undertaken by William J. Harvey and Leo Petrokofsky of OXSREV.

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OVERVIEW

Some 4 billion people—more than half of the global population—are without access to modern energy cooking services (MECS), instead relying on traditional biomass fuels using rudimentary stove technologies that burn fuels inefficiently (ESMAP 2020). The adverse development impacts from households' continued use of polluting stove-and-fuel combinations are significant. Household air pollution (HAP) accounts for some 4 million premature deaths each year, disproportionately affecting women and children (WHO 2018). Fuel harvesting and use represent a significant time burden for women and girls, who may spend up to six hours per day on cooking-related tasks. A substantial share of cooking woodfuel is harvested unsustainably, and residential cooking contributes significantly to global black carbon emissions (Bailis et al. 2017; Batchelor et al. 2019). Transitioning this population to MECS—part of UN Sustainable Development Goal 7 (SDG 7), which aims to ensure access to affordable, reliable, sustainable, and modern energy for all by 2030—would thus have important development benefits, particularly for public health, climate/environment, and gender equality (United Nations General Assembly 2015).

The minimal success of past cookstove programs has been attributed to their failure to account for important supply- and demand-side considerations, including affordability, availability of fuels and parts, and sociocultural values. Many of the documented barriers are highly context-specific, reflecting the individual or household-level scale at which they have been analyzed. Increasingly, development organizations are moving away from a predominantly project-level approach, which lacks the scale and speed required for low-access countries to achieve universal access by 2030 (IEG 2015). Many such organizations are moving toward sectorwide frameworks and engagement plans for implementing rapid access scale up. This trend creates an urgent need to ask what factors are critical to driving such a large-scale transition and what solutions can overcome barriers to scaling.

SYSTEMATIC EVIDENCE SYNTHESIS AND STUDY OUTPUTS

This study sought to systematically review the published evidence on demand- and supply-side drivers of and barriers to transitioning populations to MECS at various scales to inform more holistic policy decisions and customized design of pathways to universal access. Specifically, the study explored the following question: **What factors are critical to achieve a large-scale transition toward sustained use of modern energy with particular reference to cooking in low- and middle-income countries?** Given the multifaceted nature of this question, the study took a systematic mapping approach, incorporating a diverse body of knowledge on transition drivers and barriers, including multiple interventions, populations, and outcomes. The open-access, interactive systematic map presented in this report—the first ever produced from studies in the field of modern cooking energy—includes 160 studies selected from nearly 14,000 articles in the global research databases, using transparent inclusion criteria agreed by a broad range of experts in the field. Although the final set of studies synthesized from the systematic review process did not yield sufficient data for a meta-analysis, the assemblage of evidence relevant to the research question was robust and can thus be used to make statements about evidence on the findings and gaps where further research is warranted.

The design of the systematic map allows for additions over time should the community of interest wish to access ongoing evidence. From the assembled data, further analyses on transition drivers and barriers can be run, focusing on such elements as countries, rural or urban localities, and type of cooking energy or technology, among others. The map also allows for filtering, based on study quality. The exercise generated a comma-separated values (CSV) file of more than 600 publications that passed the initial screening stages, but were rejected at full-text screening, having failed to meet the full criteria set for this review. Additional sheets in the CSV file list articles rejected at the title and abstract stage, as well as eligible articles that could not be traced by the review team. The availability of files of all articles evaluated at each stage of the systematic review process makes it possible to scrutinize and re-evaluate the evidence from this wider library.

KEY FINDINGS

Evidence from the systematic mapping exercise shows that such features as a young demographic, higher level of education, and higher levels of household income encourage MECS adoption while their counterparts often negate it. Financing solutions that address affordability constraints, as well as targeted education and after-sales support, can drive adoption. Similarly, higher level policy changes that lead to higher income levels or targeted financial support to the poor to overcome financial barriers can drive a large-scale transition to MECS.

Ease of access to traditional baseline fuels, which were often reported as cheaper and easily available, was a major barrier to transitioning to MECS. For a transition away from dependence on such cooking fuels to occur, modern energy sources must offer better and reliable services. Notable success was seen in cases where policies were designed to promote MECS and, at the same time, limit dependence on traditional fuels.

Peer influence was another key factor encouraging adoption of MECS. Peers served as an important validation step prior to the adoption and first source of stove information. It is thus important that the technologies introduced adequately meet the needs of early adopters in order to avoid the cascading effects of negative program experience.

The evidence pointed to an important role for women in the MECS value chain, with success reported when programs were promoted through women's groups compared to traditional marketing channels. Some evidence showed that male influence on MECS adoption had an overall negative effect. Gender roles require further probing, particularly on how women's involvement in a MECS program affects their time use, to which they are reported to attach a very high value.

Technological characteristics were important, with functionality having more prominence as a driver than technology performance (e.g., reducing household air pollution or fuel use). A new technology's durability and reliability were important drivers of uptake, and breakdown of the technology was the most important reason for discontinued use and non-adoption. The evidence base shows that users are willing to pay more for good-quality options.

After initial adoption of MECS, an important transition driver was follow-up by implementers to monitor and record program successes and weaknesses and respond to users' feedback over an extended period of time, particularly when the new technologies differed substantially from traditional ones and involved a steep learning curve. Lack of follow-up was a major transition barrier.

Lack of appreciation of the benefits of clean cooking systems was reported, but only in some settings as most programs entailed awareness-raising components. Generally, programs of nongovernmental organizations (NGOs) were more successful in generating awareness than the few private-sector initiatives reported, which struggled to overcome this hurdle. As lack of public awareness affects the entire sector, the role of awareness raising should be supported by governments, who could incentivize partnerships between the private sector and NGOs, a model that some programs reported as having worked well.

While several NGO-led programs reported success in distributing large numbers of cookstoves and getting households to adopt them, many of the initiatives were not sustained for lack of market-based approaches, with many failing after the initial pilot period. This finding further emphasizes the important role of partnerships with the private sector, which could help in sustaining such interventions beyond the NGO funding cycle.

EVIDENCE GAPS

The findings showed a clear evidence gap in understanding MECS transitions in urban settings. The growing trend of rapid urbanization among youth presents an opportunity for understanding their behavior and exploring whether their experiences with modern cooking energy can be harnessed as a force to influence families they have left in rural areas. The evidence points to a strong role for networks and communication channels, including person-to-person knowledge transfer.

The role of subsidies as a driver of MECS adoption was covered well by the evidence base; however, it did not distinguish between short- and long-term transition effects. In a few cases, earlier subsidies were reported to have discouraged adoption, suggesting the need to sustain subsidies once introduced if the primary goal is to achieve an energy transition. Further studies are needed to better understand whether such subsidies are sustainable and what alternative policy measures can overcome poverty, which was reported to limit the transition across all settings.

Given the wide range of benefits attributed to MECS, further research is needed to identify those that can motivate the transition. In this evidence base, users reported several advantages of the new cooking systems; however, it was unclear whether those factors informed their decision to adopt MECS and remain with the transition. The findings reveal that users favorably perceived and continued to use some

technologies whose performance in later evaluations was poor. Thus, knowledge of what factors users value would make it possible to design and market technologies that respond to their needs.

ACKNOWLEDGING UNCERTAINTY

Had the evidence base been stronger, this evidence synthesis might have been able to provide decision-makers specific information on which set of drivers and barriers to focus their efforts to transition large populations to MECS and meet the SDG 7 target. However, drawing such conclusions from the current evidence base was not possible for several key reasons. First, the evidence base is fragmented, comprising a broad range of interventions targeting a variety of outcomes, implemented at differing scales in regions across the globe. Multiple studies assessing the same set of populations, interventions, and outcomes, which would allow for linking drivers and program outcomes, were rare. Second, most of the studies were assessed as liable to bias, owing, in large part, to unaccountable missing data or the use of unverifiable secondary data. While several studies mentioned success drivers and barriers, they did not incorporate any verifiable data on outcomes that would enable linking them to the drivers. Third, because clean cooking is a complex intervention, it is quite difficult to attribute an outcome to a single driver or barrier. This feature, coupled with the low methodological quality of the studies resulting from the extensive literature search, makes it difficult to assign causal attribution to what does or does not work in an intervention program. The study's findings and recommendations therefore acknowledge this uncertainty in the current evidence base.

1: INTRODUCTION

Progress toward the 2030 goal of universal access to modern energy cooking services (MECS) has been slow.¹ Unlike electricity access, which saw a global rate increase from 83 percent in 2010 to 89 percent in 2017, the global population relying on traditional biomass cooking fuels and technologies has remained constant, and in Sub-Saharan Africa has increased owing to population growth (IEA et al. 2020). If business as usual continues, one can expect that 4.5 billion people will remain without access to modern energy cooking services (MECS) by 2030 (ESMAP 2020). This disappointing potential reality not only points to the size of the 2030 access challenge. It also underscores the need to intentionally mobilize solutions at significant scale. This concern has led to an overall scale-up of ambition, with an increased focus on national-scale programs. For its part, the World Bank's Energy Sector Management Assistance Program (ESMAP) established a US\$500 million Clean Cooking Fund in 2019, which leverages financing of the World Bank and other multilateral development banks (MDBs), as well as private-sector investments, to catalyze the transition to MECS.

Against the backdrop of the 2030 energy access target, a dearth of evidence remains on how to achieve large-scale transformation of the world's cooking systems. Most prior evaluations of clean cooking technologies and fuels have been based on small-scale and experimental studies. Evidence at this scale, while informative for pilot projects, may have limited generalizability for large-scale transition programs as envisioned by the 2030 agenda. Empirical studies on transition drivers and barriers have been the subject of a few systematic reviews (Lewis and Pattanayak 2012; Puzzolo et al. 2016; Stanistreet et al. 2014). These reviews identified a large array of interrelated contextual factors, which could reflect the scale under which many of the analyzed studies were conducted—often at the individual or household level. Most past reviews in the cooking sector have been restricted to low- and middle-income countries (LMICs), which limits the breadth of knowledge available on the topic. Evidence from higher income countries that have experienced transitions to cleaner cooking may also be highly relevant to the design of transition programs in LMICs.

Current policy decisions must be informed by a more holistic evidence base integrated at various scales to provide a tailored pathway for transitioning the 4 billion people without access. One key concern that has characterized the past several decades of cooking sector development has been the failure of policies to account for both supply- and demand-side transition barriers. For example, the broad social and environmental benefits of transitioning to MECS could lead to policies that tackle supply-side challenges. But their effects might be outweighed by households' perceptions of private benefit from making the switch, which drive the demand for clean cooking solutions (Jeuland et al. 2019). Basing current policy decisions on a sound evidence base would help tackle this problem.

It is also necessary for the clean cooking sector to learn from the drivers and barriers that have characterized transition pathways and sustainability factors in other sectors with a longer history that faced similar adoption challenges (e.g., clean water and sanitation). Similarly, highly successful emerging sectors that have achieved large-scale transitions in LMICs (e.g., mobile telephony and IT) can provide useful lessons and insights, particularly where technologies are bundled in innovative ways to overcome traditional supply and distribution hurdles (e.g., use of the IT platform to distribute ethanol cooking fuel).

The current review explores the drivers facilitating and barriers hindering the transition to MECS and seeks to link them with enabling or inhibiting factors. The assessment of the published and grey literature takes a systematic approach to gathering, mapping, and evaluating the evidence base (CEE 2018). The review forms a core component of the broader MECS research program, which aims to generate an understanding of the holistic system of cooking and MECS transition pathways and find solutions to overcome barriers to scaling.

SYSTEMATIC EVIDENCE EVALUATION

The need for rigor, objectivity, and transparency in reaching conclusions from a body of scientific information is evident in many areas of policy and practice, from clinical medicine (where systematic review methodology was first standardized) to environmental management, education, and social justice. International development is no exception. Many of its urgent problems require a reliable source of evidence on which to base actions, many of which may be controversial and/or expensive. Thus, it is important that they be informed by the best available evidence and not simply the assertions or beliefs of special interest groups or literature searches tailored to individual knowledge or what is easily available. To be credible, evidence synthesis requires that legitimate and reliable standards regarding its conduct be clearly defined. This report follows best-practice guidance for reporting systematic evidence evaluation developed by researchers in the field of conservation and environmental science (Haddaway et al. 2017a, b; Haddaway and Westgate 2019).

The question posed in this report lends itself to a systematic evidence synthesis (Table 1.1). The two most commonly used types are systematic review and systematic mapping. Both are recognized standards for accessing, appraising, and synthesizing scientific information. Systematic mapping is particularly valuable for broad, multifaceted questions that can include multiple interventions, populations, or outcomes.

TABLE 1.1: KEY ELEMENTS OF A SYSTEMATIC EVIDENCE SYNTHESIS

QUESTION ELEMENT	DEFINITION
Population (of subjects)	Statistical samples or populations of subject(s) to which the interventions will be applied or exposed to described conditions (e.g., households in a rural village targeted for efficient cookstove rollout)
Intervention	Policy, action, or environmental variable impacting the populations or to which the subject populations are exposed (e.g., a program to make subsidized, efficient cookstoves available)
Comparator	Either a control with which the intervention or exposure is compared or an alternative intervention or counterfactual scenario (e.g., a study comparing various levels of subsidy)
Outcome	Consequences of the intervention or exposure, including all relevant variables that can be reliably measured (e.g., views of the population about factors that encouraged uptake of the efficient cookstove)

Source: ESMAP/World Bank.

Systematic review and systematic mapping follow the same rigorous processes to evaluate relevant evidence and minimize potential bias and lack of transparency, which are often found in traditional literature reviews (James, Randall, and Haddaway 2016). Both approaches share many initial planning steps, but exhibit key differences in their analytical approaches and outputs (Table 1.2). A systematic review usually aims to answer a question by synthesizing findings from individual studies in order to produce an aggregate measure of effect or impact, mostly through meta-analysis or another form of statistical analysis. Systematic mapping, on the other hand, does not aim to answer a specific question. Rather, it collates,

TABLE 1.2: COMPARISON OF SYSTEMATIC REVIEW AND SYSTEMATIC MAPPING APPROACHES

KEY COMPONENT	SYSTEMATIC REVIEW	SYSTEMATIC MAPPING
Protocol	Required	Required
Systematic Searching	Required	Required
Systematic Study Selection	Required	Required
Critical Appraisal	Required Ensures robustness of the review answer; directly influences the data synthesis and interpretation steps	Optional (possible if study validity indicators can be captured using the coding method, but unlikely in practice) Does not influence the mapping process
Data Coding and Extraction	Required Meta-data coded and outcome measures (e.g., effect sizes) extracted	Required for coding of meta-data (e.g., study type, population type, and intervention description) Optional for extraction of outcomes, with a caution about “vote counting” since strictly regulated meta-analysis is not being conducted
Data Synthesis Approach	Aggregative Seeks an unbiased answer with known precision; could involve meta-analysis	Exploratory May include coding and subgroup analysis (i.e., separately examining subsamples of the population)
Outputs	A quantitative or qualitative answer with an indication of uncertainty and any threats to validity May include estimate of variance caused by external factors	Describes the evidence base, showing the distribution and abundance of evidence across various elements of the question May provide a stand-alone database of studies showing the coding and data extraction elements May include the construction of an interactive geo-map, based on the database of coded studies

Source: Adapted from CEE 2018.

describes, and “maps” findings in terms of distribution and abundance of evidence, often configured in relation to various elements of a question.

In systematic mapping, the evidence is presented in a searchable database and can be accompanied by an interactive geo-map, with clearly defined elements similarly coded across the body of evidence collected through an extensive search of multiple sources, including academic journals, organizational databases, collections of theses, unpublished reports, and publications suggested by stakeholders interested in the review question. As systematic maps may include multiple populations and interventions or exposures, the database usually allows for cross-tabulation of data to explore the evidence base thoroughly. This feature makes it possible to identify trends, knowledge gaps, and evidence clusters. Unlike systematic reviews, systematic maps are unlikely to include a detailed extraction or statistical synthesis of study results. The mapping process involves: (i) a rigorous evidence search; (ii) filtering of the relevant evidence; and (iii) coding of key individual study elements in the evidence set.

The systematic mapping approach is best suited for a research question that requires a descriptive overview of the evidence base, is open framed (e.g., “What interventions have been used to increase the uptake of improved cookstoves?”), or is closed framed with multiple subject populations, interventions, and outcomes to consider (e.g., “What are the impacts of different marketing strategies on the uptake of improved cookstoves?”). Systematic mapping is a useful exercise for assessing where evidence gaps may exist and, conversely, where sufficient evidence may warrant further statistical synthesis of evidence subsets.

This study chose the systematic mapping approach, given the breadth of evidence needed for the broad scope of policy- and practice-related questions it sought to answer and the desire to explore the entire evidence base instead of limiting the set of studies to those reporting data that could potentially contribute to a meta-analysis or similar statistical analysis. The methodology was guided by input from participants at two stakeholder meetings and an advisory group. The body of research identified is a robust sample of that which is most relevant to the research question utilizing a rigorous and transparent synthesis process. This process differs from a conventional literature review, where selection of the body of research is usually based on individual knowledge or other criteria prone to bias. In the current review, the body of literature reports on possible drivers of and barriers to the MECS transition for a range of outcomes, resulting from a wide array of interventions in the clean cooking sector and other sectors with a longer history that can inform cooking-sector transitions. The enabling (drivers) or inhibiting (barriers) factors are grouped into 10 domain themes (Chapter 2). For the types of questions investigated in this review, it was not possible to infer which of the reported factors could be causally attributed to the MECS transition, but trends and evidence gaps are discussed.

REPORT ORGANIZATION

This report is organized into seven chapters. Chapter 2 explains this review’s study methods, including development of the research question and systematic map. The next four chapters together form a robust assessment of the systematically reviewed evidence base. Chapter 3 focuses on results of the quantitative analysis, and Chapter 4 presents the functionality of the systematic mapping tool for all studies that met the inclusion criteria. Chapter 5 turns to the factors reported in these studies that can drive or inhibit the transition to MECS, while Chapter 6 takes an in-depth look at the evidence base. Finally, Chapter 7 recommends policy measures to address transition barriers and, based on the evidence gaps, suggests areas that warrant further research.

2: STUDY METHODS

DEVELOPMENT OF THE REVIEW QUESTION

A pathways analysis providing evidence for understanding how and when a transition to modern energy cooking services (MECS) can occur and finding solutions to scaling barriers are core components of the MECS research program. The broad review objectives for this study were distilled into the following researchable question: **What factors are critical to achieve a large-scale transition toward sustained use of modern energy with particular reference to cooking in low- and middle-income countries?**

Engagement of Stakeholders and an Advisory Group

Development of the review question was guided by input from two stakeholder meetings and an advisory group. Following good practice for systematic evidence evaluation (CEE 2018; Haddaway et al. 2017a, b; Haddaway and Westgate 2019), two meetings were held to engage relevant stakeholders in the systematic mapping exercise. The first one was held at Loughborough University in October 2019. It included 15 participants, comprising mainly academicians with expertise in modern energy cooking systems, transitional pathways, and theories of change. Participants discussed the complexities of modern energy uptake, understanding transition in the context of cooking energy, and the goals of a MECS transition for development outcome focused on health and climate. The next month, the second stakeholder meeting was held in Nairobi against the backdrop of the 2019 Clean Cooking Forum. It engaged 21 participants—mainly policymakers and practitioners from nongovernmental organizations (NGOs) and the private sector—in a discussion of the review question and scope of the review developed at Loughborough University. Stakeholders suggested strategies and relevant terminology to include in database searching; in all, more than 100 terms were suggested. Both stakeholder meetings produced comprehensive lists of potential study sources, including organizations, networks, and communities of interest with relevant published or archived evidence. It was agreed that these organizations would be contacted by email to request grey literature, and requests would also be sent to publicize the project in relevant networks and news-alert services.

The systematic mapping exercise was also guided by a 19-member advisory group representing a broad range of expertise in research, policy, and practice. The advisory group was engaged to varying degrees throughout the systematic mapping process. This included refining the review question; providing feedback on the protocol, which clearly laid out all of the review methods; and reviewing data-extraction sheets and the final report.

Integrating Learning from Other Sectors

In addition to the cooking sector, other sectors (e.g., clean water and sanitation and telecommunications) were selected to gain potential insights from studies on factors considered critical to large-scale, sustained technology transitions. The aim was to discover whether the reported lessons in those sectors might

apply to developing strategies for modern energy cooking transitions in low- and middle-income countries (LMICs). These sectors were not intended to be covered as comprehensively as the modern cooking energy sector; of necessity, the search terms used to assess that body of literature was much less detailed than those for modern cooking energy, which formed the principal question.

Defining Elements of the Research Question

The study used the well-established Population, Intervention, Counterfactual, and Outcomes (PICO) Framework developed for systematic review methodology to define the following elements of the research question:

- **Population:** This element refers to users at a large-scale² level that have experienced a technology transition from a baseline/traditional level or have been exposed to a program promoting a transition.³
- **Intervention:** This element refers to the technology program or intervention implemented at scale.
- **Counterfactual:** Since a review of drivers and barriers may have few studies that consider a control group not exposed to the intervention, this element was not made a necessary precondition for inclusion; however, it was to be recorded if present in a study's design, including before-and-after features and quasi-experimental studies.
- **Outcomes:** This element refers to data reporting uptake of the technology (in numbers of people or density of uptake) and information on factors driving or inhibiting uptake.

INCLUSION CRITERIA

Based on the definitions established using the PICO Framework, articles were required to meet the following criteria to be included in the systematic map:

Population. Participants in a large-scale (e.g., village, regional, or national) technology or fuel-change program. Transitions to electric cooking were limited to studies from LMICs, the rationale being a desire to focus on transition from biomass to cleaner cooking, which is critical for achieving the Sustainable Development Goals (SDGs) in LMICs. The decision to limit the population element to LMICs was made after considering the enormous amounts of historical literature on coal-to-gas and gas-to-electricity transitions in European and North American countries, which are not the focus of this review. The search was not adjusted to accommodate this limitation, but the screening process excluded studies from higher-income countries in this category.

Intervention. Restricted to large-scale programs aimed at producing a technology change in any sector. Within programs, all studies that analyzed groups of individuals (i.e., households, villages, or areas) were included. Studies reporting individual choices outside an obvious program (either reported in the study or widely known, such as a national cookstove program or policy) were excluded. Large-scale electrification studies from non-LMICs were not assessed.

Counterfactual. Not required for inclusion. Pilot searches revealed few papers with counterfactuals or controlled research designs; however, the presence of a control was recorded if included in the study design.

Outcomes. Presence of one of three measures: (i) data reporting positive/negative/neutral changes to social, economic, or environmental variables as a result of the program or intervention; (ii) reported

measures of uptake or sustained use; and (iii) drivers and/or barriers to change, where supported by tabulated or qualitative results that indicated number of respondents. We note that the review question relates to a sustained transition, but discussions with stakeholders identified significant problems in trying to predefine what constituted sustained use. For example, fuel stacking is a well-known phenomenon among communities moving toward modern energy systems (Ochieng et al. 2020). Thus, it was not considered useful or informative to exclude studies reporting fuel stacking as an outcome on the grounds that this did not represent a transition or a sustained transition. The presence of stacking was therefore coded among the outcome measures.

Inclusion criteria also covered the language of articles. No restrictions were placed on research design, date of publication, or type of publication with the exception of Power Point presentations, which were sent as part of the call for grey literature and rejected. Three articles could not be processed at full text due to the study team's language limitations (two written in Croatian and one in Chinese); these were recorded as "excluded" and the language reported. Studies suggested through a call for grey literature that were entirely in Chinese were set aside and not analyzed for the current report. The review team had expected to assess studies at full text in French, Spanish, and Portuguese, but none of the articles in these languages were retained after abstract screening, having failed to meet the inclusion criteria. Thus, all studies in the final set were in English.

SYSTEMATIC FILTERING PROCESS

Searching for the Evidence Base

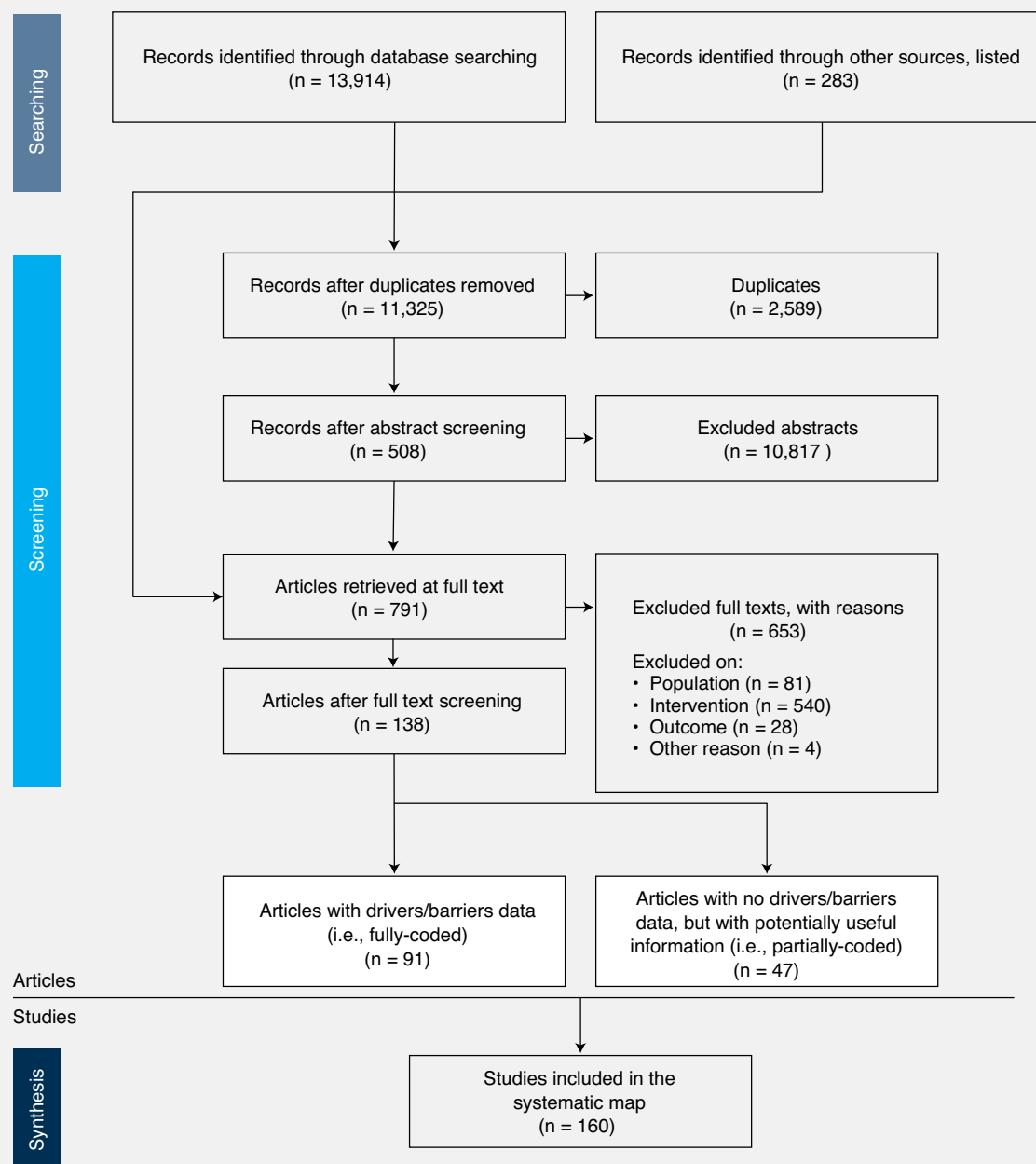
The search tools for publications related to MECS transition drivers and barriers included online bibliographic databases covering academic journals, conferences, theses, books, and other reports and websites of relevant organizations. These were assessed in a series of systematic filtering stages by a team of reviewers using the methods summarized below (described in full in the protocol) to arrive at a final set of publications comprising the systematic map of evidence relevant to the research question. Articles obtained through the literature search, including those searched through "snowballing" (i.e., following references in relevant reviews or references cited by included studies) or suggested following the request for grey literature, were screened using the inclusion criteria. The methods and protocol were developed in collaboration with stakeholder meeting participants and the advisory group.⁴

Figure 2.1 shows the number of articles examined at various stages of the review process. A total of 13,914 potentially useful articles were examined, out of which 791 were retrieved at full text. Of these, 653 were excluded. By the final full-text screening stage, articles were assessed to identify whether multiple studies were reported within the same article. Subsequently, the identified studies were treated as separate entries for coding, data extraction, and mapping, with each assigned a unique identifying number. This powerful use of the systematic review methodology made it possible to consider all research strands of a published article and select only those that met the review criteria for analysis.

Article Screening

Bibliographic information on articles retrieved from the search process were downloaded to the EndNote reference management tool, and duplicates were removed. The remaining set of articles was uploaded to Colandr,⁵ an open-source tool created to incorporate computer assistance for screening and meta-data

FIGURE 2.1: FLOW CHART SHOWING THE SYSTEMATIC SELECTION PROCESS FOR ARTICLES AND STUDIES



Source: Adapted from Haddaway et al. 2017c.

extraction. Colandr semi-automates the synthesis process but continues to retain significant user oversight to ensure transparency. Its machine-learning capability has been shown to considerably reduce time spent on screening (Cheng et al. 2018). The literature retrieved was screened sequentially for relevance at three stages: (i) title, (ii) abstract, and (iii) full text. After the title and abstract screening stages were completed, reviewers exported the accepted articles from Colandr into Google Drive for full-text screening, coding, and data extraction. Based on the PICO Framework's inclusion criteria, reasons for rejecting articles at full text were recorded (e.g., wrong population or not reporting any of the three types of outcomes).

Although the inclusion criteria specified that data on drivers and/or barriers were a requirement, the screening process identified articles that contained detailed discussions of factors affecting the transition but without supporting data. Rather than exclude these entirely, they were included in the evidence base as partially coded articles. After full-text screening, the final set of studies in the systematic map totaled 160 (Figure 2.1), found in 138 articles (91 fully coded and 47 partially coded; see Appendix A).

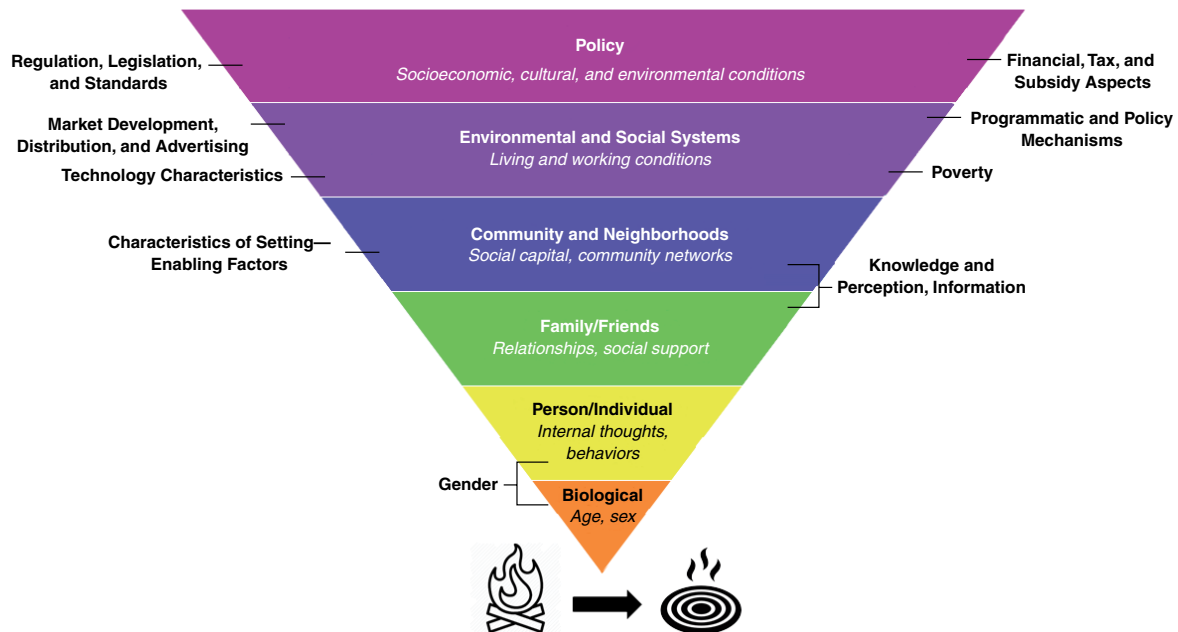
Compiling Data Sheets for the Evidence Map

The coding and extraction template devised for this mapping exercise comprised 79 extraction elements organized into 17 categories and subcategories: article meta-data (e.g., author, date of publication, journal, doi/url, and abstract), population details (e.g., location, including country, rural or urban locality, and number of people affected by the intervention), intervention details (e.g., sector, funders and implementers, dates, aims, baselines, and transition objectives), study design and critical appraisal proxies (e.g., missing data and use of secondary data), measured outcomes of the transition (listed under social, economic, and environmental), and drivers and barriers in 10 domain themes.

The framework for compiling the reported barriers and drivers was taken from domain areas highlighted in previous literature as being necessary for successful transitions at scale (Bruce et al. 2006). Preliminary testing of the coding template found the framework, adapted by Puzzolo et al. (2013, 2016) and Stanistreet et al. (2014), well suited to the current review. The original seven domain themes are: (i) characteristics of setting; (ii) knowledge, perception, and information; (iii) technology and fuel characteristics; (iv) financial, tax, and subsidy; (v) regulation, legislation, and standards; (vi) market development; and (vii) programmatic and policy mechanisms, with three themes added for this review: (viii) poverty, (ix) gender, and (x) other (i.e., drivers and barriers that did not fit neatly into any one of the named categories). These 10 themes map onto the commonly used Dahlgren-Whitehead "rainbow" model, which shows the relationship between an individual, his or her environment (social, political, and ecological), and health (Figure 2.2). Although health was not the focus of the current review, it is a key outcome of cleaner energy use, and the model usefully puts into context the levels at which the review's analytical framework operates on the individual making the transition.

Some data were coded in more than one category, and, given the possibility of considerable overlap between categories for some types of information, not all of the domain themes were used for analysis. Other groupings that better suited analysis emerged from the evidence, and a column for adding relevant notes was available. While this coding structure was useful for data extraction, it was not applied in the data analysis; however, it has been used in the narrative reporting to embrace themes that emerged from within and across the coded elements.

FIGURE 2.2: MODIFIED DAHLGREN-WHITEHEAD MODEL OF RELATIONSHIPS BETWEEN AN INDIVIDUAL AND HER ENVIRONMENT



Source: ESMAP/World Bank.

QUALITY OF STUDIES

In addition to capturing the population size affected by the intervention or program, the number of replicates in comparative studies was captured, together with two measures of time: (i) duration of the study and (ii) time passed since project implementation when outputs were assessed. Various other characteristics were recorded for each study that could be used as a proxy for quality measures. Studies were not assessed for quality as an exclusion criterion, which would have reduced the size of the evidence base and introduced potential reviewer bias. Applying critical appraisal is a time-consuming process, with no single method for determining quality accepted by the systematic review community (CEE 2018). Schemes used for critical appraisal of randomized control studies in the medical field do not translate well into reviews of complex social or environmental topics. In attempting to apply quality assessments that are neither transparent nor replicable, reviewers risk adding bias on top of inherent ones in the primary data. The time frame for the current review made critical appraisal unfeasible. Furthermore, critical appraisal is not a requirement for systematic maps unlike systematic reviews including meta-analysis, where minimizing risk of bias is extremely important for robust statistical analysis.

3: QUANTITATIVE ANALYSIS OF THE EVIDENCE

This chapter presents the results of the quantitative analysis, which is critical to understanding the extent of the evidence available to policymakers, practitioners, and other decision-makers. These results reveal information on the types of studies that have been conducted relevant to key questions of concern and where past trends in identifying evidence gaps may have responded more to funding priorities, research agendas, and criteria other than importance of the topic. The chapter also addresses the issue of study quality, which is necessary for evaluating the strength of the evidence.

CONSISTENCY OF INCLUSION DECISIONS

Consistency of independent inclusion decisions between individual screeners was assessed in two rounds of 100 articles using Cohen's kappa (Altman 1991), which accounts for the level of agreement between screeners that would occur by chance. The results showed high agreement, which was not surprising given that all members of the review team had attended both stakeholder meetings and follow-up discussions with experts that participated in the 2019 Clean Cooking Forum in Nairobi. Table 3.1 shows the kappa figures for the first and second screening rounds following group discussion on differences of opinion on inclusion. Intense exposure to such a broad spectrum of experts from research, policy, and practice was hugely beneficial for the efficient completion of the review. After the second round, screeners worked alone on records screened at the title and abstract stage.

TABLE 3.1: CONSISTENCY OF INDEPENDENT SCREENING DECISION, USING COHEN'S KAPPA

SCREENING ROUND	KAPPA	STANDARD ERROR OF KAPPA	95% CONFIDENCE INTERVAL
First	0.668	0.076	0.520–0.817
Second	0.872	0.039	0.795–0.948

Source: ESMAP/World Bank.

REASONS FOR EXCLUDING ARTICLES AT FULL TEXT

Articles at full text were recorded as excluded if they failed to satisfy criteria for Population, Intervention, Outcomes, or Various other reasons. Only one of these four categories could be selected. A high incidence of exclusion was based on lack of a large-scale program (i.e., Intervention; Table 3.2). However, this does not mean that these studies had no reported results on drivers and barriers (Outcomes) of potential interest. Simply, it meant that the results could not be correlated with an activity that could be considered an intervention of interest in this review. Studies were retained if this relationship could be easily inferred without having to perform an additional literature search (e.g., by reference made to a national cookstove program or policy). All interventions that entailed experiments with participants outside an obvious program were excluded. Following feedback from independent reviewers, studies originally assessed as excluded based on no evidence of their being part of a regional or national program were re-screened; six of these studies were reassigned as included in the evidence map. The issue of program scale was also difficult to assess, and inclusion was based on the presence of a description in the article on the program's ambition.

TABLE 3.2: REASONS FOR EXCLUDING ARTICLES AT FULL-TEXT SCREENING

KEY ELEMENT	EXCLUDED ARTICLES (NUMBER)
Population	81
Intervention (program)	540
Outcomes (results, drivers, and barriers)	28
Other (various reasons)	4

Source: ESMAP/World Bank.

In this review, all 653 articles excluded at full text are listed in a stand-alone comma-separated values (CSV) file.⁶ Articles that could not be retrieved and were not rejected but were not included in the review are also listed. The reason for making these files available for scrutiny is in keeping with best practices for systematic evidence evaluation. Subsequent review groups may wish to examine articles with a potentially high relevance that, for some (documented) reason, failed to satisfy the inclusion criteria in the current review. Other review groups might also be able to locate the articles that this review team could not retrieve.

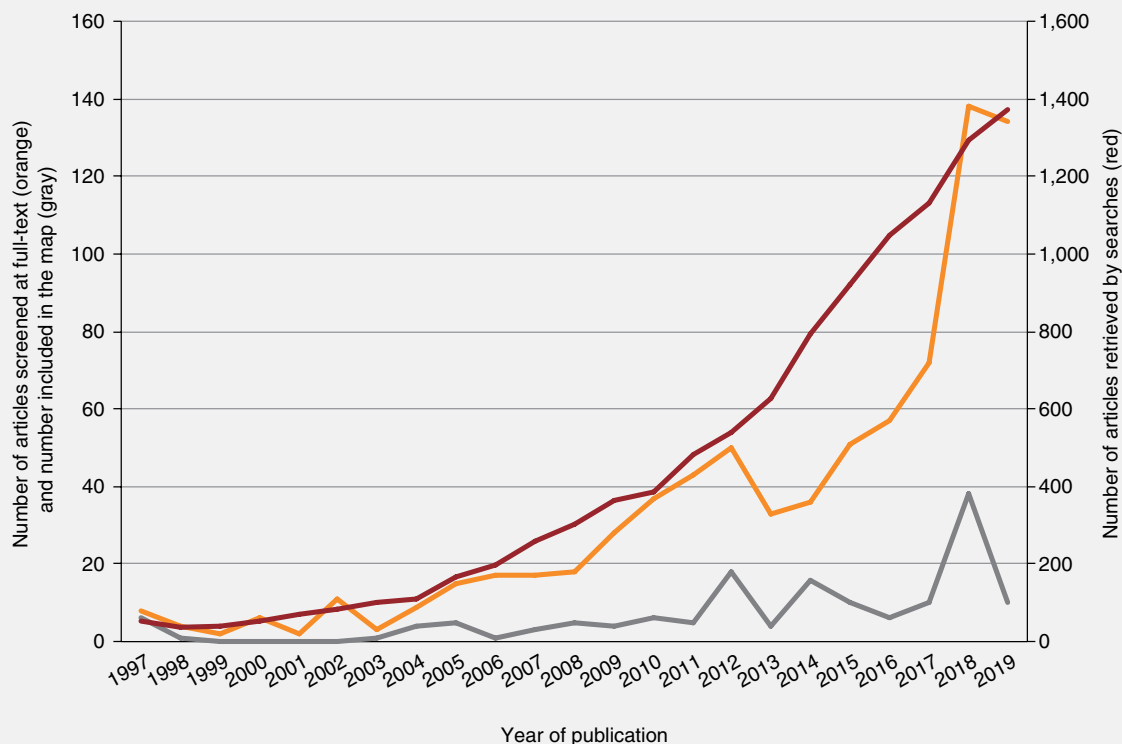
CHARACTERISTICS OF INCLUDED ARTICLES

Publication Date

By year of publication, the number of articles included in the evidence map follows a slightly upward trajectory. The overall population of published articles of potential relevance (i.e., the total number of articles retrieved from the bibliographic databases before any screening) exhibits a steep upward trend, as does the total number of articles of potential interest screened at full text (Figure 3.1).

Possible explanations for these trends are increasing public interest on the subject of modern energy and clean cooking, and thus the proliferation of (i) discussion articles on the subject even though they do not report results of any particular programs designed to achieve an energy transition, (ii) discussion papers

FIGURE 3.1: COMPARISON OF ARTICLES RETRIEVED, SCREENED, AND INCLUDED IN THE EVIDENCE MAP, BY PUBLICATION YEAR



Source: ESMAP/World Bank.

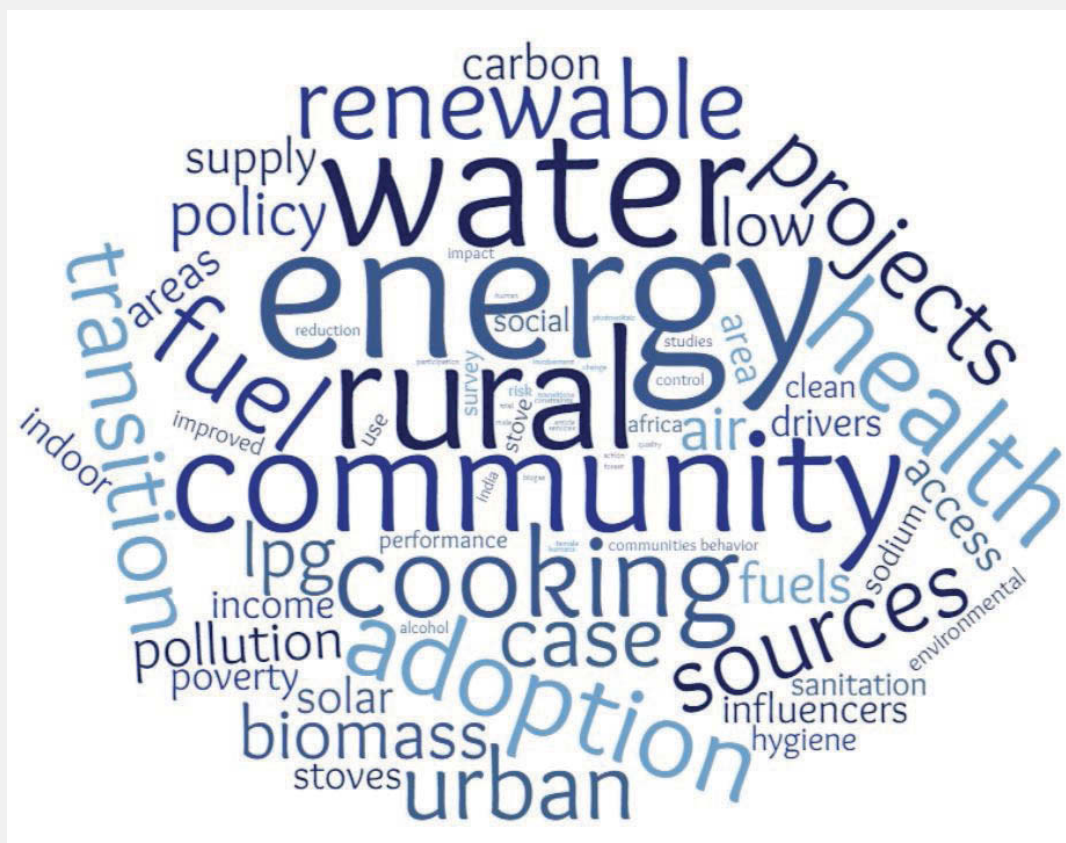
Note: Vertical scales are separate.

on specific programs not backed up by any evidence on the transition drivers or barriers, and (iii) studies focusing on a few individual households. The earliest year of publication shown in Figure 3.1 (1997) is the first for articles included in the evidence map. Although the searches retrieved older studies, many were excluded at full-text screening for failure to meet the inclusion criteria.

Broad Topics by Keyword

Although not a strong analytical approach, highlighting the keywords used to index articles in academic journals can be useful for guiding coding by reviewers. Figure 3.2 illustrates the frequency of keywords for the included studies, as used in the academic journals that published the articles retrieved from the bibliographic databases. Articles discovered through grey literature searches or snowballing are not included, as the review team did not write abstracts for papers or add keywords where these were not available.

FIGURE 3.2: PROMINENCE OF KEYWORDS ASSIGNED BY ACADEMIC JOURNALS TO THE SET OF INCLUDED ARTICLES



Source: ESMAP/World Bank.

CHARACTERISTICS OF INCLUDED STUDIES

The analyses in this section refer to the separate studies within individual articles. Where relevant to the review question, these studies were treated as individual entries and were assigned a unique identifying number and separately coded.

Publication Type

Twenty studies in the evidence map were from synthesis papers, with results drawn from more than one piece of research and incompletely reported research designs. Synthesis papers are typically not included in systematic reviews because the research quality is difficult to ascertain unless the original research is also located and screened. For this review, however, it was agreed that synthesis articles would be included in the systematic map, provided they reported on factors that affected adoption of change following programs that promoted or supported transitions to modern energy cooking services (MECS) in

TABLE 3.3: JOURNAL SOURCES OF PUBLISHED STUDIES INCLUDED IN THE EVIDENCE BASE

JOURNAL TITLE	NUMBER OF STUDIES
<i>Energy Policy</i>	35
<i>Energy for Sustainable Development</i>	31
<i>Contemporary Social Science</i>	9
<i>Lancet Global Health</i>	5
<i>Boiling Point</i>	4
<i>Journal of Water and Health</i>	4
<i>Sustainability</i>	4

Source: ESMAP/World Bank.

Note: Only journal sources for four or more studies are included here.

low- and middle-income countries (LMICs). The objective was to provide as much evidence as possible that met the inclusion criteria to allow users of the systematic evidence map to decide whether to filter out these studies or retain them when using the map. Therefore, all synthesis papers that met the inclusion criteria, including those whose constituent papers could not be located, were at least partially coded in the systematic evidence map. These can be filtered out in the interactive map as a feature of transparent quality.

Of the 160 studies included in the evidence base, 139 were from articles in academic journals, with only 11 from reports, 8 from books, and 2 from theses. Given the topic of this review, it is quite likely that more non-journal studies could be assessed, but these can be difficult to locate, even when using large-scale requests for grey literature.⁷ The study sources totaled 48, with just 2 journals accounting for 66 studies (Table 3.3).

Geographical Location

A total of 44 countries are represented in the evidence base, with India and China accounting for most of the studies (Table 3.4). Brazil, Russia, and countries of North Africa are underrepresented. Even though populations in those countries are not dependent on solid fuels for cooking, the search was not specific to studies about cooking with solid fuels and should have captured transitions here. This underrepresentation may reflect a lack of programs implemented in these regions, a dearth of research on those programs, a limitation of the English language search strategy (an almost certainty for Russia), or other reasons that require due consideration.

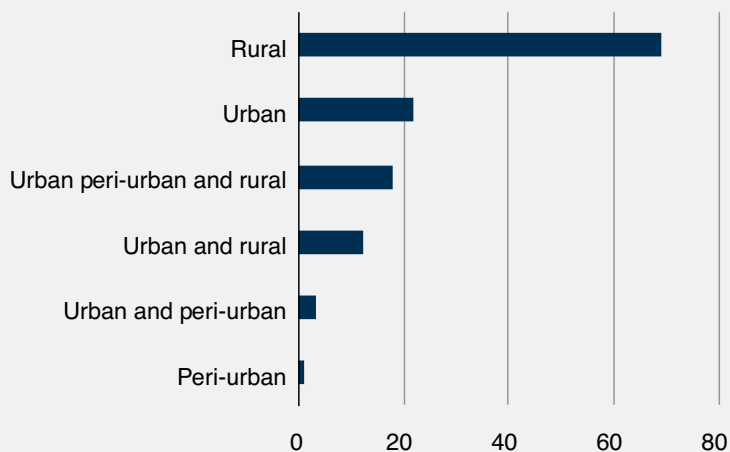
Nearly half of the studies were in rural settings, compared to just 14 percent in urban settings. Also, many studies had multiple settings (Figure 3.3). Urban underrepresentation reflects a dominance of academic journal articles in the evidence base,⁸ including 101 studies that assessed households and 19 that assessed individuals; only 5 assessed communities or villages within a transition program. The number of “units” studied (e.g., households or villages) ranged from 4 to 250,000, with a median sample size of 247.

TABLE 3.4: TOP 10 COUNTRIES WHERE STUDIES WERE UNDERTAKEN

COUNTRY	NUMBER OF STUDIES
India	25
China	16
United Kingdom	10
Kenya	9
Nigeria	6
Peru	6
Uganda	6
Indonesia	5
Mexico	5
Rwanda	5

Source: ESMAP/World Bank.

Note: Multiple countries may be represented in a single study.

FIGURE 3.3: NUMBER OF STUDIES, BY SETTING

Source: ESMAP/World Bank.

Quality

Following good-practice guidance for systematic maps, the included studies were not assessed for quality as an exclusion criterion. However, the review team did record various characteristics of each included study that could be used as a proxy for quality. Studies typically rejected in systematic reviews (e.g., synthesis papers, papers that rely on analysis using secondary data that is not easily verifiable, and studies with missing data) were included. The quality features documented as part of the coding process were as

TABLE 3.5: STUDIES WITH POTENTIAL RISK OF BIAS OR UNRELIABILITY

QUALITY PROXY	NUMBER OF STUDIES
Synthesis Study	21
Data Missing	45
Data Missing and Not Accounted For	15
Use of Secondary Data	42

Source: ESMAP/World Bank.

Note: These studies are not mutually exclusive: many had more than one adverse quality proxy.

follows: (i) whether the study was part of a synthesis paper (i.e., did not report primary data); (ii) whether the study reported missing data and if it could be accounted for; and (iii) whether secondary data was used that could not be independently verified. The evidence base can thus be examined for studies that meet the higher standard of transparency and repeatability (i.e., no occurrences of these factors). Table 3.5 shows the number of studies with one or more of the potentially low-quality proxies. The evidence map can allow for filtering out studies with these quality proxies and excluding them from independent analyses, if required.

Transition in Other Relevant Sectors

Despite applying the same inclusion criteria to articles from sectors other than cooking or modern energy (lighting, telecommunications, water and sanitation, and agriculture), the vast majority of these articles were rejected for lack of clear evidence that the study was part of a large-scale program. Searching the file of excluded studies for these keywords indicates how many studies are related to these sectors. As excluded studies, they were not coded for the evidence base, so the precise number of articles by sector is not available. As previously discussed, the reasons for exclusion by the reviewers can be contested, and the value of providing access to the full list of excluded articles is a large benefit of the systematic evidence evaluation approach.

The evidence base contained only six studies from other sectors found in three key articles: Diaz & van Vliet (2018), Opryszko et al. (2010), and Wilson et al. (2018). This disappointing lack of comparative studies may be attributed to the high-level search strategy, but terms in the search should have picked up relevant research on what factors drove the adoption of new technology or incentivized transitions. No relevant studies outside the modern cooking energy sector were suggested by the wide request for grey literature. The reason may be that the organizations suggested by stakeholder meeting participants had a strong cooking focus. In fact, Wilson et al. (2018) was also a cooking-focused study as the intervention was an improved cookstove with the added presence of a universal serial bus (USB) charging port for households' mobile phones. The addition of this technology dramatically increased cookstove adoption, driven primarily by improved convenience and time savings during cooking, or cooking and charging; however, charging only as a mode of function carried with it perceptions of negative impacts on emissions.

Opryszko et al. (2010) reported a small-scale, randomized control trial of a sanitation program in Afghanistan that correlated positive health and well-being outcomes with a transition to chlorinated water and associated greater uptake with higher economic status. The program could not be fully implemented in five villages for technical reasons, which may have affected outcomes. This lack of evidence in the current map probably does not mean evidence is lacking in the wider literature; but the current systematic review's attempts to locate relevant studies found an evidence gap.

Sustainability of Transition Programs

Capturing sustainability of a transition is limited by a general lack of long-term research. Examining studies conducted over several years is an important factor indicating, to a certain extent, their likely usefulness in determining sustainability. Sixty percent of the studies that reported clear information on duration were those conducted over one year or less, while 26 percent lasted more than two years. Encouragingly, 18 percent were of a duration of five or more years. These findings are consistent with those of other systematic reviews, which have similarly shown that short-term research dominates the literature. Data on years since the intervention—a very strong indicator of sustainability—were not well reported. Of the 34 studies with reliable information, 21 had started more than three years since introducing the transition program, while 13 started one year or less after the program introduction.



Credit: © United Nations.

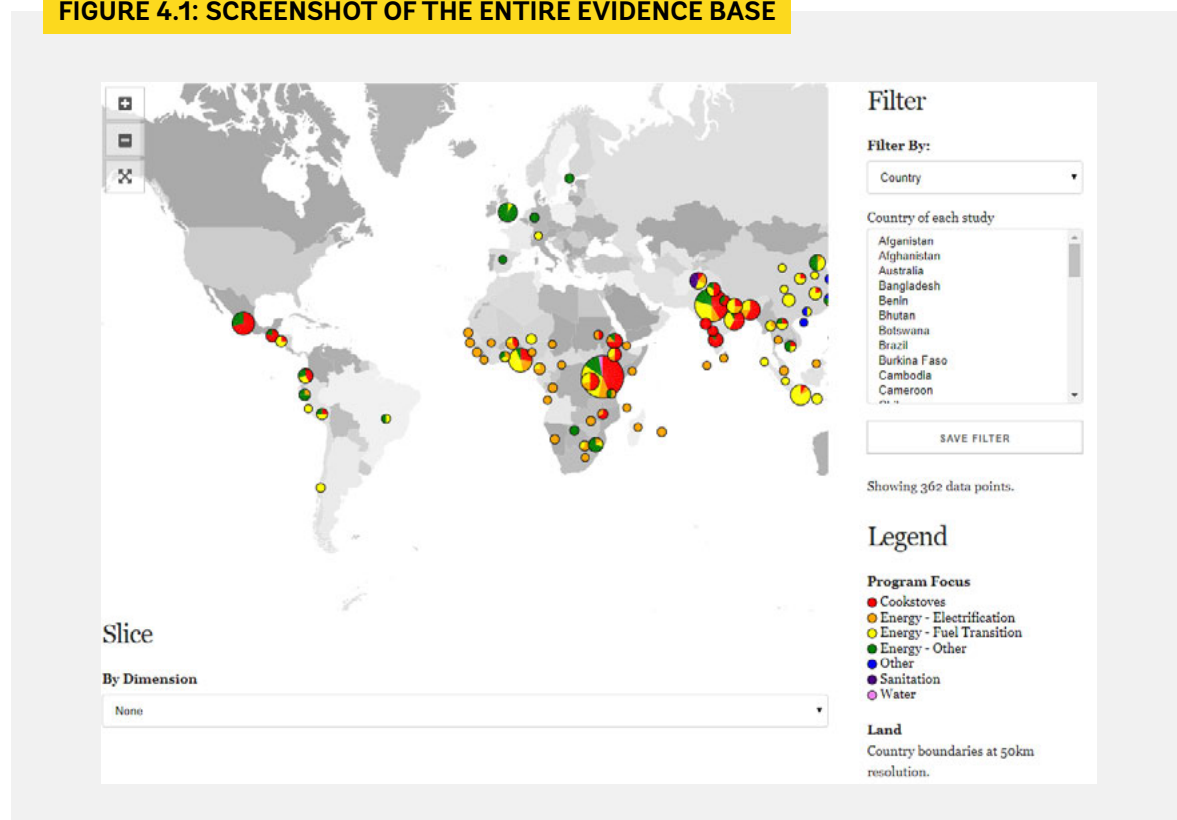
4: THE SYSTEMATIC MAPPING TOOL

This chapter presents the functionality of the systematic mapping tool for all studies that met the inclusion criteria. Most of the information presented is discernible from the visual map of the evidence base assembled from the data sheets of the 160 studies. These data sheets have been linked with an interactive mapping tool that users can manipulate to find sets of studies filtered by selected data-sheet criteria. For those studies conducted in more than one geographical location, all locations are mapped. The interactive map is therefore the richest source of information about the evidence base. It can be used independent of the current report and is freely available at <https://energydata.info/apps>.

DISPLAY OF PROGRAMS' FOCUS

Figure 4.1 shows how studies are geo-referenced and displayed as points on a global map. Each color code in the legend represents a major program focus for the technology transition found in the evidence base, such as “red” for cookstoves or “orange” for electrification.

FIGURE 4.1: SCREENSHOT OF THE ENTIRE EVIDENCE BASE



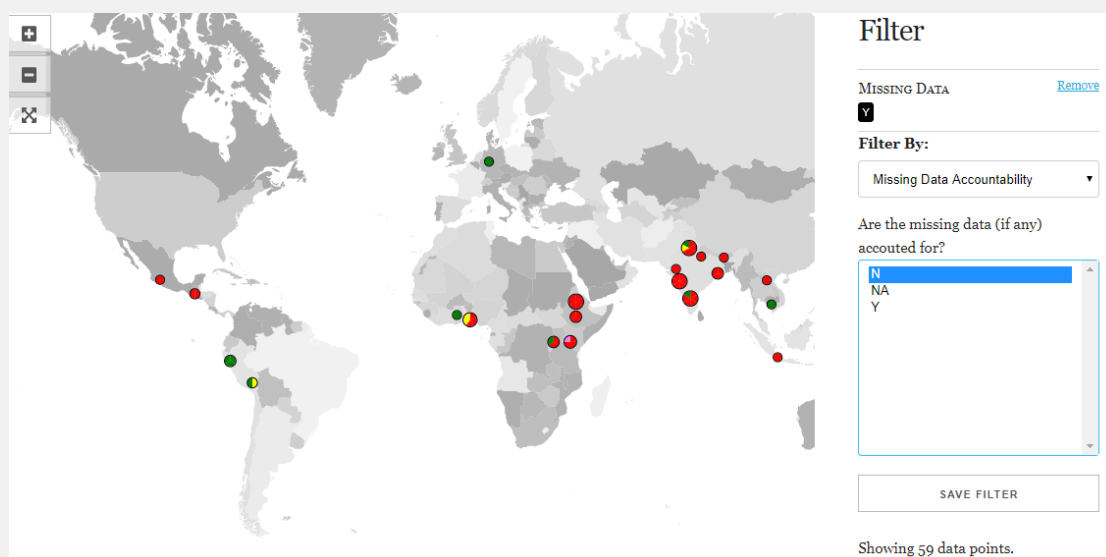
Source: ESMAP/World Bank.

FILTERING RESULTS

Users can view subsamples of the studies by applying a filtering function. A filter can be used to sort the data displayed by a variety of categories, including such quality criteria as missing data accountability (Figure 4.2).

Multiple filters can also be selected (e.g., China, Ghana, and India), and filters can be combined using a “save” option if users want to view results with multiple active filters (e.g., studies from China, Ghana, and India with information on cookstoves in a rural setting) (Figure 4.3).

FIGURE 4.2: MAP OF STUDIES WITH BIAS RISK DUE TO UNEXPLAINED, MISSING DATA



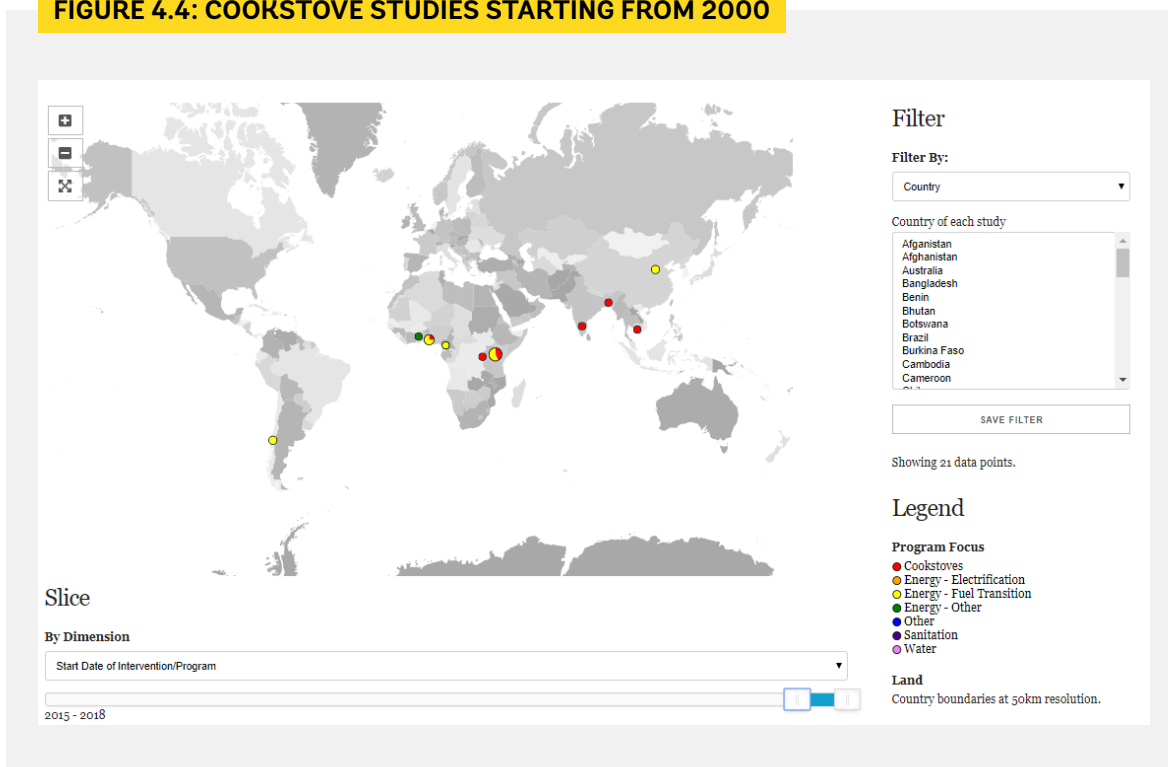
Source: ESMAP/World Bank.

FIGURE 4.3: VIEWING RESULTS WITH MULTIPLE ACTIVE FILTERS



Source: ESMAP/World Bank.

FIGURE 4.4: COOKSTOVE STUDIES STARTING FROM 2000



Source: ESMAP/World Bank.

The “slice” option, another way to filter results, enables the sectioning of data by year of publication; study sample size, start date, and duration; and start date of the intervention or program (Figure 4.4). Like filters, slices can be saved for multi-filtered viewing of results and can be combined with other filters.

Filtering can also support the discovery of where urban versus rural transitions to modern energy cooking services (MECS) have occurred and in what years. This functionality is especially useful, given that some studies reported evidence in both urban and rural settings.

VIEWING DATA SHEETS

All data sheets have full bibliographic details and a link to the full text of the article from which the study was taken, if available. The systematic mapping tool also contains partial data sheets of studies that did not contain supporting data on drivers or barriers but did have sufficient information to be of value to potential users (Figure 4.5).

To view a coding sheet, users select a result by double-clicking its point on the map. This will display the associated data sheet below the map.

FIGURE 4.5: EXAMPLE OF A PARTIAL DATA SHEET

ID	106
Reference Type	Journal Article
Year	2014
Authors	Sehgal, R; Ramji A.; Soni, A.; Kumar, A.
Title	Going beyond incomes: Dimensions of cooking energy transition in rural India
Journal Title	Energy
ISBN/ISSN	0360-5442
DOI	https://doi.org/10.1016/j.energy.2014.01.071
URL	http://www.sciencedirect.com/science/article/pii/S0360544214000930 ; https://www.sciencedirect.com/science/article/abs/pii/S0360544214000930?via%3Dihub
Abstract	<p>Most studies on household energy choices have considered income and education as suitable proxies for sociocultural contexts, primarily because the available data on household energy is from census surveys which are mainly household consumption surveys, not focused energy surveys. Acknowledging the existing data constraints, a more focused household energy survey was designed for rural India with the aim of better understanding determinants of current energy use patterns, energy choices, to measure the impacts of these factors, and importantly, arrive at key policy insights. This paper revisits the definition of access to include for reliability and quality going beyond conventional understanding. It also relooks at the role of gender in household energy choices. Having established that apart from income, sociocultural factors may have a greater role in determining household energy choices, the model results indicate electricity access would have a positive impact on cooking energy choices only after meeting a minimum threshold requirement. As women move toward more formal employment, the odds of choosing cleaner fuels increase significantly. Thus, while macro-policies may provide important guidelines and the necessary framework, implementation strategies need to be designed at the local level through a participatory approach making energy an integral part of the development paradigm.</p>
Volume	68
Issue	
Pages	470–477
Keywords	Energy access; Logit model; Household choices
Country	India
LatDD	23.26623
LonDD	77.412062
Rural/Urban/Peri-Urban	Urban, Peri-Urban, and Rural

Source: ESMAP/World Bank.

5: SYNTHESIS OF REPORTED TRANSITION FACTORS

This chapter presents the findings on factors that help drive or inhibit the transition to modern energy cooking services (MECS), as reported by the 91 fully coded articles (and the interactive systematic map). The evidence base captured these program factors as positive, negative, or neutral, based on what the studies in the articles reported and not independent statistical analysis. Depending on its characterization, any single factor could function as both a driver and a barrier. That is, the factors were viewed as operating along a spectrum, rather than as discrete enablers or barriers, so that “when present or satisfactory, they were enabling and vice versa” (Puzzolo et al. 2016).

These factors were extracted from the studies in the evidence base, according to the 10 domain themes explored (Chapter 2), many of which are overlapping. Subsequently, they were assessed in categories reflecting emerging issues that best responded to the specific questions motivating this review, a type of approach routinely used in qualitative systematic reviews (Finfgeld-Connett 2014). Overall, these factors may help to explain the population characteristics that determine MECS adoption, where and when transitions have occurred, and how the 10 domain themes, among other factors, drive or impede large-scale transitions.

PROGRAM-REPORTED OUTCOMES

This section summarizes the reported outcomes of the assessed programs that were supported by measurements or documented data on achieving their goals. The perceived transition- and impact-level outcomes were reported as positive (successes), negative (failures), or neutral.

Transition Outcomes

Just under a quarter of the 160 studies reported on transition success—the adoption and uptake of clean fuels or stoves—as a program outcome. Of these 37 studies, 35 also reported at least some data on success measures and transition drivers and barriers. Of these, 21 were reported as programs targeting more than a thousand people. Adoption of the transition ranged from 5 percent of the total affected population to 69 percent, exhibited by Indonesia’s large-scale Kerosene-to-LPG Program targeting all regions of the country (Thoday et al. 2018). Other studies with high reported adoption rates included a large-scale, commercially based distribution program of an advanced pellet-gasifier stove in India (Thurber et al. 2014); the transition rate was 45 percent for purposively selected participants, compared to 16 percent for randomly selected households. In Mexico, a large-scale program introduced an improved cookstove to communities of mainly indigenous people who traditionally cooked on open fires (Pine et al. 2011); a 55 percent adoption rate was reported, which continued to be sustained 8 months post intervention. In China’s Hebei province, a large-scale, clean heating program had transitioned 2.53 million rural households from

coal-fired stoves to natural gas and electric stoves by early 2018, with a reported 30 percent reduction in provincial pollution (Nan et al. 2018). In Ghana, a large-scale program covering more than 25,000 households reported a 30 percent adoption rate of improved wood or charcoal cookstoves in preference to traditional stoves (Dickinson et al. 2019). Additional studies of much smaller programs reported moderate uptake levels of about 30 percent. Two of these programs, one in Rwanda (Jagger et al. 2019) and the other in Uganda (Levine et al. 2018), aimed at transitions from traditional cookstoves to improved solid-fuel stoves. The third study analyzed uptake under the Africa Biogas Partnership Program in Kenya, Tanzania, and Uganda, which had an overall target population of 500,000 households. While the program targeted 32,000 households in phase I (2009–13) and 54,000 in phase II (2014–19), and had reached nearly 30 percent of this target group by 2017, this figure represented just over 5 percent of the overall target population (Clemens et al. 2018).

Impact-Level Outcomes

Information on intended program outcomes was captured for three main categories of measured benefits reported to accrue from transitioning to modern cooking energy: (i) social/health/well-being, (ii) economic, and (iii) environmental (Table 5.1). The interactive systematic map includes all three benefit categories as filters.

TABLE 5.1: STUDIES REPORTING ON IMPACT-LEVEL RESULTS FOR THE MODERN ENERGY TRANSITION

FIRST AUTHOR ^a	MEASURED BENEFIT		
	SOCIAL/HEALTH/ WELL-BEING	ECONOMIC	ENVIRONMENTAL
Acharya 2017		IN– FU–	
Aklin 2018			
Alberts 1997 (a–c)		CS FU+	DE+
Andadari 2014		FU	
Asante 2018	HH		EM
Astuti 2019	CO+ HH+ HY+	CS+	EM+
Banerjee 2016	DR+	FU+ CS+	
Barnes 2012a	TS+ CL+ HH+	FU+	EM+
Barnes 2012b	CL+ TS+	FU+	EM+
Barnes 2012c	HH+ TS+ CL+	FU+ FU+	
Barnes 2012d	TS+ CL+ HH+	FU+	
Barnes 2012e	CL+ HH+ TS+	FU+	EM+
Barnes 2012f	TS+ HH+ CL+	FU+ FU–	EM–
Bielecki 2014			
Boso 2019		CS+	EM+
Calvo-Gonzalez 2017	HH–		

TABLE 5.1: CONTINUED

FIRST AUTHOR ^a	MEASURED BENEFIT		
	SOCIAL/HEALTH/ ^b WELL-BEING	ECONOMIC	ENVIRONMENTAL
Calzada 2018	HH+	SF+ SC–	EM+
Catalan-Vazquez 2018	HH+ CO+		EP+
Chang 2018		SU+	
Christiaensen 2014	TS+ GE+ LE+ HH+ DR+	FU+ IG+	EM+
Clark 2017	CO+		EM+
Clemens 2018	HH+ DR+ CO+ HY+ TS+	CS+ FU+	DE+
Coelho 2018		FP– FU+	
Coyle 2005 (a)	CO+ TS+	CS+	
Coyle 2005 (b)	CO+ TS+ ED+	CS+	DE+ EM+
Dendup 2019	HH+ DR+	IN+	
Dickinson 2019	TS TS+	FU+ IN+	EM+
Foley 1997 (a–d)	HH+		DE+
Garland 2015 (a–b)			DE+
Hanna 2016	HH+		AP+ GH
Jagger 2016	SA+ TS+ DR+		EM+
Jagger 2018	AS+ HH+ HY+ TS+		EM+
Jagger 2019	HH+ TS+		
Jeuland 2019	CC+	WP+	
Keese 2017	CO+ TS+	CS+	
Kuai 2020 (a–e)	HH+		
Lee 2015			DE–
Levine 2018 (a–b)	ED+ TS+	CS+	
Mobarak 2012	TS+	CS+	
Mudombi 2018	HY+ CO+ SA– TS+	IN– CS– CS+	
Nan 2018			EM+ EP+
Obueh 2008 (a–c)	SA+	CS+	
Opryszko 2010 (a–d)	HH+		
Ortiz 2012 (a–d)	AW+		
Ozier 2018		WP+	
Patel 2016	CO+	CS+	
Pollard 2018	HH+		
Sesan 2012	SA+		
Sovacool 2011	SA+ TS+	EP+ CS+	EP+
Toonen 2009	ED+ TS+		

(continued)

TABLE 5.1: CONTINUED

FIRST AUTHOR ^a	MEASURED BENEFIT		
	SOCIAL/HEALTH/ ^b WELL-BEING	ECONOMIC	ENVIRONMENTAL
Troncoso 2007	HY+ AE+ DT+	FU+ CS– TP–	
Usmani 2017	DR+	FU+	
Vulturius 2017	GE+	SF+	
Wilson 2018	CO+ TS+		
World Bank 2004	ED+ TS+ GE+	CS+	
Yadoo 2012 (a)	ED+ HH+ TS+	CS+ EP+	EP+
Yadoo 2012 (b)	SA+ LE+ HH+ ED+		
Yadoo 2012 (c)	SA–	CS	
Yasmin 2019		CS+	

Source: ESMAP/World Bank.

Note: AE = aesthetics, AP = air pollutants, AS = aspiration, AW = awareness, CC = choice, CL = cleanliness, CO = convenience, CS = cost savings, DE = deforestation, DR = drudgery, DT = decision-taking, ED = education, EM = emissions within homes, EP = employment, FP = fuel price, FU = fuel use, GE = gender, GH = greenhouse gas emissions, HH = human health and well-being, HY = hygiene, IG = income generation, IN = inflation, LE = leisure, SA = safety, SC = supply chain, SF = sustained funding, SU = subsidies, TP = technology performance, TS = time savings, WP = willingness to pay, + = positive impact, and – = negative impact.

a. Only the first author's name and study date are included; Appendix A provides complete bibliographic details. Multiple studies contained in one article and individually coded are denoted with alphabets.

b. Although health is a commonly reported outcome measure of cookstove programs, none of the interventions had it as their only goal; thus, it is included with other social benefits of transition.

The broad spectrum of included studies resulted in a large set of measured outcomes. The most frequently measured positive outcomes of cleaner energy transitions across programs were human health and well-being (10 studies), cost savings (8 studies), and deforestation (5 studies). Time savings, safety, and emissions within homes were reported as positive outcomes in 3 studies each. More studies reported positive outcomes than negative ones, probably resulting from publication bias toward positive results (Frampton, Livoreil, and Petrokofsky 2017). It is also possible that studies reporting new technology features were overrepresented compared to those with whole-system evaluation as a result of publication bias (Newcomer, Hatry, and Wholey 2015).

Measured Social and Well-being Benefits

The most frequently reported social/health/well-being benefits were human health and well-being (29 studies), time savings (19 studies, with another 6 discussing drudgery), convenience (10 studies), education

(7 studies), and safety (7 studies). An additional 18 studies discussed the benefits for hygiene, awareness of specific program objectives or transition benefits, gender, leisure, aesthetics, aspiration, choice, and decision-taking. Negative changes in human health and safety were reported by 1 study each. No change in time savings and human health and well-being were also reported by 1 study each.

Measured Economic Benefits

The most frequently cited economic benefits were cost savings (20 studies) and reduced fuel use (16 studies). Other reported beneficial factors were related to income (3 studies); sustained funding, employment, and willingness to pay (2 studies each); and income generation and subsidies (1 study each). Negative effects were reported for fuel use and cost savings (2 studies each) and fuel price, fuel use, cost savings, supply chain, technology performance, and inflation (1 study each). No change in response to the transition was reported for fuel use and cost savings (1 study each).

Measured Environmental Benefits

The most frequently cited environmental benefits were reduced emissions within homes (13 studies) and reduced deforestation (11 studies). No study reported forest degradation, likely owing to historic difficulties in discerning and quantifying it and the resulting dearth of literature compared to that on deforestation (Sasaki and Putz 2009). Negative effects were reported by one study for deforestation, while one study each reported negative effects on emissions within homes and air pollutants. One study each recorded no effect following the technology adoption for emissions within homes and greenhouse gas emissions.

TRANSITION DRIVERS AND BARRIERS BY CODED CATEGORY

Data on transition drivers and barriers were extracted from the 91 fully coded articles. As shown, many of the studies in these articles contribute knowledge on multiple aspects of interest in response to the review question (Table 5.2). Of those that included information on transition drivers and/or barriers, 49 yielded data in 4 or more of the 10 domain areas. Gould et al. (2018) reported the highest number of categories, at 9; followed by Andadari, Mulder, and Rietveld (2014), Astuti, Day, and Emery (2019), and Troncoso et al. (2007), at 8 categories each.



Credit: © Bokeh Cambodia.

TABLE 5.2: STUDIES THAT RECORDED TRANSITION DRIVERS AND BARRIERS BY CODED CATEGORY

CATEGORY (CODE) AND DESCRIPTION	NUMBER OF STUDIES	
	DRIVERS	BARRIERS
Characteristics of Setting (CH) Enabling factors, such as, household characteristics, farm, uplands, lowlands; confounding factors	20	20
Knowledge, Perception, and Information (KP)	22	17
Technology and Fuel Characteristics (TC)	21	19
Financial, Tax, and Subsidy (FT) Whether the presence or absence of financial incentives led to program success or failure	23	25
Regulation, Legislation, and Standards (RL)	4	2
Market Development (MD) (e.g., distribution and advertising campaigns)	10	3
Programmatic and Policy Mechanisms (PP) (e.g., setting up of government networks and government promotion)	11	17
Poverty (PO)	3	7
Gender (GE)	10	6
Other (OT)	8	13

Source: ESMAP/World Bank.

The most frequently reported drivers were in the categories of financial, tax, and subsidy (23 studies); knowledge, perception, and information (22 studies); technology characteristics (21 studies); and characteristics of setting (20 studies). Similarly, the most commonly reported barriers were financial, tax, and subsidy (25 studies); characteristics of setting (20 studies); technology characteristics (19 studies); knowledge, perception, and information (17 studies); and programmatic and policy mechanisms (17 studies). Various studies reported the following domains as both a driver and a barrier: technology characteristics (11 studies); characteristics of setting (10 studies); financial, tax, and subsidy (9 studies); knowledge, perception, and information (7 studies); programmatic and policy mechanisms (5 studies); and gender (4 studies). The next chapter explores the reported findings from the 91 fully coded articles in greater depth to better understand how the drivers and barriers influence the MECS transition.

6: NARRATIVE REFLECTIONS ON THE EVIDENCE

This chapter reflects only on those studies in the evidence base (both fully and partially coded) that offer in-depth insights into how certain factors, including context-specific information,⁹ played a role in facilitating or inhibiting the transition to modern energy cooking services (MECS). The findings are organized by seven major domain themes that emerged from the evidence base as having influenced the transition:¹⁰

(i) population characteristics, including poverty and wealth status; (ii) peer influence and trust in information source; (iii) competition with existing fuels and technologies, including low incentive to change; (iv) technology and fuel performance; (v) cost as a barrier to adoption; (vi) sociocultural perspectives and gender; and (vii) after-sales support.

POPULATION CHARACTERISTICS

The evidence base shows a strong correlation between such individual characteristics as age, education, and socioeconomic status (SES) and the MECS transition. This correlation is supported across programs and settings despite wide variations in methodology, outcome measures, setting characteristics, and the interventions evaluated. Many studies utilized logistic regression models to assess the influence of age, education, wealth status, and other sociodemographic variables on MECS adoption, with the majority finding common results. Despite the potential limitations of modeling assumptions, small sample sizes, and inadequate control for confounding factors, the similarity of study findings is striking. The findings are also highly consistent with those of qualitative studies that directly asked survey respondents what had driven them to or prevented them from making the transition to MECS. In multiple cases, income, age, education (knowledge), and other individual characteristics were strongly associated with adoption.

Quantitative Findings

An overwhelming number of studies found that poverty was a critical factor affecting the transition. Some programs that had earlier been touted as successful were later evaluated as having excluded the very poor, who were their target groups (Troncoso et al. 2007). Urpelainen and Yoon (2017) report the following:

Poverty distribution in both the SHS [solar home system] and ICS [improved cookstoves] samples suggests that the dissemination of both technologies is currently not pro-poor oriented according to the definition of the German Federal Ministry for Economic Cooperation and Development (BMZ), as the proportion of poor people among the respondents is below the regional average of 48 percent in the research region.

Programs that included interventions to tackle income barriers demonstrated some success. The evidence on population characteristics, including wealth status as a driver of or impediment to the MECS transition, is thus a compelling key finding that emerged from the evidence base.

Clark et al. (2017) report stove use to be negatively associated with age of the main cook and the household's SES, among other variables. In Cameroon, Pope et al. (2018) find an association between the use of liquefied petroleum gas (LPG) and a household's wealth status (household head with secondary and tertiary education, access to piped water and sanitation, income above the national average, and asset ownership); however, age showed no relationship to adoption in rural settings. In the peri-urban setting, however, age was negatively associated with LPG use. Thurber et al. (2014) report a strong correlation between LPG adoption and use and household income and age. Troncoso et al. (2019) report a strong correlation between use of firewood and socioeconomic levels, with households in the lowest level preparing 81 percent of their meals using firewood, compared to 40 percent of those in high-income strata. Gould and Urpelainen (2018) report that older cooks utilized the intervention less than did younger cooks, which they viewed as unsurprising. Mudombi et al. (2018), who assessed the adoption of ethanol cooking fuel by wealth status using a multidimensional poverty index, find that poverty is lowest among adopters, higher for those who adopted and then abandoned the technology, and highest for non-adopters. In Ethiopia, Beyene and Koch (2013) report that wealth increased the adoption rate for the Mirt stove but did not affect adoption of the Lakech stove. According to the authors, the Mirt stove is large, requiring additional space, while the Lakech stove is simpler and portable. Thus, the authors were not surprised to learn that homeowners with separate kitchens (a reflection of higher wealth status) reported higher rates of Mirt adoption.

Yasmin and Grundmann (2019) find that wealthier farmers were more likely to adopt biogas technology; education was also a predictor of adoption. In Bangladesh, Hafeez et al. (2017) similarly find that education affected biogas adoption. Li (2009) reports higher levels of formal education among biogas users (in addition to higher income, farm size, and number of cattle), compared to the overall village population, with the exception of some subgroups. In another biogas study, Amir et al. (2019) grouped respondents into two categories based on their monthly income: (i) those at a lower level (PKR up to 15,000) and (ii) those at a higher level (PKR 15,001–33,000). Households in the higher income category were significantly more likely to adopt the technology. Kishore et al. (1998) report that the literacy status of household heads had a positive influence on biogas demand. Suliman (2013) reports asset poverty, low educational attainment, and low status as deterrents to clean fuel adoption. The influence of age, while not significant, was noted as positive, with more years of the household head's formal education increasing the likelihood of adoption.

Other studies, however, present contrasting findings, particularly regarding the adoption of biogas technology. Walekhwa, Mugisha, and Drake (2009) report that biogas non-users had larger households and rear more livestock, although they did have lower income (not significant) and fewer cattle compared to adopters. Biogas users and non-users had similar patterns of monthly household income and earnings. In Pakistan, Amir et al. (2019) report that age and educational attainment of the household head were negatively related to biogas adoption, with younger and less educated household heads being more likely to adopt the technology. This finding is consistent with that of Christiaensen and Heltberg (2014), who report a higher probability of biogas adoption among younger household heads in China. While the findings on the relationship between age and adoption are consistent with other fuel-change solutions, the result on income is consistent with other studies, which show a higher probability of adoption with increasing income.

These common findings on the relationship between clean fuels and age, income, and SES were also observed for populations adopting improved cookstoves (ICS), with some exceptions, given the diverse quality and prices of the technologies covered. The ICS evaluated by the studies ranged from simple stove designs that mimic traditional cookstoves to advanced gasifier types that entail establishment of fuel supply chains.

In Rwanda, Jagger et al. (2019) report that households adopting improved pellet stoves had more assets and higher per capita hygiene expenditures. Education level, however, was correlated only modestly with

stove adoption in rural areas. Jan (2012), reports that education and household income were the most significant factors that determined a household's willingness to adopt improved biomass stoves. Alvarez, Palma, and Tay (2004) report that stove and non-stove users shared similar socioeconomic characteristics; however, non-adopters cited lack of the required cash payment (45 percent of the stove cost) as the reason for not participating in the project. In India's Haryana state, Barnes, Kumar, and Openshaw (2012b) report that the influence of income moved in the opposite direction, with most users of improved stoves consisting of low-income households with lower literacy levels. But this setting was unique in that it featured a high penetration of LPG as the main fuel for wealthier households. The income gradient was also reflected in the type of ICS used, with low-income households using mainly less expensive, single-pot stoves and better-off households using both single- and two-pot stoves. Mobarak et al. (2012) report on a program that offered two stove choices. Women with at least some education were more likely to choose the chimney stove, which was better for health, than the lower-cost, efficiency stove.

Troncoso et al. (2007) report a positive correlation between SES and level of adoption, but not between education or age variables and adoption. However, the authors note that their sample sizes were too small. In urban Ethiopia, Beyene and Koch (2013) used survival analysis to explore both the outcome of adoption and the speed at which it occurs. They report that education, income, and wealth were important contributors to adoption. Income was the only variable that influenced the speed of adoption. Unlike other studies that have found a positive relationship between LPG use and income, Thompson et al. (2018) report that households with higher median incomes used wood-fueled stoves (both improved chimney stoves [planchas] and open fires) more hours per day, but did not increase their use of gas stoves, compared to households below the median income level. Agurto Adrianzén (2009) reports a significantly higher proportion of households with at least a secondary education among adopters compared to non-adopters. Adopters were also found to have more assets than non-adopters. Even so, these findings are surprising given that the stove cost was fully subsidized.

The important role of SES also emerges when examining other programs that entailed free or heavily subsidized stove distribution. In one stove replacement program that included a 100 percent subsidy, income, education, and other factors were found not to influence adoption (Boso, Oltra, and Hofflinger 2019). The only significant factor was age, which was positively related to enrollment in the stove replacement program, whose goal was to improve indoor air quality. In another free stove distribution program, Gould and Urpelainen (2018) report a negative association between household SES and use of the intervention technology. In South Africa, where one of the few successful large-scale stove transitions has been reported (i.e., from solid fuels and paraffin to electricity in low-income suburbs), Kimemia and Annegarn (2016) report rising income levels as one of the transition drivers.

Family size, another commonly reported transition driver or barrier, showed mixed results by technology type. For example, its negative effects are reported on LPG adoption by Troncoso et al. (2019) and Yasmin and Grundmann (2019) and on ICS adoption by Agurto Adrianzén (2009). In the case of LPG, cost was the cited barrier as the fuel was too expensive to be used to cook for large families. For ICS, the barrier to adoption was explained as limited labor availability for wood processing. By contrast, Amir et al. (2019) and Kishore et al. (1998) report a significantly positive effect of family size on biogas adoption. In this case, a larger family size meant greater availability of labor to tend the plant.

Qualitative Insights

The largely quantitative findings of the above-cited studies are supported by qualitative studies whose findings offer insights about those relationships. They show, for example, that the influence of age and

education are particularly strong when an intervention is completely new and differs substantially from the old technology, requiring much learning. In such situations, some people opted out of the technology, as illustrated by the following excerpts:

LPG FOCUS GROUP PARTICIPANT: My daughter insisted on buying a gas stove after I got ill. . . . With a gas stove she prepares her own breakfast, but I only use it for re-heating. I'm too old [laughing] . . . Sometimes the matches don't light and you hear "shhhhh" [onomatopoeia] from the gas, so I get afraid it will explode. With the plancha [ICS], you know the fire is on or off. (Thompson et al. 2018)

STOVE PROMOTER: The Upesi [basic ICS] is more common than the solar cooker because the solar requires young women. But [with] the Upesi, even the elderly women can learn how to use it easily. You find the older lady may not know where to put it. Then you find, your food you put it in the opposite direction, then your food will not cook. That's why the elderly ladies don't like it. The Jiko is easy because it's just an extension of the traditional way they're used to. (Sesan 2012)

STOVE DISTRIBUTOR: The young want the more modern Tandoor. The old are more habitual [in food preparation and taste] with [the] old Chulha. (Wang and Bailis 2015)

These narratives are supported by findings that reveal the high degree of learning necessary for certain technologies and the design complexity of some transition programs. In Himachal Pradesh, India, for example, where a program tried making LPG more accessible to village women of different castes and income levels by removing connection barriers, a bureaucratic application process resulted in low uptake among the target group (Wang and Bailis 2015). In El Salvador, Yasmin and Grundmann (2019) report on an LPG subsidy reform that, although beneficial for the poor, was highly unpopular among them initially. At the outset of the reform, the authors found visible differences in program satisfaction across education levels; however, attitudes changed as more information about the reform became available. Well-informed respondents exhibited high satisfaction with the reform with low negativity bias—a relationship not observed for any other variable analyzed (e.g., income, cooking fuel source, and gender). Barnes, Kumar, and Openshaw (2012f) report how most users in the West Bengal case study were unaware that the improved stoves being promoted were subsidized; those who were aware did not understand the subsidy pattern, and this lack of awareness and information outreach was found to have negatively influenced adoption. Similarly, Malakar (2018) reports that a couple who wanted, but believed they could not afford, a new LPG connection, explained to the interviewer that they “did not exactly know” the price, lacking information on the government subsidy.

Pollard et al. (2018) document how lack of knowledge deterred LPG adoption for a program in Peru, as follows:

The complexity of the enrollment process and confusion about eligibility emerged as important barriers to adoption. Among the 149 households in the community survey who had never participated in the Social Energy Inclusion Fund (FISE), 41 (27.5 percent) reported not participating in FISE because they do not know how to sign up. Others are not fully informed about the eligibility criteria. For example, 90.4 percent (199 out of 226) of beneficiary households and 94.0 percent (140 out of 149) of non-beneficiaries did not know their SISFOH [poverty classification] status, a key component of FISE eligibility criteria. In addition, because electricity companies participate in implementing the FISE program, many participants believe they must have electricity to participate; thus, those without electricity often do not attempt to enroll. Additionally, 14.8 percent (22 out of 149) of households who were not participating in the program reported having submitted all requirements but never hearing word of whether they qualified; many of these households assumed they were ineligible but were unsure why.

In Rwanda, Seguin, Flax, and Jagger (2018) report how a complex fuel-purchase protocol for the new technology can deter adoption, as follows:

RESPONDENT NO. 1: They [Inyenyeri] gave us the purchasing date. For instance, I have to buy the fuel pellets on the 20th, otherwise, they could not allow me to buy before then.

INTERVIEWER: What if your fuel pellets are finished on the 17th, wouldn't you be allowed to buy?

RESPONDENT NO. 1: No, I have to wait until my purchasing date. . . . You have to find some other cooking fuels to cook with.

RESPONDENT NO. 2: You have to buy pellets on your purchasing day, and if pellets are finished and you need some more, you need to buy per kilo . . . and that was more expensive than buying in bulk. So, I realized it was not going to change and decided to stop using it [the Inyenyeri stove].

According to the authors, these interview responses reflected a misunderstanding of the fuel-purchase protocol, which did not actually bar anyone from purchasing fuel when it ran out or penalize them for buying it more frequently.

By contrast, Gould and Urpelainen (2018) report that participants in their study rarely cited lack of information on obtaining an LPG connection and knowledge of how to use it as a reason for non-adoption. Rather, these authors found that the connection fee and monthly cost were the only deterrents to non-adoption.

Although most programs provided training to bridge the knowledge gap, some provided only partial training or none at all. Furthermore, most such training was one-off. The need for consolidation and reinforcement of knowledge emerged from most studies. In a Chinese biogas program (Christiaensen and Heltberg 2014), only 60 percent of adopters received technical training in how to make best use of the biogas residue. Of those trained, only 64 percent were aware that the residue can also be used to soak seeds before planting, which would have optimized an outcome that was a strong driver for continued use. In another Chinese setting, Li (2009) reports that many villagers lacked basic knowledge on how to operate biodigesters. They frequently inserted unsuitable materials, which shut down their systems, and many never serviced them, not understanding the importance of servicing in resolving their problems. In that study, 39 percent of the surveyed households reported that lack of knowledge and skills discouraged them from biogas adoption, while 58 percent of users expressed an urgent need to learn more about biogas.

Barnes, Kumar, and Openshaw (2012a) report that nearly half of the beneficiaries of an ICS program in Maharashtra, India, were unaware that the chimneys of their stoves required cleaning, and, as a result, they never cleaned them. Also, knowledge varied by SES. According to the authors, "The condition of the improved stoves was dismal among backward classes" (Barnes, Kumar, and Openshaw 2012a). The problem of damaged chimneys was one of the major causes of stove inefficiency and discontinued use, with most of those stoves installed by the program falling into disuse within six months.

Wentzel and Pouris (2007) report that solar cookers were in disuse because, even though people had received training, they had already forgotten how to use the technology. Some programs (e.g., in Bangladesh, Guatemala, and India) were reported to have provided participants training materials as part of training programs (Alvarez, Palma, and Tay 2004; Thompson et al. 2018; Urpelainen and Yoon 2017), which presupposes literacy among the beneficiaries. Urpelainen and Yoon (2017) report that only 39 percent of the beneficiaries interviewed considered the training manuals they received as helpful. In that community, the authors found that knowledge about ICS use and maintenance was low. For a program in rural Mexico, Troncoso et al. (2007) report that "a number of stove users recounted that getting used to this very different technology engaged time and effort."

Some studies showed how providing knowledge can be a driver of adoption. For example, Alvarez, Palma, and Tay (2004) report on one setting where 83 percent of those interviewed said they had received training in stove use and maintenance, and most of the stoves were functioning. The program went on to have more demand than it could meet. Sovacool and Drupady (2011) report on a private company that had a high adoption rate, using an approach that entailed large demonstrations of solar and cooking devices, followed by door-to-door visits to familiarize communities with the technology. One agent is reported to have stated that those visits were necessary because “people have been cooking with traditional stoves for thousands of years . . . and many do not think a smaller, more efficient stove with smaller pieces of wood can actually cook the same.”

The foregoing discussion points to the value of training and also emphasizes the impact of literacy on the uptake of solutions that entail a steep learning curve. These qualitative findings corroborate the quantitative ones and extend them by explaining why such features are important to the MECS transition. The successful examples suggest that low levels of education and possibly other SES characteristics that deter the transition can be addressed through well-designed programs that take these factors into account. For example, information can be shared in a format understood by people of all literacy levels (e.g., demonstrations), or transition to a new technology can be designed in such a way that it is accomplished in gradual steps. Troncoso et al. (2011) report on a program where stove adoption kept pace with a gradual increase in stove feature improvements. The highest adoption rate, reached at the third improvement stage, was attributed to technology improvement. The program thus successfully balanced the need for a technology that people could relate to with one that performed sufficiently higher than the baseline to warrant the change. This evidence also suggests that making a change that is too small, with no appreciable difference between it and the existing traditional technology, could inhibit the transition.



Credit: © Prime Cookstove.

PEER INFLUENCE AND TRUST IN INFORMATION SOURCE

Apart from knowledge about the process of acquiring, using, and maintaining the intervention technology, the presence or absence of prior knowledge about its benefits would be expected to either enable or inhibit adoption. For example, Barnes, Kumar, and Openshaw (2012b) report that users in a few well-off villages in Haryana, India, were willing to pay more if better informed about the improved stoves. Alvarez, Palma, and Tay (2004) report that awareness creation gradually led to increased interest in the technology in both rural and urban areas. Other studies, however, do not clearly demonstrate that awareness alone impacts adoption. For example, Mudombi et al. (2018) report that all respondents without an ethanol stove had heard about it. Thurber et al. (2014) find that smoke- and health-related messages did not significantly influence the ICS purchase decision, even though those marketing messages did affect households' perceptions about smoke. Gould and Urpelainen (2018) report that LPG users and non-users alike held highly positive views about the fuel's convenience and cleanliness for cooking. In a case study in Gujarat, India, Barnes, Kumar, and Openshaw (2012d) report that household users acknowledged certain benefits provided by the improved stoves, but said they were willing to pay only slightly more than they currently did, citing poverty as the reason.

Knowledge from Peers and Social Networks

The evidence base shows that knowledge from peers and social networks experienced in using the new technology is an important driver of adoption if positive and barrier if negative. In urban Rwanda, for example, Seguin, Flax, and Jagger (2018) report that discouragement from peers was a significant factor in potential adopters' decision to forego the improved cooking system and one of the two most frequently reported barriers to adoption. One non-adopter said, "I was told that Inyenyeri cookstoves require constant follow-up to prevent food from overcooking. . . . Some women told me they returned the stoves because they damaged their cooking pots and overcooked food. . . . That is why I do not use them." Conversely, the authors found that peer encouragement, through positive feedback on the stove's performance, was an important enabler of adoption. Peer influence also validated the users' own decision about having adopted the stove.

Trust in Source

Peer influence as a transition driver is further supported by studies that assessed the main source of stove information that led program participants to adopt the new technologies. Yasmin and Grundmann (2019) report that relatives and friends were the main information source for adopters, at 46 percent, compared to less than 20 percent for mass media. By contrast, Pollard et al. (2018) report that 74.9 percent of those who had heard of the FISE program learned of it through their community governors and other local authorities, compared to only 9.76 percent who had learned of it through family members. It is worth noting that this program is reported to have not reached many of its target groups, who were unaware of its existence. Patel and Nyangena (2016) report how having energy champions within the community was an effective way to promote a new product and gain new users; out of 41 referrals, 19 (46 percent) came from just two individuals. Ramirez et al. (2014) report that one successful program utilized only social networks (e.g., local leaders and housewives), without any investment in formal marketing, installing more than 40,000 stove units in communities at a distance of up to 150 km from its operational base. According to the authors, whose analysis focused on how stove information is transmitted, most communication occurred between people who were relatively close acquaintances and maintained some degree of trust. Comparing

the experiences of two stove implementers, Vulturius and Wanjiru (2017) report that the stoves promoted using existing social groups achieved much higher levels of adoption than those sold through traditional marketing channels. Troncoso et al. (2011) report that the high adoption rates experienced during the third phase of an ICS project resulted, in part, from technology improvement; however, talking with the health team and other women for an entire year during the second project phase also influenced the late adopters' decision.

The role of peers and social networks emerges clearly from the evidence as an adoption driver, while that of the media and other information sources is inconclusive, pointing to the importance of trust. Higher trust might be placed in peers since they are not stove promoters and do not stand to benefit from the process; they can therefore validate the information obtained from promoters and other sources. However, for peer influence to act as a driver, countering the relative advantages of traditional cooking systems, the new technology ought to have performed according to user expectations, reflecting the interdependence of drivers and barriers reported in this review. Several studies in the evidence base, however, report negative user experience following the transition to MECS, which should be of major concern to developers in the sector.

COMPETITION WITH EXISTING FUELS AND STOVES

While technical attributes, such as fuel efficiency and improved combustion, have been the main drivers of most MECS programs to date, the reasons why users adopt the technologies are quite varied. To sustain transitions, the new cooking solutions must, first and foremost, be able to compete with traditional stoves on the basis of contextual advantages (e.g., versatility and ease of use), as well as technical ones. This can be quite challenging, given that the technologies and fuels being displaced are ingrained in local cultures and are lower in cost or free (whether true or perceived) to the target populations, who are poor. Understanding how users perceive MECS relative to traditional alternatives, even without additional information on what influence this has on their ultimate decision-making, provides important insights on the transition barriers and drivers.

Thompson et al. (2018) report that households did not prioritize the purchase of LPG stoves over other household items. Many had smartphones and stereos, which, according to the authors, were apparently more aspirational than acquiring a gas stove. One-third of the households with gas stoves had received them as gifts from parents, children, or a spouse. In that study, wood collection, which is often perceived as a driver of adoption, was not viewed as drudgery but as an enjoyable activity. A participant in the wood and gas focus group is reported to have stated, "Going out to gather some branches is relaxing because I can spend a few hours outside. What is tiresome is being always at home cleaning and cooking!" Another participant similarly noted, "Going out to get some firewood is not a problem. I like to go out with my neighbor so we can chat [laughing]."

Sesan (2012) reports that a relative food shortage in the study location meant that people did not spend sufficient time in the kitchen to even experience smoke as a problem. The author found that households that could least afford to eat well were the least exposed to kitchen smoke and could least afford to purchase smoke-alleviating interventions. For those households, the issue of immediate priority was not kitchen smoke but food security. This finding is similar to those of Barnes, Kumar, and Openshaw (2012b) in India, where lower income households in areas of biomass scarcity assigned greater importance to food over improved stoves. In Guatemala, Bielecki and Wingenbach (2014) report that stoves in a rural community had several layers of practical importance beyond cooking food. Most prominently, household members valued stoves as sources of heat and light, as well as a social gathering point for families. This

meant that fuel-efficient ICS designs sacrificed important functional, social, and cultural needs. Wentzel and Pouris (2007) report that survey respondents said they had stopped using their stoves because “they became too lazy to use the stove [and] bored with it” once the initial attraction had passed. In various case-study settings in India, Barnes, Kumar, and Openshaw (2012a–f) report that the low ranking of fuelwood savings as a perceived benefit of the stove was attributed to users’ easy access to fuelwood and agricultural residue. Troncoso et al. (2007) report that, although some users recognized the burden of carrying non-purchased wood, by and large, the no-value perception of drudgery and time savings was dominant. In another study focusing on the implementer’s perspective, the authors noted the following: “The main problem during this stage was convincing women in the communities to accept [the] ICS. Women were reluctant to try the new technology, particularly because they did not perceive the need to change their cooking habits” (Troncoso et al. 2011).

Li (2009) reports how several benefits of biogas technology were not perceived by the households, even though they had adopted the technologies. According to the authors, “Just 10 households thought it was a benefit that sludge offered a potent fertilizer. Only 5 identified cash savings on electricity, chemical fertilizers, and pesticides as one of the benefits, and only 3 considered reduction in firewood consumption a benefit of biogas.” These findings suggest that factors beyond the promoted benefits motivated adoption. In some Indian villages, women adopted the stoves because they believed that the improved stove program would be followed by other government programs (e.g., cemented kitchens or sanitary latrines) from which they could benefit in the future; the women were reported to have been disappointed when those programs did not materialize (Barnes, Kumar, and Openshaw 2012b). Others adopted the stoves because they thought they were required to do so by law (Barnes, Kumar, and Openshaw 2012b).

Thurber et al. (2014) report that one program’s lack of success was due to competition with other technologies at both ends of the spectrum. The authors explain that:

... for all the technological sophistication of the Oorja stove, the version we studied ultimately did not achieve its aim of being a cost-effective biomass stove with LPG-like performance. Respondents who had experience with LPG, [the] Chulha, and Oorja felt that the Oorja could not quite compete with LPG on convenience, flexibility, prestige, and smoke performance and that it fell short of the traditional Chulha on economic criteria, taste, and reliability.

Thompson et al. (2018) report an interplay between barriers and enablers: While free wood encouraged sustained use of the wood stove, unreliable LPG distributors discouraged sustained use of the LPG stove. Jürisoo et al. (2019) report that participants could not appreciate the cost of charcoal relative to LPG because charcoal prices fluctuated widely by season, neighborhood, and vendor. None of the participants interviewed could confidently estimate their charcoal expenditure. Instead, they emphasized the value of being able to purchase it anywhere (on street corners) and choosing the quantities they purchased each time. Patel and Nyangena (2016) report on the following challenges experienced by an implementer seeking to displace a traditional fuel:

Everything they were trying failed. The main fuel that Pika Poa is competing against is charcoal. In urban and peri-urban areas charcoal is readily available and most households can access it within close proximity of their house. Our baseline data shows that 82 percent of households who took the [pellet] stove were using charcoal either as their primary or secondary fuel. Out of these, 69 percent bought the fuel 1 km away or less from their home. For people to switch to using pellet fuel, making it equally easy to access will be an important factor.

Wentzel and Pouris (2007) report how solar cookers, with their higher prices, could not compete with the well-established and trusted alternative cooking appliances on the market. A kerosene stove that could be

bought for one-tenth of the price of a solar cooker was available in a variety of outlets with easy access to repair services. Barnes, Kumar, and Openshaw (2012a–f) report that the importance of fuel savings to ICS adoption varied by fuelwood availability. In villages where fuelwood was readily available from the local environment, the issue of stove efficiency was less critical than in locations where fuel collection was labor- and time-intensive or where fuel had to be purchased. Similarly, households that had other stove types, such as LPG and biogas, showed little interest in installing ICS. Troncoso et al. (2007) report that women appreciated the versatility of the traditional stove, which the ICS was lacking. According to the users, “It [the traditional stove] can be made anywhere, at any time, and since it is on the floor it does not require the user to lift heavy pots to the height of a stove. . . . Wood pieces of any size can be used, and the fire heats the pot directly, thereby achieving a faster heat transfer.” In that same study, some users cited using the open fire simply because they were used to it. Li (2009) suggests that the association between income levels and LPG use may be weak in regions where high consumption of home-produced or collected solid fuels is prevalent.

Thoday et al. (2018) report on a program in Indonesia that provides some insight on overcoming the barrier presented by an existing fuel. The program, which made LPG cheaper relative to kerosene through subsidies, is one of the few successful, large-scale transition programs found in the evidence base (Box 6.1). These findings, when considered alongside those of programs that reported substantial challenges of competing with traditional fuels, suggest that achieving a substantial transition may require interventions on both fuels. The form of such interventions and their long-term implications are beyond the scope of the current study. At the very least, cookstove programs should fully appreciate the competition that the existing cooking systems present to the new solutions being introduced.

BOX 6.1

Key Features of Indonesia’s Kerosene-to-LPG Conversion Program

Under Indonesia’s Kerosene-to-LPG Conversion Program, free LPG starter packages were distributed to households and micro-businesses. These packages consisted of a 3-kg filled cylinder (chosen for easy handling), one-burner stove, rubber hose, and regulator. At program inception in 2007, the per-package cost to Pertamina, the program’s implementing agency, was estimated at about US\$33 (US\$21 in 2017). By 2010, the program had achieved its 2012 distribution target of 42 million starter packages. As of 2015, distribution had reached more than 57 million units.

The 2006–15 period saw a 92 percent drop in kerosene consumption (from 10.0 million to 0.8 million kl) and a nearly sixfold increase in LPG household consumption (from 1.1 million to 6.3 million tons), which represented 8 percent of Indonesia’s total energy mix in 2015. Between 2007 and 2015, LPG per capita consumption grew by 19.7 kg (from 4.7 to 24.4 kg), accompanied by a 54.2 kg decline per capita in kerosene consumption (from 57.3 to 3.1 kg).

Source | Thoday et al. 2018.

TECHNOLOGY AND FUEL PERFORMANCE

Even where programs have succeeded in getting users to switch to the transition technologies and fuels, various barriers may have prevented the adopters from staying with the transition. According to the evidence base, these challenges are unique to the distinct features of the technology types (e.g., whether changes were required for both the stove technology and fuels used, whether design features were fixed or amenable to alterations, and practical functions). While some studies sought direct answers from participants on what led them to adopt and continue with specific stove technologies and fuels, others inferred these reasons from user responses to survey questions that asked what they liked most about the new stoves or disliked about the traditional ones. But without additional information on how these factors influenced user decisions and trade-offs, caution is warranted in interpreting them as drivers of the transition (e.g., they may simply indicate awareness based on knowledge acquired during stove promotion efforts). That said, the evidence base contains studies reporting clear transition barriers that are unique to technology types or to continuing with the transition. Viewed collectively, this body of evidence indicates that user appreciation of the benefits of MECS and the relative disadvantages of existing technologies is important for long-term adoption—an aspect of sustainable change that is extremely difficult to determine from short-duration studies.

Thompson et al. (2018) report that common reasons for acquiring the new stove included speed of cooking (e.g., to facilitate on-time arrival at work), cleanliness, and ease of use. Improved social status and health were not repeatedly mentioned. Troncoso et al. (2019) report that nearly all of the interviewed program participants recognized the advantages of cooking with LPG, as well as the health problems associated with firewood use. Mudombi et al. (2018) report ease of lighting and use as the benefits most commonly cited for switching from a charcoal stove to an ethanol stove, and these findings were corroborated in focus group discussions (FGDs). Person et al. (2012) report high fuel consumption as a commonly cited disadvantage of using traditional cookstoves, in addition to smoke, inability to control the heat, lack of cleanliness, and safety risks. In contrast, Seguin, Flax, and Jagger (2018) report inability to control the heat as a negative feature of the pellet ICS cited by survey respondents. For smoke alleviation, the findings of Sesan (2012) contradict those of other studies. According to the author, when study participants were asked about the smoke-reduction performance of the ICS, they stated that the quality of the fuelwood being used, not the ICS device, determined the level of smoke emitted. The cooks reportedly knew the value of dry wood and purchased it whenever they could for use in the ICS, as well as in traditional stoves. Benka-Coker et al. (2018) report convenience and cooking speed as the ICS benefits cited by study participants, and cost as their reason for not transitioning from firewood and charcoal. Sequin et al. (2018) report adopters' cited problems with the ICS, including excessive smoke and damage to cooking pots, to be inconsistent with the advertised features. The stove's fast cooking speed was found to result in the need for constant tending and overcooking of food. Some participants cited this feature as the primary reason for not purchasing the stoves, even though others cited it as a motivator for adoption. Otte (2009) reports the slow speed of solar cookers, which participants cited as slower than firewood (even on sunny days), as the main deterrent to adoption.

Shastri, Sangeetha, and Ravindranath (2002) report that, in an opinion survey, fuel savings was the feature most appreciated by users. Patel and Nyangena (2016) also report fuel savings as a benefit reported by the majority of survey respondents (55 percent), although a sizeable proportion (18 percent) said the stoves increased their fuel expenditure; the remainder could not determine whether they were achieving any fuel savings. This finding is similar to those of Urpelainen and Yoon (2017). Patel and Nyangena

(2016) suggested that high variability in stove performance relative to how the fuel was loaded and duration of burning could have accounted for differences in user responses, explaining that:

... our in-house testing showed that higher levels of fuel efficiency were experienced when using pellets for short, high-heat cooking applications, such as cooking tea or ugali, whereas for long, low-heat applications, such as cooking maize or beans, pellets could be more expensive. It also requires users to tailor the way they use the stove to maximize the fuel efficiency (e.g., only filling the stove with as much fuel as is needed and adding small amounts of pellets to lengthening cooking times in a controlled manner). This takes time for users to get right and is a point that many users never reached.

Muneer (2003) reports the cited advantages of the ICS as reduction in fuel use, cooking time, and smoke. Barnes, Kumar, and Openshaw (2012a–f) report the perceived benefits cited as smoke reduction, faster cooking (as a result of being able to use two pots simultaneously), and a cleaner cooking environment. In Urpelainen and Yoon (2017), users also cited time savings (resulting from fast cooking speed) as an important benefit. They also observed less smoke in their kitchens and had a perception of better health, but these factors were not prominent. Financial savings from reduced fuel use was mentioned by one-third of households, but an equivalent proportion was unable to quantify any fuel savings. Among those still using the stoves, high levels of satisfaction were reported. Satisfaction with the ICS is also reported by Hanna, Duflo, and Greenstone (2016), which is in sharp contrast to the study's findings on actual stove performance, which showed none of the advertised benefits were achieved. To the contrary, the authors suggested that the stoves increased women's time expenditure because they had to repair them. Agurto Adrianzén (2009) found that high firewood consumption associated with the new stove was the major inconvenience cited by those who had stopped using the stoves.

Financial savings were more apparent to users of biogas systems, compared to the other stove technologies. For example, Quinn et al. (2018) report that a majority of biogas users cited savings in money and time as a major benefit of the technology. When users were asked what benefits they appreciated, ease of cooking and cleanliness (but not health) were mentioned repeatedly. Sovacool and Drupady (2011) report that one program participant was able to create a stove and fuel business from the excess biogas she produced from her farm and earned a regular income from it. In rural China, Christiaensen and Heltberg (2014) report that 98 percent of adopters said biogas saved them both cooking time and time expenditure on fuel collection. Where users were reported as unaware of financial benefits, benefits related to health and environment were mentioned (Li 2009).

The evidence also shows the importance of striking a balance between simplicity and performance. For example, Sesan (2012) reports that the solar stove differed substantially from the ICS, which was set at floor level and similar in form and operation to the traditional three-stone stove. Users found the solar stove's technical-precision requirements cumbersome (e.g., the need to tilt the reflective surface to a specific angle in order to optimize the sun's rays), which inhibited adoption. In contrast, Jagger and Das (2018) report users' higher customer satisfaction with the pellet stove, which differed substantially from their traditional stove, because of its "modern" appearance and performance, believing they could use it in the living room, as well as the kitchen.

Apart from the technical performance features (e.g., fuel savings and smoke reduction), the stove's practicality was equally, if not more, important to users, as evidenced by their modifications to the technology to better suit their cooking needs and perceptions of performance, often to the detriment of objectively assessed efficiency gains. Thus, while the goals of promoters and users were similar in some cases (e.g., fuel-use reduction), how to achieve those goals with a cooking technology was viewed quite differently at times, even among the users themselves.

Barnes, Kumar, and Openshaw (2012a) report that, despite users' perceptions about the benefits of ICS, they faced multiple practical problems (e.g., chimney leakage, inappropriate pothole size, inconvenient grate design, greater fuel consumption, and the need for frequent chimney cleaning). As a result, about one-fifth of the users modified their stoves. The authors recounted the following challenges:

Users were reluctant to cut fuelwood to the required size for feeding. Instead, they used large wood pieces, which often damaged the firebox mouth; to correct the problem, they plastered the mouth opening with a clay-dung mixture, which changed its size. . . . The depth of the firebox [was modified] to accommodate a variety of fuels (e.g., agricultural waste, leaves, and dried dung). In addition, they often enlarged the tunnel diameter of the two-pot stove to facilitate heat flow to the second pothole. To reduce the frequency of chimney cleaning, they used a chimney pipe with a 10 cm [diameter], instead of the required 7.5 cm diameter.

In another setting, Troncoso et al. (2007) observed similar challenges, as follows:

A wide variety of problems of improved cookstoves were mentioned by users. The small entrance to the chamber involves problems for lighting the fire and for chipping the wood down to small sizes. Some complaints concerned specifically the secondary “comales” of the improved cookstoves (a “comal” is a ceramic dish or metal hotplate for cooking tortillas): users would prefer having independent combustion chambers or being able to [place] heavy pots, such as the ones used for nixtamal. Lastly, some people complained that improved cookstoves are not good to heat the room in winter.

The authors indicated that approximately 21 percent of the ICS were damaged to some extent. In most cases, the damage resulted from deliberate enlargement of the fuelwood entrance to fit in larger wood pieces.

Similarly, Bielecki and Wingenbach (2014) report participants' cited dissatisfaction with the small entryway for wood, which led them to modify the ICS to allow for more wood. This change was viewed as necessary to reduce cooking times and increase the amount of food that could be cooked at any given time. Participants also cited dissatisfaction with the stove's small internal combustion chamber, and many expressed a desire to enlarge it. Likewise, Wentzel and Pouris (2007) report inadequate stove capacity as a major reason for non-adoption cited by program participants. Complexity of the construction process was also a barrier, which led to variable (and poor) stove quality. The authors observed that:

. . . the quality of locally produced cookers was low and erratic, producers were unreliable, material was difficult to obtain, and the manufacturing process was extremely complex—for example, in one cooker, more than five types of material (steel, glass, fiberglass, aluminum, and rubber) had to be used.

Barnes, Kumar, and Openshaw (2012a) also report on a program's quality control challenges due to a lack of standardized stove construction materials. This led to wide variation in stove prices, depending on where the nongovernmental organization (NGO) procured its materials and the cost. Alvarez, Palma, and Tay (2004) report that one-third of a program's cited problems involved accessories, and stove modifications had to be made to suit users' needs. The authors found that, three years after stove installation, half of all chimneys had to be replaced.

Wolf et al. (2017) report on a program viewed as very successful where field-workers observed fewer cases of stove malfunction relative to other studies. Hyman and Bailis (2018) report on another program that catered to quality needs. The authors noted that “NBP delivered a technically sound product with timely and effective after-care services, including a two-year warranty on the dome and a three-year warranty on the biogas lamps.” The quality improvements provided by such programs were appreciated by users, even where they entailed extra costs. For example, Troncoso et al. (2019) report that 82 percent

of people who were offered an “efficiency” stove and a chimney stove opted for the latter, even though it was more expensive. Although Barnes, Kumar, and Openshaw (2012b) report several quality challenges associated with the stove programs evaluated, participants were found to have indicated a willingness to contribute toward the cost of a more durable stove.

Sovacool and Drupady (2011) report higher preference and adoption of fiberglass biogas units, with users citing the following advantages over the brick system:

Fiberglass units . . . can be constructed quicker and work more efficiently. It takes 15–20 days to install a brick biogas system, and is completely impossible during the rainy season. Brick systems also sometimes leak methane from pipes. But fiberglass units can be installed in two-to-three hours, anytime in the year, and almost never leak.

Bhat, Chanakya, and Ravindranath (2001) also report increasing popularity of the fiberglass reinforced plastic (FRP) floating drum design, despite its higher first cost. This suggests how reliability and low maintenance play a role in driving biogas adoption.

User needs are shown to vary by context, which programs did not always take into account. Barnes, Kumar, and Openshaw (2012a) reports that women in one Indian state (Maharashtra) preferred smaller potholes to accommodate smaller-sized vessels and made modifications to achieve this, while women in another state (Haryana) preferred wider pots and also made modifications to achieve it (2012b). Agurto Adrianzén (2009) reports how technology transfer without adaptation to local needs affected one program’s success:

The improved stove technology introduced in the Chalaco District was originally designed for rural communities in the coastal areas of Piura Region, where the main role of a firewood stove is food preparation. In this coastal area, the weather is relatively warm during most of the year and the type of firewood used is relatively uniform (mainly “algarrobo”). . . . The design did not take into account that the firewood stove also performs as a heating device in high-altitude areas where the temperature is much colder during winter months. Also, the stove combustion box was designed for the type of firewood that is common to coastal areas and did not take into account the specific varieties and qualities of firewood that are available in the different watersheds of Chalaco District.

For technologies that also involved a change in fuel, both fuel and stove-related supply challenges were reported. Similar to making cookstove modifications, users devised their own solutions to some of the fuel-related challenges before abandoning the stoves entirely. Jagger and Das (2018), for example, cite a program where adopters of a manufactured, pellet gasifier stove reported lack of a regular power supply and electrical faults with the charging system. To resolve the problem, users changed over to charcoal, which compromised efficiency and also hurt the company’s business model, which relied on the sale of pellets, not the stove.

Wilson et al. (2018) report on two separate studies where cost was widely reported as the barrier to continued use of the fuel (LPG in one study and ethanol in the other). For solar cooking, which had no recurrent fuel costs, the reported limitations, as expected, were weather conditions (Otte 2009), as previously mentioned, and cumbersomeness (Wilson et al. 2018).

Other barriers were unique to biogas adoption. Programs that could not fully meet its technical requirements (e.g., water availability, large number of animals as a source of feedstock, and labor availability), which tend to favor wealthier households, failed. Because it is stationary (a problem shared with fixed ICS), a biogas system cannot move with a family that relocates (Sovacool and Drupady 2011). Seasonal effects present another problem. For example, Christiaensen and Heltberg (2014) report on a program where the

biogas generated during the summer season was sufficient to meet cooking needs for that season, but not during winter, when colder temperatures slowed digestion speed. The authors documented the added set of complex challenges—including macro-level factors outside the energy sphere—faced by this particular program, as follows:

Although most Apricot adults were skillful pig farmers, 47 percent of surveyed villagers reported they raised two or fewer pigs, which made it not possible for these households to utilize biogas. Furthermore, 36 percent said that they had no plan to raise more pigs in the near future. In the past they raised them and the programs were successful. . . . In the past, pig farming was profitable and formed the core of the Apricot economy. . . . The piglets were cheap, farm residues were plenty, and hog prices were good. Most young men then worked in the village fields, and the older people and women could spend their time taking care of pigs. . . . As China intensified large-scale swine production to feed its growing urban population, hog farmers' profits were quickly made razor thin. Also, the cost of feed was up 20 percent from the previous year. Besides, market options were limited. The threat of disease also discouraged farmers from raising pigs. With the increasing human and animal mobility, more and more porcine diseases emerged in the region, particularly swine fever and hog cholera. When a disease broke out, farmers had neither means nor insurance to protect their pigs.



COST AS A BARRIER TO ADOPTION

A number of studies directly evaluated cost as a barrier to adoption, as opposed to wealth status as an indicator of purchasing ability. Terrado and Eitel (2005) report cost as the most important barrier to ICS adoption. The authors found that, while the potential fuelwood savings from adopting the technology was substantial, ordinary households could not fully grasp the financial benefits since they were accustomed to purchasing fuelwood in small quantities or collected it at no cash cost, as highlighted in previous sections. Seguin, Flax, and Jagger (2018) report that cost was a barrier for non-adopters of the pellet stove, as well as households who had adopted it and wanted to stay with the transition. This challenge was shared by other populations transitioning to new fuels, which entailed both start-up costs and regular fuel purchase costs. In many cases, this cost was evaluated against that of traditional cooking fuels, which required little (if any) start-up cost, had relatively stable prices, and could be purchased in small amounts compatible with irregular earnings. Seguin, Flax, and Jagger (2018) report on a program in Rwanda where a female interviewee expressed her disappointment with the increased price of fuel pellets as follows: “I didn’t mind using them [Inyenyeri fuel pellets], however, they made it impossible for us to keep using them. . . . They have increased pellets prices from 125 Rwandan francs to 200 francs per kilo, and at that price you actually spend more than what you would on charcoal.” Asante et al. (2018) report that, in Ghana, seasonality of income impacted the adoption and sustained use of LPG. One surveyed participant and non-adopter is reported to have said, “Mostly the income we get here is seasonal. When crops are in season, it might be easy to refill; however, when the farm produce is finished, that is when the refilling will stop.”

Quinn et al. (2018) report on a biogas program where cost became a barrier to adoption after withdrawal of the existing subsidy. Interviewees indicated high up-front costs and limited access to credit as the main barriers to uptake. In Rwanda, Jagger and Das (2018) report that the most commonly cited reasons for not participating in the cookstove program were lack of funds to pay the sign-up fee, inability to pay for the fuel in one monthly payment, and preference for purchasing fuel in smaller quantities. In an ICS program in Uganda, Wallmo and Jacobson (1998) report cost as the primary reason for non-adoption. Patel and Nyangena (2016) recounted an implementer’s perspective on the issue, as follows:

One of the challenges we experienced with signing up users through referrals is the ability to turn a potential customer’s interest into a purchasing user. Once we had received a sufficient number of referrals we would arrange for a sign-up event at which EcoZoom staff would invite all the referrals to participate. This event involved training in the use of the stove and fuel and how the lease works, after which they can sign up for the product, provide their baseline information, and take home training and marketing material. We found that only a small number of the referrals would actually come to the event and sign up. This was mainly due to availability of funds; when a person was referred they had funds available but when we came to do the sign-up event a week later they had already spent the money on other needs. To overcome this we tested the idea of having an agent within the community who could sign up new households as and when they became interested and had the funds available to sign up. . . . This method still did not produce high numbers of sign-ups.

This program finding is recurrent across various studies, where users’ expressed interest in the stoves did not result in a purchase, with affordability consistently cited as a barrier.

A survey published by the Ministry of Energy, Republic of Kenya (2019) reports that the main limiting factor for adoption of all the stove models evaluated was the up-front cash payments required to acquire them. Barnes, Kumar, and Openshaw (2012c) report that, in a case study in Karnataka, India, cost and competing household priorities, as well as lack of space, were cited reasons for not adopting the ICS. In Wallmo and Jacobson (1998), frequently cited reasons for non-adoption of ICS were lack of bricks for stove-building and money to buy them. Otte (2009) reports that, in Tanzania, affordability of the solar-box cookers was

one of the key project challenges. Most of the target population were poor and could not afford a box cooker that cost US\$53 (70,000 TZS). Thurber et al. (2014) report that the increased cost of fuel pellets triggered a transition away from the ICS. The authors found that:

... as the company increased fuel prices starting in late 2008 and thereafter, it saw the intensity of Oorja stove usage drop accordingly, to the point where very few households were still using the stove as of the spring of 2011. Survey responses corroborate First Energy's view that increased fuel prices were the single most significant cause of non-adoption. As higher fuel prices eroded the value proposition for consumers, dealers also found the stove business to be less attractive, leading to erosion of the distribution network and less convenient fuel availability for household Oorja users.

For LPG, various studies found that cost was a major barrier to initial adoption and continued use. Terrado and Eitel (2005) report that the commonly cited reasons for households' continued use of fuelwood was lack of financial resources, particularly for acquiring the LPG stove (cited by 48 percent of survey respondents) and/or gas cylinder (cited by 26 percent of respondents). Gould and Urpelainen (2018), in their survey of more than 8,500 households from six energy-poor Indian states, found that the initial cost of the LPG stove and connection, as well as regular fuel costs, were both important barriers to households' initial adoption and continued use. Bruce et al. (2018) report that, among LPG non-adopters in rural and peri-urban areas, 50 and 55 percent, respectively, reported initial cost as the main barrier to adoption, which were much higher figures than were reported for the other barriers. For example, the respective figures for safety concerns were 14 percent and 24 percent.

A particularly important finding is that households often do not take the refill cost of LPG into consideration at the point of adoption; afterwards, however, they realize the stoves are costly to operate and perceive the refill cost as a major barrier to continued use. One program in Cameroon, for example, found that 74 percent of LPG adopters thought the refill cost was expensive or very expensive, a factor not cited by non-adopters. Reporting on a program that subsidized the initial costs of LPG connections for poor households, Gould and Urpelainen (2018) found that 88 percent of the adopter households interviewed considered monthly fuel costs as a major barrier to continued use. According to the authors, one large cylinder, the unit purchased by 95 percent of the interviewees, accounted for 10 percent of the average household's total monthly expenditure.

Perception of high cost can also create a barrier to adoption. Velasco (2008), for example, reports that rural communities in Mexico adopted an ICS rather than an LPG stove for sociocultural reasons, perceiving LPG as an expensive or luxury technology for cooking. One interviewee is reported to have stated the following: "LPG is very expensive, more than wood; even though the price of a Patsari stove and an LPG stove could be the same we will always be more interested in the Patsari because it consumes wood and works according to our expectations and we can make tortillas on it." Malakar (2018), who did a comparative analysis of LPG versus TV adoption in India, found that lack of information was the real barrier to adoption. Based on the author's calculations, price was not a barrier even though program participants reported unaffordability as the reason for non-adoption. The author explained that:

... the TVs that research participants owned ranged from INR 8,000 to 9,000 [US\$112–126], including a wireless TV signal receiver that costs about INR 3,000 [US\$42]. A monthly renewal of a cable subscription cost INR 160–200. Hence, the annual subscription cost was between INR 1,920 and INR 2,400. ... The LPG bottle was INR 1,000 ... which was not added to the total price ... because the government of India subsidized it for BPL families. Refilling a bottle cost INR 650 of which the government would return about INR 180 as an incentive directly to the user's bank account. ... According to the house that stacked fuels, a bottle of LPG lasted up to three to four months. Hence, the annual

running cost, after deducting the subsidy amount, for LPG stoves was between INR 1,410 and INR 1,880. It is evident that both the up-front and running costs for a TV are higher than LPG.

The important role of cost is corroborated by findings of other programs that provided subsidies and other financial incentives to tackle this constraint; however, not all were successful owing, in part, to variations in design. Asante et al. 2018 report that rural households in Ghana cited financial constraints, as well as poor supply and safety, as reasons for their discontinued use of LPG. Nine months after acquiring the stoves through a government program that included initial free distribution of a filled LPG cylinder, less than 5 percent of the beneficiary households were found to be using the stoves. By contrast, Madubansi and Shackleton (2006) report on a program in South Africa with similar design features where 72 percent of survey respondents indicated their continued use of the LPG stoves and regular refilling of gas cylinders seven years after the initial rollout. The participants in this latter program were beneficiaries of a policy that provided free basic energy for households at certain income thresholds, for which over 60 percent of the participants qualified. Pollard et al. (2018) describe key features of the earlier mentioned LPG program, the Social Energy Inclusion Fund (FISE) in Peru, which entailed a free starter kit and refill vouchers. Despite the limitation of not reaching all of the target group with information, the program is reported to have achieved sustained adoption, with 88.8 percent of beneficiary households regularly refilling their LPG cylinders (Box 6.2).

Sharma, Parikh, and Singh (2019) report that an LPG capital subsidy scheme, known as PMUY (*Pradhan Mantri Ujjwala Yojana*), provided a trigger for transition among beneficiary households. Thoday et al. (2018) report how the distribution of free LPG starter packages and making subsidized LPG cheaper than kerosene

BOX 6.2

Promoting LPG Access in Peru: Key Features of FISE

In Peru, the LPG program of the Social Energy Inclusion Fund, known as FISE (*Fondo de Inclusión Social Energético*), centers on providing eligible families—those living in poverty or extreme poverty—a monthly fuel voucher worth about US\$5 (16 soles). This voucher can be used to exchange an empty 10-kg LPG cylinder (valued at about US\$10 or 32 soles) for a full one. Currently, LPG stoves, which cost approximately US\$15, are not subsidized and must be purchased by the beneficiaries. To receive vouchers, households with electricity must register with their electricity provider, while those without electricity must register with their local office of the Ministry of Energy and Mines (MINEM). Once eligibility is confirmed, households with electricity are provided vouchers via an electronic code on their monthly electricity bill, and those without electricity receive paper vouchers. The beneficiary households must use at least one LPG voucher within a four-month period or their beneficiary status is temporarily suspended. Beneficiary status expires after one year of non-use, after which households wishing to participate must re-enroll.

Source | Pollard et al. 2018.

acted as drivers of its adoption and transitioning away from kerosene. Troncoso et al. (2007) compare the outcomes of two ICS programs in Mexico, reporting that the one with free distribution had a 93 percent level of adoption (14 out of 15 interviewees), although technology design problems lowered the life expectancy of the stove. In their sample, 35 percent of the interviewees without ICS argued that they could not afford it. Terrado and Eitel (2005) report that hardly any sales were made at the initially set market prices for the two ICS models, US\$35 and US\$45, despite strong expressions of interest. Once the prices were subsidized, the stoves gained in popularity and sales increased. Later, when the stoves' selling prices were raised to US\$28 and US\$36, the sales continued, reaching 369 units at the time of evaluation. In South Africa, Kimemia and Annegarn (2016) report on a successful transition away from solid fuels and paraffin to electricity in low-income suburbs made possible by electrification and rising incomes. More than 60 percent of participating households qualified for social support and did not pay directly for their electricity consumption.

In some instances, subsidies did not succeed, especially where factors in other domains (described in Chapter 2) were reported as major barriers to adoption. The India National Cookstove Program is one such example (Barnes, Kumar, and Openshaw 2012a–f).



SOCIOCULTURAL PERSPECTIVES AND GENDER

Evidence from the systematic map confirms the critical role that gender plays in the widespread adoption and use of improved cookstoves and transition to MECS. Data on the drivers of and barriers to MECS adoption generally reflect traditional decision-making roles, with women as the primary users of home cooking systems and men influencing the purchase of new cookstoves or fuel types in certain contexts.

Thompson et al. (2018) report that men in Guatemala were key decision-makers on household investments, including fuel procurement, and yet messages about LPG did not target them. According to the authors, women were given funds to purchase food, but did not have the financial independence to make decisions about gas refills. Men were reportedly indifferent to the benefits of LPG, claiming that “women are accustomed to smoke while cooking,” “women prefer to cook with wood,” or “smoke is not necessarily a cause of illnesses.” However, they were found to have appreciated the timeliness of food prepared on LPG stoves. In another setting, where women could only control cash for food purchase, Person et al. (2012) report that a portion of those funds, as well as funds for clothes and other items, was diverted to purchasing ICS. Troncoso et al. (2019) report that 30 percent of survey respondents said the male head of household decided which fuel was to be used for cooking.

Gender roles in smoke-reducing behavior also have important implications for cookstove programs, as Sesan (2012) describes:

The objectives for wanting to be rid of kitchen smoke are slightly different on both sides: while international organizations advocate smoke eradication for health reasons, West Kochieng households originally took kitchen smoke outside the house mainly to prevent accumulation of soot on the walls—particularly of the living room—because it was important to a man that guests did not perceive his home to be dirty or ill-kept. Therefore, from the perspective of a male West Kochieng citizen, moving the kitchen outdoors may be a more legitimate solution to the problem of indoor smoke than installing an improved cooking technology in an indoor kitchen area. Indeed, building an outdoor kitchen is a higher-ranking priority for West Kochieng households than acquiring an improved stove or smoke alleviation intervention. . . . Building an outdoor kitchen, apart from traditionally requiring male authorization, is capital-intensive. This means that a woman usually has to wait until her husband decides that he has enough resources to provide an outdoor kitchen and then gives the go-ahead to build. For many women, the waiting period stretches into years, even decades.

Person et al. (2012) report that women explained during interviews that their husbands did not want them to create a necessary vent for the stove by cutting a hole in their wall, which deterred adoption and proper use of the stove. Similar to findings by Sesan (2012), the barrier was not men’s direct resistance to the technology but other living dimensions that are influenced by gender dynamics, which, in turn, translate into barriers to the MECS transition. The women in this case had purchasing power and bought the technologies, but were not using them properly and thus not realizing the smoke-reduction benefits because of gender restrictions.

Person et al. (2012) report that women’s ability to purchase ICS varied, based on their access to cash and position of power within the household. Women reported securing funds with which to purchase the cookstoves as a negotiation with their husband, co-wife, or mother-in-law. The results were mixed. One cookstove purchaser with favorable results stated the following: “My mother-in-law was the one who negotiated it for me. She told my husband that the cookstove was really good and she would like us to install one in her kitchen and mine so that we would have an easy time for cooking.” The authors found that, while most husbands were viewed as receptive to the women purchasing ICS, several of the women interviewed observed that they had no power to make such a decision.

Catalan-Vazquez et al. (2018) report that, in one study setting, male involvement in stove promotion presented a barrier to adoption. Survey respondents stated that, according to customs and traditions, a man was unwelcome to enter a home where women were alone; this, in turn, deterred male stove promoters from performing stove installation and maintenance functions. In such a context, women could not adopt ICS without their husbands' permission. Interestingly, in another setting within the same study country, the authors found that women could accept ICS installation on their own and were even encouraged by their husbands and/or in-laws to enroll in the programs.

Ramirez et al. (2014) report that men played a critical role in the entire ICS dissemination process. This behavior was attributed to that society's patriarchal character, whereby men communicated with other men more readily than women did, were more active in disseminating stove information, covered longer distances than women could (more than 30 km), and were more likely to talk to women about the stoves than vice versa. Barnes, Kumar, and Openshaw (2012) document the important roles of gender in India's stove transitions. Regular chimney cleaning, which required climbing onto the roof, was physically challenging for women, who were rarely assisted by male family members in performing the task. As a result, lack of chimney maintenance was an important contributor to stove malfunction and discontinued use. Male household heads' lack of willingness to purchase ICS was also reported as a contributor to non-adoption. Urpelainen and Yoon (2017) report that having a reputation as a stove builder was not considered prestigious for men, who viewed the work with mud and clay as "dirty work" and women's work; thus, they were not motivated to build stoves or offer after-sales service.

Gender roles in fuel harvesting are also important for MECS adoption. In rural Mexico, for example, Troncoso et al. (2007) report that men were the main fuelwood harvesters and processors. Of the women interviewed, 70 percent indicated that their husbands or another man in the family fulfilled this task, including installation of improved cookstoves. In such contexts, the indifference observed by Thompson et al. (2018) in Guatemala would be unlikely. However, 40 percent of the interviewees without an improved stove stated that their husbands had failed to keep their promise to build one. In that study, single women were reportedly at a great disadvantage as no one helped them to collect and chip wood, a problem reported by 20 percent of participants. In the study setting analyzed by Masera, Díaz, and Berrueta (2005), improving kitchen conditions (e.g., by installing cookstoves) was considered a "women's issue" and of low priority for men, who had the economic power within households.

Failing to account for gender relationships, which can vary considerably by context, can negatively impact program results. To illustrate, a stove program in Sudan reported on by Muneer (2003) targeted men but excluded women. The author argues that low ICS adoption resulted from the program not taking the setting's gender relationships into account, which included women's decision-making role in ICS adoption. The author criticized the program for its heuristic assumption that the husband is the primary decision-maker regarding all household issues.

Keese, Camacho, and Chavez (2017) illustrate how stove performance can affect gender relations and constitute a barrier to adoption. In the study setting, women's role in preparing and serving meals on time for their husbands and families was important. However, the solar CookKit was slow and thus witnessed low adoption. Women were also expected to be good hostesses, which required a larger capacity stove for preparing meals for guests, as well as their families. In that setting, men were cited as the decision-makers on energy investments.

Sociocultural dimensions that transcend gender were also identified as adoption barriers and enablers. Sesan (2012) reports that the kitchen space reflected the social, physical, cultural, and economic realities

in which the survey respondents lived. The author suggested that any external intervention to improve such a space should be guided by the lifestyles that have informed its constitution and evolution over centuries. In Zambia, Jürisoo et al. (2019) report that study participants stressed the cultural importance of their traditional stove, mentioning how it connected them to their roots and made the food taste a certain, accustomed way. Catalan-Vazque et al. (2018) describe how a community's sociocultural dimensions could variously favor or discourage ICS adoption. In indigenous communities, characterized by extended families, uptake of the new cooking technology was limited by such factors as traditional routine practices, arrangement of rooms in the house, attachment to the traditional stove, and a low- or non-risk perception of wood smoke. Conversely, in the mestizo community, nuclear families, who had previously used a raised cookstove, favored the ICS for routine cooking practices and appreciated its potential health benefits from reduced wood smoke. Reporting on a study setting in Bangladesh, Sovacool and Drupady (2011) show how sociocultural factors can affect the adoption of electric cooking, as recounted by a stove promoter:

In our culture, marital ceremonies center on traditional fuels and energy sources. When a new bride first comes to her new husband's house, for example, it is customary for her to cook boubat (bridal rice) for the entire new family, supplying a meal for all relatives. The ceremony involves firewood and it has strong symbolic meaning. There's no firewood [wood fire] if you have an electric cooker or appliance, for that reason those technologies are slow to proliferate.

Bielecki and Wingenbach (2014) report that survey respondents who exclusively used three-stone open fires stated that they continued the practice because it was a cultural custom. Similarly, Benka-Coker et al. (2018) report that, in Ethiopia, participants wanted to keep the tradition of preparing coffee on charcoal stoves.

In most of the studies where culture constituted a barrier, the evidence base points to additional contributing factors. Among others, these included practical limitations of the stove, economic factors (e.g., the need to build a new kitchen to house the stove), lack of motivation to switch, and cost of the new technology. It is therefore difficult to isolate culture from these additional variables. The following excerpt from Bielecki and Wigenbach (2014) well illustrates this interconnectedness:

The advantage of having [the open fire] is that it keeps us warm. It is a custom to have a low fire on the ground because we are used to sitting around the fire. The [ICS] is high up so we couldn't gather around it to keep warm. . . . The open fire, it is a custom to have it. Also, in the time of the elote [corn on the cob] you have to have the open fire to prepare it. Without an open fire we couldn't keep ourselves warm during the winter or grill the elotes.

Similarly, Jürisoo et al. (2019) report on a program in Zambia where participants cited a cultural attachment to their traditional stoves. The participants also said that the cooking techniques required for their everyday dishes (e.g., slow simmering of beans, grilling maize, and preparing relish and nshima—the national staple) were done quite easily on their traditional stoves (mbaula), suggesting a lack of an incentive to change.

While these sociocultural dimensions present a clear obstacle, the evidence base shows that a significant proportion of the population in such settings still makes the transition when other barriers are overcome. Thus, culture should be considered alongside many other transition barriers. Sovacool and Drupady (2011) report that some cultural factors inhibiting the transition, including occasional ceremonial events and hosting of guests, were resolved by stacking cookstoves and fuels. If cultural attachment were to preclude MECS for energy-demanding staples, it would be of great concern; however, in the few studies that incorporated such analyses, this was not the case.

Gebreegziabher et al. (2009) report that, in Ethiopia, where baking traditional bread (injera) accounts for 60 percent of household fuel consumption, a significant number of households were found to have transitioned to using electricity for preparing it. Similarly, Troncoso et al. (2007) report that, in Mexico, where making tortillas accounts for the highest cooking-energy demand, 25 percent of survey respondents had transitioned to purchasing industrially produced ones. By contrast, Banerjee et al. (2016) report that, in India, where flatbread (chapati) is an integral part of the staple diet, only 11 percent of households were found to prepare it on an induction stove, which they used for cooking nearly all other meals.

In other cases, cultural barriers were dominant, particularly regarding the choice of biogas feedstock. In Bangladesh, which comprises mainly Muslim communities, Sovacool and Drupady (2011) report that religious reasons prevented use of the most suitable biogas feedstock (pig dung). Biogas systems would also work optimally with the use of human feces injected alongside cow or animal waste, but study participants, similar to those in many other regions, rejected the idea, stating that it could counteract the freshness of their meal. The authors also found that Bangladeshi women, who pride themselves on having neat and clean kitchens, would never allow animals to enter their kitchens, and thus would have trouble using gas that emanates from animal waste in these “sacred spaces.” This example underscores that success is unlikely for interventions that fail to take cultural perspectives into account.

AFTER-SALES SUPPORT

As previously discussed, the evidence base shows that user challenges with the new stove technologies following adoption often led to reduced or discontinued use or stove modifications that affected performance. These findings raise questions about how after-sales service influences adoption and whether its provision would counter users’ negative experiences.

Clemens et al. (2018) report that a significant percentage of biodigesters constructed during the first phase of the Africa Biogas Partnership Program were non-operational at the time of evaluation. However, the rate of abandonment slowed during the program’s second phase, when designers put in call centers and repair services to address users’ reported challenges. Thurber et al. (2014) report that 23 percent of those who had reduced or discontinued their use of the ICS cited unresolved stove problems. Disuse resulted not only from breakdown of the technologies, but also fear of breakdowns without having arrangements in place to address them. One beneficiary of a program in rural Guatemala, reported by Bielecki and Wingenbach (2014), said, “I am using the open fire because I don’t want the [ICS] to break down quickly.” Another beneficiary added, “I am afraid of what would happen if some of the blocks inside break. What would I do or where would I go to get new ones?” Similarly, Li (2009) reports that the concern about technology breakdown, not the breakdown itself, led to failed biogas adoption by some participants in rural China.

Vulturius and Wanjiru (2017) report that differences in the after-sales support received helped to explain differences in stove adoption and satisfaction between two groups. Wentzel and Pouris (2007) report that stove acceptance was hampered by badly assembled stoves, as well as lost and unavailable spare parts. In one case study in India, Barnes, Kumar, and Openshaw (2012) report that the availability of after-sales support (i.e., having a stove mason living nearby) was a key determinant of ICS adoption. That particular program also included follow-up inspection of stove construction by three field officers with consequences (loss of government contract) for agencies whose stoves failed the tests. A challenge arose, however, when in just a year, NGO installations numbered 65,000, far exceeding inspection staffing capacity. In another setting covered by the study, users discarded faulty stoves after a few months due to lack of after-sales service. In a program they evaluated, Urpelainen and Yoon (2017) found that key weaknesses in the dissemination structure were lack of local technical expertise and good-quality, after-sales service. In that

program, just 10 percent of the interviewed households received after-sales service. Of those, 40 percent were dissatisfied with the support received. In more than 10 percent of households, the ICS did not work properly within one year of installation. Li (2009) reports that villagers in rural China had to visit the biogas system repair station in the county seat (far from their residences) for technical advice and had to pay a high fee for training that most attendees did not consider valuable.

By contrast, some programs were characterized by strong after-sales support services. For example, Troncoso et al. (2011) report that ICS builders in one project visited every household up to three times after construction, offering technical assistance in stove use and maintenance. In a biogas program in India, Bhat, Chanakya, and Ravindranath (2001) report that adopters were offered guarantees and warranties free of cost. Sovacool and Drupady (2011) report that, in Bangladesh, a biogas program offered adopters good after-sales service, which motivated people to sign up for the program. The company reportedly had a buyback plan, whereby clients could return their biogas system at a reduced price, and also offered clients free training on proper maintenance and minor repairs. According to the authors, "Rather than run things from Dhaka, GS has a network of more than one thousand offices spread throughout the country."

Masera, Díaz, and Berrueta (2005) stress the importance of after-sales services, drawing on lessons from their evaluation of a cookstove program in Mexico, as follows:

Adoption of improved cookstoves implies a learning period that needs to be carefully monitored. In the case of Patsari cookstoves, local women need to adapt themselves to cook standing instead of kneeling, to tend the fire in a different way, to use smaller pieces of wood, to clean the tunnels and chimney, and to cook with a metal comal instead of a ceramic one. All of these changes imply an entrance barrier to cookstove adoption; many women take a month to adapt themselves to the new cookstove, a period when cookstove monitoring and user support are essential.

The evidence base shows that the challenge of providing after-sales services was related mainly to a lack of incentive resulting from the programs' failure to invest in this component. According to Barnes, Kumar, and Openshaw (2012), interviews with stove builders in one setting revealed they were unable to visit all villages for lack of time and funds. Of the 129 user households surveyed, all reported that the builders and masons did not return after installation. In a second study setting, stove builders usually failed to check on proper functioning of the installed stoves for lack of incentives, and in a third setting, only three field officers were assigned to inspect the cookstoves, which numbered 65,000. Urpelainen and Yoon (2017) report that stove builders lacked incentives for providing maintenance. Owing to low salaries, the cookstove business retained only 10 percent of trained stove builders. High dropout rates among the youth trained in stove building and maintenance is also reported by Barnes, Kumar, and Openshaw (2012), who found that the trained youth viewed stove building as a casual job rather than a profession.

7: CONCLUSIONS AND RECOMMENDATIONS

The current review of the literature is based on 138 articles comprising 160 studies that met the inclusion criteria agreed by a wide range of stakeholders and advisory experts. While these numbers are small relative to the 13,914 articles screened and the 791 assessed at full text, they are consistent with those found in other similar, systematic reviews (e.g., Lewis and Pattanayak 2012; Puzzolo et al. 2016; Vigolo, Sallaku, and Testa 2018). While most studies were rejected for not meeting the inclusion criteria, weaknesses in design of the primary research accounted for a disappointingly high number of rejections, even though the rich information contained is of central interest to the review question. In terms of the overall availability of studies that met the criteria for understanding what factors drive the transition to modern energy cooking services (MECS), well-designed research that accounted for confounding and contextual factors of the populations targeted was relatively lacking. Many articles were rejected because key program information was missing or not reported on, or results were discussed without reference to measured outcomes that could be independently verified. One such example was the near total absence of robust, empirical studies on what factors have driven the wide-scale uptake of the Kenya Ceramic Jiko, one of the most successful cookstove development and promotion efforts in Africa, which has been extensively discussed in the literature. Future program evaluations could benefit from a more rigorous, perhaps protocol-driven approach.

There is wide scope for improving the design of studies evaluating programs transitioning to MECS and the reporting standards of research articles that emerge from them. Like the findings from other reviews in this field, the current review discovered that most of the data were from academic journals, with only a limited amount from non-journal sources (e.g., reports from international organizations, NGOs, and the private sector), meaning that much valuable work is not finding its way into the syntheses of evidence. This represents not only an intellectual loss; it also limits the value of funded work over many decades. It is beyond the scope of this review to suggest solutions other than to reiterate the need for a repository and better curation of non-journal evidence.

The evidence base pointed to the importance of sociodemographic factors—particularly age, education, and income—and contextual factors on decisions and ability to undertake transitions to modern energy systems and in continuing with them, or reverting to traditional technologies. While these results are not new—indeed we found that various programs took them into account—many other programs overlooked the characteristics of target populations. We found that programs were transferred across contexts without regard for the combined cooking and heating needs of local populations; highly complex projects were implemented without user education and after-sales support; and solutions with high up-front costs—exceeding 10 percent of users' monthly wages in some cases—were rolled out without financing options. As a result, various programs were reported as unsuccessful, while others ended up excluding their core target groups. These findings suggest that either the implementers lacked knowledge of the socioeconomic factors that could bar the transition or that underlying factors prevented the implementers from taking them into account. Further studies on the perspectives of program implementers are needed to better understand what barriers they face. Some findings in the evidence base (e.g., Barnes, Kumar, and Openshaw

2012) suggest that donor requirements and financing can limit an implementer's ability to address these challenges, a point that requires further probing.

Understandably, some of the reported barriers (e.g., availability of plentiful low-cost or freely collected biomass, low incentives to make a transition, and poverty) lie outside the influence of small-scale, nongovernmental transition programs. Overcoming such barriers would require government-level interventions, whose forms are not clear-cut and possibly controversial; thus, we are hesitant to make recommendations on this aspect. However, we can share useful insights from programs considered successful in achieving the transition to MECS. In Indonesia, for example, a successful government-led approach entailed lowering the price of a transition fuel (LPG) to a level below the traditional, secondary fuel (kerosene), making it price competitive. From the outset, the program did not target the lowest grade fuel (biomass) and thus was able to tailor the solution to a target group that could afford to pay for some of the transition costs. In Peru, where the recurrent cost of LPG was subsidized using a targeted approach, a large-scale transition is reported to have been sustained over a long period. In contrast, a program in Ghana that provided users free LPG starter packages with no subsequent financial support lasted only nine months. Although not covered in this review, anecdotal literature shows that Kenya's ban on charcoal has led to an increased adoption of LPG. Further studies on this topic would help clarify these claims.

Apart from the large-scale measures mentioned above, the evidence base also points to incremental actions that can support the MECS transition. These include implementers' follow-up monitoring and recording of successes and weaknesses and responding to user feedback over an extended period of time. This finding, along with evidence on how advice from peers can influence adoption, supports recommendations to integrate this component into programs. Other key considerations that emerge from the evidence base include the importance of the technology's durability and the need for technologies to respond to users' practical cooking needs. Finally, the review identified key evidence gaps that merit further investigation, which are described below.

LIMITATIONS OF THE REVIEW

All research reviews have limitations, and, while systematic reviews aim to minimize those caused by bias in study selection and assessment, some necessarily affect the interpretation of results. The first limitation, of course, is the scope of the review, as defined by the research question and the common understanding reached on its elements. The systematic method overcomes this limitation, to a certain extent, by including stakeholders in shaping and defining the research question and producing an agreed, rigorously peer-reviewed method (the protocol) for conducting the review. However, as previously discussed, such terms as "large-scale," "sustained," and even "transition" are open to considerable interpretation. Thus, other researchers might reach different conclusions about how these terms should be applied in deciding whether to include or exclude studies identified using the search strategy. Making excluded articles available for scrutiny and use by other researchers or policymakers helps to mitigate this limitation. The search strategy is also subject to debate, and the addition (or removal) of search terms or knowledge sources would affect the set of studies potentially available for review. We have been clear about the trade-off necessitated between the breadth of the search strategy and the available resources (time and cost) for undertaking and completing the review. By having made the literature search strategy available, other researchers will be able to adapt our methods for subsequent reviews.

POLICY RECOMMENDATIONS

As discussed above, the recommendations of any study, including systematic reviews, should be considered alongside the limitations inherent in the research design. Based on the findings that emerged from the current evidence base, we recommend the following policy measures to address the barriers to transitioning to MECS:

- **Have better targeted programs that take into account the socioeconomic realities of target groups.** The evidence base revealed that extremely poor populations did not prioritize clean cooking since they had more pressing needs, such as food security. While some programs attempted to overcome this challenge by promoting low-cost technologies, additional challenges arose that led to the abandonment of those solutions. Furthermore, some of those technologies were not viewed favorably because they did not differ appreciably from the traditional ones. Programs that target poor populations should integrate financial mechanisms that address the affordability constraints of potential users of the introduced technologies.
- **Fully consider the challenge posed by the existing stove technologies and fuels.** Meeting this challenge might require interventions on both fuels or offering a better value proposition for the new solutions. The value proposition is not clear-cut and could be subjective (i.e., in some cases, users reported high satisfaction with programs that were widely reported as having failed in achieving technical objectives). Awareness creation may also be helpful if additional evidence shows that this is a driver of transition.
- **Take women's time demand into consideration.** Program interventions should take into account the availability of women's time for attendance at multiple awareness and technology training sessions, fuel processing and stove cleaning, and marketing and promotion of solutions. Even though study findings have shown that women are more successful than men at generating stove sales, we especially caution against targeting women as promoters of MECS solutions that have not been demonstrated as successful without further evidence on how such activities impact women's overall welfare. The evidence base shows that the low overall success rate of many improved cookstove programs caused men to lose interest in promoting the stoves; but this does not mean the task should be transferred to women. The evidence base also points to the value that women attach to their time; in fact, women's reported time savings was a key positive outcome of adopting modern cooking solutions (Table 5.1). Further research is needed to support or refute this claim.
- **Broadly tackle the role of awareness creation as a separate MECS intervention.** Overcoming participants' low incentive to switch to MECS through raising awareness on the harmful health effects of traditional cooking should not be left up to individual cookstove programs. Rather, the issue should be more broadly addressed by governments as a separate MECS intervention. This approach would allow for independent, objective messaging, which, in turn, could inspire more trust and thus be more likely to elicit a behavior change. Lessons from NGOs, which are generally successful in this type of communication, can be adapted for designing such programs.
- **Ensure that evaluation methodologies are integrated into program design.** Incorporating evaluation methodologies into the design of cookstove programs, including those implemented by the private sector (many of which receive some level of donor support) will allow for the independent assessment

of essential program components that can ultimately lead to program success, while also generating knowledge for the broader sector.

- **Create a repository for grey literature on MECS.** Having such a repository would make it possible for researchers and practitioners to deposit key reports and findings on incentives for adopting cleaner cooking solutions and factors that act as transition drivers and barriers.

RECOMMENDED TOPICS FOR FURTHER RESEARCH

- **Increase the understanding of MECS and improved cookstove transitions in urban and peri-urban settings.** To date, few studies have focused on these settings. One area particularly worthy of further study centers on the growing trend of rapid urbanization, particularly among youth, and evidence that young people are more likely to adopt modern technologies.
- **Harness relevant lessons from other sectors on the drivers of long-term transitions.** The current review attempted to learn relevant lessons that could be applied to the MECS transition by including studies from the lighting, telecommunications, water and sanitation, and agriculture sectors. However, very few of those studies met this review's inclusion criteria. Additional reviews specifically targeting studies in those sectors are warranted.
- **Explore the role of stacking behavior in transitions.** Stacking was reported in nearly all of the literature reviewed. Thus, a better understanding is needed on what drives this practice and its potential positive or negative impacts on the transition process. Stacking could have a positive effect (e.g., providing households a fallback option to address inherent challenges associated with transition fuels and technologies) or a negative one (e.g., preventing populations from making a full transition). The current review was not designed to tackle this question, which would be better addressed using primary data that can define transition in stricter terms and perform separate analyses for households that do and do not stack.
- **Explore the role of subsidies in the MECS transition.** The focus of this research should include challenges related to sustaining subsidy measures and the potential adverse effects of such policies.
- **Investigate the roles of women and men in supporting the MECS transition.**

To make meaningful use of this research, it is important that publishers observe a stricter review process. Having more stringent review processes in place and adhering to publication guidelines for the design of methods will ensure more robust reporting on the studies conducted.



Credit: © MECS.

NOTES

- ¹ The term *Modern Energy Cooking Services* considers the multidimensionality of energy access, which goes beyond access to “clean” cooking (i.e., the attainment of efficiency and exposure reductions) as the transition endpoint. In addition to these technical attributes, MECS also includes the contextual attributes of convenience, safety, affordability, and fuel availability (ESMAP 2015; 2020).
- ² “Large-scale” refers to national, subnational, regional, state, district, city, town, whole village, or area of high population density.
- ³ In this report, “transition” is treated as any upward movement from a baseline cooking system to an “improved” one, as defined by the studies and programs evaluated. The review team did not seek to provide a definition of the terminology as it was expected to vary by programs, studies, and settings. Following stakeholder consultations, a decision was reached accepting that the definition could not be hardwired in a research exercise that relies on secondary data from multiple studies that do not follow a standard definition or terminology.
- ⁴ The full protocol is available at <https://energydata.info/apps>
- ⁵ Colandr is the product of a collaborative partnership between the Science for Nature and People Partnership Evidence-Based Conservation working group, DataKind, and Conservation International.
- ⁶ The excluded publications are available for scrutiny and re-evaluation at <https://energydata.info/apps>
- ⁷ Future groups examining evaluation reports of energy transition programs may wish to consider this aspect.
- ⁸ The academic literature seldom included private sector programs, which are generally found in urban areas; however, such programs might be cited in the grey literature, which, as we have noted, was challenging to locate.
- ⁹ Utilizing the systematic map, readers can interact with the entire evidence base, combining filtering criteria to determine which of the 160 coded studies reported information of interest (Chapter 4).
- ¹⁰ One should note that, owing to overlapping issues, the domain themes used in this qualitative analysis are not identical to the original 10 themes used during data collection.

APPENDIX A: ARTICLES INCLUDED IN THE EVIDENCE BASE

This appendix lists the 91 fully coded and 47 partially coded articles comprising the evidence base for this systematic review. All of the articles evaluated at each stage of the screening process, including the excluded articles, are available for scrutiny and re-evaluation at <https://energydata.info/apps>.

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