Overcoming Barriers to Clean Cooking in Thailand: A Quantitative Assessment

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Abstract

In many developing countries, people rely on inefficient stoves fuelled by biomass, coal and manure for cooking. The fine particulates ($PM_{2.5}$) emitted from these stoves not only harm human health, but they also disrupt climate systems. Unfortunately, economic, technological, social and institutional barriers have often slowed the widespread adoption of cleaner stoves or fuels. Several studies have offered qualitative assessments of these barriers. However, for those assessments to be factored into modelling studies that governments increasingly use to inform policy, quantitative evaluations of the impacts of different barriers are much needed. This paper uses the case of Thailand to offer a quantitative assessment of how much key barriers affect the diffusion of improved stoves and fuels. It shows that the combined effects of economic, technological, social and institutional barriers are significant—slowing diffusion rates by between 60 and 70 per cent. The paper further demonstrates that the social and institutional barriers—which are not typically included in modelling scenarios—are of comparable or greater size than the technological and economic barriers. The study concludes that countries such as Thailand would be well advised to focus more on creating enabling environments that support institutional coordination across relevant agencies; create consistency in policy objectives; and invest in awareness raising and encourage public comments on alternatives to traditional stoves or dirty fuels.

Acknowledgements: The authors would like to recognize the "Environment Research and Technology Development Fund of the Environmental Restoration and Conservation Agency Provided by the Ministry of Environment of Japan" for the financial support required to conduct the research featured in this article. The authors also extend their sincere appreciation to Dr. Tatsuya Hanaoka and Dr. Markus Amann for comments on the methods used to analyse the barriers in this article.

Introduction

Every year, approximately 7 million people worldwide die sooner than they should from air pollution. For many casual observers, the understandable reaction to this troubling statistic is that curbing outdoor air pollution in cities requires more attention. However, a closer look at the data reveals that a sizable proportion of the 7 million premature deaths come from *indoor air pollution* in rural areas (WHO 2014). Simply stated, air pollution is not solely an urban phenomenon. In addition, in many rural areas the main source of indoor air pollution is residential energy use for cooking and heating. Across many developing countries, people burn biomass, coal, and dung in inefficient cookstoves that emit particles that damage health, deepen poverty, and warm the climate (WHO 2016).

A sizable body of research has estimated the impacts of cookstoves as well as the potential benefits from the widespread adoption of possible solutions. Several studies have also documented the challenges of adopting improved cookstoves or shifting to cleaner fuels or energy sources. In contrast, fewer studies have sought to document how much different barriers delay the adoption of improved stoves or cleaner fuels as well as what enabling reforms could help overcome those barriers. The main goal of this article is to fill this gap in understanding by looking at the case of cookstoves in Thailand.

The remainder of this article is divided into six sections. The next section looks more closely at the cookstove issues and its multiple adverse impacts. The third section describes possible solutions. A fourth section examines potential barriers. A fifth section estimates the impacts of those barriers on the diffusion of cleaner technologies and fuels. The sixth section focuses on how Thailand has sought to overcome those barriers and the additional efforts that could help make more progress in the future. The final section concludes the discussion with a review of findings, policy recommendations, and the way forward.

The problem and its Impacts

Much of the world depends on cooking and heating from biomass-based fuels. In fact, the World Health Organisation (WHO) reports that globally 64 percent of the world's population relies on fuels derived from biomass (WHO 2016). Other studies underline the heavy reliance on these fuels: the amount of biomass fuel needed annually for basic cooking can reach up to 2 tons per family in some countries (The World Bank 2011). The dangers of this dependence are also well documented. Indoor smoke from the combustion of these fuels in frequently poorly ventilated areas poses a serious health risk. In fact, in 2016 almost 3.2 million premature deaths were attributable to household air pollution (WHO 2014).

The dependence on these fuels also has wide-ranging impacts on the other dimensions of development. Because approximately 90% of air pollution-related deaths occur in middle- and low-income countries, indoor air pollution threatens to undermine poverty alleviation (UNEP APCAP and CCAC 2019). In addition, since women and children typically spend more time indoors and are more exposed to smoke, they also tend to suffer more from its adverse impacts. This is implied in figures that underline the fact that 600,000 children under the age of 5 die annually worldwide from indoor and outdoor air pollution. Work showing that air pollution has been identified as a health hazard to prenatal children echoes a similar point (UNICEF 2016). There are also other ripple effects that amplify these gender impacts. For instance, the time it takes to collect biomass fuels such as firewood and the time it takes to cook on old, thermally inefficient cookstoves also often take time away from the women to do other things. Some studies have collected information on these monthly fuel use and collection times (Urmee and Gyamfi 2014).

The effects of indoor air pollution also may have implications for climate change. The combustion of biomass not only involves clearing land and forests that reduces carbon sinks, but the combustion of biomass-fuels also leads to emissions of the fine particulate ($PM_{2.5}$) that contains black carbon. Black carbon is a short-lived climate pollutant (SLCPs) that absorbs heat in its relatively brief atmospheric lifetime (weeks as opposed to decades or centuries associated with longer-lived greenhouse gases). Though difficult to compare because of its difference in chemical composition, some suggest black carbon is more powerful than carbon dioxide (CO_2). On a regional level, black carbon can also affect cloud formation and intensify rainfall patterns in regions that are already suffering from perturbations to the climate. Finally, when black carbon is deposited on ice and snow, it can reduce the brightness of surfaces and their capacity to reflect sunlight, accelerating the melting of glaciers in regions such as the Arctic and the Himalayas (UNEP APCAP and CCAC 2019). It is therefore not surprising that the IPCC Special Report on Global Warming of 1.5°C shows that mitigation of SLCPs and CO_2 are critical to achieving the Paris Agreement goals (IPCC 2018).

Solutions

The upside of many of the adverse impacts in the previous section is that solutions can also deliver multiple benefits. In fact, there are few interventions that could do more for making good on the Sustainable Development Goals (SDGs) than transitions to cleaner fuels and technologies in residential energy. The recognition of these benefits has led to many different types of solutions (USAID 2017).

One of the solutions involves the use of more efficient or improved cookstoves. The realization of this potential has led the market for more efficient stoves to expand greatly over the past thirty years. Some of the more frequently involve installing fans that help burn biomass more efficiently or offer design features that have similar intended effects. There are also stoves that rely on solar panels and heat-retention cookers that obviate the need for burning biomass in the first place.

A second set of options involves shifting to cleaner gaseous fuels. In this case, there can be a transition to liquefied petroleum gas stoves that burn cleaner than traditional cookstoves. Similarly, some governments and communities are turning more to biogesters, which can convert manure and other forms of waste into biogas that can be used for cooking as well as other residential energy purposes.

A third set of solutions involves transitions to electricity. While this option arguably has the potential to mitigate the effects of indoor air pollution, its impacts on climate change depend upon the sources of electricity. If the electricity comes from coal-fired power plants, then it might export some of the air pollution to regions where power is generated and cancel out the climate benefits in the process.

In all of the above cases, there is unlikely to be a single best universally acceptable clean cooking solution. The selection of appropriate stoves and fuels is almost by definition context-appropriate. Because of the need to find a good fit between the solutions and the context, careful consideration of how different technological and fuel improvements work within different enabling environments is critical to overcoming barriers to their widespread adoption.

Barriers

Another way of looking at the how to design an effective enabling environment involves understanding the barriers preventing their adoption. There are, in fact, several types of barriers that could impede shifts in this sector. For the sake of simplification, this section describes four such categories: 1) technical; 2) economic; 3) social; and 4) institutional. Before detailing each category, it merits highlighting that these are not perfectly watertight divisions between the groupings; there is some overlap across the categories (Rosenthal et al. 2018; Vigolo, Sallaku, and Testa 2018;

Sharma and Jain 2019; Thoday et al. 2018; Dendup and Arimura 2019; Khandelwal et al. 2017).

Technological barriers involve both the technology that is used in the stove itself as well as the supportive technology needed for the stove to operate effectively. Issues that fall under this category therefore include poorly designed stoves that could hinder the transition to an improved stove or one that runs on cleaner fuels. To illustrate, cookstoves that do not fit existing pots are likely to be a non-starter for many users. Another issue is lack of trained local maintenance and manufacturers who would be needed to quickly repair a dysfunctional stove or provide replacement parts (Kshirsagar and Kalamkar 2014; Vigolo, Sallaku, and Testa 2018; Chalise et al. 2018).

A further set of barriers involve the economics of purchasing a new stove and cleaner fuels. Arguably the chief economic barrier is the initial cost of purchasing a stove. Depending on the technology, the initial investment can be several times higher than the less clean alternatives. A similar set of constraints involves relatively greater costs of cleaner fuels. Especially if a user is shifting from what can be no- or low-cost biomass to a gaseous fuel, changes in costs can prove prohibitive. Yet another economic barrier pertains to government subsidies for dirty fuels such as coal or kerosene, which can artificially deflate costs and discourage transitions to less-polluting alternatives.

Social barriers focus on the willingness of users to accept a new stove or improved fuels. Under this category, some of the main challenges include reluctance to abandon traditional cooking practices that can, for instance, alter the flavour of foods. In some instances, the desire to retain certain tastes has led users to keep on using two or more stoves, with the smokier version reserved for some dishes. Another issue that comes under the social category is the lack of public awareness of the health hazards of indoor air pollution; while knowledge of these impacts is increasing, the severity of these effects continues to be an important blind spot for some users and communities. Additional social considerations entail sufficient access to sales outlets for cleaner stoves and fuels and engagement in decision making processes.

Finally, there are a set of institutional barriers that revolve around how governments work—or fail to work—to craft policies facilitating shifts to cleaner technologies and fuels. Some of the arguably more difficult institutional challenges involve lack of coordination among relevant ministries and agencies in the design and implementation of relevant policies. In many cases, clean cooking is a concern that falls between the cracks of agencies with energy, environment, and health mandates. A similar hurdle involves the shortage of administrative capacity: especially at the local level, governments may lack the human and financial resources to devote to conceiving and then rolling out solutions. Insufficient monitoring of policy effectiveness is a related problem. Resource-constrained agencies may lack the staff or resources to follow up on whether a specific intervention is working. This may result in a lack of constancy in policy objectives over time—an issue that was particularly salient in the case of Thailand.

The case of Thailand

As noted previously, both the kinds of solutions and the enabling programmes supporting their implementation are context-specific. This section reviews some of the efforts implemented in Thailand to help support shifts to sustainable cooking. These efforts have enjoyed varying degrees of success due, in part, to the barriers mentioned previously. It should nevertheless be underlined that the way these barriers appear resemble, but are not mirror images of, the more general descriptions in the previous section.

To understand those barriers, it helps to start by outlining some important background factors in the sector. A key piece of that background is that, although fossil fuels and electricity are currently the main energy sources for cooking in Thailand, more than 10 million households use the kinds of pollution-intensive charcoal cookstoves that can threaten health and cause other development challenges (Ministry of Energy Thailand, n.d.). Because Thailand is predominantly an agricultural country and has an abundance of biomass, the government has supported household and community-scale biomass energy production technology. These efforts have, at times, gained momentum because the rising fuel costs have encouraged users to turn to these stoves.

One of the early efforts that Thailand's government made to support cleaner cookstoves came in 2008 with the High Efficiency Cookstove Development and Manufacturing Project or High Efficiency Cookstove (Mahasetthi Cookstove). The Mahasetthi Cookstove was smaller and lighter than traditional cookstoves; in addition, it had a high heat capacity of around 1,000–1,200^0 C for cookware (pots) ranging from 16 to 32 inches in diameter that were heated with an average thermal efficiency of 29%. Yet another advantage was that the high-efficiency stoves could save 30–40% more than traditional cookstoves, and reduce the cost of firewood and charcoal up to THB 500–600 per household per year (Nantasiriporn et al., n.d.). Perhaps most importantly, because of its greater efficiency the Mahasetthi stove would generate less smoke or toxic gases and thereby lessen strains on health (Ministry of Energy Thailand, n.d.). The Mahasetthi stove therefore filled many of the criteria one would expect to overcome the technical and economic barriers.

Interestingly, there was also recognition from Thailand's Ministry of Energy that simply having a stove that was technically and economically feasible would not be enough. Instead, there was an effort to create policy incentives that could spread production techniques to communities and thereby generate self-sustaining businesses, jobs and greater awareness. Toward that end, Thailand's government set a target of production and use of 1.5 million cookstoves within 5 years from 2008 onwards. The project further set up 30 community-level production centres and learning centres as well as promoted e-commerce marketing and sales training (Ministry of Energy Thailand, n.d.). In many ways, these design features demonstrated that relevant government agencies were aware of the potential challenges beyond a technically sound stove with reasonable price.

After the Mahasetthi project concluded in 2008 and 2011, some of the institutional and social barriers began to become more challenging. One of the reasons that they became more problematic is that Thailand's Ministry of Energy shifted gears in its approach to the issue—though retaining a small budget to support the Mahasetthi project at the sub-district level and the community energy network as well as running a website on the higher-efficiency stoves (Ministry of Energy Thailand 2021; Bureau of the Budget Thailand 2021). The main change was a greater emphasis on renewable energy sources and allocating a larger portion of its budget to such programmes. With the course change and reduction in government support for improved stoves, several of the businesses manufacturing the more efficient stoves encountered higher costs for raw materials, a lack of skilled workers, and an inability to fulfil local demand, which ultimately forced them to close. These challenges also led to reductions in the production and use of high-efficiency cooking stoves (Ruchuwararak et al. 2013).

The shift in policy that brought the institutional and social barriers to the surface was part of a larger effort to support more renewable forms of energy. More concretely, from approximately 2011 the government's policy concentrated more on the use of renewable energy under the Alternative Energy Development Plan (AEDP). The AEDP sought to boost the use of renewable energy by 25% (2011-2021) of all energy, with a non-negligible proportion of consumption from biomass of up to 3,630 megawatts (43.24 percent) of all renewable energy receiving some forms of support. The Department of Alternative Energy and Efficiency, Ministry of Energy was tasked with overseeing the AEDP. The department worked to enable communities and households to generate their own energy and to change to clean alternative energy sources, but without an emphasis on the previous stoves (Twarath 2012).

More recently, Thailand reversed course again, returning to the previous emphasis on cleaner stoves. As fuel and cooking gas have become more expensive, the Minister of Energy has begun encouraging people to use high-efficiency cookstoves. The high-efficiency stoves have been viewed as appropriate and useful in rural areas or by food sellers who need to use the stove constantly (though not condominiums or closed households). In addition, the government has made an emphasis on including energy-saving labels on high-efficiency gas stoves, fumigation stoves (green stoves), and induction stoves that conserve gas and energy.

This most recent turn in strategy has also nonetheless generated some criticism that helps point to some of the social and institutional difficulties. Most notably, some observers have suggested that government recommendations to use high-efficiency stoves during moments of high fuel prices is inconsistent with more recent programmatic objectives. Moving forward, the same critics have contended that the government should have measures to manage and control the price of energy rather than develop and promote cookstoves, including high-efficiency stoves. Therefore, it was difficult to encourage its increased use in household cooking ("Director-General of the the Department of Alternative Energy").

Assessing current barriers

While the policies and programmes reviewed previously have made some headway, there are arguably several challenges that still exist to making cleaner stoves and fuels mainstream. To date, much of the work on the size of those challenges has focused on qualitative assessments as in the previous section. Such assessments are extremely valuable; they capture the richness of many of the issues that often require a careful eye and on-the-ground grasp of stakeholder needs. At the same time, a possible drawback of relying chiefly on qualitative descriptions is that they are difficult to incorporate into energy and air pollution models that are often used to inform environmental policy decisions. At the risk of simplification, those models are best suited to integrate quantitative data on issues such as the timing and diffusion rates of new technologies.

For this article, then, the authors aimed to quantitatively assess the magnitude of the four types of barriers for Thailand. To make such an assessment, the authors combined assessments from two different techniques: expert surveys and literature reviews.

The first technique consisted of a survey of approximately 30 experts and policy-makers who were selected because of their knowledge of clean cooking in Thailand and other Southeast Asian countries. The survey asked respondents questions about how much each type of barrier could slow the diffusion of technologies.

For each survey response and each type of barrier, survey respondents were asked how much they felt the barrier in question would slow the diffusion of two different options: cleaner stoves and cleaner fuels and/ or types of energy. The responses were associated with the possible magnitudes of the different effects that are presented in Box 1.

After applying the numerical coding to all of the responses for all of the technologies, a numerical average or mean was calculated from all of the responses for each type of barrier for each kind of solution. To provide an example, equation 1 provides the notation for this calculation for the institutional barriers.

$$\bar{x}_{inst-expert\ survey} = \frac{\sum_{i=1}^{n} r}{n} \tag{1}$$

$\bar{x}_{inst-expert\ survey}$ = *Average magnitude of the institutional barrier based on the expert survey*

r = *Coded response based on the explanation above*

n = *Number of responses*

The next step was then combining the average assessments from the survey

Box 1: Assumptions about the size of effects

- If the response was "no effect," then this response was coded as a "0" or 0%.
- If the response was "small (slowing the transition to cleaner technologies by between 1% to 10%)", then this was coded as "0.05" or 5% as this was the midpoint between 1% to 10%.
- If the response was "moderate (slowing the transition to cleaner technologies by between 11% to 20%)", then this was coded as "0.15" or 15% as this was the midpoint between 11% to 20%.
- If the response was "significant (slowing the transition to cleaner technologies by more than 20%)", then this was coded as "0.25" or 25% as this was a conservative high-end estimate on the maximum amount a barrier could slow diffusion. In theory, this "0.25" or 25% estimate also makes sense because it would suggest that, if all four types of barriers were rated as "significant" for a given solution, then it would lead to a 100% slowing of the diffusion, or lack of progress in the rollout, of the solution.

with assessment from a literature review. For converting the literature review assessment into concrete figures, the authors used the same coding scheme as used in the expert survey. More concretely, if a barrier were judged to be "small," then it would be coded as 0.05 or 5%; a barrier that was judged to be moderate was coded as 0.15 or 15%; and so on and so forth.

In determining the relative magnitude of the barriers based on the literature review, the authors used the descriptive criteria in Table 1 below. Though admittedly subjective, the criteria aimed to base the assessment on how frequently and directly a barrier was mentioned, as well as how significant it appeared to be when it was referenced.

The authors then focused on estimating the size of the barriers from the literature review. For converting the literature review assessment into concrete figures, the authors used the same coding scheme as the expert survey. That is, if a barrier were judged to be "small," then it would be coded as 0.05 or 5%. A barrier that was judged to be moderate was coded as 0.15 or 15%, and so on and so forth.

Once the average magnitude for each type of cooking alternative and barrier was calculated from the expert survey and the literature review, the figures were combined. To arrive at a figure that combined the expert survey and literature review, the authors decided to use a weighted average of the expert survey mean and literature review assessment. For the weighted average, the expert survey was given a slightly higher weight of 0.6 and the literature review assessment was given a slightly lower weight of 0.4 (see equation 2 for notation). This weighting scheme was intended to reflect the belief that the expert survey should get slightly more weight, since most of the literature was focused not specifically on the relevant barriers but rather on a range of issues. In addition, some of the surveyed studies in the literature review come from countries or regions outside of the focus region. Finally, it is likely that the literature review reflected an assessment of barriers that is at least somewhat dated, given the amount of time it takes

Table 1: Descriptive criteria for coding the barriers

Indicator	Description
No effect	The barrier is not mentioned in the literature.
Small	The barriers are mentioned indirectly and/or briefly in the relevant literature, but they are not a focal point. Moreover, when they are mentioned, they appear to have limited impact on the diffusion of solutions. For example, in the case of a "social" barrier for the introduction of a specific new measure, the relevant literature mentions in passing the need to raise awareness of the benefits of this new measure, but does not discuss the barrier in much detail beyond noting the need for greater awareness.
Moderate	The barriers are mentioned directly once or twice in the literature, but their impact on the diffusion of solutions appears to be modest. For example, in the case of a technical barrier to the introduction of a new measure, the relevant literature mentions its potential for introduction and diffusion, and elaborates on why targeted efforts to increase the availability of the proposed technology are needed to advance this new measure.
Significant	The barriers are mentioned directly and repeatedly in the literature, and their impact on the diffusion of solutions is likely to be significant. For example, in the case of institutional barriers to the introduction of certain new measures, the relevant literature focuses on the need for greater coordination between different sectors and ministries in order to make any progress in implementing the technology.

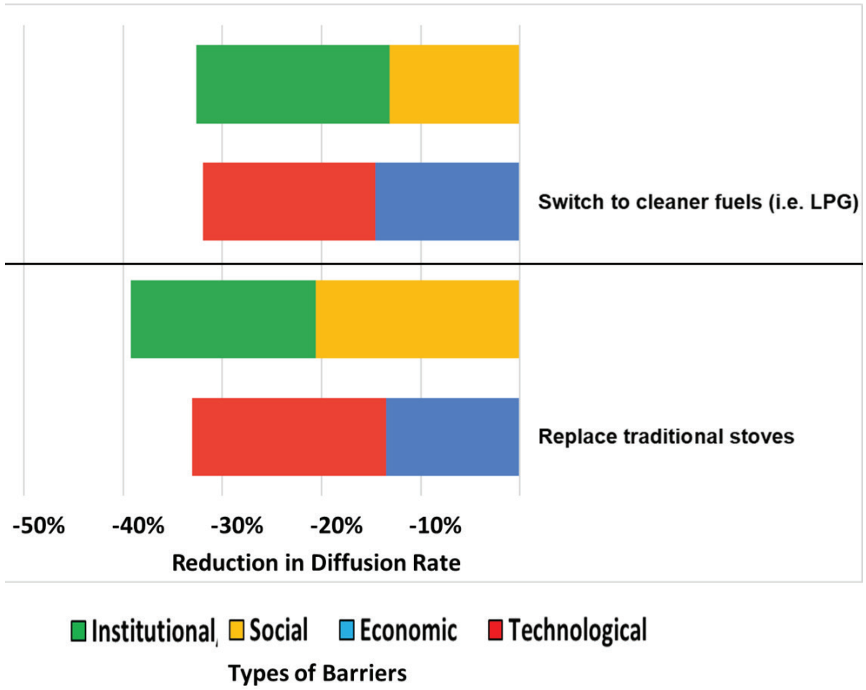

Figure 1: The effects of different barriers on diffusion rates of clean fuels and improved stoves

to develop a published article. The survey responses were likely to be more recent (see Equation 2).

$$b_{inst} = .6(\bar{x}_{inst-expert\ survey}) + .4(x_{inst-lit\ review}) \quad (2)$$

$x_{inst\text{-}expert\ survey}$ = *Average magnitude of the institutional barrier based on the expert survey*

$x_{inst\text{-}lit\ review}$ = Average magnitude of institutional barrier based on the literature review

b_{inst} = Magnitude of institutional barrier

After combining the expert survey and literature review assessments, it is possible to determine how much the different kinds of barriers slowed the diffusion of clean cooking in Thailand. The results of that assessment for both cleaner stove technologies and shifts to cleaner fuels are illustrated in Figure 1. Those results are interesting for at least three reasons.

First, they suggest that in all cases the implementation barriers are significant. In the case of shifting to cleaner fuels, the sum of the barriers implies a 60% reduction in the diffusion rate; in the case of shifts to improved stoves, the sum of the barriers implies more than 70% reduction in the diffusion rate.

Second, the magnitude of the economic and technological barriers and the institutional and social barriers is significant. For shifting to cleaner fuels, the sizes of the economic and technological barriers and the institutional and social barriers are almost the same. For shifts to improved stoves, institutional and social barriers are notably greater (by about 20 percent) than the economic and technological barriers. This is important because it is precisely the institutional and social barriers that are often not factored into models.

Third, though the interpretations of slowing diffusion may vary, one way of looking at the results is factoring in the delays in the introduction of new technologies or cleaner fuels. Those delays could amount to between 6 and 7 years over a ten-year period (the time period mentioned in the expert survey). Further, between 50% and 60% of those delays are due to institutional and social issues, which could be addressed with additional efforts to raise awareness and provide training (for the social barriers) and build capacities and enhance coordination (for the institutional barriers).

The way forward

This article examined the potential for and the constraints on clean cookstoves and fuels to reduce air pollution and mitigate climate change in Thailand. It underlined that while there has been a significant amount of research on both the potential and the related constraints, few studies have systematically analysed how much different barriers influence the diffusion of solutions. This omission is particularly worrying for institutional and social barriers, which do not naturally lend themselves to measurement needed for the kinds of data-driven modelling that increasingly informs air pollution and climate change policy. The article then underlined the need for greater efforts to include these often less visible barriers into modelling scenarios. In doing so, it illustrated that these barriers are often of greater magnitude than the more easily quantified technological and economic barriers in Thailand.

The next logical question that follows from this assessment is: What can be done to overcome these barriers in Thailand? The simple solution is to focus more energy in improving the enabling environment for clean cooking and fuels in Thailand. This simple statement requires a little more unpacking to make it more helpful for policymakers.

Some more specific suggestions entail increasing efforts to enable coordination across relevant government agencies on residential energy. The possible consequences of such coordination could, in turn, be more consistency in programmatic targets and objectives and greater efforts to sustain programmes where there appears to be significant momentum. A related consequence of greater coordination and consistency might also be regular evaluation of programme effectiveness and impact. These assessments could help in refining objectives and adapting to the changing scenarios on issues such as fuel prices.

Many of the above recommendations focus chiefly on institutional as opposed to social issues. To address some of the social issues, deepening efforts to raise awareness of sustainable alternatives is a clear need. A related need is to offer clearer explanations for shifts in policy, while also eliciting inputs from affected communities before policy changes. Both the above efforts could be pursued with greater cooperation with academic institutions and civil society. Both efforts could also inform how to support sustainable business models for cleaner stoves or fuels that build self-sustaining markets for such interventions.

While the article has shed some light on the magnitude of the often underappreciated barriers and the possible reforms to help overcome them, it is not free from limitations. Some of these limitations involve the methods for assessing barriers. The approach used herein, for instance, places a cap on the maximum size of different barriers at "slowing diffusion at 25%" per type of barrier. For further iterations of this work, one might look at ways to expand this cap. A second limitation is that some of the descriptions of the barriers are not perfectly consistent with the experiences in Thailand. More concretely, policy consistency appears to be a significant issue in Thailand, but is only one of many institutional challenges used in the analytical framework in this article. A third shortcoming of the article is that many of the barriers within and across categories are in fact related to each other. For example, the lack of awareness of the different technological options is related to both social and technological hurdles. Future work could look more closely at the interactions between the barriers.

A final area where additional research could prove useful pertains to the costs of overcoming some of the institutional and social barriers. There is a rich and extensive literature on transaction costs, which can provide insights into what it costs to develop and implement public policies. Drawing on that literature can shed much-needed light on what it could, for instance, cost a policymaker to institute some of the enabling reforms discussed earlier in this section. Coupling those cost estimates with the data from the modelling studies, as well as from the analysis of the barriers, may also open eyes to the sizable benefits from strengthening policies and institutions to promote the diffusion of other kinds of air pollution solutions in a wide range of contexts.

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