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# ENERGY CHALLENGES FOR CLEAN COOKING IN ASIA, THE BACKGROUND, AND POSSIBLE POLICY SOLUTIONS

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**Abstract**

The approximate number of people without access to clean cooking facilities is 2.8 billion, primarily in Asia and sub-Saharan Africa. Among those, 2.5 billion people cook with biomass in inefficient and polluting stoves. The health impacts are severe: it is estimated that household air pollution from solid fuel use results in more than a million premature deaths each year in the People's Republic of China and 2.8 million deaths worldwide. In addition, the biomass often comes from unsustainable sources.

In spite of intensifying efforts, programs and policies to address the clean cooking challenge have so far had limited impact, and more effective policies are needed. Clean cooking technologies and tools include improved and advanced biomass cookstoves that meet World Health Organization standards for exposure to indoor air pollution, biogas digesters based on wastes, solar cookers, electricity for cooking based on small solar home systems and mini-grids, and switching to liquefied petroleum gas, which, while not renewable, is an important option for reducing the health impacts of solid fuel cooking.

The current work aims to bring together the experiences of promoting clean cooking policies and programs in Asian countries. The quantitative results of this study will be helpful for policy and decision makers to find out the challenges, issues, and possible solutions for providing clean cooking technologies in Asia.

**Keywords:** clean cooking, supportive policies, improved cookstoves, LPG, energy insecurity

**JEL Classification:** Q48, N75, K32

# Contents

# 1. INTRODUCTION

The World Health Organization (2006, 4) affirms that “energy is essential to meeting our basic needs: cooking, boiling water, lighting and heating. It is also a prerequisite for good health – a reality that has been largely ignored by the world community.” At the household level, energy insecurity is defined as “inability to adequately meet basic household energy needs” (Hernandez and Siegel 2019, 78). Hernandez (2016) described the associated adverse consequences of household energy insecurity in environmental aspects (e.g., indoor hazardous exposures due to traditional biomass cookers, heat stress, and cold stress), health aspects (e.g., Asthma, chronic stress, mental health trigger), and social aspects (e.g., parental fear and stigma, family disruptions, and residential instability). Energy insecurity at a household level has three primary dimensions: economic; physical; and behavioral (Hernandez 2016).

The economic dimension of household energy insecurity is defined as “financial hardships associated with the cost of energy relative to income and other expenses” (Hernandez 2016, 3). The economic dimension has various sub-dimensions including poverty, material hardship and tenuous employment, energy-specific financial hardships, priorities and trade-offs (e.g., between paying the rent, bills, and food), seasonal variation, billing issues (e.g., charging a delivery fee for LPG gas capsules for cooking), landlord improprieties (mainly for shared houses and buildings), and discontinued service due to non-payment.

The physical dimension of household energy insecurity is defined as “deficiencies in the physical infrastructure of the home environment that impact thermal comfort, include harmful indoor exposures, and increase energy costs” (Hernandez 2016, 4). The main drives of physical dimension are poor overall housing quality, faulty building infrastructure, and improper changes in building energy systems.

Finally, the behavioral dimension of household energy insecurity is defined as “behavioral strategies used to cope, improvise and counteract the impacts of economic and structural energy insecurity” (Hernandez 2016, 5). The main sub-dimensions of the behavioral aspect are energy conversation (e.g., using the same device for cooking and heating in some of the households in Asian developing countries), seeking thermal comfort, and lump sum and partial bill payments.

Clean and affordable sources for cooking are a primary need in both developed and developing countries. However, nearly 2.1 billion people in Asia in 2014 were without access to clean cooking (ESCAP 2018). Widespread introduction of improved cooking technology to the poorest third of the planet has been heralded as an affordable intervention with potential to make enormous progress to mitigate these burdens (Anenberg et al. 2013; Smith and Haigler 2008). If done properly—that is, by ensuring use of clean cooking technologies that offset use of traditional, polluting stoves and fuels—and sustainably, the introduction of clean cooking technology can drive progress toward at least five of the 2030 Sustainable Development Agenda's Sustainable Development Goals (Rosenthal et al. 2018).

Table 1 shows the population of major countries without access to clean cooking in Asia. India, the People’s Republic of China, Bangladesh, Indonesia, and Pakistan have more than 100 million people without access to clean cooking. The total number of people without access to clean cooking in 14 selected countries in Table 1 is 2,059 million.

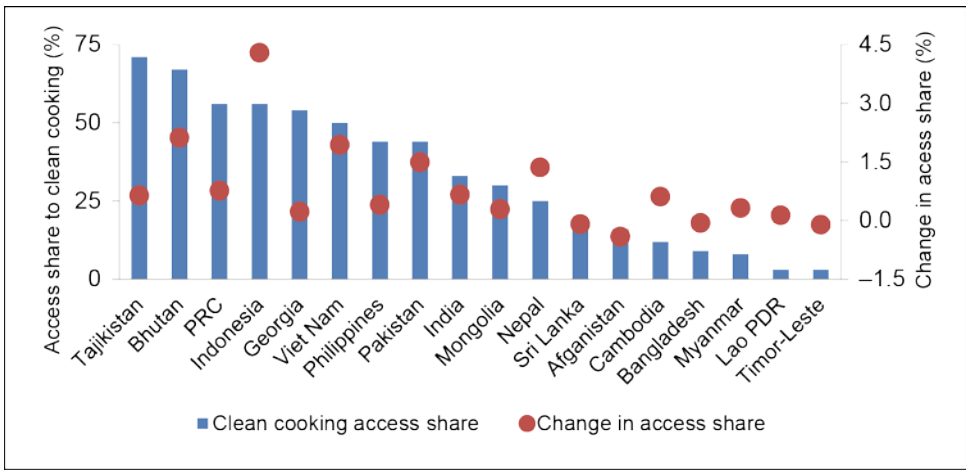
**Table 1: Population without Access to Clean Cooking in Asia by Country** (million)**, 2015**

| Country | Number of People |
|---|---|
| India | 853 |
| People's Republic of China (PRC) | 584 |
| Bangladesh | 143 |
| Indonesia | 110 |
| Pakistan | 102 |
| Philippines | 55 |
| Myanmar | 49 |
| Viet Nam | 45 |
| Afghanistan | 26 |
| Democratic People's Republic of Korea | 23 |
| Nepal | 23 |
| Sri Lanka | 17 |
| Thailand | 16 |
| Cambodia | 13 |

Source: Adapted from Economic and Social Commission for Asia and the Pacific (ESCAP) 2018. Asia-Pacific Progress in Sustainable Energy.

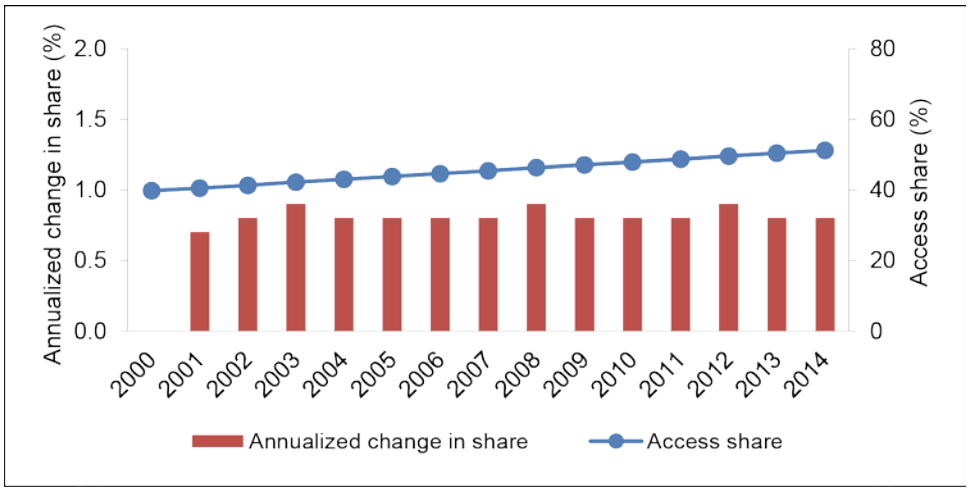
Figure 1 shows the Asian countries with a clean cooking access share of less than 75%, along with their annualized change in share of access. Indonesia showed an outstanding change in share of access (4.3%), with their recent policies for promoting clean cooking. The change in share of access for India and the PRC is 0.8% and 0.7%, respectively. Figure 2 shows the clean cooking access share and annualized change in share in Asian countries for 2000–2014. The access share in 2000 is slightly below 40%, reaching to 51.2% in 2014. The annualized change in access share is 0.7%–0.9%, showing steady progress toward increasing clean cooking access.

**Figure 1: Share of Access to Clean Cooking (for Countries less than 75%) and Annualized Change in Share, 2015**




Source: Adapted from Economic and Social Commission for Asia and the Pacific (ESCAP) 2018. Asia-Pacific Progress in Sustainable Energy.

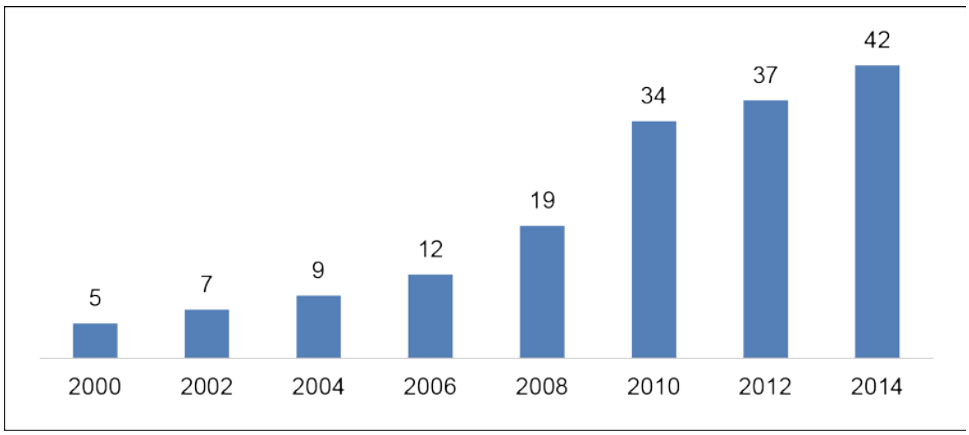
**Figure 2: Clean Cooking Access and Change Rate in Asia, 2000–2014**




Source: Adapted from Economic and Social Commission for Asia and the Pacific (ESCAP) 2018. Asia-Pacific Progress in Sustainable Energy.

In previous years, energy access issues in Asian developing countries received special attention. Figure 3 shows the number of Asia and the Pacific economies with energy access targets in 2000–2014. The economies with energy access targets increased to 42 in 2014 from only 5 economies in 2000.

**Figure 3: Number of Asia and Pacific Economies with Energy Access Targets**



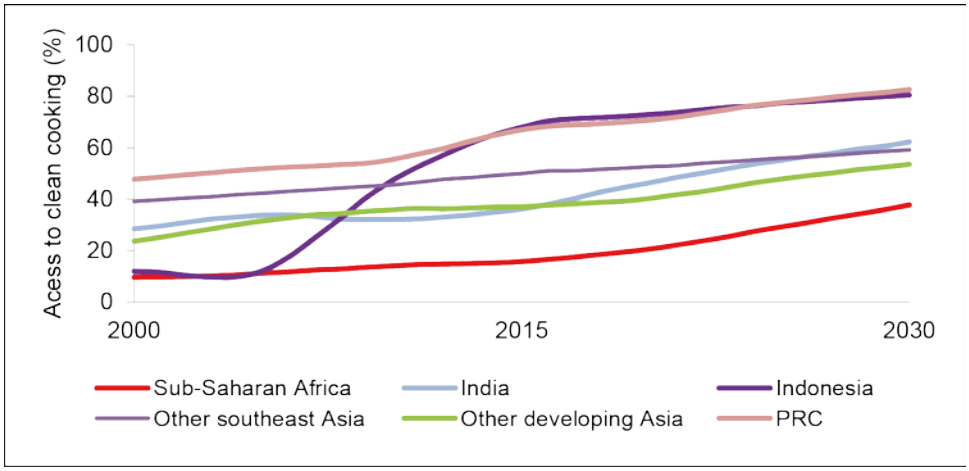

Source: Adapted from Economic and Social Commission for Asia and the Pacific (ESCAP) 2018. Asia-Pacific Progress in Sustainable Energy.

At the same time that plans and targets for energy access in Asian countries were established, “clean cooking” received special attention, due to both health impacts and energy insecurity issues. During last three decades, various programs and policies for promoting clean cooking in Asia started, including:

- International and multilateral initiatives;
- Capacity building;
- Facilitating access to finance; and
- Financial incentives.

Results of these programs increased access to clean cooking in Asian developing countries. As shown in Figure 4, progress in increasing access to clean cooking in Asian countries is steadily rising. However, the speed is not enough. Figure 4 shows the past and future goals for clean cooking in various regions and countries by 2030. Most of the countries and regions are aiming to achieve 60–80% access to clean cooking by 2030, which requires an intensive set of actions and policies to meet the goals.

**Figure 4: Clean Cooking Access Share, History (2000–2015) and Projections (2015–2030)**




Source: Adapted from International Energy Agency (IEA), 2017. Energy Access Outlook 2017.

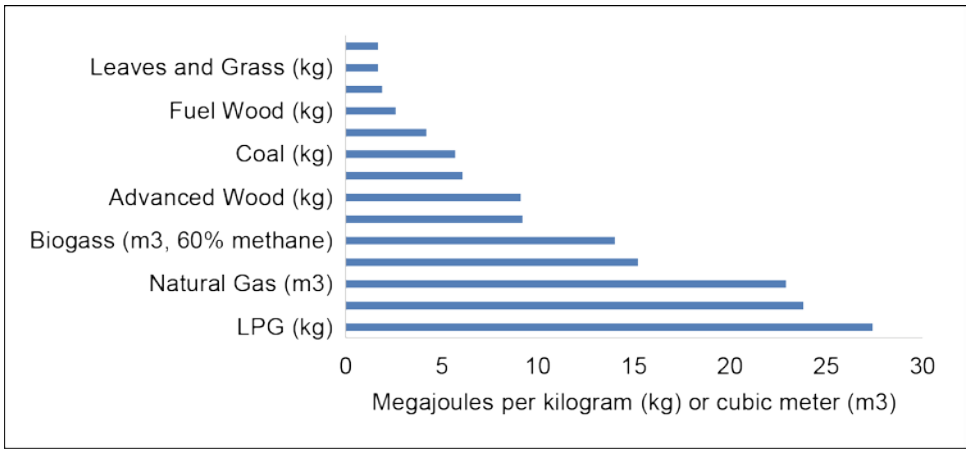
This study aims to provide a picture of clean cooking in Asian's countries, the policies for promoting clean cooking with their impacts, the reasons for limited success in some cases, and possible policy solutions for accelerating access to clean cooking in Asian countries.

# 2. COOKING FUELS, TECHNOLOGIES, AND HEALTH IMPACTS

Various fuels and technologies are meeting cooking energy demands, ranging from traditional to modern technologies. Figure 5 shows the main sources for cooking fuels, with their energy contents. As is shown, traditional cooking fuels have very low energy content per unit of weight. The use of traditional fuels needs a considerable amount of time per day for fuel gathering and it causes household air pollution (HAP), which comes with threats to the inhabitants' health.

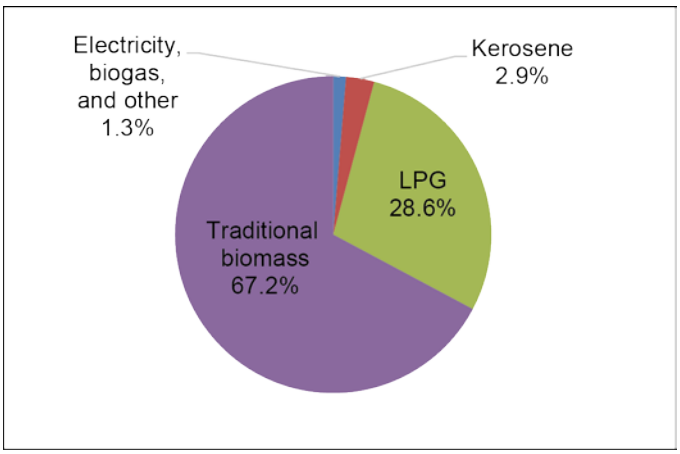
Figure 6 and Figure 7 show the fuel sources for cooking in India and Japan, respectively. More than 67% of energy for cooking in India is supplied by traditional sources like firewood, crop residue, cow dung cake, coal, lignite, and charcoal. In a developed Asian country like Japan, the main cooking energy sources are city gas, LPG, and electricity.

**Figure 5: Energy Content of Cooking Fuels**



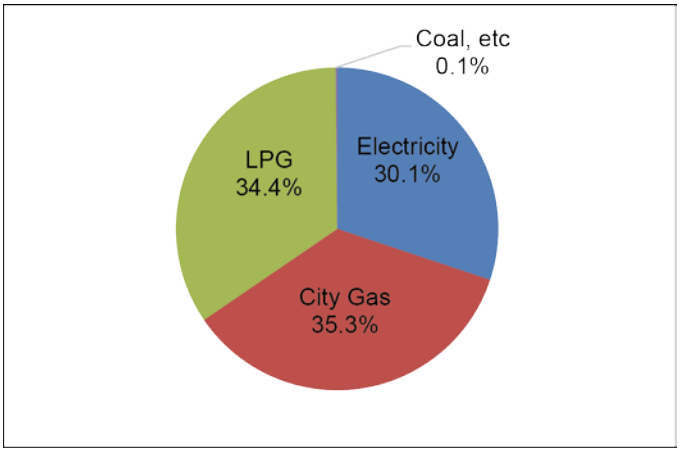

Source: Adapted from World LP Gas Association (WLPGA) 2014. Cooking with Gas: Why women in developing countries want LPG and how they can get it.

**Figure 6: Cooking Fuel Sources in India (2015)**




Source: Adapted from World Health Organization 2018. Opportunities for Transition to Clean Household Energy.

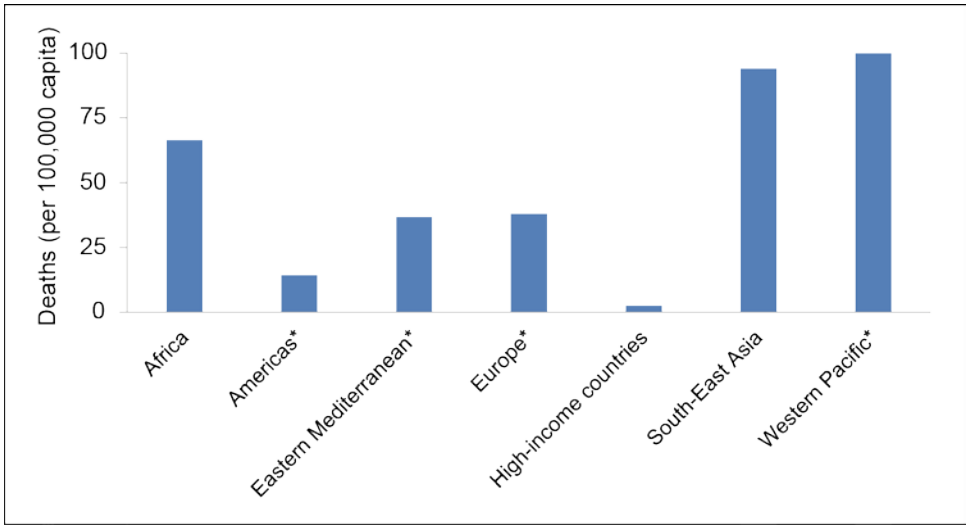
**Figure 7: Cooking fuel sources in Japan (2015)**




Source: Adapted from Energy Data and Modelling Center (EDMC) 2017. Handbook of Japan's and World Energy and Economics Statistics.

Quantitative studies conducted to measure the health impacts from the collection of fuels (Parikh 2011) show that they include neck ache, headache, backache, bruises, burning eyes, coughing, and even wild animals and snake encounters. Additional harmful effects on health are due to HAP, including ischaemic heart disease (IHD), stroke, lung cancer, chronic obtrusive pulmonary disease (COPD) for adults, and acute lower respiratory infection (ALRI) for children. Figure 8 shows the rate of deaths attributable to HAP (per 100,000 capita) in various regions. This number in South-East Asia is as high as 94; limited access to clean cooking and technologies is one of the reasons behind it.

**Figure 8: Deaths Attributable to Household Air Pollution (per 100,000 capita)**



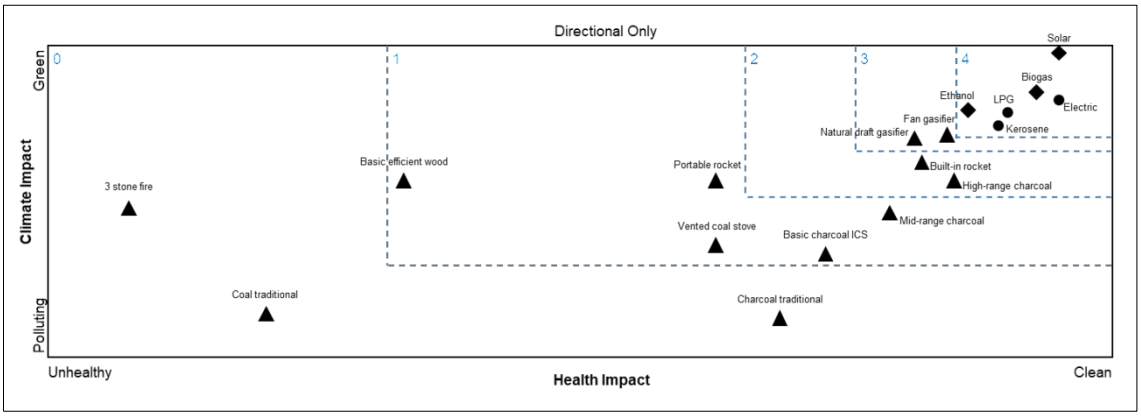

* Low- and middle-income countries.

Source: Adapted from World LP Gas Association (WLPGA) 2014. Cooking with Gas: Why women in developing countries want LPG and how they can get it.

Energy consumption for cooking has impacts on health and climate. Figure 9 shows the health impact and climate impact of cooking technologies. The minimum impacts on health and climate achieved by modern cooking technologies (Region 4 in Figure 9), and the least impacts are attributed to modern renewable technologies (biogas and solar).

Increasing the contribution of LPG in meeting cooking energy demand over biomass (e.g., in India) and kerosene (e.g., in Indonesia) is one of the key targets in most of the clean cooking programs in Asian countries. Table 2 shows the pros and cons of LPG in comparison with biomass and kerosene as cooking fuels. The important criteria in Table 2 are ease of use, safety, ease of transport, health and air quality, greenhouse gas emissions, dependence on centralized networks, impact on children's time, local ecosystem, and costs.

**Figure 9: Health Impact and Climate Impact of Cooking Technologies**




Source: Adapted from International Renewable Energy Agency (IRENA) 2017. Biogas for Domestic Cooking.

**Table 2: Summary of Advantages and Disadvantages of LPG, Compared to Biomass and Kerosene as Cooking Fuels**

| Characteristic | LPG compared to Biomass | Kerosene compared to LPG |
|---|---|---|
| Ease of use of household cooking | Controlling, ignition, and storing LPS in easier than biomass. Nevertheless, it is necessary to buy LPG in large volumes. | Controlling and ignition of kerosene is easier than biomass, but harder than LPG. There is a possibility for small kerosene purchase and storage. |
| Safety | Transportation and usage of LPG in local scale has some safety concerns that governments must address. The additive odorants in LPG containers are helpful for leakage warning and reducing the risks at the household level. | Storage and consumption of kerosene has safety concerns including fires and child poisonings in some cases. |
| Ease of local transport | The LPG cylinders are heavy to carry for women and children for refilling purposes. | The pressure cylinders are not necessary for kerosene. |
| Health-damaging air | The polluting emission from LPG combustion is much lower. | The polluting emissions in case of kerosene is lower than biomass, but not lower than LPG. |
| Greenhouse pollutants | We should always consider net emissions. However, greenhouse gas emissions in case of LPG is still lower than with biomass if biomass goes through a poor combustion process. | Greenhouse gas emission in case of kerosene is higher than LPG. |
| Dependence on centralized networks | LPG production is a function of the global petroleum cycle and market. Distribution of LPG at local scales needs necessary infrastructure (railroad and/or trucks) with careful planning and management. | Kerosene production is a function of global petroleum cycle and market, same as LPG. The different point with LPG is the competition of kerosene with other petroleum products (e.g., diesel) in the production process. |
| Impact on demand for children's time | Biomass harvesting is a time-consuming activity for children. | |
| Local ecosystem | Unsustainable biomass harvesting is affecting the local ecosystems and causing soil degradation and deforestation. | |
| Daily cost at household level | If we exclude the value of the time for biomass harvesting, the LPG in rural areas (that the biomass gathers) is more expensive. | Kerosene is usually cheaper than LPG. |
| Capital cost at household level | Traditional biomass stove is cheaper than LPG cooking systems. However, the price of advanced cookstove is not different with LPG system. | Kerosene stoves are usually cheaper than LPG cooking system. |

Source: Adapted from World LP Gas Association (WLPGA) 2014. Cooking with Gas: Why women in developing countries want LPG and how they can get it.

Table 3 groups the cooking technologies into three categories: improved cookstoves, modern fuel stoves, and renewable fuel stoves. Each cooking category consists of three or more technologies, and each technology is graded (minimum 0 and maximum 4), according to nine criteria: affordability; custom; durability; safety; fuel saving; cooking time; environment; health; and employment. This table provides a picture of multiple options for improving the quality of cooking from various points of view. According to the information in Table 3, most of the clean cooking technologies are not properly meeting the affordability criteria. The clean cooking programs and incentives are mainly targeting affordability, aiming to provide affordable clean cooking fuels and technologies for the households in Asian countries that are suffering from this issue.

**Table 3: Various performance metrics by stove type**

| | | Affordability | Fit W/ Custom | Life/Durability | Safety | Fuel Savings | Cooking Time | Environment | Health | Employment |
|---|---|---|---|---|---|---|---|---|---|---|
| Improved cookstove | Legacy Stoves | ●●● | ●●●● | ●○○○ | ●○○○ | ●○○○ | ○○○○ | ○○○○ | ○○○○ | ●○○○ |
| | Basic Efficient Stoves | ●●●○ | ●●●● | ●○○○ | ●●○○ | ●○○○ | ●○○○ | ●○○○ | ●○○○ | ●●●○ |
| | Chimney Rocket | ●●●○ | ●●○○ | ●●●○ | ●●●○ | ●●●○ | ●●○○ | ●●○○ | ●●○○ | ●●○○ |
| | Portable Rocket | ●●○○ | ●●●○ | ●●○○ | ●●●○ | ●●○○ | ●○○○ | ●●○○ | ●○○○ | ●○○○ |
| | Advanced Charcoal | ●○○○ | ●●●○ | ●●○○ | ●●●○ | ●●●○ | ●●○○ | ●●○○ | ●●○○ | ●○○○ |
| | Natural Draft Gasifier | ●○○○ | ●○○○ | ●●○○ | ●●●○ | ●●○○ | ●●●○ | ●●●● | ●●●○ | ●●○○ |
| | Fan Gasifier/Jet | ●○○○ | ●○○○ | ●●○○ | ●●●○ | ●●○○ | ●●●● | ●●●● | ●●●● | ●○○○ |
| Modern | LPG | ●●○○ | ●●○○ | ●●●● | ●●○○ | – | ●●●● | ●●●○ | ●●●● | ●○○○ |
| | Electricity | ○○○○ | ●●○○ | ●●●● | ●●●● | – | ●●●○ | ●●●○ | ●●●● | ○○○○ |
| | Kerosene | ●●○○ | ●●○○ | ●●●○ | ●●○○ | – | ●●●○ | ●●●○ | ●●○○ | ●●●○ |
| Renewable | Ethanol | ●●○○ | ●○○○ | ●●●● | ●●○○ | – | ●●●○ | ●●●○ | ●●●○ | ●●○○ |
| | Biogas | ●○○○ | ●○○○ | ●●●○ | ●●●○ | ●●●○ | ●●●● | ●●●● | ●●●● | ●●○○ |
| | Solar | ●●○○ | ●○○○ | ●●○○ | ●●●● | ●○○○ | ○○○○ | ●●●● | ●●●● | ●○○○ |
| | Briquettes/Pellets | ●●●○ | ●●○○ | – | ●●●● | ●●○○ | – | ●●●● | – | ●●●○ |
| | Retained Heat Devices | – | ●○○○ | ●●○○ | ●●●● | ●●○○ | ○○○○ | ●●●● | ●●●● | ●○○○ |

Source: Adapted from International Renewable Energy Agency (IRENA) 2017. Biogas for Domestic Cooking.

# 3. PLANS, POLICIES AND ACTIONS FOR CLEAN COOKING IN ASIA

The actions and supportive policies for promoting clean cooking in Asian countries are mainly focused on improving the quality of traditional biomass cookstoves, replacing traditional cooking fuels with modern fuels including LPG, kerosene and electricity, and utilizing renewable sources for clean cooking, including biogas, solar, and bioethanol.

India has the highest population without access to clean cooking in the Asian countries (see Table 1). Clean cooking policies, programs, and schemes have been conducted for increasing market penetration of LPG in India (WHO 2018). Since the 1970s, LPG was the main option for clean cooking policies in India. During the last decades, a large part of society received subsidies for LPG. LPG subsidy leakage is one of the issues and

there are programs for preventing leakage by transferring the subsidies directly to the families below a specific income level. In order to expand LPG distribution in rural areas, the Indian government made the distribution license criteria easier for the applicants. By investing US$4.6 billion in the LPG infrastructures, the Indian government is aiming to provide LPG to 95% of households by 2019. Total capacity of LPG bottling will be expanded to 21 million tons by adding 47 new plants by the state-owned oil companies. The total budget for LPG subsidies in India for 2016–2017 was US$2.9 billion.

The Indian Ministry of Petroleum and Natural Gas (MoPNG) is managing the Pratyaksha Hastaantarit Laabh (PAHAL) scheme, launched in 2014 in order to directly transfer the subsidies to households and prevent the subsidy leakages. This program covered 45 and 622 districts in 2014 and 2015, respectively. LPG consumers who join the PAHAL scheme can obtain LPG cylinders at the nonsubsidized price and receive the LPG subsidy by direct payment into their bank account. The PAHAL subsidy is not covering the cost of LPG cylinders. However, the refilling subsidies directly transfer to consumer bank accounts. The number of subsidies were 130 and 174 million in 2014 and 2016, respectively. Direct transfer of subsidies to the households in rural areas has challenges due to lack of banking infrastructure and limited familiarity of consumers with cashless subsidy transfers.

Pradhan Mantri Ujjawala Yojana (PMUY) program launched in May 2016 by Government of India and MoPNG is acting as the nodal ministry, aiming to provide LPG connection to 50 million women in the families that are below the poverty line. The PMUY program supported 20 million connections out of the total 32.2 million new LPG connections in India in 2016–2017 fiscal year. As the result, LPG penetration reached to 86%. In spite of the considerable success of PUMY scheme, the second LPG refill is not receiving support under this program. Refilling of the LPG cylinder is not affordable for most the household below poverty line in India.

MoPNG launched the “Give it up” or “Giveback” scheme in March 2016. They asked households with high incomes to give up their subsidies for LPG voluntarily. The idea behind this program is moving the existing LPG subsidies toward the poor households. As a result of this program, almost 10 million households agreed to give up their subsidies. Ujjwala Plus Scheme is an ongoing program by MoPNG in India, which was started in August 2017. This program aims to provide free LPG connections for low-income households. It works by asking high-income households (that have already given up their LPG subsidies) to provide free LPG connections for neighboring families who cannot afford the connections.

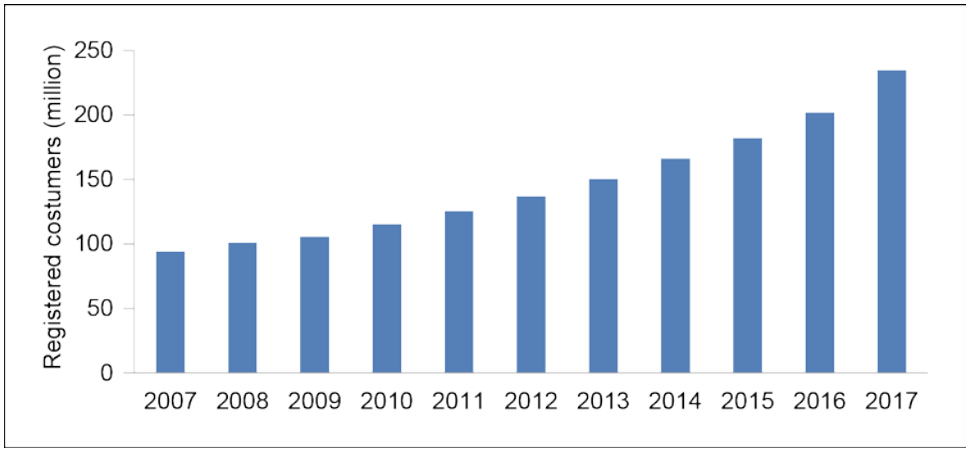
The SAHAJ program launched in August 2015, and oil manufacturing companies are acting under the MoPNG. SAHAJ is trying to make the application for new LPG connections easier by providing the possibility for online applications. After the online payment and issuance of an “e-SV”, a new LPG connection releases. The pilot step of the SAHAJ program was conducted by the Indian Oil Corporation on May 2015 in Delhi. On the first day of the pilot step, 550 e-SV were issued for the online applications by covering 308 distributors. As the result, 98% of online applications were successful to release the LPG connection within 7 days after registration. Nevertheless, due to lack of access to internet connections and lack of skills for making online applications by households in rural area, this program is facing some challenges in these areas.

Some of the programs are directly dealing with the safety issues related to LPG consumption as cooking fuel. For instance, MoPNG in India dedicated an emergency multilingual line for LPG consumers beginning in January 2016. The line is available 24-

hours per day with a web-based application for monitoring the calls. The total calls to the LPG emergency line exceeded 137,000 calls by November 2016.

Figure 10 shows the LPG market in India for 2007–2017. The number of registered domestic LPG consumers in 2017 reached 235 million, from 94 million in 2007, with programs and policies for promoting clean cooking.

**Figure 10: Domestic Market for LPG in India (2007–2017)**




Source: Adapted from World Health Organization 2018. Opportunities for Transition to Clean Household Energy.

The clean cooking programs in India are not limited to LPG (Council on Energy, Environment and Water (CEEW) 2017). Some of the programs were working on improved biomass cookstoves (ICS) in India. The National Program on Improved Chulhas (NPIC) started in April 1986, and 35 million ICS were distributed in 16 years. After finishing NPIC in 2002, research and development (R&D) on improving ICS continued using public investments. The Unnat Chulha Abhiyan (UCA) scheme stated a target of 2.75 million ICS in 2014–2017. However, only 1% of UCA's target was achieved.

In the long run, the results of studies in India Energy Security Scenarios (IESS) showed that 20% of India's population in rural areas will use traditional biomass for cooking in 2047. Taking this number into the calculations, US$1.2 billion of investment will be necessary to provide ICS for them. According to CLEAN estimation for 2017–2020, the largest enterprises in the sector require US$1.5 million, US$9 million, and US$761,500 in the form of debt, equity, and grants, respectively.

Biogas is another fuel for clean cooking in India. The National Biogas and Manure Management Program (NBMMP) has been acting as the main supportive scheme for promoting biogas in India since 1981. NBMMP provides financial support for installing biogas plants for households, as well as training courses for using and maintenance of the plants. This program achieved 55% of its target for deployment in 2016–2017. More investment (approximately US$9 million) is necessary to meet the target.

Other sets of programs are targeting piped natural gas for clean cooking in India. The main effort of the Indian government is to provide natural gas at uniform prices to the city gas distributors (CGDs). The priority for receiving petroleum and natural gas (PNG) was given to CGDs from 2014 in order to control prices for consumers. Results of a study by the Petroleum and Natural Gas Regulatory Board (PNGRB) showed that demand for piped natural gas in India would reach almost 1.26 million standard cubic meters in 2030,

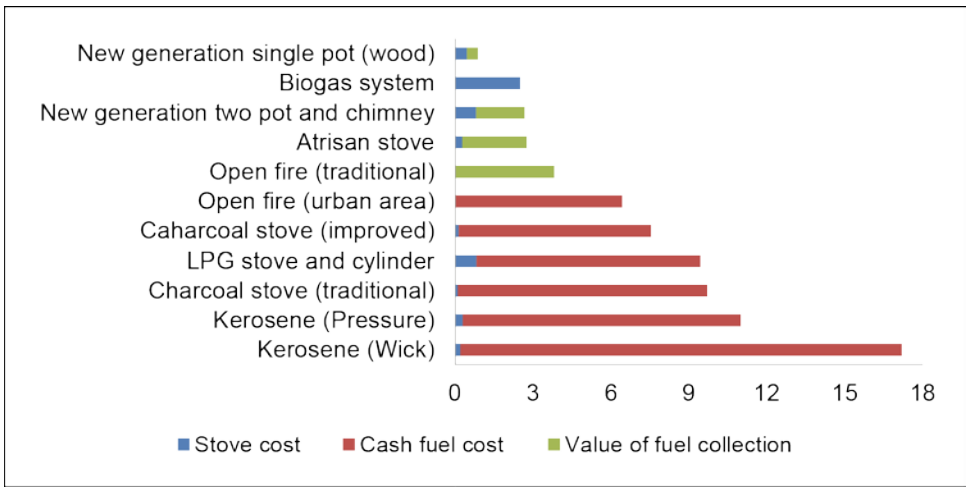
from around 0.24 million standard cubic meters in 2017. The target number for PNG connection is 20 million by 2020, while it was 3.3 million in 2016. In terms of number of cities, there is a plan to add 228 cities to existing CGD network by 2022. This shows the necessity of investments for increasing the capacity of natural gas distribution in India in the upcoming years. The total investment in India's natural gas sector will be US$100 billion by 2022.

For cooking with electricity in India, universal household electrification is the first step. The Deendayal Upadhyaya Gram Jyoti Yojana (DDUGJY) is a program that aims to improve electricity for 100% of rural villages in India by 2019. The total budget for this program is US$12 billion. The Pradhan Mantri Sahaj Bijli Har Ghar Yojana (SAUBHAGYA) scheme is working on universal household electrification by investing US$2.5 billion.

One of the main barriers for increasing the deployment share of clean cooking technologies is the relatively higher cost of these technologies and lack of proper financing schemes, as was pointed out in Table 3. Figure 11 shows the cost of cooking with different fuels and stoves in developing countries. The cost of technology consists of stove cost, fuel cost, and value of fuel collection.

Households with low income in developing countries face a big challenge in affording the clean cooking fuels and technologies. The CEEW report (2017) investigated clean cooking affordability issues for India. Currently, the share of biogas deployment is less than 1% in India. The average cost for a biogas plant under the NBMMP plan is US$307, which is not affordable for low income families. Subsidies for biogas plant installation varies between US$138 and US$261.

**Figure 11: Typical Cost of Cooking with Different Fuels and Stoves in Developing Countries, 2010** (US$/month)




Source: Adapted from WLPGA, 2014. Cooking with Gas: Why women in developing countries want LPG and how they can get it.

The CEEW report states that 88% of households in India do not use LPG due to its high cost and affordability issues. It is interesting to note that the share of cooking energy cost for more than 40% of households in energy-deprived states in India is zero.

Electricity-based cooking is another technology investigated as to its affordability in CEEW's report. The report concluded that the monthly cooking energy cost with

electricity is comparable with LPG (US$8). Cooking with electricity requires reliable and universal access to the grid. On the other hand, having access to clean cooking technologies does not necessary mean to use it as the primary source of cooking. For example, in 2015, 1% of households in rural areas used ICS or electricity for cooking, while the share of households that used those technologies as primary cooking technologies was only 0.01%.

In order to decrease clean cooking affordability issues, financial tools and policies are necessary in developing countries. The CEEW report (2017) worked on the clean cooking financial ecosystem in India by various institutions, including the government, microfinance institutions, banks, multilateral agencies/donors, and impact investors.

The Microfinance Institutions (MFIs) provide loans for end-users. The ICS manufacturers work closely with MFIs and they combine the demand and provide financial support for the consumers. The size of loans for ICS is small and MFIs cannot do investments at scale. Nevertheless, the MFIs worked with clean energy solutions for finding the primary customers. MFIs also act as ICS distributors and after-sale service providers.

The government of India supports the clean cooking strategies mainly by subsidies and grants. MoPNG and the Ministry of New and Renewable Energy (MNRE) provide subsidies and invest in the clean cooking infrastructure. The amount of investment for promoting biomass cookstoves was US$45 million. They also allocated US$138–260 subsidies for the biogas plants with the size of 2–6 $m^3$ for households. The total expenditure in this sector was US$20 million. The PUMY programs act to provide LPG connections for 50 million families below the poverty line by 2019 with a total investment of US$1.2 billion.

Indian banks are providing loans for enterprise finance. One of the important points is improving access to credit from banks. The level of familiarity of decision makers in the banks with technical aspects and the benefits of clean cooking technologies should be improved in order to increase access to loans in this sector. High interest rates for loans (e.g., 12%), as well as the necessity of collateral, are other obstacles for receiving clean cooking loans.

Multilateral agencies and donors provide grants, seed-funding, and interest subsidies on loans to promote clean cooking in India. They support clean cooking solutions by integrating resources and capacity building. GACC works on clean cooking issues in developing countries by collaborating with global partners. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and Tata Trusts are organizations that work on ICS and biogas policies and programs with the government of India.

Lastly, investor contributions in clean cooking financial ecosystems in India fund the enterprises. GACC and Deutsche Bank started the Clean Cooking Working Fund and invested in Envirofit and Biolite in 2016. The Shell Foundation has been supporting Envirofit since 2007.

The PRC recognized the importance of clean cooking issues and implemented programs and policies to promote solutions for deployment of clean cooking technologies by households within the last couple of decades. More than 180 million ICS were distributed in the PRC during the 1980s and 1990s under the PRC's National Improved Stoves Program (NISP).

The Chinese government and the World Bank launched the China Clean Stove Initiative (CSI) in 2012 as part of the East Asia and Pacific (EAP) CSI program (covering Indonesia, Mongolia, Lao PDR, and the PRC). The main idea is providing ICS for low-

income families and the families in rural areas that are going to use solid fuels for cooking after 2030.

In the first phase of CSI in the PRC, they conducted initial stocktaking and developed the implementation strategy. In the second phase, they mainly worked on capacity building and institutional strengthening. In the third phase, they implemented the scaled-up program. Finally, the program was evaluated and its lessons were disseminated in the fourth phase.

The next step of SCI in the PRC will mainly focus on improving the standards of the stoves in a collaboration with Global Alliance for Clean Cookstoves, as well as improving the testing methods of stoves by the building of a regionally recognized stove testing center (The World Bank, 2013).

The fuel changing program in Indonesia launched in 2007 in order to replace kerosene with LPG, even for the households that don't use kerosene as their primary energy source (see Table 2 for the differences between kerosene and LPG as cooking fuels). The target was 6 million and 42 million households in 2007 and 2012, respectively. As a result of this program, kerosene consumption decreased by 92% in less than 10 years. In 2015, the Indonesian National Statistics Agency conducted a survey and reported that 68.8% of households claimed that LPG was their main cooking fuel. The share of firewood, kerosene, electricity, and charcoal as the main source for cooking were 24.4%, 4.4%, 0.6% and 0.2%, respectively (Thoday et al. 2018).

In Bhutan, biogas and ICS for clean cooking were first promoted in the 1980s. The Bhutan Biogas Project (BBP) and Bhutan Sustainable Rural Biomass Energy (BSRBE) program were launched in 2008 in order to support biogas and ICS as clean cooking technologies in rural areas. The rural electrification program started in 1990 in Bhutan. As the result of this program, 100% of household electrification was achieved in 2015. This program is also providing100 units of free electricity per month for each rural household. The clean cooking programs in Bhutan have had considerable achievements during the three decades. However, results of studies show that indoor air quality is still a big issue in rural households (Dendup and Arimura 2019).

The Pakistan Centre for Renewable Energy Technologies (PCRET) is working on promoting biogas as a clean cooking technology in Pakistan. More than 1,600 biogas plants were installed in Pakistan by 2006 with the support of PCRET. In 2009, the Pakistan Domestic Biogas Program (PDBP) started as the result of collaboration between SNV (Netherlands Development Organization), Winrock International, and United Nation Development Program (UNDP) Pakistan in order to provide biogas as a clean cooking fuel for rural households using animal dung. The target of this program was providing incentives to install 14,000 biogas plants in Central Panjab by 2014. They installed 5,360 biogas digesters in Central Panjab by 2014. A biogas plant with a capacity of 4 cubic meters can provide cooking energy for a family with four members (Yasmin et al. 2019; Noorollahi et al. 2015; Ghimire 2013).

The Asian Development Bank (ADB) is conducting clean cooking programs in some of the developing countries. These programs are mainly covering biomass, biogas, ICS, and LPG. The Quality and Safety Enhancement of Agricultural Production and Biogas Development Program started in 2009 in Viet Nam in order to support installation of biogas digesters for providing clean fuel for households in rural areas. Initially, the biogas program was supported by SNV, and ADB's credits and subsidies added US$19 million for expanding the biogas infrastructure and facilitating biogas access for low-income families. The total amount of support by ADB and SNV facilitated the installation of 40,000 digesters by 2015 in 16 provinces in Viet Nam (ADB 2013).

In Lao People's Democratic Republic (Lao PDR), the Harnessing Climate Change Mitigation Initiatives to Benefit Women started in 2011 as a technical assistance (TA) program with US$2.7 million investment. This program was the next step of existing ADB and nongovernment organization (NGO) programs for expanding low-carbon technologies and providing the possibility for women to receive benefits for their contributions. The SNV's Improved Cook Stove National Program connected to this program in Lao PDR, aiming to increase clean cooking technology deployment, increase indoor air quality, and control black carbon emission to the atmosphere. In this program, women can play a role in ICS manufacturing and marketing, providing direct benefits for women from ICS sales.

The Capacity Building for the Efficient Utilization of Biomass for Bioenergy and Food Security Program started in 2011 in Greater Mekong Subregion as a technical assistance (TA) project to support bioenergy, while considering the food insecurity issues. With US$4 million investment, 10 pilot projects including ICSs, biogas, and biochar started in Loa PDR, Cambodia, and Viet Nam.

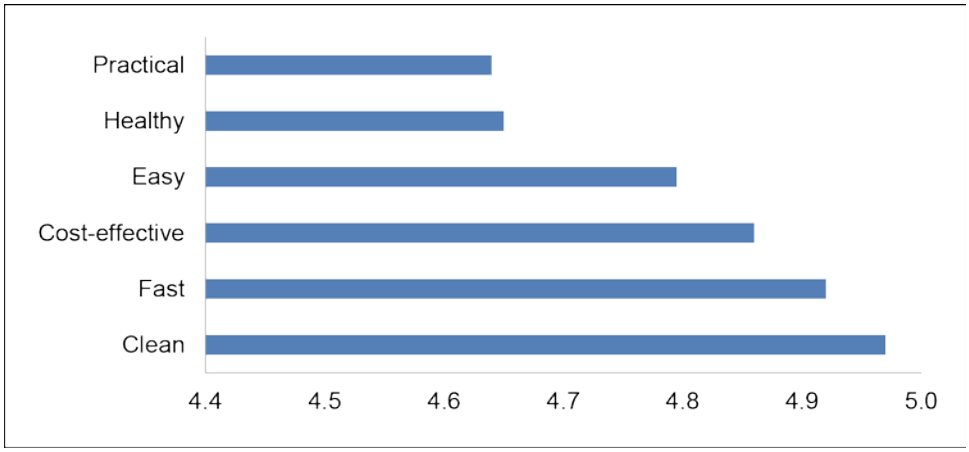
In 2013, the Rural Energy Project started in Cambodia. In a collaboration between ADB, the Australian Agency for International Development, and Groupe Energies Renouvelables, Environnement et Solidarités (GERES), US$6.11 million of grant funds was provided for 11 ICS manufacturers to produce 90,000 ICSs with higher fuel combustion efficiency for households in rural areas.

The policy tools (e.g., subsidies on LPG and clean cookstoves) have considerable effect in improving the access rate to clean cooking in Asian countries. At the same time, various studies worked on the importance of social networks in dissemination and deployment of clean cooking options in poor communities. For example, Kumar and Igdalsky (2019) investigated the role of social networks in clean cooking technology deployment, including ICSs, LPG stoves, PNG stoves, biogas digesters, and ethanol-based stoves. They drew on interventions in reproductive health, microfinance, and clean cooking to outline a perspective on how social networks could have a significant role in disseminating clean cooking systems in poor communities. They looked into three cases studies in their research: personal communication networks to an entertainment-education radio soap opera in Tanzania; self-help groups in India; and the role of social networks in diffusion of non-traditional cookstoves across Western Honduras.

Results of their study showed that the rural households using traditional stoves were homophilous, sharing similar socioeconomic challenges at the household level. Controlling for other network attributes such as opinion leaders and gendered networks, these rural poor communities presented an ideal social system for a successful CCS dissemination and implementation. It was also found that in a gender segregated social system, women's networks are critical for disseminating innovations, especially at the community level. This finding is in line with the recommendations of the World LP Gas Association report (WLPGA, 2014). This report also emphasized the importance of shaping decisions of the laggards regarding opinion leaders in adoption of a technological innovation. Women opinion leaders can play an especially powerful role because of the stronger homophily within their networks. The "domino effect" of female opinion leaders in a homophilious social structure of women is more pronounced than in the case of men's networks. Also, interaction with the opinion leaders helps women members of the communities shape their arguments and advocate for clean cooking technologies in their own households.

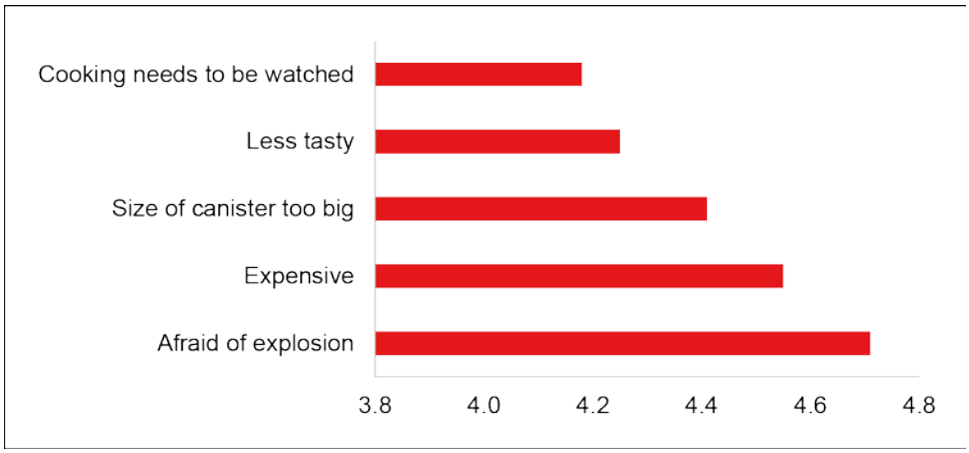
Top-down approaches (programs and policies) are the main factor for increasing clean cooking technology deployment in developing countries in Asia. However, household opinions on accepting this technology for cooking are also very important. As an example, Figures 12 and 13 show the main reasons for accepting/not accepting LPG as the cooking fuel in Indonesia.

**Figure 12: Main Reasons for Using LPG by Households in Indonesia**




Source: Adapted from WLPGA 2014. Cooking with Gas: Why women in developing countries want LPG and how they can get it.

**Figure 13: Main Reasons for Not Using LPG by Households in Indonesia**




Source: Adapted from WLPGA 2014. Cooking with Gas: Why women in developing countries want LPG and how they can get it.

Household cooking fuel choices analysis is an important topic, in parallel to the clean cooking policies. Several empirical analyses of the determinants of household energy choices in developing countries can be found in the literature (e.g., Campbell et al. 2003; Heltberg 2004, 2005; Alem et al. 2016).

Poblete-Cazenave and Pachauri (2018) proposed a structural model to estimate household demand and choices for cooking fuel using micro-datasets from nationally representative surveys for a subset of developing countries. They found that the model provides a close approximation to the observed patterns in the data from the surveys. They also reported that as long as incomes rise and the relative difference between the prices of biomass and cleaner fuels decreases, households would transition to cleaner

cooking fuels. They discussed potential applications of the method for constructing and analyzing future scenarios of cooking energy transitions. The MESSAGE-Access model and similar models are useful for analyzing and forecasting the effects of policies on increasing the clean cooking access rate in developing countries.

# 4. RENEWABLE TECHNOLOGIES FOR CLEAN COOKING

Fossil fuel-based cooking prevents the health impacts of the polluting, traditional cookstoves. However, the deployment of LPG and kerosene on a large scale has potential impacts on climate change issues and the dependency of developing countries on imported energy. Clean cooking using domestic renewable fuels could prevent these issues. Biogas is produced from various resources and is a clean, renewable source for cooking in developing countries.

Table 4 and Table 5 show examples of biogas yields from livestock and crops, respectively. Biogas digesters are of various sizes, and the selection is usually based on the biogas demand, available investment, and available material. Table 6 shows the key parameters of biogas digesters with different sizes in Pakistan. Table 7 shows the number of household-scale biogas digester units in selected Asian countries in 2014.

**Table 4: Examples of Biogas Yields from Livestock**

| **Biogas Source** | **Feedstock per Year** | **Biogas Methane Yield per Year** ($m^3$) |
|---|---|---|
| 1 cow (milk) | 20 $m^3$ liquid manure | 500 |
| 1 pig | 1.5–6 $m^3$ liquid manure | 42–168 |
| 1 cow (beef) | 2–11 tons solid manure | 240–880 |
| 100 chickens | 1.8 $m^3$ dry litter | 242 |

Source: Adapted from IRENA 2017. Biogas for Domestic Cooking.

**Table 5: Examples of Biogas Yields from Crops**

| **Feedstock** | **Tones of Dry Stock per Hectare** | **Methane Yield (**$m^3$/ton **Fresh Weight)** | **Biogas Methane Yield per Hectare** |
|---|---|---|---|
| Maize (whole crop) | 9–30 | 205–450 | 1,660–12,150 |
| Grass, cut | 10–15 | 298–467 | 2,682–6,305 |
| Sudan grass | 10–20 | 213–303 | 1,917–5,454 |
| Red clover | 5–19 | 300–350 | 1,350–5,985 |
| Reed canary grass | 5–11 | 340–430 | 1,530–4,257 |
| Sugar beet | 9.2–18.4 | 236–381 | 1,954–6,309 |
| Wheat (grain) | 3.6–11.75 | 384–426 | 1,244–2,428 |
| Barley | 3.6–4.1 | 353–658 | 1,444–2,428 |
| Alfalfa | 7.5–16.5 | 340–500 | 2,295–7,425 |
| Rapeseed | 2.5–7.8 | 240–340 | 540–2,387 |
| Potatoes | 10.7–50 | 267–400 | 2,658–18,000 |

Source: Adapted from IRENA 2017. Biogas for Domestic Cooking.

**Table 6: Key Parameters of Biogas Digesters with Different Sizes in Pakistan**

| **Plant Size** ($m^3$) | **Required Animal Dung** (kg) | **Gas Production** (hour/day) | **Installation Cost** (USD) | **Fuel Cost Saving** (USD/?) |
|---|---|---|---|---|
| 4 | 30 | 4 | 470 | 3.3 |
| 6 | 45 | 5–6 | 550 | 3.5 |
| 8 | 60 | 6–8 | 600 | 5.9 |
| 10 | 75 | 8–10 | 670 | 6.1 |
| 15 | 113 | 13–15 | 800 | 6.2 |
| 20 | 150 | 16–18 | 950 | 9.3 |
| 25 | 188 | 19–21 | 1,200 | 18.1 |

Source: Adapted from Yasmin and Grundmann. 2019. Adoption and Diffusion of Renewable Energy – The case of biogas as alternative fuel for cooking in Pakistan.

**Table 7: Household-scale Biogas Digester Units in Selected Asian Countries, 2014**

| **Country** | **Number of Units** |
|---|---|
| PRC | 43,000,000 |
| India | 4,750,000 |
| Nepal | 330,000 |
| Viet Nam | 182,800 |
| Bangladesh | 37,060 |
| Cambodia | 23,220 |
| Indonesia | 15,890 |
| Pakistan | 5,360 |
| Lao PDR | 2,890 |
| Bhutan | 1,420 |

Source: Adapted from CEEW 2017. Access to Clean Cooking Energy in India.

# 5. CONCLUSION AND RECOMMENDATIONS

Clean and secure energy resources are necessary for the household to prevent the potential effects of polluting, traditional cooking methods on health and quality of life. Various programs and policies have been implemented mainly during the last 2 decades to increase access by households to clean cooking fuels and technologies in Asian countries. So far, improved cookstove programs and promotion of LPG for cooking have achieved considerable success in many countries. Although the progress is steady, it is slow in some countries.

The clean cooking programs are successful mainly in the cities; households in rural areas are facing difficulties in receiving the incentives in the programs. New programs and plans are necessary to provide incentives for households in rural areas with limited access to bank accounts in developing Asian countries.

A considerable number of programs are targeting LPG promotion for cooking. In other words, most of the clean cooking programs in Asia are subsidies for fossil fuels. The population of developing Asian countries is increasing and these programs will impose dependency on imported energy with hard-to-predict prices. Renewable sources for clean cooking should receive more support and attention. Biogas can be produced from

domestic resources in both urban and rural areas at reasonable prices. Intensive programs and plans are necessary for promoting biogas for cooking.

Some of the studies showed that fuel prices for cooking with electricity might be comparable with LPG. In order to increase the share of electricity for clean cooking, universal access to the electricity grid must be achieved along with shaping household fuel choices with training and the sharing of information. By increasing the share of renewables in power generation in the upcoming decades, cooking with electricity will also have a long-run positive effect on climate change issues.

Increasing the awareness of women about clean cooking technologies and improved cookstoves is crucial. A comprehensive set of actions for increasing awareness is necessary to guarantee the success of clean cooking programs in developing countries. Conducting impactful research on modeling of consumer choices for cooking fuels in Asian countries, as well as developing the right business model for scaling-up the clean cooking market will be helpful for successful design and implementation of clean cooking policies and programs.

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