ENERGIZING INDIA

FUELLING A BILLION LIVES

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FOREWORD

Fatih Birol

In 2017, India became an associate member of the International Energy Agency (IEA). The IEA is far richer for having India in the family, given India's importance in global energy markets and the remarkable insights it provides to other members. I have praised India's energy policy achievements around the world and highlighted the lessons other countries can learn. At present, India faces an unenviable challenge—building a secure and sustainable energy system to power its remarkable economic growth.

Globally, the energy system is in transition. Oil markets are entering a new period of volatility and uncertainty. Electricity is expected to have a more prominent role in the global energy system in the future while the declining costs of solar and wind technology put renewable energy at the forefront of the energy discourse for future generations. Meanwhile, the sustainability of the energy industry is becoming more important as greenhouse gas emissions are rising again, with cities continuing to struggle with the pollution generated from energy consumption and energy-intensive industries.

India is rapidly becoming one of the most important countries in the global energy system, while dealing with many of the challenges facing the global energy sector. Energy will continue to underpin India's rapid economic growth and human development,

4

HOUSEHOLD ENERGY TRANSITION IN INDIA AND ELSEWHERE: THE ROLE OF LPG

Kirk R. Smith and *Abhishek Jain*[1]

Unlike Western countries, India has developed a modern economy, with modern sources of pollution and associated health impacts, even when much of its population has still not transitioned away from traditional household cookfuels—primarily various forms of biomass. When air pollution risks were recognized in the US and Europe in the 1950s, by comparison, household air pollution from cooking with solid fuels was a memory from previous generations. This divergence—with part of the Indian population moving towards modern sources of energy, like natural gas and electricity, while others are stuck using traditional fuels—results in a double health risk from modern forms of air pollution such as coal-fired power plants as well as from household air pollution, primarily in poor rural populations. Currently, estimates are that the total impact is some 1.6 million premature deaths annually—but perhaps more

[1]We appreciate comments by Ajay Pillarisetti, Ambuj Sagar and Alok Tripathi.

tellingly, it is thought to be the second most important cause of lost healthy life years in the country, after the malnutrition that causes low birth weight, childhood stunting and anaemia (IHME 2018). A number of other low- and middle-income countries are in similar situations.

Household use of biomass is also understood to cause other social problems. Hundreds of millions of hours are spent by householders every week around the country in gathering fuel and in the extra time needed to cook. It is increasingly recognized that this is a drag on the life of villagers—particularly women—and this time could be used for income generation, childcare, education, and to reduce the burden of rural life. Indeed, in the modern sector, we have become accustomed to technologies being promoted simply as 'labour saving', which is considered a benefit even without direct evidence of how the saved time would be used. Time consumed because of the use of traditional biomass in cooking remains one of largest targets in India (and the world) for labour-saving interventions.

Since the 1950s, there have been efforts in India to promote so-called 'smokeless' chulhas, culminating in the National Programme on Improved Chulha starting in the early 1980s and running till 2003 in its original form with a brief revival around 2009. This approach has been termed as an attempt 'to make the available clean', that is, to burn available biomass more efficiently and cleanly (Smith 2014). In recent decades, however, evidence linking air pollution and health has grown and it is now understood that the necessary emission levels from the cook stoves have to be very low to be truly health protective (WHO 2014). To date, in spite of widespread progress by dozens of researchers, cookstove enterprises, government programmes, international agencies and donors—and hundreds of well-

meaning NGOs—no stove system has emerged worldwide that is reliably clean enough while using unprocessed biomass (Jetter 2012). Various processed biomass fuels show promise but have not yet been shown to be scalable with the necessary utility-style support services to enable sustained use of cleaner fuel. Work also proceeds on other fronts, including new developments in photovoltaic-powered cooking systems that show promise.

Meanwhile, India has rapidly developed economically: GDP per capita has grown from $260 in 1980 to over $2000 today (in 2017 US dollars)—a mean annual growth rate of over 6 per cent (World Bank). In spite of the growth of clean fuel in the middle class during this period, however, the rural population was not gaining access to clean fuels, and about 700 million people still had no clean fuel until 2015 (HEI 2018). This has been termed India's 'chulha trap'—that is, a constant large poor population staying behind as the rest of the country makes the energy transition (Smith 2014).

MAKE THE CLEAN AVAILABLE

In the middle of this decade, a new paradigm came to the fore, to break out of the chulha trap. As shown in Figure 1, in addition to continuing to try to find technologies to make biomass clean, greater emphasis is now being placed on trying to 'make the clean available' (Smith 2014). In other words, there is a push to enhance access to well-developed clean cooking systems for economically poor populations.

This approach has advantages over promoting new and novel advanced biomass fuel technologies that need both product as well as customer development. Clean fuels such as liquefied petroleum gas (LPG) are usually aspirational, since poor populations see

them in the movies, on TV, and in use by richer neighbours. Given that 60 per cent of the world already uses gas or electricity for cooking, there is little doubt about eventual acceptability for the rest and the ability to cook nearly all cuisines. In addition, gas and grid electricity comes via utilities with major organizations responsible for assuring reliable supply. They may do so poorly in some circumstances but the responsibilities are clear and the entire value chain is already established for improving service reliability.

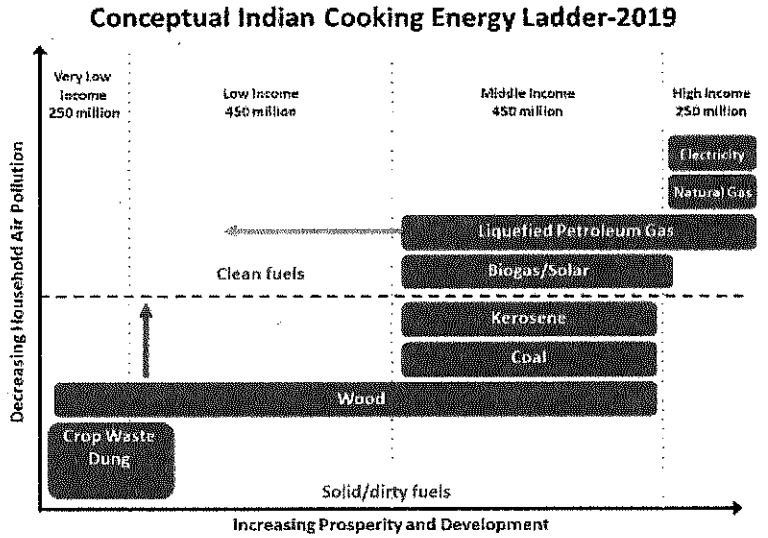

Figure 1: Energy ladder in India. The need is to provide cooking methods for the poor that are clean, that is, fill the upper left quadrant. Two main methods have been attempted—the red arrow, making the available biomass clean; and the blue arrow, making clean LPG available to the poor. Of course, there are policies being undertaken across all the fuels shown.

Source: Based on figure in Smith and Sagar, 2014.

The make-the-clean-available approach does not avoid one of the big problems from a health standpoint, which is what the energy field calls 'stacking'—that is, the tendency for households to move only partly to a new technology at first and to continue to use traditional biomass for a period. At least, however, the new technology is clean—that is, it meets the World Health Organization (WHO) indoor air pollution guidelines (Shen 2018). Thus, the more it is used, the more it cleans up indoor air pollution, which is not necessarily the case with many of the smokeless chulhas that have been promoted. In addition, this lag between availability and full use is a common one in health: just providing condoms, latrines, bed nets and institutional delivery services, for example, is not enough. There must be efforts to accelerate the full transition—to enhance usage—and the health sector has much experience in finding ways to do so.

There are three major constraints on usage: lack of knowledge, reliability of supply and affordability. The first two of these are directly amenable to government, private sector and NGO interventions of the types applied in other arenas. The last has been addressed by application of subsidies of various kinds—to encourage poor households to shift to LPG, for example. As shown in the India case below, the current national LPG programme has developed highly creative ways to use what is called 'Digital India', that is, the rapid development of information technology in the population's normal life (mobile phones, electronic bank accounts, social media, etc.) to address the affordability issue. The country is moving towards being able to justify that the taxpayer funds required to promote use of clean cooking fuels among the poor can be considered as a 'social investment' rather than a subsidy, due to its public health benefits (Smith 2018).

THE INDIAN LPG STORY

The Indian Government has supported expansion and consumption of LPG in the country through its public sector oil marketing companies (OMCs) and direct subsidy of LPG, for more than four decades. As a result, more than 50 per cent of Indian households had an LPG connection in 2011 and about 29 per cent of the population was using it as their primary fuel for cooking (MoHA 2011; PPAC 2016). However, since then, the current decade has been by far the most dynamic time for LPG in India.[2]

LPG service improvements have occurred over a number of fronts. To improve availability of LPG in rural areas, in 2009, the Ministry of Petroleum and Natural Gas (MoPNG) introduced a new category of LPG distributorships to make the distributor model economically viable in rural contexts. Later on, in 2016, LPG distributorship guidelines were further streamlined and aimed to improve LPG availability and supply reliability in rural areas by mandating home delivery of LPG.

[2]It is useful to explain the special characteristics of India's LPG system, which often do not exist in other countries. First is the concept of 'connection', which means an official sanction for a household to buy subsidized fuel. It is a separate application process in India and, by itself, does not indicate usage. It costs about ₹1,600 ($23) and covers primarily the deposit on the cylinder. Usage comes from purchasing refills as needed, with the cylinders being swapped out—that is, an empty one is exchanged for a full one. The OMCs, therefore, own the cylinders and are responsible for their maintenance. Urban households typically have paid the deposit for two cylinders, which ensures continuity of consumption between refills of cylinders. About 43 per cent of household connections in the country are for two cylinders. Refills are subsidized currently (up to twelve per year) to keep the price at ₹500 ($7.2 for 14.2 kg LPG), irrespective of the international price. The difference in cost is the subsidy paid by the OMCs and the government. All connection and refill transactions are managed by the OMCs who maintain detailed websites and databases, including one of every customer in the country.

In 2012, two major initiatives were introduced regarding LPG. One, for the first time since its introduction, the number of subsidized LPG cylinders available to a household got capped—first to a level of six cylinders annually, then nine, and eventually to twelve—limiting the potential of wasteful consumption and diversion. Two, as part of the project 'Lakshya', the OMCs under the aegis of MoPNG exploited the full potential of information technology by undertaking a 'Know Your Customer' (KYC) drive while simultaneously streamlining and integrating LPG consumer databases among themselves. The OMCs re-engineered their business process to ensure software de-duplication prior to release of the connection with the help of the National Informatics Centre (NIC). The KYC exercise led to identification of about 15 per cent of all connections as potential duplicate or ghost connections. The exercise was also integrated with Aadhaar, a universal identification programme for Indian residents linked to their basic demographic and biometric information and stored in a centralized database (Mittal 2014).

The KYC exercise resulted in streamlined, IT-enabled LPG consumer databases, which became the foundation of another major LPG initiative—first tried in 2013 and later implemented pan-India in 2014–15—the Direct Benefit Transfer for LPG (DBTL), also known as the PAHAL scheme. PAHAL reduced the market price difference between residential and commercial LPG. It reduced the incentive for LPG distributors to divert LPG intended for household cooking to unintended users or purposes by enabling direct transfer of consumption-linked LPG subsidies into the bank account of consumers. PAHAL, covering 140 million consumers during its implementation in less than a year, became the world's largest benefit transfer scheme. The scheme helped control the diversion of subsidized commodities from

the distribution value chain (Jain, Agrawal and Ganesan 2018). Unlike conventional reforms for reducing the fossil fuel subsidy, the DBTL focused on improving the efficiency of the subsidy delivery mechanism to decrease the leakage of the subsidized commodity. More importantly, it enables the possibility for the government to selectively target the subsidy to specific groups of beneficiaries, instead of providing it universally (as was the case before it was introduced).

Just as PAHAL implementation was nearing its completion, the Indian Government launched a unique initiative in 2015 called 'Give it Up', a public campaign to urge well-to-do households who could afford their LPG consumption at the market price to give up their subsidy. The campaign was led directly by the Indian Prime Minister; at his behest, well-to-do households could give up their LPG subsidy so that the saved resources could be used to provide LPG to poorer populations. 'Give it Up', a real-world example of nudge theory in action, managed to have more than ten million LPG consumers (about 7 per cent of the consumer base in 2015) voluntarily giving up their subsidy and many more not taking subsidy when first connecting. More importantly, the campaign created an enabling environment for the government to bring in another regulation, later in 2016, to wean away the subsidy from households with an annual income greater than ₹1 million (PIB 2015). However, this is merely the start of what could be done towards subsidy rationalizations and targeting.

In 2016, the Indian Government brought unprecedented focus on LPG penetration in the country by way of the Pradhan Mantri Ujjwala Yojana (PMUY) with an initial budgetary allocation of ₹80 billion (~$1.1 billion). The scheme had an ambitious target to provide fifty million new LPG connections at a subsidized cost to socioeconomically weaker households in three years (PIB

2016). However, the implementation of the scheme was even more ambitious than its target, achieving it in less than two-and-a-half years, which led to a revised target of eighty million connections by 2020 (PIB 2018). On average, more than 50,000 new connections are established every day since the start of the programme making the sheer scale and pace of LPG expansion unprecedented.

Even for the implementation of PMUY, information technology is significantly leveraged for both regular progress monitoring as well as to minimize implementation gaps. PMUY provides connections to the lead female member of the household, linking her Aadhaar number, bank account and the household's mobile number. These data are used to ensure that connections are being provided only to those households which are not existing LPG consumers and which belong to socio-economically weaker sections. As of January 2018, more than sixty million connections have been released under PMUY. Interestingly, efforts to implement PMUY have also led to a significant increase in new rural connections beyond PMUY, increasing the overall penetration of LPG connections to close to 85 per cent of the Indian population.

While PMUY focuses on overcoming the significant adoption barrier of high upfront costs, a high level of LPG use—displacing traditional biomass—is required by the households to realize the health benefits. To understand the impact of PMUY in transitioning households from using traditional biomass, it is important to have large-scale, field-based representative data. One way to assess the situation at the aggregate level is to use the administrative data from the OMCs on various fronts, including the number of beneficiaries across different social groups and refill rates by social groups and regions—and to compare this data with similar information for regular LPG users (non-PMUY). While

the government has made significant efforts in enabling greater transparency of LPG-related data through public data portals for each OMC, these outlets are not currently structured to be conducive to obtaining data at the scale or in a form suitable for assessing on-ground realities.

In the absence of such easily accessible and usable data, primary surveys are the main approach to gathering information on LPG consumption, its stacking with traditional fuels, households' cooking energy expenditures and so forth. In 2018, Jain et al published findings based on an energy access survey[3] of ~9,000 rural households in six major energy-access-deprived states—Bihar, Jharkhand, Madhya Pradesh, Odisha, Uttar Pradesh and West Bengal. These states collectively account for about 50 per cent of the Indian rural population. It is the follow-up to the first round of the survey, which was conducted in 2015, that provides the baseline for understanding the impact of PMUY, which started in 2016 (Jain et al. 2015; Aklin et al. 2016). The sampling framework for the surveys was designed to be representative of the rural areas in each of the six states, which have received 60 per cent of the total PMUY connections (PPAC 2018). The following paragraphs are based on the results from this set of surveys.

The two rounds of surveys found that the proportion of rural households of the six surveyed states using LPG had increased from 22 per cent in 2015 to 58 per cent in 2018. Importantly, inequity in access to LPG among different social groups also declined. The proportion of Scheduled Caste and Scheduled Tribe[4] households

[3]The ACCESS survey in 2018 was a joint collaboration between the Council on Energy, Environment and Water, the National University of Singapore, and the Initiative for Sustainable Energy Policy.

[4]The Scheduled Castes and Scheduled Tribes are officially designated groups of historically disadvantaged people in India. The terms are recognized in the

who reported using LPG in 2015 and in 2018 increased from 12 to 55 per cent and 8 to 38 per cent respectively, significantly improving LPG penetration among marginalized groups.

Rural populations' aspiration to adopt LPG has also increased over time. In 2018, 83 per cent of households without LPG in these six states expressed interest in acquiring a connection compared to 48 per cent of such households in 2015.

Beyond connections and rising aspirations, the proportion of households reporting LPG as their primary and only cooking fuel also increased from 14 per cent to 37 per cent and from 5 per cent to 19 per cent respectively. Of the total number of LPG-using households in 2018, almost one-third are using it exclusively—that is, no stacking with traditional biomass—up from 22 per cent in 2015.

For non-PMUY LPG users, the survey found a strong correlation between average annual LPG consumption and age of the LPG connections, potentially indicating that full consumption of LPG in new connections takes time to evolve (see Figure 2). Thus, judging the impact of PMUY through refill rates after only two years could be premature. This does not necessarily suggest, however, that the evolution of LPG consumption for PMUY households will be similar to that of non-PMUY households. Non-PMUY households are those that were able to afford the upfront cost of the LPG connection, and hence are presumably better off economically than PMUY households. Thus, it is likely that LPG consumption for PMUY and non-PMUY households may exhibit different rates of change over time.

Constitution of India.

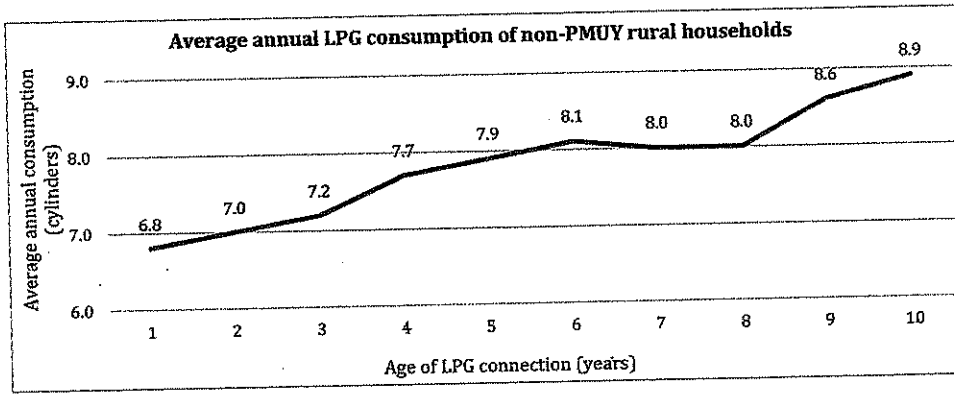

Figure 2: Refill rate versus time since connection for non-PMUY households.

Source: Jain et al 2018

Stacking of traditional biomass with LPG or cleaner options remains a critical challenge from a health perspective. To evaluate if stacking varies between PMUY and non-PMUY households, Jain et al (2018) categorize LPG users into three groups—PMUY households, non-PMUY households with connections up to two years old, and all non-PMUY households—to control for age of the connection. It finds that across states, a higher proportion of PMUY households stack LPG with biomass than their non-PMUY counterparts with similar age of connection. Among non-PMUY households, stacking reduces with the age of connection (see Figure 3).

The current national LPG programme has developed highly creative ways to use what is called 'Digital India'.

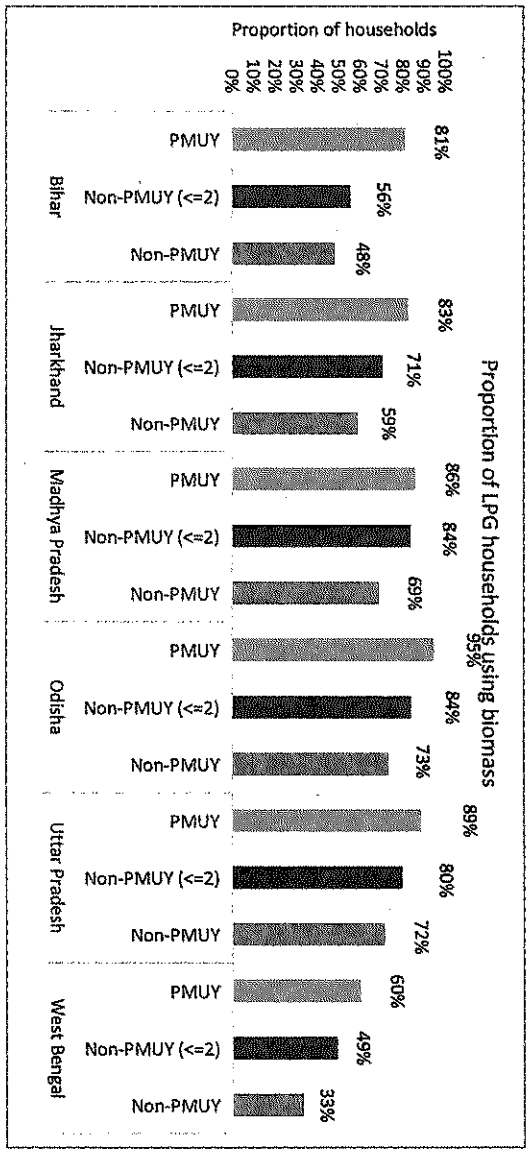

Figure 3: Proportion of households with LPG connections reporting biomass usage:

PMUY; Non-PMUY for less than two years; and total non-PMUY

Source: Jain et al 2018

When asked why they do not use LPG for all their cooking needs, recurring cost and availability of free-of-cost biomass were the most frequently cited reasons by both PMUY and non-PMUY households (Figure 4). The two reasons are somewhat related, of course, for if the opportunity cost of the time spent gathering and preparing biomass is zero or very low, gathering biomass may have no perceived cost compared to purchasing LPG, even with a subsidy. Transitioning to LPG saves time otherwise spent collecting and preparing biomass, preparing traditional stoves, cooking food and cleaning utensils, which blacken when used over traditional stoves with biomass fuels. Providing avenues and opportunities for women to use their newly free time in income-generating activities could help improve the purchasing capacity of the household and give them a means to pay for recurring use of fuel.

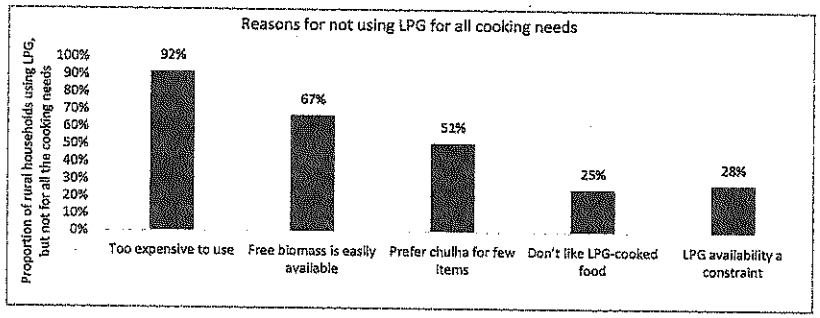

Figure 4: Households not using LPG for all needs mention cost of using LPG and the availability of free-of-cost biomass as the two most common factors preventing their complete transition to LPG.

Source: Jain et al 2018

The PMUY tries to provide some agency to women: LPG connections under PMUY are only given in the name of the female lead of the household and the consumption-linked subsidy is also transferred into the woman's bank account. The survey found, however, almost two-thirds of LPG-using households reported that the decision about when to order a refill is made by a man in the household. This may change, however, as women participate more in household income generation by utilizing time saved due to use of LPG.

Although understanding and attending to intra-household gender dynamics is important, the affordability of LPG remains a significant concern and barrier to its sustained use for all cooking energy needs. Thus, coinciding livelihood interventions, particularly for women, along with PMUY and other LPG initiatives, could potentially go a long way in creating a reinforcing loop. The government should also consider better subsidy targeting strategies to provide differential subsidy support based on health vulnerability, household size and economic situation. At the same time, finding more effective ways of continuing to reduce subsidy for the middle- and upper-income groups would keep the total cost to the exchequer low (Tripathi 2015; Jain, Agrawal and Ganesan 2014).

In all, the progress shown by India on improving LPG access throughout the country, by leveraging—among other things—the window of opportunity provided by lower than normal international oil prices is highly praiseworthy. Provision of connections is the first major step towards universal clean cooking energy for all Indians and early results show that connections are translating into use of LPG, albeit slowly. A challenge ahead is to ensure buffering against a potential ballooning of fiscal outlays towards LPG subsidies

with the increase in international oil prices, and the increasing consumption of the fuel.

PROGRESS IN OTHER COUNTRIES

Although India's LPG promotion programme is the largest in operation today, other countries have initiated programmes over the last half-century to promote LPG use among the poor with varying degrees of success. These have covered a wide range of approaches but generally have relied on subsidized access to fuel and distinct from India's current programme, have not included a specific focus on the health benefits of using LPG in comparison to using biomass. Usually, they focus on social development objectives that vaguely incorporate health criteria. Thus, they have been justified on somewhat different grounds. Here we focus on programmes in three other quite different but large middle-income countries.

Brazil: A diverse country, which is heavily forested throughout much of its territory, Brazil has had a long history of promoting LPG use among the poor as part of social development. Beginning in 1973, as part of the arrangement that led to the partial privatization of the national oil company, Petrobras, Brazil began heavy subsidies of the fuel for everyone and worked to standardize LPG supply and prices throughout the country. As a result, by the 2000s, about 95 per cent of Brazilian households reported LPG use for cooking, although fuelwood still supplied about 45 per cent of total cooking energy. This programme was paid, largely, by cross-subsidizing with other petroleum products (Coelho 2018).

In 2001–02, with liberalization of the economy, however, the subsidies ended and LPG came to be sold at market prices. In 2003, a system of vouchers for LPG aimed at the poorest

groups was initiated, but was considered largely a failure due to poor implementation and associated corruption. Since 2004, the government shifted to an income transfer scheme for the poor that does not focus on LPG, but on income support in general. Use of LPG has remained high, but there has been little reduction in wood fuel use since 2001 as there had been steadily through the 1990s with the older subsidy scheme (Coelho 2018).

This illustrates a dilemma in development economics between consumption-linked benefits to the poor versus providing general funding to the poor for them to spend as they see fit. The former typically has implementation challenges leading to leakages and inefficiencies. But the latter, in many instances, does not lead to intended outcome of improving use of cleaner cooking fuel. Simply providing money to the poor may be persuasive if LPG purchase related mainly to lifestyle, like clothes or travel. People are much better at prioritizing their needs for these than the government. However, in recent years, LPG is increasingly recognized as being more than a lifestyle issue, as being an important component in health protection and time use—that is, productivity. Everyone must cook and if they are using wood fuel, their health status and productivity are inherently limited.

Clearly, the government has a responsibility to promote the health and productivity of its population, in addition to addressing equity issues surrounding poverty. Increased health and productivity enhance every aspect of economic development. Thus, nudging the population to act in a manner leading to improved health and productivity may warrant linking subsidies to specific products and services promoting health benefits. Promoting use of a clean fuel such as LPG is an example of such a policy objective. Like rural primary health care or primary schools, government expenditures can be justified as social investments and not simply

as subsidies for the poor as long as they achieve the intended benefits, particularly at community scale. To do so, however, the subsidy targeting system needs to be quite effective and cannot be granted to everyone—specifically the middle- and upper-income classes, who would use LPG and natural gas anyway. Given the evolution of LPG consumption in Brazil in two eras of direct LPG subsidy and general income support to the poor, it may be prudent for Brazil to consider reserving part of its income transfer scheme again for an LPG consumption-linked support programme by leveraging IT-based targeting of the poor that does not benefit the better off. Such a programme should be framed clearly to be temporary with gradual reduction in support as the poor shift to higher income categories.

Indonesia: Kerosene is another fuel that has been subsidized by many developing country governments for decades as an ostensive social benefit for the poor. Around 2008, the Indonesian government realized that the large and growing subsidy cost for kerosene was becoming a major fiscal burden (Thoday 2018). Being easily diverted to alternative uses, particularly in diesel engines, much of the subsidy was also not meeting the intended objectives. Attempts to decrease the subsidy had led to large public demonstrations, however, as the population had become accustomed to it (Beaton 2017).

In the meantime, however, Indonesia had made great strides in electrification, being well on its way to the current target of ~97 per cent of households having electricity provision at the end of 2019. This was no easy feat, given the archipelagic geography of the country, with over 900 permanently inhabited islands. It meant, however, that one of the main uses of kerosene by the poor—lighting—is increasingly becoming redundant. Everywhere in the

world, people are happy to substitute clean and bright electric lights for traditional kerosene lamps and with better batteries and hybrid solar lamps, intermittent power supply becomes less troublesome. Increasingly, the only remaining use of kerosene in Indonesia was thus for cooking (ADB 2016).

In 2007, the Indonesian Government requested the national oil company Pertamina to embark on a massive programme to switch out kerosene for LPG. This programme had a number of innovative aspects, but relied heavily on a steady reduction of kerosene subsidies combined with a slight increase in those for LPG. The net change was designed to be roughly the same for the consumer, but save the government billions of US dollars in subsidy (Thoday 2018). Today, it is thought that some two-thirds of all Indonesian households were connected to LPG over this period, although it is difficult to determine exactly how much change would have occurred without the programme.

The Indonesian programme was initiated solely for budgetary reasons, but over the same period international research had made it clear that kerosene use for lighting and cooking has adverse implications for both health and climate. In 2014, on health grounds, WHO—through its indoor air quality guidelines—recommended elimination of kerosene as a household fuel (WHO 2014). Kerosene's particle emissions are also nearly pure black carbon and it thus has a significant climate forcing impact (Lam 2012).

Although now claiming health and climate benefits, the Indonesian programme was not designed for evaluation of these benefits. Pertamina records, however, indicate that there was a major shift in LPG and kerosene sales, which must be having major benefits for both climate and health.

China: Like India, China had a major programme to introduce improved biomass stoves, which ran from around 1980 to the mid-1990s (Smith 1993). Unlike the Indian programme, however, it is credited as being a major success, introducing some 180 million stoves in rural areas during that period (Sinton 2004) and thus being one of the most cost-effective energy efficiency measures ever undertaken in the country.

As in India at that time, however, pollutant emission reductions were not part of the programme's objectives. Thus, while all the introduced Chinese stoves had chimneys and seemed to reduce indoor concentrations by 40 per cent or so when working well, there was little impact on outdoor pollution. As a result, by 2010, studies were beginning to show that the combination of biomass and coal combustion used for cooking and, in winter, space heating, was responsible for some 30 per cent of ambient air pollution exposures in the country (Liu 2016). One study showed that a major reduction in total exposure had occurred even before the major control measures taken in 2013, due to changes in household fuel that had occurred between 2005 and 2015 because of urbanization and economic growth, not policy (Zhao 2018).

In 2013, due to public and media pressure resulting from winter pollution episodes in Beijing and other cities, China embarked on a major programme of new controls for outdoor air pollution, including a range of actions. In 2017, the newly established Beijing–Tianjian–Hebei (BTH) air pollution control district introduced ambitious targets for eliminating solid fuel use in households across a wide area of that part of the country—covering both biomass and coal, for cooking and space heating (Zhao 2018).

The programme to date has focused on electrification for cooking with induction stoves and heat pumps, and introduction of piped

natural gas in villages where possible. LPG is also being promoted, but seemingly less so than the others, although future natural gas supplies are uncertain. Subsidies are provided to households for fuel/electricity costs for a few years, with some uncertainty as to the longer term.

It is ironic from the health standpoint that this large Chinese programme focuses solely on the ambient air pollution impact and does not consider the significant benefits to the households themselves from eliminating polluting fuels, as did the study mentioned above (Zhao 2018).

SUMMARY

From the health standpoint, any gaseous fuel—LPG, natural gas or biogas—or electricity are clean at the household level. Most improved cook stoves still struggle to meet indoor air pollution guidelines, especially with non-standardized biomass being used in reality on the ground. They need improvement in technology, development of value-chains of standardized fuels such as pellets and a strong push on innovative business models to effectively address operations and maintenance and after-sales-service issues. Biogas remains a sound option from a technology standpoint but most developing countries struggle with developing enterprise-led innovative business and operational models to provide biogas as a service. It does not seem to work well to rely on the skills of the households themselves to provide maintenance, repair and supply reliability.

Clean cooking energy could only be provided in a sustainable manner through service-based business models—be it for LPG, biogas, improved cook stoves with standardized fuel, or electricity. LPG and electricity are more promising solutions for clean cooking energy today, because of their service-based business models—

where the energy provider takes care of the supply. These supplies are not the most reliable in rural areas currently but the underlying delivery structure lends itself to scale and improvement.

While a suite of technologies needs to play a role in households' energy transition towards cleaner fuels, following are the key lessons from the LPG programme in India and across the three other major middle-income countries examined here:

- Better targeting of subsidies for economically weaker sections of the population accompanied by even greater reductions of subsidy among middle-class and well-to-do households is important to fiscally sustain LPG programmes.
- Application of modern IT methods offers efficient and transparent ways to administer and target subsidies.
- Given the productivity and health benefits compared to use of traditional solid fuels, programmes can be termed 'social investments', which has a major difference in connotation compared to 'subsidy'.
- Programmes with adequate targeting, such as the PMUY, help reduce the disparity in access to clean fuels across different social and income groups.
- Cleaner household fuels have a strong role to play in cleaning up ambient air pollution in many countries, including India and China.
- In India, Brazil and Indonesia, semi-private oil companies, which are still owned mainly by the government, have the operational scale needed to bring change quickly and respond to national needs for such social programmes.
- Once electrification has developed, shifting subsidies away from kerosene for lighting is good for public health and can lower government expenditures.
- Until households make a transition towards electricity-based

cooking, support for clean fuel for cooking programmes is required to enable sustained use of such fuels to support health and productivity.

In the longer term, most household energy in the world will probably be supplied by electricity, powered by non-carbon sources. In the medium term, however, just as Organization for Economic Cooperation and Development (OECD) countries are adopting to natural gas as an efficient, clean, and lower carbon transition fuel moving away from coal, LPG can serve a similar role for household cooking energy needs in low and middle-income countries, moving households away from traditional biomass.

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JOURNEY TOWARDS A GAS-BASED ECONOMY: DECARBONIZING INDIA FOR A SUSTAINABLE FUTURE

Dharmendra Pradhan

INTRODUCTION

Choosing the appropriate primary energy mix for fuelling the economy of a country is among the most critical decisions that governments and policymakers across the world have to make in the twenty-first century. People, in general, and the youth, in particular, have become vocal about their aspirations. At the same time, environmental concerns can no longer be cast away as inconsequential in the perennial growth versus sustainability debate. If anything, the growing frequency of natural disasters attributable to anthropogenic factors, such as the devastating floods in the southern Indian state of Kerala in August 2018, make it imperative that governments take the lead in mitigating and managing the adverse fallouts of climate change—while also delivering sustainable growth to the citizenry.