Cooking with cleaner fuels in India: a strategic analysis and assessment

This "Policy Briefs Series" is the culmination of a joint research on healthy cooking fuel options for India, carried out by TERI and AIIMS during 2009–10 with funding support from UNICEF. The findings are based on extensive primary and secondary research that included literature reviews, interviews, focus groups, and field studies in select villages of Haryana state.

The first brief, *Indoor Air Pollution: A Case for Change* presents the health implications of indoor air pollutants derived from less cleaner cooking fuels. Then, *Cooking Fuels in India: Trends and Patterns* tracks the usage and adoption of different fuels in rural and urban homes and also across select states in India. This brief *Choices for Change: Evaluating Cooking Fuels* discusses the advantages and disadvantages of different cooking fuels and their suitability for certain user segments. In conclusion, *Call for Change: Catalysing a Cleaner Future*! invokes all stakeholders–the governments, funding agencies, industry, and consumer groups–to work in a concerted manner to accelerate adoption of cleaner cooking fuels and secure a cleaner and healthier home.

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POLICY BRIEF

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CHOICES FOR CHANGE: EVALUATING COOKING FUELS

In this paper, we provide a comparative assessment—including adoption trends, challenges, and prospects—for different types of cooking fuels.

Biomass: stove designs and improvements

Typically, rural communities in India burn solid biomass in the form of twigs, wood, shrubs, crop residue or cow dung using a crude combustion apparatus—the *three-stone* fire. Combustion of solid biomass in such crude, low-efficiency cook stoves is generally incomplete, and releases significant amount of pollutants like particulate matter (PM), carbon monoxide, and volatile organic compounds.

More recently, manufacturers in the organized sector, such as Envirofit (Rocket Stove), Philips (Fan Stove), and others have introduced new stove models that incorporate design and material improvements and are significantly less polluting. Different cooking stoves can be compared using indices, such as heat-transfer efficiency, energy consumption, and pollution levels. Expectedly, the energy consumed in cooking and pollutant emissions are highest for *three-stone* fires and are lower for *Fan* and *Rocket* stoves.

Government agencies, as well as NGOs, have launched many initiatives and programmes to encourage the adoption of improved cook stoves. In summary, their experiences in the field have shown reduction in indoor air pollutants, although successful adoption of improved cook stoves depends on sustained use, supported with continuous technical assistance and maintenance.

A study led by Development Alternatives on improved cook stoves (*Sukhad chulha*) in Bundelkhand, Madhya Pradesh, from January 2003 to 2005 reported that the improved stoves reduced CO by 70% and $PM_{2.5}$ by 44%.[1] Similarly, Appropriate Rural Technology Institute (ARTI)'s improved cookstove—Lakshmi stoves—also yielded positive results in high-rainfall areas. These stoves reduced CO by 39% and $PM_{2.5}$ by 25%.[2]

Improved cook stoves present a desirable option for villages that are economically backward, difficult to be served with modern fuels, and have to partially or completely rely on traditional fuels.

The government is playing its role, too. It launched the '*National Biomass Cookstove Initiative*' in December 2009 that incorporated lessons from prior programmes, and was developed in consultation with experts and stakeholders. Through a series of pilot-scale projects that use commercially-available cookstoves, the government plans to encourage adoption of next-generation stoves and biomass-processing technologies. The initiative also includes plans to establish sophisticated testing, certification, and monitoring facilities, and strengthen R&D programmes in key technical institutions.

Biogas

Biogas is a clean and convenient fuel for cooking and lighting purposes that is derived from a local resource—animal dung—in an environmentally benign manner.

Methane-rich biogas is produced by the anaerobic digestion of organic wastes generated from cattle dung and animal waste, following a more complex process, even from some crop residue.[3] Biogas plants also provide high quality organic manure for sustaining soil fertility and facilitate management of animal waste.

The Government of India (GOI)'s Ministry of New and Renewable Energy (MNRE) promotes several biogas-generating plants/models through state nodal agencies. Subsidies are offered through Central Financial Assistance Schemes. Under its flagship programme, the *National Biogas and Manure Management Programme (NBMMP)*, MNRE reported the installation of 4.13 million family-type biogas plants in its 2009–10 Annual Report. This equates to a 33% achievement, when compared to a total potential of 12.34 million domestic biogas plants in India.

The NBMMP aims to provide fuel, and organic manure to rural households, mitigate drudgery of rural women, and improve sanitation in villages by linking sanitary toilets to biogas plants. The programme is implemented through state governments, nodal agencies, and the Khadi and Village Industries Commission (KVIC).

The biogas plants are predominantly deployed in areas that are rural rather than urban, where more convenient and easy-to-use fuel options like liquefied petroleum gas (LPG) prevail. Although use of biogas has been extensively promoted in India during the last three decades, these efforts have yielded mixed results. According to the data in the MNRE 2009–10 Annual Report, the top six states accounted for over 66% of the family-type biogas plants, whereas 15 states and union territories together claimed less than 1% of the total installed base of similar plants in the country.

Independent analysts and researchers have countered the government's claims of success, and

Biogas from food waste

Community biogas plants that run on food waste, instead of animal dung/manure as feedstock, have been developed by the GOI and NGOs.

Appropriate Rural Technology Institute (ARTI) has built a compact plant that is used by urban and rural households of Maharashtra. However, two major challenges have emerged: first, the model requires waste from multiple homes to generate sufficient energy to meet the cooking energy needs of a single household; and second, the technology requires willingness by the user household to handle, manage, and process the slurry generated from food waste.

[1] Chennagappa, *et al*. 2007. **Impact of improved cook stoves on indoor air quality in the Bundelkhand region in India.** *Energy and Sustainable development* **XI** (2)

[2] Smith *et al*. 2007. **Monitoring and evaluation of improved biomass cook stove programmes for indoor air quality and stove performance: conclusions from the household energy and health project.** *Energy and Sustainable development* **XI** (2), June 2007

[3] www.hedon.info/ImprovedCookstove

have identified low cattle-to-human ratio as a key factor that hampers widespread adoption of biogas plants in India. Other technical and commercial factors have also been cited to explain the slow growth of biogas plants in India. Faced with this challenge, some areas have even tried community-level biogas plants.

From a commercial perspective, biogas plants require large investments, and although they yield environmental benefits, they often do not lead to cash income.

In summary, it appears that while deploying biogas plants might be a challenge for households in general, these may be more easily adopted by eateries, *gaushalas* (cow barns), and dairy farms, which have the requisite size and scale to handle the nuances of managing and operating these plants. What would add further impetus to the programme would be a 'fool-proof, off-the-shelf' product. Of course, the user households have to be prepared to perform the daily chores of collecting and processing the feed for the biogas plant, be it kitchen waste or cow dung.

Kerosene

Currently, a small percentage of households use kerosene oil as their source of cooking energy. The All-India 2006–07 National Sample Survey Organization (NSSO) report points to a low 1% usage in rural homes, and 8% in urban households. In rural areas, kerosene loses out to 'free biomass' as a cooking fuel, and is mainly used for lighting. Even that use is on the decline with rise in rural electrification. Comparatively, in urban areas, the per capita usage is higher, but has been falling in recent years. Use of kerosene for urban cooking peaked during the 1970s and early 1980s, but the growth of LPG, coupled with difficulties in kerosene availability, shifted the demand away from this fuel.

The availability of kerosene is restricted and supplies are primarily routed through the public distribution system (PDS) at subsidized rates. Unfortunately, significant quantities of kerosene never make it to the targeted group, and are diverted to the open market. Here, it is sold at a premium and used for industrial applications, and even as an adulterant in diesel. The apex trade and industry group, The Associated Chambers of Commerce and Industry of India, estimates that 38% of the kerosene subsidy is diverted away from its targeted use, the cost of which to the exchequer works out to be ₹57 billion (August 2006).[4]

Various governmental groups, including the Kirit Parikh Committee (2010), have recommended reducing kerosene allocations and raising its PDS prices. These twin actions will lead to a reduction in subsidies. In order to contain the menace of unauthorized use and adulteration, the planners are considering distribution of PDS kerosene to below-poverty-line (BPL) families through smart cards with biometric identification.

Liquefied Petroleum Gas (LPG)

As of April 2010, government publications report that LPG reaches 105.6 million domestic customers in India. What remains unclear is the actual number of households that use LPG, since the above data includes multiple connections.

LPG was introduced in India in the early 1960s, but its growth remained rather limited during the

Improved access, supported by a vibrant clean energy campaign, may aid more households in their transition to LPG, which has in the past, lost out to the 'free fuel from the backyard' in rural areas.

Rajiv Gandhi Gramin LPG Vitrak Scheme

In October 2009, the Government of India announced the Rajiv Gandhi Gramin LPG Vitrak Yojana (RGGLVY), an initiative aimed at setting up small-size LPG distribution agencies to extend the availability of LPG in rural areas.

This scheme is initially being launched in eight states covering over 1,200 locations, where the reach of LPG is very low. The RGGLVY programme is also considering plans to offer gas connection without payment of security deposits to below-poverty-line (BPL) families.

[4] http://www.assocham.org/prels/shownews.php?id=646

first two decades. Penetration rose sharply in the 1980s following considerable expansion of refining capacities and addition of new refineries.

LPG is sold at a controlled price to the domestic consumer, and the government and oil companies upstream and downstream share this burden. These subsidy levels have fluctuated over the last decade, and recently hovered around ₹250 per cylinder (14.2 kg gas content).

Currently, 83% of the LPG distribution network is in urban areas. Considering this imbalance, it is not surprising that the beneficiaries of these subsidies are mainly the urban populace as reflected by the urban usage pattern.

Several researchers and policy-makers have argued for a more market-based approach that reduces, and even eliminates, subsidies. They have suggested alternative approaches like capping the subsidy and/or targeting the subsidy for lower income groups. A case in point: the Parikh Committee[5] suggested increasing the retail price of the LPG cylinder (14.2 kg) by at least ₹100, which, in turn, would reduce the subsidy burden by ₹75 billion.

Many marketing initiatives have also been suggested to encourage the adoption of LPG. These include waiving the upfront cost for new connections and launching small-sized cylinders.

As part of the 'Vision-2015' adopted for the LPG sector, overall LPG coverage is targeted to reach 75% of the national population, which translates to adding 0.055 billion new customers by 2015.[6]

Although these plans have the potential to benefit a large section of the population, at the same time they impose a financial burden on the government. As Figure 1 shows, India imports LPG to augment its domestic production. This entails spending foreign exchange resources to import LPG, and then bearing the subsidy cost when LPG is sold at the retail level to the domestic users.

In any case, even a marginal/partial climb in adoption would be a step towards a healthier environment. Improved access, supported by a vibrant clean energy campaign, may aid more households in their transition to LPG, which has in the past, lost out to the '*free fuel from the backyard*' in rural areas.

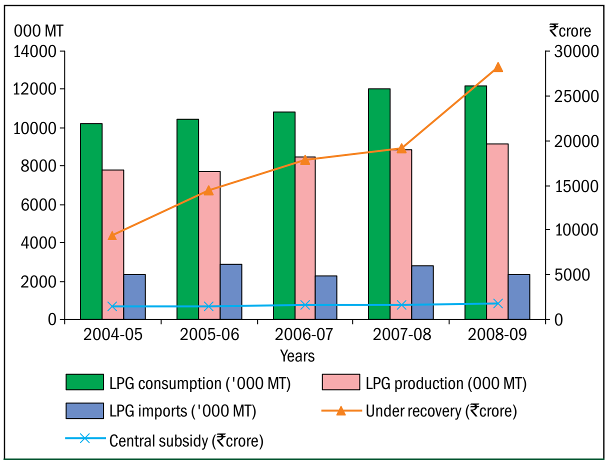


Figure 1 LPG Trends

One of the oft-cited reasons for poor penetration or transition to LPG in rural areas has been its affordability for the end user. Nationally, India has an average monthly per capita expenditure (MPCE) of ₹695 for rural residents and ₹1,312 for urban residents. In comparison, LPG users in urban areas report average MPCE of ₹1,627, with their rural counterparts pegged at ₹1,274. Those rural segments that have MPCE close to this number can be potential targets of the improved network of LPG.

Differential pricing is yet another possibility, but it is prone to abuse and would also impose a heavy burden on the exchequer. In order to reach out to BPL families and make LPG affordable, several strategies have been proposed, prominent among these is the unique-sized cylinder (5 kg) that would entail smaller and more affordable individual transactions. In another innovative programme, HPCL, a gas marketing company, has launched LPG-based community kitchens in rural areas and hard-to-reach populations.

Piped Natural Gas (PNG)

India is investing heavily in the infrastructure required to support increased use of piped natural gas, which is composed primarily of methane. Under the Vision 2015 plan, the government intends to provide PNG to more than 200 cities by 2015.

[5] GoI Report of Expert Group on 'A Viable and Sustainable System of Pricing of Petroleum Products', 2 February 2010.

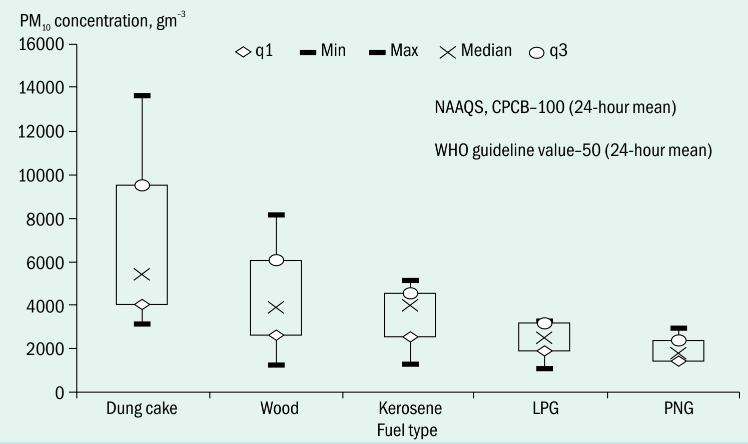
[6] Ministry of Petroleum and Natural Gas, GOI, Annual Report 2009–10

Concentrations of air pollutants during cooking in rural areas

The TERI team assessed the quality of air during the process of cooking in 55 households in three villages of Haryana. Air pollution levels for particulate matter–size up to 10 and 2.5 microns in aerodynamic diameter (PM_{10} and $PM_{2.5}$), carbon monoxide (CO), polycyclic aromatic hydrocarbons (PAHs), benzo(a)pyrene (BaP), and total volatile organic compounds (VOCs) were assessed in the cooking areas. While particulate matter is primarily associated with respiratory problems, benzene among VOCs, and BaP are known to increase incidence of cancer.

Major findings of the research team are summarized as follows.

- Air monitoring of cooking area during winters revealed a wide range of pollutant levels for different cooking fuels in use.
- Highest levels of pollution in the cooking area were recorded among animal dung users (18 households), followed by households using crop residue (15 households), kerosene (4 households), and LPG (10 households). Lowest pollution levels were recorded in houses using PNG (4 households).
- Households using animal dung or crop residue as cooking fuel exhibited extremely high geometric mean levels for PM_{10} (5,000 and 3,000 µg m^{-3}) and $PM_{2.5}$ (4,000 and 2,000 µg m^{-3}) concentrations during cooking. The chart below depicts the pollution intensity for households using each type of fuel.



- High levels of CO were recorded for animal dung and crop residue users. CO levels exceeded CPCB standards for one hour (4,000 µg m^{-3}) and exhibited three times higher CO levels than LPG users.
- Benzene levels for biomass users (average levels of 110 µg m^{-3}) were nearly 10 times higher than that of LPG households. These were within the National Institute of Occupational and Safety Health (NIOSH) recommended exposure limit for benzene (at 319 µg m^{-3}), although the levels were higher than the CPCB standard (5 µg m^{-3}) for outdoor air. Earlier studies have reported benzene in households using kerosene in India having average indoor levels of 103 µg/m^3.
- Households using kerosene exhibited the highest level of the 16 PAHs, which were analysed. The concentration of carcinogenic PAHs for kitchens using kerosene was found to be seven times higher than kitchens using LPG. BaP, a carcinogenic PAH, was found to be highest among households using animal dung, followed by households using wood and kerosene (12.25, 7.76, and 7.28 µg m^{-3}, respectively). These levels exceed the standard of 1ng m^{-3} set by CPCB for outdoor air quality.
- According to these air quality measurements, rural women cook in an environment where pollution levels are well above the WHO and Central Pollution Control Board (CPCB) standards for PM_{10} and $PM_{2.5}$ for ambient air. This high level of pollution in rural environment is caused either by the cooking fuel used in the house or because of the fuel pattern in the neighbourhood.

Currently, at the end-user level, PNG is priced marginally cheaper than LPG. The advantage in promoting PNG for rural and urban homes lies in its uninterrupted supply, and the assurance of subsidy reaching the targeted families. Moreover, users can control their expense by regulating the amount consumed at the household level. Targeting PNG at villages, which are along the path of the gas pipelines that snake through the country, can be especially beneficial, without the hassle of intermediaries or associated transportation costs.

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Resistance from gas marketing companies to selling PNG in rural areas is understandable, as the rate of economic return from a village is less in comparison to revenues generated from densely populated cities. Another reason often cited by marketing companies to explain the poor rural network is the *kutcha* (weak and temporary) infrastructure, and quality of dwelling units in rural areas.

Incentives can be introduced to expedite development of the rural network. State governments can also mandate rural expansion of PNG pipelines when awarding distribution contracts to gas marketing companies. Villagers of Dayalpur in Faridabad district of Haryana have witnessed the benefits of clean cooking fuel after the gas provider in the region extended the PNG network to the village.

Electrical energy and renewable energy

Unlike the developed world, where electrical cook stoves and ovens are mainstream, the use of electrical energy as primary cooking fuel is almost non-existent in India. According to the data carried in the NSSO 63rd Round, 2006–07, only 0.3% of urban homes and even lesser number of rural homes reported the use of electrical energy as their primary cooking fuel. Although this seems negligible overall, in urban areas, the use of electrical cooking is fairly common, but is used as a secondary energy source mainly to run ovens, microwaves, and other kitchen appliances. In rural areas, the almost total absence of electrical cooking is due to low electrification and high shortages of electricity supply.

In recent years, the Indian government has been very active in promoting renewable sources of energy—solar thermal, solar photovoltaic, wind, and biomass—especially in rural areas. Since solar energy is abundantly available, the government is trying to promote solar cookers, not to necessarily replace conventional fuels, but to help in substituting traditional fuels to some extent.

Different types of solar cookers have been developed. MNRE also provides financial support for installation of solar cookers.

Conclusion

The merits and limitations of each type of cooking fuel have been enumerated in the discussions above. In each section, the opportunities and potential target groups for each fuel have also been identified.

From an engineering perspective, one can endlessly debate the advantages of one fuel type over another. However, in the broader Indian context, given the country's geographical, infrastructural, social, and demographic diversity, it would be more appropriate to adopt a hybrid strategy that uses a combination of fuels, each targeted at a specific region, segment or social strata. For each such community, the focus should be to promote fuels that are easily *available*, *affordable*, and *acceptable*, while migrating people towards a cleaner and energy-efficient choice. Clearly, such an approach would be holistic and inclusive!