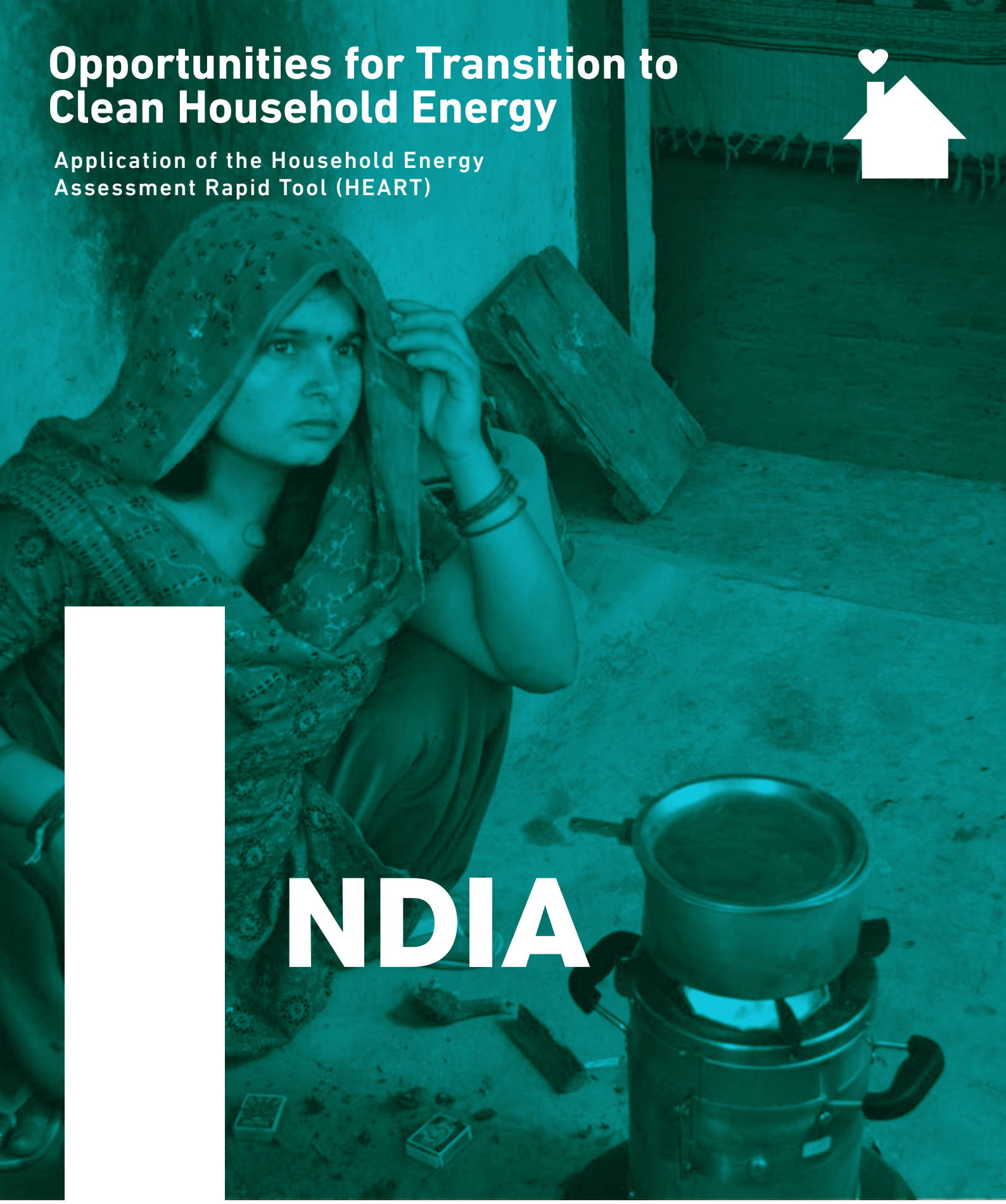
Opportunities for Transition to Clean Household Energy

Application of the Household Energy Assessment Rapid Tool (HEART)



INDIA

World Health Organization

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Opportunities for transition to clean household energy: application of the Household Energy Assessment Rapid Tool (HEART) in India

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Contents

Abbreviations and acronyms

BPL	below the poverty line
CAG	Comptroller and Auditor General of India
COPD	chronic obstructive pulmonary disease
DDUGJY	*Deen Dayal Upadhyaya Gram Jyoti Yojana*
DWCD	Department of Women and Child Development
FPS	fair price shop
HAP	household air pollution
HEART	Household Energy Assessment Rapid Tool
JGSY	*Jawahar Gram Samriddhi Yojana*
LED	light emitting diode
LPG	liquefied petroleum gas
MNRE	Ministry of New and Renewable Energy
MoHFW	Ministry of Health and Family Welfare
MoPNG	Ministry of Petroleum and Natural Gas
NCD	noncommunicable disease
NGO	nongovernmental organization
NITI Aayog	National Institutions for Transforming India
NSS	National Sample Survey
PDS	public distribution system
PHFI	Public Health Foundation of India
PM	particulate matter
$PM_{2.5}$	particles that can pass through a size-selective inlet with a 50% efficiency cut-off at 2.5 µm aerodynamic diameter. $PM_{2.5}$ corresponds to the "high-risk respirable convention" as defined in ISO 7708:1995, 7.1
PMUY	*Pradhan Mantri Ujjwala Yojana*
TERI	The Energy and Resources Institute
TSP	total suspended particles

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Preface

Household air pollution (HAP) from inefficient fuel combustion is one of the most important global environmental health risks today. Almost 3 billion people, mainly in low- and middle-income countries, still rely on solid fuels (wood, animal dung, charcoal, crop wastes and coal) burnt in inefficient, highly polluting stoves for cooking and heating. In 2012 alone, no fewer than 4.3 million children and adults died prematurely from illnesses caused by such HAP. Widespread use of polluting cookstoves causes some 4 million premature deaths annually among children and adults from respiratory illness, cardiovascular diseas and cancer, as well as serious injuries from scalding, burns and poisoning. Widespread use of kerosene stoves, heaters and lamps also results in many serious injuries and deaths from scalds, burns and poisoning.

The WHO Guidelines for indoor air quality: household fuel combustion (2014) are addressed to public health policy-makers and specialists in energy, environmental and other issues to introduce the best approaches to reducing HAP: the greatest environmental health risk in the world today.

The Household Energy Assessment Rapid Tool (HEART) was developed by WHO and is being pilot-tested for use in conducting rapid situational assessments and stakeholder mapping of a country's readiness to address access to clean energy technologies. The objective of this tool is to gather and synthesize information on household energy use and its public health impacts in a country and use the information to stimulate informed discussion on evidence-based impacts of household energy interventions, shared responsibilities and coordinated actions, country-specific barriers to implementation and opportunities for the public health sector to accelerate the transition to clean household energy.

The rapid assessment does not take the place of the detailed economic evaluation required in identifying national energy priorities, national and global mapping of disease prevalence associated with polluting fuels, nor the social and political considerations required for implementing major social interventions to support a transition to clean energy. It does provide a broad overview of the current household energy and health situation, identifies key stakeholders and will ultimately support intersectoral cooperation. This report presents the results obtained with HEART in India.

1 Context

1.1 Geographical context

Much of India's population depends on forests and other trees for fuelwood. According to a report on the state of forests in 2015 *(1)*, the total forest and tree cover is 701 673 km^2, or 21.3% of the total geographical area of India.

India is an agrarian economy: about 60% of the land area is used for agriculture. The agriculture sector provides livelihoods and employment to more than 48.9% of the workforce and contributes around 17.4% to the gross domestic product *(2)*. From its huge agricultural land area, India produces a substantial amount of crop residue both on and off farms. The pattern of use of crop residues for domestic energy varies by region.

Livestock rearing is an integral part of the agricultural system, resulting in large quantities of manure from cows and buffalos. The most common uses of manure are application to the land as a fertilizer or directly as a fuel.

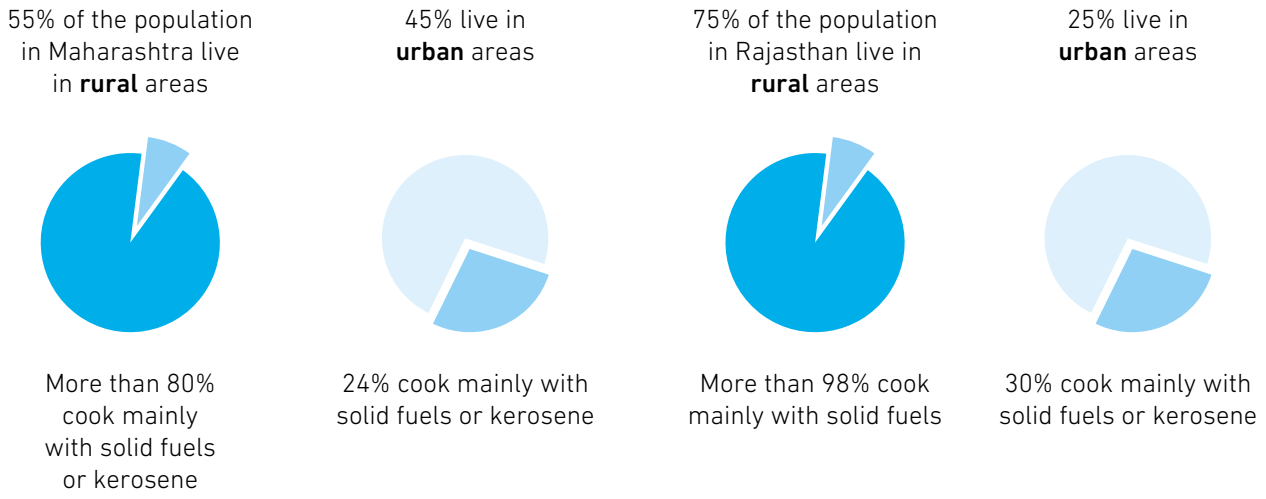
1.2 Demographic and economic factors

The energy choice and transition trajectories at household level are influenced by demographic and economic factors. The 2011 census report estimated the total population of India to be 1.2 billion, a 17.7% increase since 2001.

Urbanization is a major demographic driver of energy demand. The amounts and types of energy used by rural and urban households will continue to differ significantly. In 1991, the level of urbanization in India was 25.73%; in 2001 it had increased to 27.82%, and in the 2011 census it was 31.14% (Table 1 and Fig. 1).

↓ ***Table 1.*** *Key demographic and economic indicators*

	India		Maharashtra		Rajasthan	
Population (millions)	1210	377 (urban) 833 (rural)	112	51 (urban) 61 (rural)	68	17 (urban) 51 (rural)
Sex ratio (females to males)	940		929		928	
Nominal gross domestic product	US$ 2.45 trillion *(3)*	11.54 (2013–2014 percentage growth)	US$ 390 billion *(4)*	7.55 (2013–2014 percentage growth)	US$ 115 billion *(5)*	11.86 (2013–2014 percentage growth)



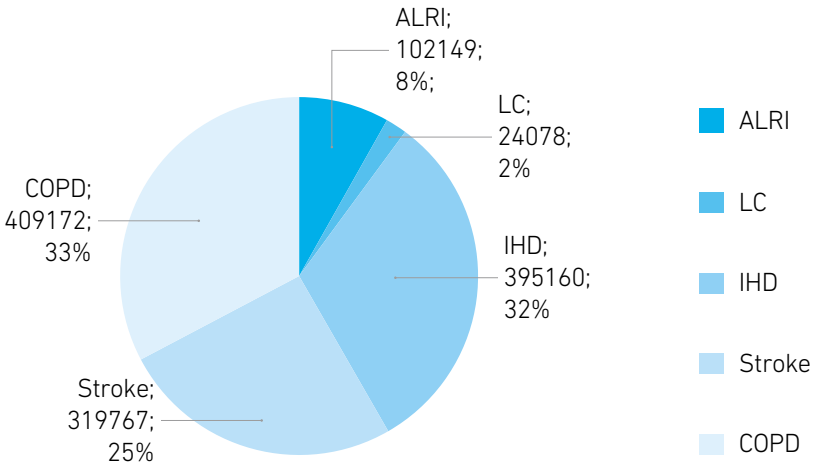
↑ ***Fig. 1.*** *Demography and energy status, Maharashtra and Rajasthan*

Source: 2011 census.

2 Health sector data

The evidence base on the health impacts of exposure to HAP in India consists of numerous epidemiological studies, starting from the early 1980s *(6)*. The studies addressed a range of health outcomes in women and children, including acute lower respiratory infections, chronic obstructive pulmonary disease (COPD), lung cancer, tuberculosis, low birthweight and cataracts, as catalogued by Balakrishnan et al. *(7)*. Many of the studies were based, however, on qualitative indicators of exposure, including data collected in demographic health surveys, on the type of fuel used for cooking and proximity to the source of exposure.

It has been estimated that exposure to HAP caused over one million deaths per year in India in 2012 and that chronic cardiovascular and respiratory diseases and acute lung and respiratory infections in children are the main causes (Fig. 2). The latest edition of the *Global burden of disease (8)* showed that HAP was the fourth most important risk factor for mortality and morbidity in India.

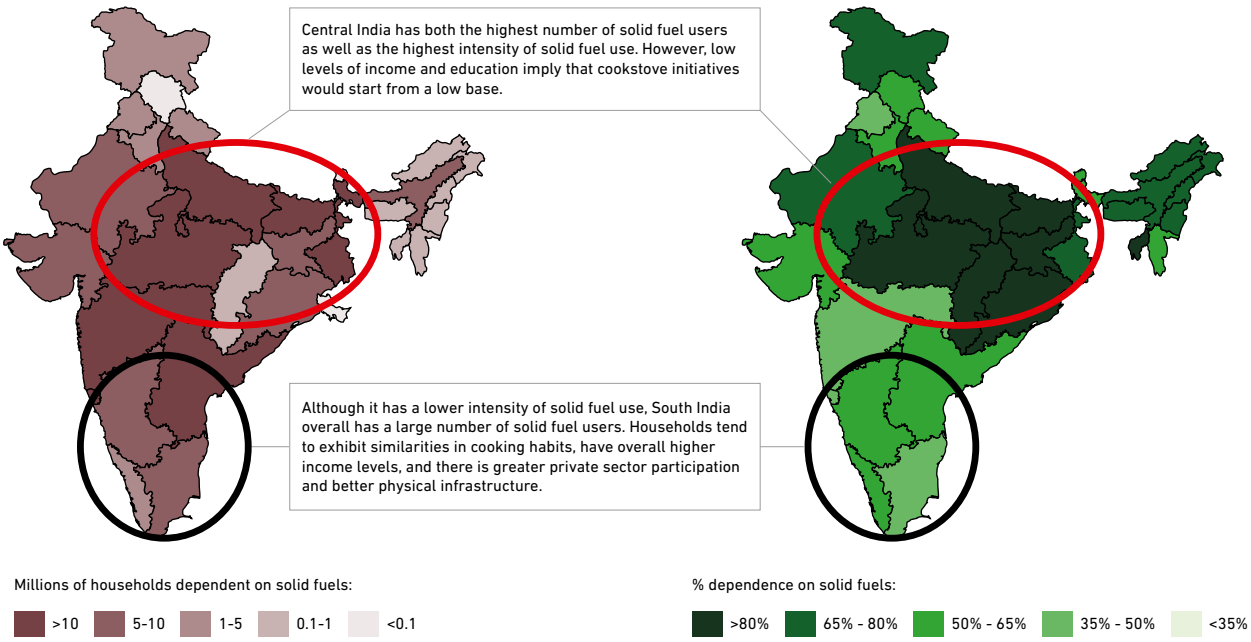


↑ ***Fig. 2.*** *Deaths attributable to household air pollution exposure in India, 2012*

COPD, chronic obstructive pulmonary disease; LC, lung cancer; ALRI, acute lower respiratory infection; IHD, ischaemic heart disease.
Source: reference *8*.

The impact of HAP has been decreasing steadily over time, morbidity per 100 000 population decreasing from more than 5000 in 1990 to around 1730 in 2016, primarily due to decreasing background disease rates.

Women and their young children are the worst affected. They are exposed to particle concentrations of 500–1500 µg/m^3 during cooking, far above the levels prescribed in WHO's air quality guidelines *(9, 10)*. The number of solid fuel users and intensity of solid fuel use are depicted in Fig. 3.



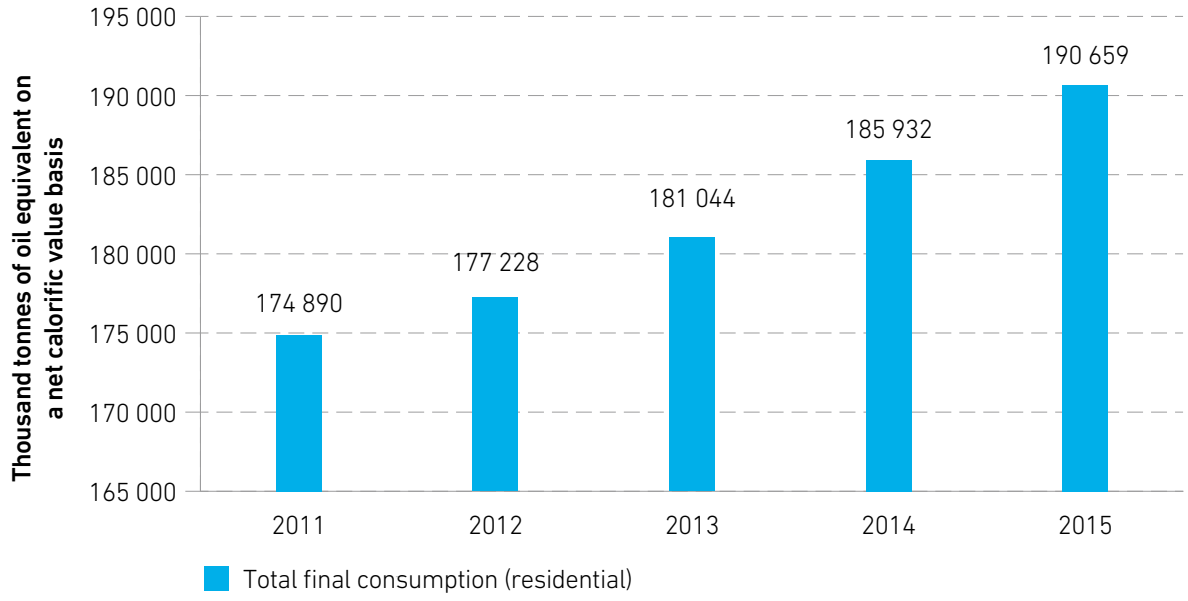
↑ ***Fig. 3.*** *Distribution of solid fuel users in India (millions of households) on left; Intensity of dependence on solid fuels (% of households) on right*

Source: reference *11*.

3 Household energy – the current situation

3.1 Household fuel share

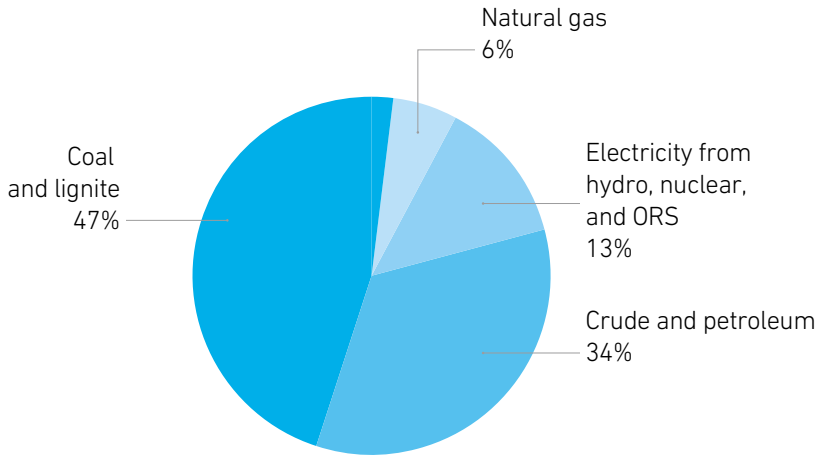
Rapid urbanization and the quest for economic growth, poverty alleviation, modern lifestyles and improved quality of life are increasing the demand for primary energy sources. For example, in the residential sector between 2011 and 2015, a growth of 9% in total final energy consumption was recorded (Fig. 4).



↑ ***Fig. 4.*** *Total final energy consumption in the residential sector*

Source: reference *12*.

Currently, fossil fuels dominate India's energy mix. Hence, most of the existing demand is met with nonrenewable sources of energy. During the financial year 2015–2016, fossil fuels constituted over 80% of India's energy consumption mix (Fig. 5).



↑ ***Fig. 5.*** *India's energy mix during 2015–2016 (percentage share of each fuel type)*

ORS, other renewable energy sources.
Source: reference *13*.

The residential sector, comprising more than 1 billion inhabitants, was estimated to have consumed 24% of the total electricity (which is generated primarily from coal), 11% of the total natural gas and 20% of the total petroleum products in the country between 2015 and 2016 (Fig. 6).

The country is now attempting to move from fossil fuels in order to protect the environment. At household level, however, particularly in rural and remote areas and in urban slums, the transition to clean technology and modern fuels remains a challenge despite the new policies. It is difficult to assess exactly how much progress has been made towards modern household fuels owing to the lack of comprehensive national surveys since the last census in 2011. A good national household energy survey is urgently required (see recommendations in section 7.3).

In the 2016 edition of the International Energy Agency's *World energy outlook (14)*, for example, it was estimated that more than 700 million people relied on inefficient burning of solid biomass for cooking and that more than 100 million lacked access to electricity, but these estimates are based on conditions in the early part of the decade. Since 2015, national liquified petroleum gas (LPG) programmes have added an additional 60 million consumers (more than 120 million people) supplied by public sector oil marketing companies, and 99% of the 18 452 census villages that had not been electrified by 2015 now have electricity, although this has not been verified by a reliable survey.

In most Indian households that lack access to modern energy sources, cooking accounts for a significant proportion of energy consumption. The National Institution for Transforming India (NITI) Aayog[1] recently promulgated its India Energy Security Scenarios, 2047 tool,[2] which allows modelling of various scenarios for cooking and other household energy demand and supply issues. It is assumed that an average total energy of 1104 TWh annually is currently used for domestic cooking in Indian households *(15)*. The average energy required per day for cooking per household with modern energy (electricity, LPG, piped natural gas), taking stove efficiency into account, is approximately 7 MJ/day. NITI Aayog *(16)* has estimated that 8–10 LPG cylinders, 170 standard m^3 of piped natural gas or 1022 kWh of electricity are consumed annually for cooking. The concept of "useful energy" in cooking does not work well for comparing solid with liquid, gaseous or electric fuels. Solid fuels burn for much longer, both before and after cooking, thus producing smoke well beyond the cooking period, while stoves with modern fuels can be turned on and off nearly instantly. With regard to electricity, the tool calculates that lighting and major appliances

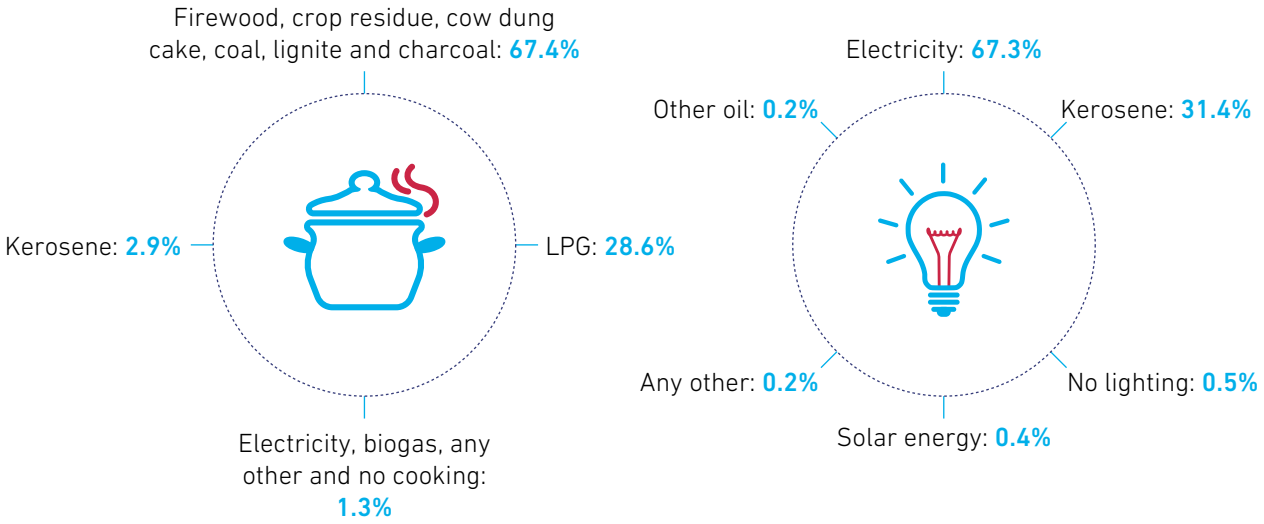
1 In 2017, NITI Aayog presented a draft national energy policy, which is currently open for public consultation.
2 The tool was developed by NITI Aayog in partnership with institutions in and outside India. The tool is accessible at: http://www.indiaenergy.gov.in/iess/what_IESS.php.

such as ceiling fans, televisions, refrigerators and air conditioners consume almost 80% of the electricity used in households.

In recent years, with the introduction of targeted schemes by the Government, the coverage of village and household electrification and residential LPG fuel has increased substantially. Although data about physical access and coverage of village and household electrification and residential LPG coverage are available, no recent survey or evaluation report on the scale of the census is available. Most of the progress has been achieved since completion of the 2011 census and the 68th round of the National Sample Survey (NSS). A more detailed discussion on each of the major fuel sources – solid biomass, coal, kerosene, LPG and electricity – is provided in the following sections.

At household level, the two major uses of energy that are captured in the available large surveys,[3] the census and the NSS, are lighting and cooking.[4] As noted above, however, the new initiatives taken since the last national surveys mean that the situation is likely to have changed, perhaps significantly. Nevertheless, the present study had to rely on the available information.

In the 2011 census, a sharp contrast in the levels of access to electricity for lighting and access to clean cooking was observed (Fig. 6).



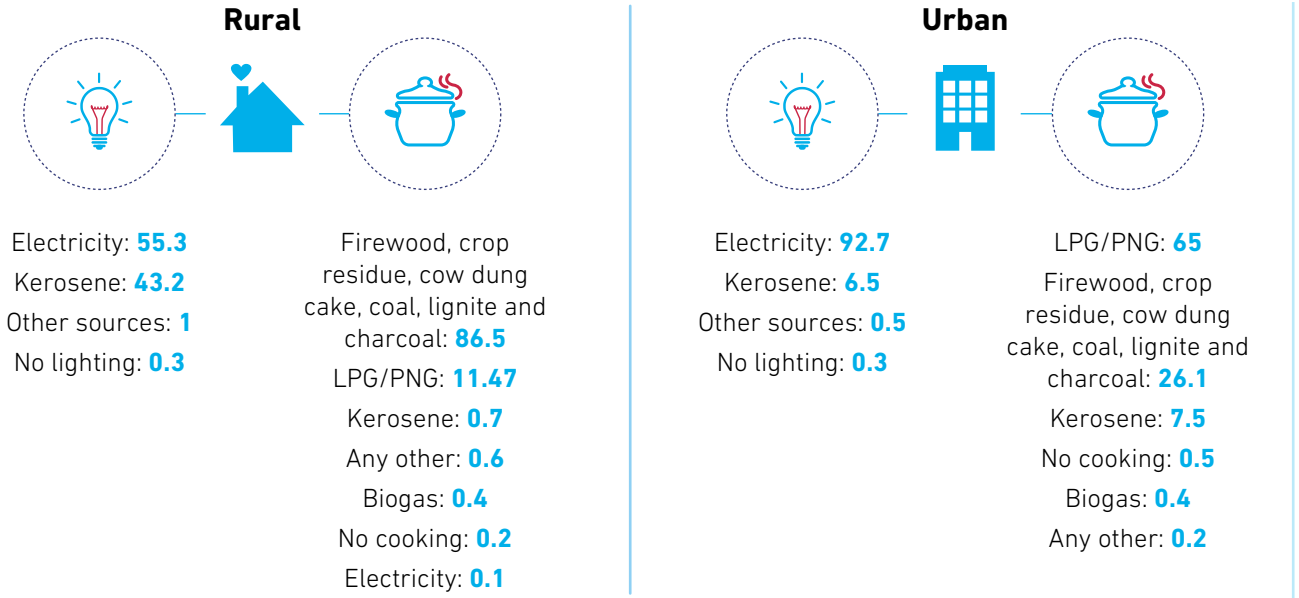
↑ ***Fig. 6.*** *Access to fuel sources for cooking and lighting in India*

LPG, liquefied petroleum gas.
Source: 2011 census.

For cooking, 67.4% of households were reported to use primarily solid biomass, and 2.9% used kerosene. The national LPG coverage in the residential sector was reported to be 28.6% (2011 census). Although 67.3% of households reported using electricity as the primary source for lighting, an almost negligible percentage (0.1%) reported using electricity for cooking. A significant percentage of households (67.3%) reported that they used kerosene for lighting.

The disparity between rural and urban areas is evident in the 2011 census. In rural areas, more households relied on solid biomass for cooking and kerosene for lighting and cooking (Fig. 7). In urban areas, access to energy is a challenge in slum areas, particularly in unauthorized slums. Around 4.5 million and 1.9 million households in slums were reported to use solid biomass and kerosene for cooking, respectively, and 1.1 million households were reported to use kerosene as an energy source for lighting.

3 Most large surveys, such as the census of India and the NSS, do not capture data on energy sources used for space heating, boiling water or heating food for livestock in the home.
4 None of the more recent sources of household energy uses is as large as the 2011 census and the NSS (68th round conducted between July 2011 and June 2012).



↑ ***Fig. 7.*** *Energy access in rural and urban areas (in percentages) as per the 2011 census*

LPG: liquefied petroleum gas; PNG: piped natural gas.
Source: reference *17*.

3.2 Biomass fuels

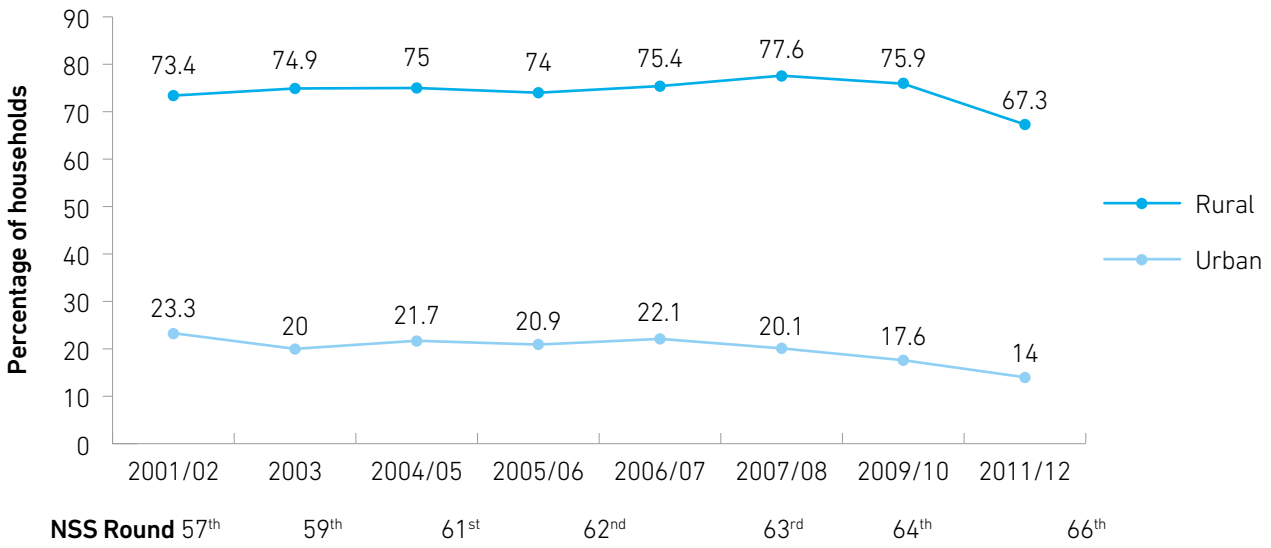
Although biomass is a renewable energy resource, it burns inefficiently in traditional stoves, resulting in emission of a range of air pollutants and particulates. Similarly, kerosene, which is often considered a modern fuel, increases the concentration of pollutants such as black carbon in the home when used in traditional cookstoves for igniting a fire or in kerosene wick lamps. WHO *(18)* reported that almost 30% of outdoor air pollution in India comes from household sources and that HAP is responsible for 29.6% of the ambient particulate matter ($PM_{2.5}$).

There is a growing literature on the difficulties of finding an adequate amount of biomass for cooking in some parts of the world *(19)*. On average, women who use traditional stoves spend up to 374 h every year collecting firewood *(20)*. In mountainous regions such as Himachal Pradesh, the difficult terrain increases the drudgery of women, who usually carry biomass on their heads. In the State, biomass is also used for space heating and for boiling water, adding to the amount or frequency of fuelwood collection *(21)*.

3.2.1. Household use

Biomass fuel use for cooking is common in India, in both rural and urban areas. The free availability and cost of biomass fuels significantly influences the scale of its consumption and choice over other fuel options.

The consumption pattern of biomass like fuelwood differs in urban and rural India (Table 2 and Fig. 8) and between rich and poor Indian states. Households in poorer states use biomass like fuelwood, dung, charcoal and crop residues, while richer states use more modern fuels. For example, the 68th round of the NSS indicated that nearly 10% of rural households still cooked with dung. Biomass fuels are also used for space heating, particularly in the hilly regions of north and north-eastern India. Biomass is also burnt to heat animal fodder and bathwater in many parts of the country.



↑ ***Fig. 8.*** *Proportions of rural and urban Indian households in which fuelwood is the primary energy source for cooking, 2001–2012*

Source: Compiled from various NSS reports.

↓ ***Table 2.*** *Proportions of rural and urban households that use firewood and chips as the energy source*

	India	Maharashtra	Rajasthan
Rural	67.3	62.1	89.3
Urban	4.0	57.0	18.7

Source: reference 22.

3.2.2. Environmental and social impacts

India is a major consumer of biomass fuels (wood, crop residues, dung and charcoal). In 2011, the results of the forest survey showed that fuelwood supplies about 40% of the country's cooking and heating energy needs, making India the largest global consumer of fuelwood *(23)*. The consumption of fuelwood and timber in the country was 23.5 and 40 million m^3, respectively, as compared with the availability of 40 million m^3 and 15 million m^3 from forests.

Although forests fall under the Indian Constitution, each state has its own system for regulating the procurement of fuelwood. Over the past few decades, the Government has implemented several policies on fuelwood. In 2009, the Ministry of Environment and Forests issued a notification to restrict the use of fuelwood by commercial establishments for cooking and bonfires. Only LPG is allowed for use as a fuel for commercial establishments, including hotels. Although an action plan for implementing this notification was proposed, no concrete steps have been taken to ban commercial use of fuelwood.

Not all firewood is free, and expenditure on fuelwood remains high in many areas. Fuelwood is harvested to meet the demand not only of rural households but also of urban areas close to forests (see Table 2). The average person in rural India spends about Rs 48 per month on fuelwood, while urban dwellers spend Rs 13, although many households do not pay at all (see Table 3). Paying for fuelwood is therefore not just an urban phenomenon.

Table 3 illustrates the impact of the use of solid fuels for cooking on people's lives, with the estimated time spent gathering fuelwood, the cost and estimated consumption.

↓ ***Table 3.*** *Time spent collecting fuelwood, cost and consumption*

Time spent collecting fuel	Fuel cost (Rs/GJ)		Estimated mean consumption (MJ/capita/annum)	
• 2.74 h per adult per week • 16 min per girl per week • 10 min per boy per week	Urban	80	Urban	1000
	Rural	62	Rural	3250

Sources: references *24* and *25*.

Indian rickshaw pullers warm themselves around a fire in Amritsar. The northern Indian city of Amritsar faces severe cold conditions with the temperature dipping towards the zero degree Celsius mark. Credit: Getty Images/AFP/Gnarinder Nanu

3.2.3. Production and distribution of biomass pellets

Biomass pellets are mostly used in India for residential cooking and heating (with pellet stoves) and/or commercial purposes. A number of companies in India produce and distribute energy-efficient biomass pellets with the aim of replacing LPG and thereby reducing direct carbon dioxide emissions. Industrial-scale manufacture of renewable solid fuel pellets and briquettes is making them more affordable, and production is expanding exponentially. At present, more than 250 factories in India manufacture biomass pellets for cooking fuel, mainly for commercial and industrial use rather than for households *(26)*.

For example, more than 400 000 stoves with a combination of a uniquely designed "micro-gasification" device or stove and biomass-based pellet fuel were sold in India between 2006 and 2010, although this type of stove is no longer being sold *(27)*.

The scope of the pellet fuel industry to meet household needs for clean energy in India appears to be large, given the biomass surplus available from agriculture, forestry and wasteland (for biomass pellet production), which was estimated to be 242 Mt in 2010–2011 and is expected to rise. Simple energy economics and local experience in India indicate, however, that the market for pellets will be dominated (and thus the price determined) by the commercial and modern sectors, where they are valuable fuels, as is the case for other biofuels, such as bioethanol. Creating a separate supply system for poor and rural households at a different price would therefore be difficult or impossible.

3.2.4. Stove types

India has perhaps the longest history of any country in the public and nongovernmental organization (NGO)-funded development and use of "smokeless *chulhas*" or "improved" biomass cookstoves, since the 1950s *(28)*. A large national programme, the National Programme for Improved *Chulhas*, ran over 20 years from the early 1980s, involving international agencies such as the World Bank and the International Development Research Centre. Many states had their own programmes, and hundreds of NGOs, both national and local, participated, with dozens of stove models developed.

The National Biomass Cookstoves Initiative was launched by the Ministry of New and Renewable

Energy (MNRE) on 2 December 2009 with the aim of increasing the use of improved biomass cookstoves. The initiative included setting up modern testing, certification and monitoring facilities and strengthening research and development. The aim was to design the most efficient, cost-effective, durable, easy-to-use device. A new initiative for improved cookstoves was undertaken by the MNRE at the Indian Institute of Technology, New Delhi, during 2009–2010 to assess the status of various types of improved *chulha*s, their suitability and delivery mechanisms.

As a follow-up to the National Biomass Cookstoves Initiative, the Ministry issued revised standard and test protocols for portable natural and forced draft types of improved domestic and community biomass cookstoves, which was published by the Bureau of Indian Standards in August 2013. Accordingly, the test facilities were strengthened with advanced equipment and testing methods for performance testing of cookstoves.

The MNRE maintains a list of models it has approved on the basis of their performance in accordance with the Bureau of Indian Standards 13152 (part 1) 2013 specification in tests conducted at MNRE-supported test centres. To be eligible for subsidies under the MNRE programme, stoves must comply with the performance requirements shown in Table 4.

Air pollution monitoring equipment is suspended on a wall at household in India
Credit: Heather Adair-Rohani

↓ ***Table 4.*** *Standard performance parameters for biomass cookstoves*

Type of biomass cookstove	**Standard performance parameters**		
	Thermal efficiency (%)	CO (g/MJ per day)	PM (mg/MJ per day)
Natural draft	Not less than 25	≤ 5	≤ 350
Forced draft	Not less than 35	≤ 5	≤ 150

Source: reference *29*.

The limits in Table 4 are, however, far higher (less restrictive) than those promoted by either WHO in its guidelines for indoor air quality *(10)* or the International Organization for Standardization in its interim standards *(30)*. For example, the best household stove by far in the appendix of the MNRE report, the forced-draft XXL Eco *chulha*, which meets Indian standards, has a measured rate of particulate emission of 56 mg/MJ. This metric is a different from that used in international guidelines and is not health-related, but is roughly equivalent to 1.6 mg/min in Indian conditions or about seven times that recommended by WHO for unvented stoves to protect 90% of Indian households (0.23 mg/min). Thus, the Indian standard could be improved to reflect current thinking on how clean stoves should be to protect health.

3.3 Coal use

While a certain amount of coal and lignite are used as cooking fuel in the country, their use is higher in the coal-rich states of Jharkhand, West Bengal, Chhattisgarh, Meghalaya and Manipur. Therefore, tailored policies could be introduced in those states.

3.4 Kerosene use

3.4.1. Household use

Kerosene is used as a supplementary fuel for lighting and cooking in rural areas with no electricity supply and in urban areas with limited LPG penetration. Dependence on kerosene as a primary fuel for cooking or for lighting has decreased in India, and it is used much less for cooking than for lighting. The 2011 census indicated that kerosene is used as the primary cooking fuel in only 0.7% and 7.5% of all rural and urban households, respectively; however, 86.5% and 26.2%, respectively, rely primarily on biomass (including firewood, chips, dung cake and crop residues) for cooking but use kerosene to light the fire in the cookstove.

In 2011, 33% of the 247 million rural households in India had no access to grid electricity, and about 95% depended primarily on kerosene lamps for lighting (2011 census). About 91% of rural households use simple kerosene lamps for primary or back-up lighting, and these lamps are dim, inefficient and polluting. Extension of the electricity grid to rural areas, which was initially slow, has increased rapidly in recent years *(31)*.

3.4.2. Legal, regulatory and institutional framework

As kerosene is distributed through the Public Distribution System (PDS),[5] states' departments of food and civil supplies submit their requirements for kerosene to the Ministry of Petroleum and Natural Gas (MoPNG), which approves the requests with the necessary revisions (for example, allocations to states in India were reduced by about 8.5% between 2011–2012 and 2012–2013 and by about 4.5% between 2012–2013 and 2013–2014). Once the MoPNG has finalized the allocations, it directs the oil marketing companies to provide the allocated amounts. Wholesale dealers procure kerosene from company depots at a subsidized price and subsequently supply it to fair-price shops (FPS), which are the point of sale to the consumer. FPS are shops that are licensed to distribute essential commodities by an order issued under section 3 of the Essential Commodities Act, 1955 to ration card holders under the targeted PDS. Established by the Government under the Ministry of Consumer Affairs, Food and Public Distribution, FPS are managed jointly by state governments. Subsidized kerosene is sold to consumers in accordance with the entitlement fixed by the state government.

3.4.3. Market and supply constraints

A fixed amount of subsidized kerosene is available to poor households each month from FPS. It is used mainly for lighting, but some is used as cooking fuel. Kerosene can also be purchased on the open market, because of leakages in the

5 An Indian food security system through which food and non-food items are sold to poor households at subsidized rates in state-owned ration shops or through the PDS network.

PDS supply chain *(32–34)*. Studies of the leakages of kerosene from PDS suggest that kerosene subsidies should be reformed *(35–37)*. Analysis of data from the 68th NSS round undertaken by the Council on Energy, Environment and Water in 2016 *(38)* showed a leakage of about 51% of the allocated PDS kerosene and that about 44% is diverted for other uses.

Boys study by lantern light in a house in Chowkipur India. Chowkipur is a village 60 KM from Patna that has no electricity. Credit: Getty Images/Simon de Trey-White

3.4.4. Industry structure in terms of producers and wholesale distributors

The allocation of subsidized kerosene to states decreased from 10.36 million kL in 2011–2012 to 6.93 million kL in 2016–2017. The plan is to continue to decrease kerosene subsidies and to end them nationally by early in the next decade. Delhi, Haryana and other jurisdictions have already been declared "kerosene free".

3.4.5. Prices, taxation and subsidies

PDS kerosene is sold for less than international market prices, as the Government provides a fiscal subsidy. The subsidy, however, covers only part of the difference between the cost price (including marketing costs) and the selling price, resulting in "under-recoveries" for oil and marketing companies. A large portion of the under-recovery is compensated for by cash assistance from the Government, over and above the fiscal subsidy, while another portion is covered by financial assistance from upstream oil and gas exploration companies.

3.5 LPG use

Domestic LPG is used mainly as fuel for cooking in India, but it may also be used for lighting, heating and refrigeration. It is used to power stand-alone and very large cooking stoves. In some rural areas, LPG is used as a backup by people who rely on solar energy, for instance in winter, when there is less sunlight *(39)*. LPG has attributes such as accessibility and low cost per unit, as well as being an environmentally friendly, clean fuel that is safe for use indoors and leads to lower consumption of fuel.

A woman cooks food on a gas-connected stove at her home in the village of Mangrauli, Uttar Pradesh. Credit: Getty Images/Bloombert/Prashanth Vishwanathan

3.5.1. Penetration

The Petroleum Planning and Analysis Cell *(40)* estimated the LPG coverage in India from the number of households on 1 July 2017 (based on the household growth rate during 2001–2011) as per the 2011 census and active domestic connections of public sector oil marketing companies. LPG coverage in the country was estimated to be 75.5%, with 243 million domestic consumers and 206.7 active domestic connections of public sector oil marketing companies (Table 5). These estimates have not, however, been independently verified by national survey results. LPG coverage in the states of Rajasthan and Maharashtra was estimated to be 79.7% and 87.0%, respectively, and the numbers of registered double-bottle connections were estimated to be was 12.54 million and 26.31 million in the two states, respectively.

↓ ***Table 5.*** *Domestic market for LPG*

Year	LPG registered domestic consumers (million)	DBC registered customers (million)	LPG active domestic customers[a] (million)	LPG coverage[b] (estimated percentage)
2007	94.3	49.0	NA	NA
2008	101.0	50.9	NA	NA
2009	105.7	52.2	NA	NA
2010	115.1	56.9	NA	NA
2011	125.4	62.4	NA	NA
2012	137.1	68.9	NA	NA
2013	150.4	74.9	NA	NA
2014	166.3	82.7	NA	NA
2015	181.9	91.7	148.6	56.2
2016	201.8	101.9	166.3	61.9

Year	LPG registered domestic consumers (million)	DBC registered customers (million)	LPG active domestic customers[a] (million)	LPG coverage[b] (estimated percentage)
2017	234.6	108.9	198.8	72.8
1 July 2017	242.8	110.6	206.7	75.5

DBC, double bottle connections; LPG, liquefied petroleum gas; NA, not available.
[a] Customers other than those registered whose duplicate, fake or inactive accounts has been blocked under the direct benefit transfer scheme and related initiatives.
[b] Estimated from active domestic LPG connections of public sector oil marketing companies divided by estimated number of households.
Source: reference *40.*

The Government has initiated various schemes. The latest information on the numbers of BPL households covered under various schemes in the five regions and nationally is shown in Table 6.

↓ ***Table 6.*** *BPL customers covered under various schemes as of 1 July 2017*

Region	No. of households covered under state government-sponsored scheme	No. of households covered by corporate social responsibility funds of public sector oil companies	No. of households covered under PMUY Scheme
North	239 566	1 787 557	8 814 726
North-east	189 036	116 060	28 923
East	104 207	1 113 108	9 111 728
West	225 350	1 331 438	5 990 047
South	10 569 073	2 649 901	531 332
India	11 327 232	6 998 064	24 476 756

PMUY, *Pradhan Mantri Ujjwala Yojana.*
Source: reference *41*.

Box 2: LPG status in Rajasthan

The Global Alliance for Clean Cookstoves commissioned a study in Rajasthan to determine the sources of fuel for cooking in 2010 *(42)*. The study showed that 24% of the households surveyed had access to LPG stoves, but most still used solid fuel (firewood, dung, crop residue and charcoal) as the main source of fuel for cooking. With respect to LPG access and usage, 75% of the connections were less than 5 years old, and more than 68% were single-cylinder connections. The households reported that, on average, one cylinder lasted for more than 2 months, indicating low usage, probably for only a limited set of cooking tasks.

Box 3: Fuel consumption pattern in Sangli District (Maharashtra)

Kumbhar & Pawar *(43)* reported on fuel consumption in a sample survey of rural households in Sangli District, Maharashtra. They found that 30% of the households surveyed used LPG as the main fuel for cooking, while some used a combination of LPG, biogas and wood. When the type of fuel for cooking was ranked by preference, firewood was the first and LPG the second preference, indicating that households were willing to shift to LPG. The study also showed that consumption of LPG in kitchens was related to the level of income.

3.5.2. Legal, regulatory and institutional framework

LPG is the responsibility of the MoPNG. It is an essential commodity and is therefore administered under the Essential Commodities Act, 1955 and the MoPNG Liquefied Petroleum Gas (Regulation of Supply and Distribution) Order 2000, which states the terms of use of LPG cylinders *(44)*. The Government has recognized LPG as an important of source of modern fuel for cooking and, to encourage its use, has subsidized household supplies since the 1960s *(45)*.

In 2014, the MoPNG revised the cap on subsidized LPG under the direct benefit transfer scheme to 11 cylinders for the year ending 31 March 2014. Further, each beneficiary is entitled to 12 subsidized LPG cylinders per annum, with a cap of one cylinder per month. In cases of genuine emergency, oil marketing companies were authorized to provide more than one cylinder per month *(46)*.

LPG is marketed mainly by public sector oil marketing companies, the three major ones being the Indian Oil Company, the Hindustan Petroleum Corporation and the Bharat Petroleum Corporation. Several private companies (for example, Reliance) market LPG at non-subsidized rates.

3.5.3. Barriers and constraints to penetration and adoption of LPG

LPG has low commercial viability for LPG distributors, as rural markets are considered to have low LPG uptake due to their low population density, migration patterns, poor road infrastructure, high price subsidies and lack of awareness in low-income rural households *(47)*. Furthermore, the limited LPG distribution system in rural areas, especially in remote and hilly areas, is a major obstacle to complete penetration of domestic LPG. The lack of LPG distributors within a reasonable distance is a major problem, as carrying cylinders over long distances (5–11 km) is exhausting, especially in view of the lack of roads in some rural areas.

Another barrier is lack of proof of a proper address, a bank account or an identity card. In semi-urban areas, most of the immigrant population lives in slums and have no means to prove their residential address.

The initial investment cost, which is about Rs 3000 (approximately US$ 50), is high for poor households, limiting the uptake of LPG. The cash outlay for each refill presents another barrier to the uptake and regular use of LPG by all low-income households.

There is also lack of awareness in rural households about the benefits of LPG (environmental, time-saving and health). In some areas, LPG is perceived as unsafe or even dangerous, particularly by older householders. Lack of literacy can be another obstacle, as illiterate people tend to prefer their traditional practices and to be resistant to change.

A woman carries cylinders of Liquefied Petroleum Gas (LPG) on her back.
Credit: Getty Images/UIG/Majority World/Mahmud

Interviews indicated that many households preferred the taste of *roti* made on traditional *chullah* and initially found the taste of *roti* cooked on LPG stoves unacceptable. This was another disincentive in rural households. The demography or the age and gender structure of the household plays a critical role in deciding whether to adopt LPG. Households with more adult members are

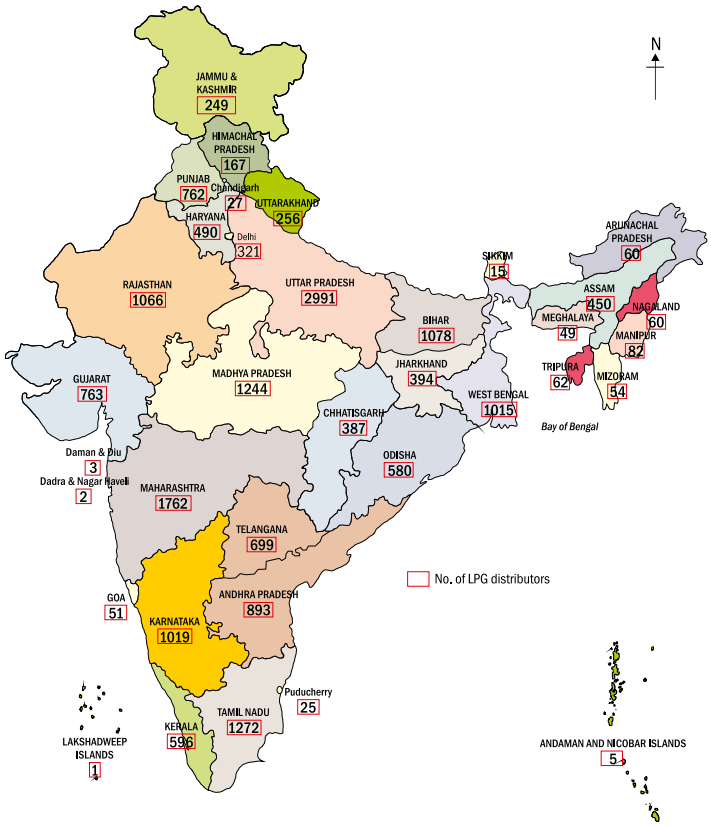
likely to have fixed opinions and perceptions about using firewood for cooking, and changing behaviour in these populations can be difficult. Younger households may be more readily motivated to adopt LPG, as they are more likely to understand the benefits of LPG and be willing to make changes for better health and the environment.

Rural areas and communities often have an apparently cheaper or free fuel alternative, such as wood, dung or crop residue, which is yet another obstacle in marketing and adopting LPG. Many rural areas are near forests, and residents have no motivation to change to LPG. Furthermore, many do not take into account the value of the time taken to collect and prepare biomass fuel.

3.5.4. Industry structure: producers and wholesale distributors

LPG is produced in India by both public and private sector firms. Some of the major LPG producers in India are the Oil and Natural Gas Corporation, GAIL India Ltd and Reliance Industries. The three main public sector oil marketing companies that produce and market LPG in India are the Indian Oil Company, Bharat Petroleum Company and Hindustan Petroleum Company. The Indian Oil Company has the largest number of refineries and the largest capacity to produce LPG; it has a 49% market share *(48)*.

The numbers of LPG distributers in India has increased significantly, from 15 930 in 2014–2015 to 17 916 (up by 12.5%) in 2015–2016. The PPAC Industry Profile, 2017 *(41)*, showed that there were 18 950 LPG distributors in India on 1 July 2017. The number of LPG distributors in the country increased by 12.5% between 2015 and 2016 and by 4.9% between 2016 and 2017.



↑ ***Fig. 9.*** *Numbers of LPG distributors per state on 1 July 2017*

Source: reference *41*.

3.5.5. Current refinery capacity and receiving storage capacity

According to MoPNG figures, the current refinery capacity is 215.06 million t per annum. In 2017, there were 189 bottling plants in the country with a total bottling capacity (number of shifts at plants) of 16 414 000 t per annum. LPG bottling capacity increased by 8.03%, from 14 044 000 t per annum in 2014–2015 to 15 172 000 t per annum in 2015–2016.

3.5.6. Prices, taxation and subsidies

In 1975, the Government established an "administered price mechanism" for pricing petroleum products, including subsidization of domestic LPG. The mechanism was dismantled in 2002, when the Government decided to provide subsidies on domestic LPG at specified flat rates under the budget. Further, to ensure proper administration and implementation of budgetary subsidies, the Government formulated the PDS kerosene and domestic LPG subsidy scheme in 2002. This scheme helped to insulate Indian consumers from the impact of volatile and high global oil prices by keeping the retail selling price of sensitive petroleum products, including domestic LPG, low. This resulted in large amounts of under-recoveries for the oil marketing companies. The price of domestic LPG is still controlled by the Government, and oil marketing companies are mandated to sell LPG below the cost price in the international reference period.

3.5.7. Market promotion measures

Measures to promote uptake of LPG are summarized in Table 7.

↓ ***Table 7.*** *Policies, programmes and schemes for increasing market penetration of LPG (see also Annex 1)*

Policy, scheme or programme	Nodal ministry	Launch date and status	Objective	Success	Limitations
PAHAL scheme: direct benefit transfer of LPG	MoPNG	Launched in 2014 in 54 districts (first phase): extended in January 2015 to 622 districts of India. Status: ongoing	To rationalize subsidies by reducing subsidy leakages but not the subsidies themselves. LPG consumers who join the PAHAL scheme can obtain LPG cylinders at the non-subsidized price and receive the LPG subsidy (as per their entitlement) by direct payment into their bank account.	The number of LPG subsidies increased from 13 *crore*[a] in 2014 (launch year) to 17.4 *crore* in 2016.	Rural areas (especially hilly and remote villages) lack banking services and have poor infrastructure, which are obstacles to promoting cashless transfer of LPG subsidies to poor households.
Pradhan Mantri Ujjawala Yojana (PMUY)	MoPNG	Launched in May 2016 Status: ongoing	The Government launched PMUY to provide LPG connections to 5 *crore* women in BPL families over 3 years, starting in financial year 2016–2017.	Under the PMUY scheme, 709 districts are covered and 29 543 113 connections have been supplied to BPL households. In 2016–2017, there were 32.2 million new LPG connections, of which 20 million were PMUY beneficiaries.	There is no concession for the second refill, and even a subsidized cylinder costs around Rs 450, which is a large amount for a poor household to pay each month.
Ujjwala Plus Scheme	MoPNG	Launched in August 2017 Status: ongoing	The scheme was launched for low-income people to increase coverage of free LPG connections. Under the *Ujjwala* Plus Scheme/*Yojana*, LPG consumers who have voluntarily given up their subsidy on cooking gas are asked to provide a free LPG connection to nearby needy families.	Results not yet available.	Results not yet available.

Policy, scheme or programme	Nodal ministry	Launch date and status	Objective	Success	Limitations
"Give it Up" or "Giveback" scheme	MoPNG	Launched in March 2015 Status: ongoing	Higher income households are asked to voluntarily give up their LPG subsidy. The main objective is to enable provision of LPG to poor households.	Nearly 1 *crore* LPG consumers have voluntarily given up their LPG subsidy.	It is a voluntary scheme.
SAHAJ	Oil manufacturing companies, under the MoPNG	Launched in August 2015 Status: ongoing	SAHAJ is a digital initiative intended to facilitate application for a new LPG connection. An LPG connection is released after online payment and issuance of an "e-SV".	The Indian Oil Corporation pilot-tested the SAHAJ scheme in Delhi on 1 May 2015. It covered 308 distributors, and 550 "SAHAJ (e-SV)s" were released for online registration and payment. Almost 98% of the connections, registered online were released within 7 days of registration.	Rural areas lack the Internet connections and infrastructure required to use the services. Some people in the rural population are illiterate and cannot use information technology.
Emergency helpline no. "1906"	A multilingual LPG emergency helpline was dedicated to the nation on 1 January 2016 by the MoS(I/C) MoPNG	Launched in January 2016 Status: ongoing	This facility is available around the clock, with two shifts of 12 h for attending to emergency LPG leakage reports. The call centre has a web-based application for logging, viewing and monitoring calls and updating the contact details of mechanics and field officers.	As of 29 November 2016, 137 832 complaints had been received and 137 814 had been resolved on this emergency helpline number.	Anecdotal evidence suggests that some customers have difficulty in connecting to the helpline.

[a] One crore = 10 million

3.5.8. Leakage from end-use

In both rural and urban areas, some LPG cylinders are sold on the black market. Furthermore, during the festival season, domestic LPG is often misused due to lack of vigilance or monitoring. Domestic LPG is sold on the black market for commercial uses such as small fast-food outlets, *dhabas*, restaurants and small hotels. For example, in Shimla, there are about 1500 commercial gas connections but there are three times that many hotels, *dhabas*, restaurants and fast-food outlets, clearly indicating the existence of leakages in the LPG market *(49)*.

The Indian Oil Corporation Madurai area office conducted a raid in March 2017 of various locations in the city and seized domestic cylinders at gas filling stations and on business and commercial premises. The officer stated that people were misusing domestic LPG for commercial purposes owing to the price differential between domestic and commercial cylinders *(50)*. Interviews indicated that a consumer generally uses six to seven LPG cylinders in a year. As domestic consumers generally use a mix of fuel types (for example, LPG, firewood, cow dung and kerosene), they are often left with extra cylinders that they can sell on the black market as a source of extra income *(51)*.

Leakages also occur in the LPG subsidy. The audit report of the Comptroller and Auditor General of India (CAG) in 2016 *(52)* noted that many LPG connections have the same identity card number, bank account or name in oil marketing companies. A random check of the Hindustan Petroleum Corporation showed that 1400 LPG connections were linked to 700 identity card numbers, indicating multiple connections. Similarly, the database of the Indian Oil Corporation revealed that 43 323 LPG consumer identification numbers were linked to only 21 504 bank accounts, clearly indicating that two connections were often linked to one bank account.

3.5.9. Enablers for LPG adoption

- An LPG household energy policy would reduce misuse of LPG for commercial purposes, extend the provision of two-cylinder connections, establish a uniform, systematic transport and delivery system, rationalize price diversity and a marketing strategy, include innovative payment schemes (for example, "pay as you go") and establish a more robust system for monitoring LPG connections and their use.
- Timely delivery and periodic safety checks by dealers and prompt consumer service by the oil marketing companies would ensure greater adoption and use of LPG by households.
- An online system such as the Digital India initiative would allow prospective consumers to obtain all the necessary information on LPG, apply for an LPG connection, track their LPG connection, complain about an LPG cylinder, find a nearby LPG dealer or refill station and minimize difficulty from LPG distributors.
- Regular public awareness campaigns in traditional and social media could be used to disseminate information about the benefits and safety of LPG and how to adapt cooking practices.
- The health sector would be the most credible sourse of messages on LPG and health, e.g. in primary health centres, by "accredited social health activists" (community health workers instituted by the MofHFW as a part of the National Rural Health Mission) and in primary health networks.
- Linkage of LPG to the benefits package for pregnant women could reach households of any income level in which biomass is burnt during a period when behaviour change is likely.
- Linkage of the LPG schemes with the rural employment programme could emphasize the economic value of the significant saving of time.
- The number of LPG filling facilities should be increased and made available at *haat*, fairs and local markets commonly visited by villagers.
- The Government should promote the concept of *rasoi ghar* (community kitchens) equipped with an LPG cylinder and stove and also promote the use of 5-kg cylinders with mounted stove for small families or migrants.
- Deforestation regulations should be enforced to curb tree-cutting for firewood, enabling a shift to LPG.

3.6 Electricity use

3.6.1. Penetration

The Government launched the *Gramin Vidyitikaran* mobile application and an accompanying online dashboard (GARV dashboard) *(53)* in order to ensure transparency in reporting to citizens on village electrification and household electrification in rural areas. The dashboard shows that 17 states and union territories have achieved 100% electrification of inhabited census villages, and the states of Maharashtra and Rajasthan have achieved 100% electrification of census villages. In Rajasthan, over 20% of households are yet to be electrified, while, in Maharashtra, less than 3% of the households are estimated to lack electricity.

3.6.2. Household use

Electricity is used by households for lighting and, in a growing number of houses, for charging mobile phones. As several states in India have a very humid climate and high ambient temperatures during the summer, space cooling is required. Unlike most households in urban areas, which have air conditioners, poor households in rural areas have only a ceiling fan or a table fan for space cooling.

The 68th round of the NSS reported on distribution of electrical appliance ownership in rural and urban areas. Fans are owned by 93% of urban and 64% of rural households, refrigerators by 44% of urban and 9% of rural households, televisions by 80% of urban and 50% of rural households and air conditioners or air coolers by 24% of urban and 6% of rural households *(54)*.

The Government is also promoting the transition of households to efficient equipment. For example, as part of the *Unnat Jyoti* "affordable LEDs and appliances for all" scheme, launched by the Prime Minister in 2015, incandescent and compact fluorescent lamp bulbs are to be replaced by efficient light-emitting diode (LED) bulbs. As of 16 October 2017, more than 269 million LED bulbs had been distributed within this scheme *(55)*.

The Government's *Saubhagya* scheme acknowledges that access to electricity and lighting after daylight hours increases personal safety, especially for women, and encourages economic and social activities *(56)*.

3.6.3. Reliability of service

With the introduction of new policies such as the *Ujwal DISCOM Assurance Yojana* scheme by the central Government and better monitoring of electricity service delivery, the reliability of the supply in rural areas is improving. For urban areas, the Government has launched a website to facilitate access to data on the reliability of the power supply. The website *(57)* provides the average number and average duration of power cuts in each states and union territory.

The responsibility for the power supply and distribution is, however, vested in each state government and the electricity distribution companies operating in the region or state. Hence, a distribution company that lacks sufficient financial resources may not be able to purchase power.

3.6.4. Pricing structure, taxation and subsidies

Electricity is under the jurisdiction of both the central and the state governments; however, state governments decide on subsidies for consumers.

In the ongoing schemes, *Deen Dayal Upadhyaya Gram Jyoti Yojana* (DDUGJY) and the previous *Rajiv Gandhi Gramin Vidyutikaran Yojana* shared the financial overheads for village electrification with the central and state governments. The guidelines of the DDUGJY set a maximum grant (including

an additional grant payable upon achievement of prescribed milestones) of 90% for "special" states and 75% for the other states. The state government is mandated to provide an upfront subsidy to the respective utility and is also expected to arrange for a contribution from the utlity. Expenses for strengthening and improving the electricity infrastructure are borne by the state government or the utility. Within the DDUGJY, all BPL households are given a free electricity connection.

The price of electricity for consumers is regulated by the electricity regulatory commission of each state. Although the overall pricing structure is guided by orders of the Central Electricity Regulatory Commission, each state has its own pricing structure, which is guided by the National Tariff Policy 2016 *(58)*. The National Electricity Policy 2005 states that the tariff for BPL consumers shall be at least 50% of the average (overall) cost of supply.

3.6.5. Programmes and incentives to increase penetration

India had an electricity generating capacity of more than 350 000 MW during the financial year 2016–2017, and the lowest deficit ever (–0.7%) was registered for the actual power supply position in terms of energy requirement and energy availability. The gap between demand and supply was not due to lack of power, implying that India has made significant progress and is expected to achieve a power surplus. The demand for domestic power is, however, expected to grow due to additional energy requirements in newly electrified households and newly constructed houses in rural and urban areas.

3.6.6. Carrying capacity and electricity demand for cooking, heating and lighting

In villages that have had electricity for some time, the distribution infrastructure requires maintenance and upgrading; otherwise, it will be unfit for larger loads. Similarly, productive load and cooking applications might not be technically feasible for households that have access to only single-phase power supported by older infrastructure. Newer, higher capacity distribution transformers and other infrastructure will be required to support productive loads; therefore, the local electricity distribution company must be financially sound.

Off-grid communities and poor households may be provided with a low-capacity connection, primarily because of their limited capacity to pay; they are therefore unable to use electricity for heating and cooking.

3.6.7. Increasing grid capacity

Two general barriers restrict augmentation of grid generation and supply capacity. While the grid has reached almost 99% of census villages, it has not reached small dispersed hamlets and non-census villages, and extending it to mountainous terrain, such as in the north-eastern state of Arunachal Pradesh, will be difficult. With regard to nonconventional energy sources, such as hydro and biogas, consistency in the availability is a primary requisite. For example, in the State of Nagaland, much electricity is generated from hydro-energy, which depends on the rains.

For difficult and inaccessible terrains and locations, the *Deendayal Upadhaya Gram Jyoti Yojana* and the *Saubhagya* scheme provide off-grid systems, and the Government has committed itself to increasing the cumulative share of renewable energy sources in the electricity generation mix. Off-grid and decentralized generation systems based on renewable energy are attracting interest from both Indian and international social enterprises, with impetus from the Electricity Act, 2003, and the subsequent Rural Electrification Plan, 2006, which promoted the participation of private players.

After private enterprises began providing micro- and mini-grids based on renewable energy, the Government issued a draft national policy in 2016 *(59)*. Only Uttar Pradesh State already has a mini-grid policy in place *(60)*. Several social

enterprises and non-Government institutions have installed or commissioned micro-grids in rural areas. The Government provides not only solar-based technology but also biogas for off-grid power generation *(61)*, and the national biogas and manure management programme is the largest central Government scheme for promotion of biogas in the country *(62)*.

3.6.8. Enablers and barriers to adoption of electricity for cooking

The 2011 census reported that barely 0.1% of households were using electricity for cooking. Although electricity infrastructure is available in most urban and rural villages covered by the census, a number of factors limit complete transition.

The barriers include:

- inadequate electricity capacity for BPL households (usually < 1 KW), while most induction stoves require a minimum of 1 KW;
- generally large families in rural areas, while most commercially available induction cookstoves are not suitable for cooking for large families;
- certain food preferences, such as thick bread, that might be difficult to cook on an induction stove;
- limited, unpredictable disposable income of the rural poor;
- lack of reliable after-sales service;
- availability of free biomass and agricultural residue; and
- distrust by many rural residents for new technologies.

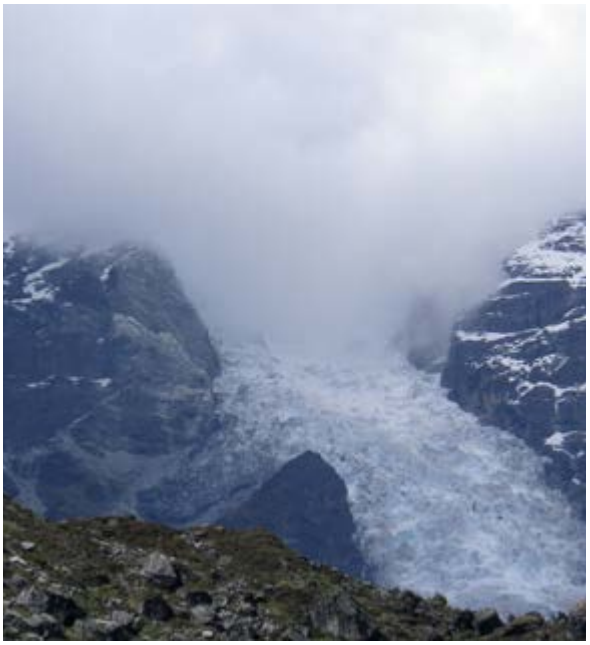
An Indian villager is shown a new 'Clean Cooking Stove' by members of The Self Employed Women's Association (SEWA) as she prepares food on a traditional stove made of mud at her residence in the village of Keiyal, some 50 kilometers from Ahmedabad. Credit: Getty Images/AFP/Sam Panthaky

The enabling factors are:

- adequate infrastructure and a relatively reliable power supply in urban areas;
- smaller families in urban areas;
- multicultural environment in cities, where households are more open to modern cooking and eating habits that suit their working hours and might be attracted to induction stoves to save time;
- lower price of electricity as compared with the alternative, LPG;
- access to after-sales service due to the multiple options for procuring stoves; and
- limited availability of solid biomass fuel for cooking.

3.7 Climate change considerations

The reliance of energy-poor households on traditional, inefficient, polluting fuel sources for cooking and lighting has an environmental impact, including degradation of local tree cover. Further, during burning of solid biomass, the toxins that are emitted include black carbon, which is a short-lived climate pollutant *(63, 64)*.



The retreat of snowfields and glaciers in the Himalayan region threatens communities dependent on meltwater to irrigate subsistence crops. Credit: Jonathan Mingle

Improved biomass cookstoves have been promoted in India for decades to protect the health of women and to reduce emissions of harmful soot; however, Sambandam et al. *(65)* reported that most commercially available improved biomass cookstoves on the Indian market fail to provide benefits for either health or the climate. Garland et al. *(66)* assessed seven types of cookstove and found that simple wood and rocket stoves had the highest median emissions of black carbon, while charcoal stoves and advanced biomass stoves had the lowest emission factors.

Modern lifestyles and climate variations also affect people's choice of fuel and food. For example, the number of cows is decreasing in modern urban areas and also in drought-prone areas of states such as Rajasthan and Maharashtra. Hence, a biogas system cannot be recommended as the most appropriate solution in all locations. Technology should match lifestyles and local climatic conditions, and research is required to make affordable, more effective technology available to users.

4 Social welfare programmes

4.1 Poverty alleviation programmes

The aim of poverty alleviation programmes is to generate employment through Panchayati Raj institutions and self-help groups. Welfare initiatives to boost employment *(67)* have immense political importance *(68)*, as they are popular and mandate intersectoral cooperation, thereby offering a mechanism to integrate HAP mitigation. Some programmes with potential to address HAP are described below.

4.1.1. Mahatma Gandhi National Rural Employment Guarantee Act

The scheme guarantees 150 days of paid work and increases employment in unskilled work. The 2017 union budget made the highest allocation of Rs 480 billion to the programme, which is reported to have generated 50 million jobs *(69)*. It has significantly increased household income by creating alternative employment for the poor and has been an instrument of reform by imposing conditionality. For example, the construction and use of a latrine by a household is a prerequisite for the employment card *(70)*. Such schemes could be leveraged to promote the use of clean energy, as they give households the economic capacity to buy clean fuels.

4.1.2. Self-help group initiative

The aim of the initiative is to alleviate poverty and improve women's ability to achieve their rights and well-being. It is an intersectoral initiative of the Ministry of Tribal Welfare and Justice, the Ministry of Rural Development, the Ministry of Panchayati Raj, the Reserve Bank of India and the Micro-credit Innovation Department of the National Bank for Agriculture and Rural Development. The model addresses economic needs by prompt, easy access to credit. The initiative could be used to promote safe energy, like the latrine promotion initiative in the Swachh Bharat Mission. It could be used to finance purchase of an LPG stove and refills under the *Pradhan Mantri Ujjwala Yojana*.

The MNRE's biogas programme subsidizes individual households for installation of a biogas plant by providing half the amount. Micro-credits through self-help groups could provide financing for beneficiarie *(57)*.

Woman using biogas cooker.
Credit: Getty Images / Universal Images Group

4.1.3. Public distribution system (PDS)

The PDS, under the Ministry of Consumer Affairs, Food and Public Distribution, with its network of 400 000 FPS, plays an instrumental role in the distribution of LPG cylinders at subsidized rates. The PDS system could be used to extend the LPG distribution network to underserved areas.

4.1.4. Jawahar Gram Samriddhi Yojana

Jawahar Gram Samriddhi Yojana was started improve infrastructure in rural areas and to provide sustained wage employment to BPL families and funds for individual beneficiary schemes for scheduled castes and scheduled tribes. The programme is administered through village *panchayats*. The scheme, like the Mahatma Gandhi National Rural Employment Guarantee Act, could be used to promote uptake of clean cooking options *(71)*.

4.1.5. Integrated Rural Development Programme

The aim of the Programme is to alleviate rural poverty by creating sustainable opportunities for self-employment in the rural sector. Assistance is given in the form of a subsidy from the Government and term credit advanced by commercial banks, cooperatives and regional rural banks. The target group is small and marginal farmers, agricultural labourers and rural artisans who have an annual income less than Rs 11 000. The Programme could cater to both the demand and the supply of clean fuel by increasing purchasing power and promoting green businesses *(72)*.

4.2 School feeding programmes

India's midday meal scheme, established by the Ministry of Human Resource Development as the National Programme of Nutritional Support to Primary Education, now covers students in grades 1–8 in Government, Government-aided and local schools.. The meals, cooked on school premises by designated cooks and helpers, are a means of encouraging school enrolment and attendance while improving the nutritional status of children. Members of the midday meal programme have access to subsidized LPG cylinders. Increasing the number of midday meals cooked with LPG instead of biomass could increase clean fuel usage *(73)*.

Credit: Heather Adair-Rohani

4.3 Other welfare programmes

***Pradhan Mantri Awas Yojana*:** The aim of this programme, run by the Ministry of Rural Development for Rural Areas and the Ministry of Housing and Urban Affairs for urban areas, is to provide permanent housing with basic amenities including a hygienic cooking space, to people without a house or who are living in dilapidated houses by 2022. The programme could ensure that houses built under its auspices have adequate ventilation to reduce exposure to harmful air pollutants. *Pradhan Mantri Awas Yojana* also provides assistance for the construction of toilets by convergence with programmes such as the Swachh Bharat Mission – Gramin (Clean India Mission – Rural) and the Mahatma Gandhi National Rural Employment Guarantee Act.

***Sansad Aadarsh Gram Yojana*:** Through this scheme, Members of Parliament are encouraged to build model villages in their constituencies to ensure integrated development in areas such as agriculture, health, education, sanitation, environment and livelihoods, generating models of local development and effective local governance. The Indian Oil Corporation is leading some initiatives to create smokeless villages. The scheme could encourage the development of "smokeless villages" and "open defaecation-free villages", which are currently mandated under the Swachh Bharat Mission (Clean India Mission).

Smart Cities Mission: The objective of this project is to promote sustainable, inclusive cities that provide core infrastructure and a decent quality of life in a clean, sustainable environment by application of "smart" solutions. These include adequate water and electricity supplies, sanitation (including solid waste management), affordable housing, robust connectivity and digitalization, good governance (especially e-governance and citizen participation), a sustainable environment, safety and security (particularly for women, children and the elderly), health and education *(74)*. Access to clean fuels for cooking and heating,

although currently not included in the objectives, could be considered in order to prevent a rise in urban and periurban use of biomass.

Swachh Bharat Mission: The objectives of this mission are to eliminate open defaecation, stop manual scavenging, introduce modern, scientific municipal solid waste management, change unhealthy sanitation behaviour and raise awareness about sanitation and its link with public health *(75)*. The Ministry of Health and Family Welfare *(76)* recommended creation of villages that were free of both open defaecation and smoke. As environmental awareness is greater in villages free of open defaecation, they would be good places to test the smokeless village concept, in which every household has access to and uses clean fuels for cooking and heating.

***Green Business Scheme*:** The Ministry of Social Justice and Empowerment launched this scheme to address climate change by providing loans for a unit cost up to Rs 0.1 million at a concessional rate of interest to Scheduled Castes for equipment such as e-rickshaws, solar pumps and solar energy-powered implements and polythene tunnels *(77)*. This scheme could offer mechanisms to encourage the use of clean and renewable energy sources for cooking and heating.

5

Stakeholder organization and coordination

The stakeholder mapping exercise identified 11 government ministries and 16 programmes and schemes of NGOs and civil society and community organizations working in clean household energy and health (see Annex 2). At Government level, the MNRE, the Ministry of Environment, Forest and Climate Change, the MoPNG and the Ministry of Power, with the nodal departments (Fig. 10) undertake energy initiatives; however, there is no convergence with the MoHFW.

5.1 Role of the health sector in addressing HAP

Although health is a State subject, the MoHFW manages and implements health policy and aligns the Integrated Child Development Services programme of the Ministry of Women and Child Development. The National Programme for Prevention and Control of Cancers, Diabetes, Cardiovascular Diseases and Stroke is under the National Health Mission, and the Directorate General of Health Services is the technical and advisory arm for the NCD programme.

To address the substantial health burden attributable to ambient and HAP, the MoHFW established an expert committee on air pollution and health in 2015. This has been recognized as the first step by a low- and middle-income country to address air pollution as a national health concern. The aim of the committee's actions, outlined in 2016, was to achieve the greatest possible reduction in exposure and consequent health benefits *(78)*. A notable policy action was the Government's commitment of at least US$ 1.5 billion in the 2016–2017 budget to address HAP by providing clean cooking gas to 50 million poor households by 2019. Although health was not the driver of this policy action, it will improve health outcomes.

MoHFW programmes and policies (see below) could include the health effects of air pollution. For example, to address the growing burden of NCDs, India established the national programme in 2010, and recognition of COPD as a leading NCD led to its inclusion in the programme in 2016. As part of this plan, district health centres will be provided with a COPD clinic, COPD counsellors and equipment such as spirometers *(79)*. The objective is to strengthen primary health centres and community health centres to ensure preparedness and improvement of existing referral systems for COPD cases. The initiative is designed to ensure early detection, control, prevention and awareness and to build the capacity of the health system to address COPD. Pilot studies with population-level screening for COPD are to be conducted in 100 districts.

The 2017 National Health Policy, for the first time, listed exposure to air pollution as a priority for action and outlines alignment of the Policy across sectors *(76)* to halt and reverse the growing incidence of chronic diseases, the primary manifestation of the impact of air pollution. This is to be achieved by an integrated approach to reduce morbidity and preventable mortality, with screening as the first step. The mechanisms for achieving these aims will be included in the comprehensive primary health care network, with links to specialist consultations and follow-up at the primary level. The policy proposes medication and access for patients with selected chronic illnesses around the year, and an increased emphasis on research. Screening will be conducted for oral, breast and

cervical cancers, COPD, hypertension and diabetes. The policy recommends use of accredited social health activists and the revival and strengthening of a multipurpose male health worker cadre to manage emerging infectious and NCDs at community level.

Despite the national health policy directives intended to address the burden of chronic diseases, funding for these programmes is only a fraction of that provided for other diseases. Currently, a considerable proportion of public health funding is targeted to maternal and child health, vaccination and control of infectious diseases.

There is currently no action or systematic plan to incorporate air pollution into health sector plans or policies. While the Government has adopted the Sustainable Development Goals to reduce mortality and morbidity associated with exposure to air pollution, it has no clear pathway to achieve those targets *(18)*.

5.2 Health sector policies and programmes related to household energy and women's and children's health

Work on NCDs is the responsibility of the flagship National Health Mission and the programmes on Reproductive, Maternal, Neonatal, Child and Adolescent Health and on Communicable Diseases. To address acute lung and respiratory infections, the Mission has used accredited social health activists to identify and manage cases, especially in children under 5 years. COPD is also included in the NCD initiative of the programme; however, the Mission and its auxiliary programmes are not overtly linked to HAP because of the lack of techniques to measure the sources of pollution and its adverse effects on health and also the lack of health system resources to address the burden.

The programmes and schemes for pregnant women and early childhood care comprise health systems strengthening, disease management at facilities and in households and programmatic and financial support to reduce mortality and morbidity among vulnerable mothers and their children. Some of these programmes could be used to raise awareness about the benefits of clean household energy or serve as an alternative delivery platform. For example, the Programme on Reproductive, Maternal, Neonatal, Child and Adolescent Health includes 10 schemes for a multifaceted approach to maternal and child health, and clean household energy fuels and technologies could be incorporated into a scheme like the *Janani Shishu Suraksha Karakram*, which entitles pregnant women and sick newborns to care until 30 days after birth, including treatment, medicines, consumables, diagnostics, blood and transport, all offered free of charge. The *Pradhan Mantri Matrivite Vandana Yojana* conditional cash transfer programme for new mothers could provide cash incentives for clean household energy use.

The National Health Mission has a targeted scheme to reduce mortality and morbidity related to acute respiratory infections and diarrhoeal diseases through the promotion of zinc and oral rehydration and provision of antibiotics. A collaborative initiative by the MoHFW and the Ministry of Women and Child Development within the National Health Mission is the technology-based mother and child tracking system**,** which tracks every pregnant woman, infant and child up to 3 years of age. The system allows for timely provision of antenatal care, institutional delivery, postnatal care and vaccination, among other services. A "mother and child protection card" is used for counselling and family empowerment according to the health status of the mother and her newborn and assessment of their development needs.

Pradhan Mantri Matritva Vandana Yojana is a conditional cash transfer scheme for pregnant and lactating women for their first two live births. It is run by the Ministry of Women and

Child Development and provides a partial wage compensation to women during childbirth and child care and conditions for safe delivery and good nutrition and feeding practices. The cash incentives are given to all pregnant and lactating mothers except those regularly employed by the central or state governments or public sector entities and those who are receiving similar benefits under any other scheme.

Janani Suraksha Yojana is a maternity benefit scheme, which promotes institutional delivery among poor pregnant women by providing cash incentives for public, private and home deliveries for eligible women. In general, the scheme targets BPL populations, especially in states that are classified as "low performing", with fewer than 25% institutional deliveries.

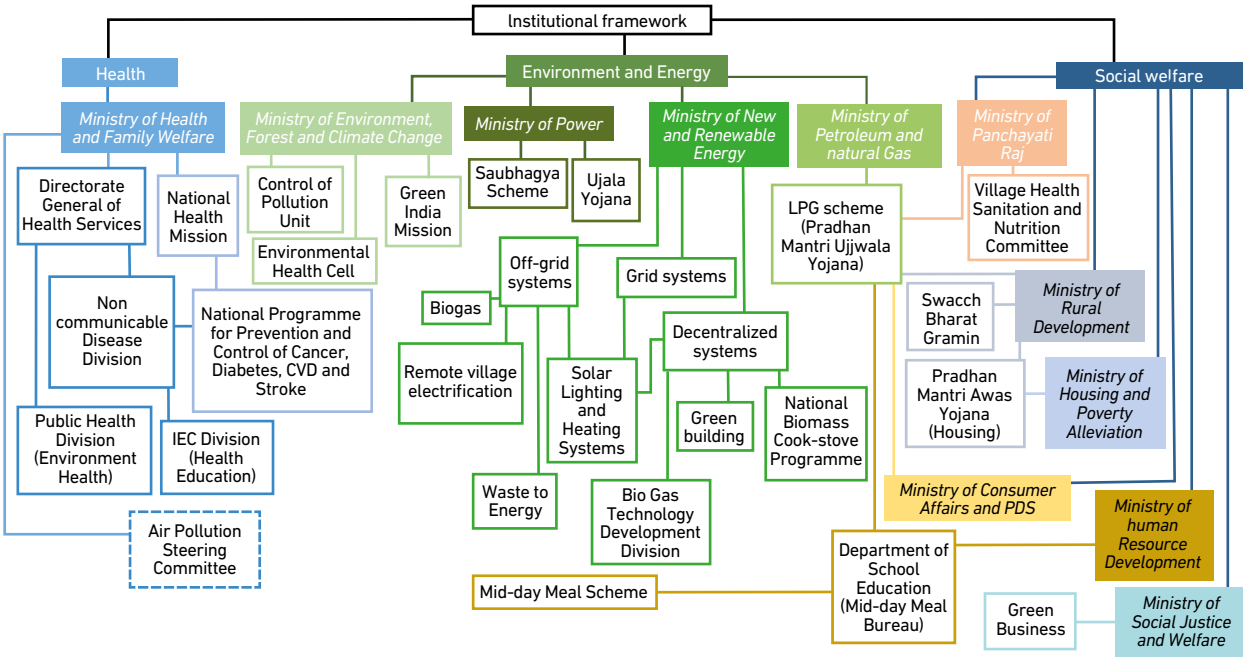
Pradhan Mantri Surakshit Matrutava Abhiyan ensures early identification and prompt treatment of high-risk pregnant women during the second and third trimesters, under the guidance of a specialist. The services include issuance of a mother–child protection card identifying mothers at high risk, examination, laboratory investigation, ultrasonography, vaccination with tetanus toxoid and provision of iron, folic acid and calcium tablets. Under the scheme, mothers also receive counselling in groups of 10–12 on diet, sleep, regular antenatal check-ups, institutional delivery, breastfeeding and contraception. Awareness of the effects of HAP on fetal health and risk mitigation could be included in these sessions.

Mission Indradhanush is India's universal vaccination programme, which is one of the largest in the world. The programme has significantly reduced morbidity and mortality due to vaccine-preventable disease and has reduced India's infant mortality rate. Pneumococcal vaccine was added to the programme in 2017. This development is significant, as 43 million cases of pneumonia are predicted for children under 5 years in India *(80)*.

Nongovernmental and civil society organizations concerned with energy and health in India are listed in Annex 2.

5.3 Environmental health risk assessments

The Environmental Health cell within the Directorate General of Health Services is responsible for conducting environmental health risk assessments and provides technical assistance to states that express an interest. Few environmental health risk assessments for HAP have been conducted in India. According to the NCD statistical monitoring and evaluation division, risk assessment studies are planned for all NCDs and will be conducted for COPD once the COPD programme gains momentum.



↑ ***Fig. 10.*** *Institutional engagement in household energy access, control and management of HAP and related risks (accurate at the time of report preparation in December 2018, although subsequent re-organization may have occurred)*

6 Discussion

6.1 Barriers to adoption of clean technology

Lack of technical knowledge and awareness in the population about clean energy technologies is a major barrier to adoption *(81, 82)*. Householders' fear that LPG cylinders might explode and that electric stoves might cause fires are deterrents to the adoption of clean energy. Poorly designed policies and incorrect implementation due to ignorance of policy-makers about the use and application of clean household energy can have negative outcomes *(83, 84)*. In addition, insufficient technical knowledge and too few skilled personnel for setting up and operating renewable energy technology-based systems can affect their long-term success and performance *(81, 82)*.

Adoption of clean energy systems depends not only on its technical efficiency but also on whether its design meets people's preferences. Most of the schemes to promote clean cookstoves focus only on technical aspects, such as their efficiency and the achievable emissions reductions, whereas the social, cultural and economic suitability of new stoves determine their continued use. Technological innovations in cookstoves and cooking vessels are needed for people to change to clean cooking systems for preparing traditional foods.

The poor may not adopt electricity as the primary energy source for household lighting, as it is expensive and the supply is unreliable. Because of the lack of a reliable electricity supply, many people use two sources of energy for lighting, especially in rural India.

Government schemes like Ujjwala are seen to be motivated more by considerations of energy access than by health and gender equity. The scheme addresses the provision of LPG connections to the poor but ignores issues like affordability (for refilling cylinders), behavioural aspects and the distribution network, which must be taken into consideration in order for the scheme to be effective in the long run. Furthermore, the false expectation of poor people that energy supplies will be available for free indefinitely will limit the success of universal access programmes.

6.1.1. Challenges to health sector engagement

Lack of data

Addressing the multidimensional and multisectoral issue of air pollution requires an approach based on the best epidemiological evidence and cost–benefit analyses of interventions. It also requires a strong communication platform to disseminate information about the health impacts of air pollution and the advantages of its mitigation. There is, however, a dearth of work on these areas in India.

Research on the health effects of air pollution in India faces many challenges, mostly associated with the quality and the availability of data on air quality and health outcomes. Although data on ambient air quality are available from national monitoring programmes, exposure to HAP has been characterized mainly in individual studies since the 1980s. Good-quality data on health outcomes from public and private medical facilities are scarce due to lack of standardized or electronic health record-keeping, and data on air quality collected by Government agencies are few and of questionable quality. The number of studies of the impact of exposure to $PM_{2.5}$ on health, including mortality, is also limited.

Interdepartmental cooperation

Currently, there are no linkages among ministries and departments responsible for health, social welfare and access to energy. An overarching agenda is required, involving the departments and ministries that address or are well positioned to address access to clean household energy and its implications for public health, pollution and welfare.

Despite the overlap in their objectives for HAP reduction, the Ministry of Environment, Forest and Climate Change and the MoPNG have no mechanism for cooperating with the Ministry of Health to share information or incorporate health messages in their information, education and communication strategies. Moreover, the two ministries have separate environmental health cells to fulfil their mandates. Although it has been recommended that a body be established to coordinate the various ministries that address household energy goals, little progress has been made.

Lack of awareness and capacity in the health system

The national programme for prevention and control of COPD will be implemented at state, district, subdistrict and village levels, where there is little awareness of the disease and its risk factors. Health workers should be made aware that HAP is an important risk factor for COPD.

There is clearly a lack of capacity within the health system for the management of COPD, and it should be strengthened. Front-line staff should be trained to screen for COPD, and medical staff, health administrators and nurses at health facilities should undergo training.

Making accredited social health activists responsible for risk communication and screening for COPD, in addition to their current tasks, would probably overburden them, making the strategy ineffective. Therefore, other mechanisms should be found for front-line engagement. The COPD programme includes not only training and capacity-building activities but will also find an appropriate incentive mechanism to encourage the engagement of accredited social health activists in HAP-related activities.

A woman takes a spirometry test to measure her lung function in a clinic in Odisha, India. Credit: Jessica Lewis

6.2 Opportunities for increasing access to clean fuels

Make clean household energy available. Some improvement in the reliability of the supply has helped to promote use of LPG, but full reliability in rural areas remains a challenge. The relatively large number of household LPG connections indicates potential multiple and dormant connections, although the proportion has decreased substantially since 2014. The increased number of LPG connections has not yet resulted in a significant increase in the demand for LPG in rural areas; however, the programme is still quite new, and little is known about the longer-term impact.

A worker rides a tricycle loaded with Hindustan Petroleum Corp. liquefied petroleum gas (LPG) cylinders at a depot operated by the company in Mumbai, India
Credit: Bloomberg via Getty Images/Dhiraj Singh

Fuel subsidies should be further targeted. Fuel subsidies tageted to the very poor can be a good social investment. Some 12 million middle-class households have given up their LPG subsidies and several hundred thousand have lost them since establishment of the new income threshold (> Rs 1 million/year). There are nevertheless still tens of millions more middle-class households that no longer need the subsidy to continue to use LPG. Thus, better ways should be found to target subsidies to the very poor and to eliminate the subsidies to the middle-class (slowly, to avoid political disruption). More creative use of information technology offers possibilities. The result would be less total Government expenditure and a substantial increase in use of LPG by the poorest groups.

Kerosene is supplied through FPS at subsidized prices. In contrast to LPG, kerosene requires little initial investment, and the subsidized price offers a significant incentive for unintended use (smuggling and adulteration with diesel). Further, Rao *(32)* contended that the kerosene subsidy is regressive and that more benefits accrue to the urban population than to the rural poor, as the rural population uses it for lighting. Moreover, for import-dependent countries like India, the subsidized supply becomes a financial burden when prices in the international market rise, and governments operating under severe budget constraints face difficulties in maintaining such subsidies in the long run.

Biogas should be promoted. Bond & Templeton *(85)* reported that about 50% of the biogas plants in the world are not functional due to poor maintenance and repair. Therefore, future prospects for the technology hinge on developing adequate servicing networks. They also argue for flexible designs to reduce dependence on livestock manure, cost reductions and enhanced functionality, with an emphasis on reducing HAP to improve the prospects of biogas plants.

In the near-term, rural electrification should be considered part of the solution for clean household energy in rural areas. As argued by Bhattacharyya *(86)*, rural electrification alone cannot resolve the problem of energy access in rural areas because it is unlikely to be competitive with the biomass fuels used by the poor for cooking. Biomass requires little economic cost, although it has heavy social costs. Electricity

could become the major cooking fuel in the longer term, with modern induction cookstoves and other electric cooking devices. This is consistent with plans to electrify vehicles and generally move India to an electric economy powered by renewable energy sources.

A woman in Uttarakhand, India, cooks with an electric coil stove. Credit: Jessica Lewis

More thought should be given to the technical design and user acceptability of advanced combustion cookstoves. India's national programme on improved *chulhas* met with little success, due to poor technical design, low household uptake and high cost, among other factors. Venkataraman et al. *(87)* reported that a national biomass cookstoves initiative to reduce emissions and improve energy efficiency would prevent 570 000 premature deaths and 4% of India's greenhouse gas emissions. Clean, widely acceptable stoves have yet to be designed.

Given the extensive use of solid fuels for cooking and heating by the poor, an "LPG-plus" approach to cooking energy might be taken. There are opportunities to eliminate traditional cookstoves and introduce improved biomass cookstoves for the very poorest populations.

New programmes to support research, financing and introduction of clean cookstoves in developing countries could accelerate the transition to clean household energy. A large part of the Indian population could be connected to LPG and, with encouragement, is expected to change to this clean fuel in the coming decade. This would align India with the strategy followed in Europe and North America, with gas fuels substituting for solid fuel (coal and biomass) as a clean, efficient transition to an all-electric future.

6.2.1. Strengthening the evidence base

Cost–benefit analyses of interventions to address HAP are based mainly on estimates of the effect of exposure on the incidence of chronic cardiovascular and respiratory illness or death. These data are currently lacking. Their availability could strengthen the case for greater investment in clean cooking.

Several studies have found that economically disadvantaged rural communities, where both fuel and labour are abundant, do not attach importance to the time spent in cooking or fuel collection. It has been noted that households that purchase rather than collect solid fuels themselves are more likely to switch to cleaner fuels, reflecting the greater perceived value placed on monetary rather than time savings *(88)*.

Studies should be conducted of the composition of air pollution and the health impacts of the pollutants. A wide variety of fuels are used in India for cooking and heating. Understanding the composition of biomass smoke will help to identify the health effects of the different sources *(89)*. For instance, although $PM_{2.5}$ has many constituents, the association of black carbon with health outcomes is by far the strongest.

6.2.2. Improved interdepartmental cooperation

The link between HAP and health was recognized in the national health policy only in 2016, when COPD was included in the National Programme for

Cancer, Diabetes, Cardiovascular Disease and Stroke. Recognition of COPD as a key health outcome and addressing it with systemic responses, risk communication and harm reduction strategies will lead to its adoption in state implementation plans.

The National Rural Health Mission has identified an overlap in the operational scope of the Department of Women and Child Development and the Department of Health and Family Welfare and lists means for convergence. The Integrated Child Development Services addresses the nutrition and health of children under 6 years and their mothers and is implemented by *Anganwadi* workers and helpers in villages. It collaborates informally with accredited social health activists, village health, sanitation and nutrition committees, schoolteachers and other community organizations. The two departments have published a manual for capacity-building of self-help groups and Panchayati Raj Institution members, highlighting primary health care issues, the rights and responsibilities of the public sector health service delivery system and community and household action for disease prevention and health promotion. These interdepartmental convergences with the health cadre are often a prerequisite to health-centred efforts to tackle HAP. They could also serve as a launch for the COPD programme.

In addition to the above, the National Health Mission formulates behaviour change communication strategies, Information, education and communication materials and messages and operational strategies for planning at village, block and district levels. It is also developing management information systems, including common indicators and identification of functional areas for training of staff, to ensure effective implementation of the NCD programme.

6.3 Recommendations for accelerating the transition

6.3.1. Convening and coordination

- **Increase technical and government cooperation**: Collaboration among technical experts and Government agencies in planning and implementing household energy interventions should be increased to reflect actual conditions. The results will enable state governments and energy companies to plan resources.
- **Facilitate institutional and interministerial coordination and cooperation:** While several current programmes are linked to household energy and health, they function in siloes. Lack of communication among relevant ministries on household energy policy and programmes prevents health from being a priority in decision-making. The proposal by the MoHFW to establish a standing committee on air pollution could result in more cohesive, health-centred policy-making on household energy. Such interministerial cooperation may require intervention by the Prime Minister's office.
- **Overcome regulatory barriers:** Current regulatory barriers, such as tariffs on micro- and mini-grids, restrict participation and scaling-up of off-grid suppliers in the electricity sector. Similarly, in the case of cooking technologies, clear standards and protocols (for example for improved biomass cookstoves) will not only facilitate the design and development of effective technology but will also strengthen mechanisms for reporting progress.
- **Integrate care pathways into health programmes:** More emphasis should be given to health strategies to reduce inefficient household energy use and to developing direct care pathways for diseases that are directly attributable to HAP. For instance, HAP could be incorporated into the work of the National Programme for Cancer, Diabetes, Cardiovascular

Disease and Stroke or as an intervention during post-screening NCD counselling.

- **Link the benefits of clean cooking to health programmes:** Convergence of existing energy and health interventions could protect the most vulnerable populations from the ill effects of HAP. For example, linkage of the list of the Socio-economic Caste census for LPG subsidies with the maternal and child health tracking system of the National Health Mission could facilitate the uptake of clean household energy.

6.3.2. Assessment, monitoring and evaluation

- **Design survey tools, and plan future scenarios:** In view of the surge in LPG connections and the rapid increase in village electrification, a large-scale survey or evaluation should be undertaken to determine whether the provision of connections leads to long-term adoption of clean household energy and the impact of this transition on health, livelihoods, the environment, etc. The survey should collect detailed information on household energy use, such as an inventory of all the fuels and technologies used, the impact on livelihoods and housing characteristics (for example, ventilation).
- **Integrate health information systems and surveillance:** Currently, there is no surveillance of the chronic diseases and injuries (burns) associated with HAP, although these are required for effective policy and planning. While the national NCD programme has initiated some screening, there is no mechanism for follow-up and treatment over time. An integrated system should be designed to track the health impacts of household energy use and ensure better patient care and follow-up.
- **Embed monitoring, evaluation and continuous learning**: Many of the programmes initiated to address household energy have failed. Monitoring and cataloguing what and how different factors (for example, community ownership, funding) affect the success of a clean household energy use project or programme chould inform future policy and programme development. A system for information-sharing would facilitate exchange of experiences and lead to more effective programmes.
- **Conduct social and health costing**: In India, few accurate cost–benefit analysis studies have been conducted to determine the social and health costs or savings associated with household energy. Such analyses should be prioritized to support policy and adequate allocation of financial resources.

A research team conducts a survey on household energy use in Uttarakhand, India. Credit: Jessica Lewis

6.3.3. Communication and education

- **Conduct information, education and communication activities:** Behaviour plays a strong role in adoption of modern, efficient technology. To gain support from both men and women, health workers, Government energy and health departments, village heads and schoolteachers, they should be informed about clean household energy and its benefits. Information, education and communication should be cross-cutting and tailored for different stakeholders.
- **Generate awareness in the health system**: There is lack of awareness about the health impacts of HAP and also misperceptions about the risks associated with HAP throughout the health system, including among medical professionals. Consequently, physicians do not advise their patients on the health impacts of HAP and how to mitigate the risk. A concerted effort should be made to educate and strengthen the capacity of the health sector to address household energy as a health risk.
- **Provide refresher training for front-line health workers:** Engaging front-line health workers by introducing a HAP module into their training programmes to advise users of traditional household energy about the health risks could help to change behaviour.

6.3.4. Policy advocacy

- **Find customized solutions for access to energy**: In a widely diverse country such as India, a universal solution is not realistic. Targeted technologies should be promoted, such as affordable advanced combustion cookstoves for the rural poor in remote areas and electrical induction stoves for urban areas. Biogas programmes should be extended and targeted to the appropriate communities, accompanied by innovative approaches to financing and local capacity-building for maintenance. Dry-cell batteries and solar lighting could be promoted in remote locations where access to electricity is not possible int the short-term.
- **Find innovative service delivery mechanisms:** The current mechanism of distribution of LPG cylinders in rural and remote areas is not viable for either the consumers or the distributors. Distributors have little business (refilling LPG cylinders), and the consumers do not have their cylinders refilled for logistic, behavioural and financial reasons. Smarter delivery models are required, including better mechanisms for financing and distribution.
- **Delivery effective subsidies**: The subsidy currently offered to poor households is too low and the delay to receiving the subsidy too long to encourage LPG adoption. The upfront costs of cylinders and refills also discourage LPG use. When the subsidy for millions of consumers just above the poverty line is phased out, the transition to cleaner household energy will be even more challenging. Broader criteria for beneficiaries should be defined so that they include populations living just above the poverty line.
- **Better tools for delivering subsidies and technologies:** More effective, smarter ways should be found to identify the best technology and the appropriate target group for each solution (technology, financial instruments and subsidies).
- **Innovate consumer financing:** Easy access to finance for refilling LPG cylinders is essential. Poor households often have limited, unpredictable disposable income, which is barrier to adoption of clean household energy in India. Innovative micro-finance and savings schemes that would make LPG pricing competitive with that of biomass could encourage broader usage. Pilot studies in sub-Saharan countries with a "pay-as-you-go" model for LPG use might be a viable model for India, and a pilot study in the rural areas of Rajasthan and Maharashtra could shed more light on the appriateness of the model.

7 Conclusions

The health sector could encourage adoption and sustained use of clean fuels and technologies for household energy in four areas.

Convening and coordination

- Establish and support an interministerial group headed by the Ministry of Health and Family Welfare.
- Review current policies, and provide health-based recommendations.
- Convene leaders in health and energy to promote a health-based policy for clean household energy.

Assessment, monitoring and evaluation

- Prepare scenarios of household energy policies and health impact assessments.
- Assess the capacity for surveillance of disease, injuries and incidents associated with fuel use,
- Identify and evaluate a peri-urban clean fuel demonstration project that could be scaled up.

Communication and education

- Design campaigns and training for the health sector.
- Provide information for Government leaders and staff.
- Evaluate the impact of these activities.

Policy advocacy

- Promote adoption of WHO Guidelines.
- Promote adoption of new laws and policies on use of LPG.
- Support the Presidential initiative to introduce LPG.
- Evaluate the impact of advocacy.

8

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Annex 1. Market promotion schemes for liquefied petroleum gas (LPG)

Pratyaksh Hanstantrit Labh (PAHAL) scheme – direct benefit transfer of LPG

The Government of India launched the PAHAL scheme in 54 districts in 2014 (first phase) and subsequently extended it to the remaining 622 districts on 1 January, 2015 (second phase). The objective was to rationalize subsidies by approach to reducing subsidy leakages but not the subsidies themselves. LPG consumers who join the PAHAL scheme obtain the LPG cylinders at the non-subsidized price, and the LPG subsidy (as per their entitlement) is paid directly into their bank accounts. Under the scheme, linking the bank account with the identity card was mandatory; however, many people did not have an identity card. CTC (cash transfer compliant) was initiated to make a link with the bank accounts of people without an identity card in order to pay for LPG subsidies.

Under the PAHAL scheme, a domestic LPG cylinder is sold to a CTC domestic LPG consumer at market-determined price (that does not include a subsidy), and the amount payable on an LPG cylinder is transferred to the beneficiary's account for each subsidized cylinder delivered (up to the cap) according to their entitlement. For non-CTC consumers, a 3-month grace period is given under the scheme, during which an application may be made to become a CTC consumer. During this period, the consumers receive their entitlement of subsidized cylinders at the then-applicable subsidized retail selling price. After the grace period, non-CTC consumers are given an additional period of 3 months, and then all non-CTC consumers receive cylinders at the market-determined price and are not entitled to total cash until they become CTC consumers.

PAHAL generated savings of up to Rs 21 000 *crore* by 2016, and the number of LPG subsidies granted increased from 13 *crore* in 2014 (launch year) to 17.4 *crore* in 2016. This number is expected to grow further. There are, however, some concerns about the PAHAL scheme. Although it promotes cashless transfer of LPG subsidies, this is possible only in urban areas, where banking infrastructure, road connectivity and information technology are available. The rural areas (especially hilly and remote villages) of India often lack banking services, and the poor infrastructure is an obstacle to cashless transfer of LPG subsidies to poor households. No unequivocal estimates or studies on the effectiveness of direct benefit transfers for LPG have been published, although there are studies with contradictory results. The Economic Survey 2015–2016 reported that direct benefit transfer of LPG was responsible for reducing the LPG subsidy by 24%, whereas Barnwal (2015) *(1)* found a more moderate impact of 11–14%.

Pradhan Mantri Ujjawala Yojana (PMUY)

The Government of India launched PMUY to provide LPG connections to 5 *crore* women in BPL families over 3 years, starting from fiscal year 2016–2017. The objective is to provide clean fuel to poor households, especially in rural areas. The Government provides a deposit-free LPG connection to the adult woman member of a BPL family, which includes a security deposit towards purchase of the cylinder and a pressure regulator, DGCC card, hose and administration and installation charges. The Government pays up to Rs 1600 for each new connection, while the customer pays for the hotplate and the first refill. Alternatively, it may be financed at zero interest by oil marketing companies and recoverable through equated monthly installments. A total of Rs 8000 *crore* has been allocated to implementation of the scheme.

Eligible BPL household beneficiaries are identified from data in the Socio-economic Caste census, 2011. Important aspects of the scheme are: the connection is issued to female members of BPL households who suffer from at least one deprivation, as per Socio-economic Caste census (rural data), and preference is given to Scheduled Caste and Scheduled Tribe BPL families

and to states with LPG coverage lower than the national average.

The PMUY scheme covers 709 districts, and 29 543 113 connections have been released. During 2016–2017, there were 32.2 million new LPG connections, of which 20 million were to PMUY beneficiaries. While the number of LPG connections grew from 10.2% in 2015–2016 to 16.2% in 2016–2017, there was only a negligible increase in LPG consumption, which rose from 9% in 2015–2016 to 9.8% in 2016–2017. This confirms reports that few PMUY customers buy refills. This is not surprising, as PMUY beneficiaries do not have to pay the security deposit when LPG connections are fitted, and they have the option of paying for a gas stove and the first refill in instalments, while there is no concession for the second refill. Even a subsidized cylinder cost about Rs 450, which is a huge amount for a poor household to pay each month *(2)*.

Ujjwala Plus Scheme

On 15 August 2017, the Prime Minister announced the launch of the Ujjwala Plus Scheme for poor people, to increase the coverage with free LPG connections. This is the next step from the PMUY Scheme. Under the Ujjwala Plus Scheme/Yojana, LPG consumers who have voluntarily not claimed their subsidy on cooking gas will be asked to provide free LPG connections to nearby needy families. Under the PMUY scheme, the Government fixed the limit of beneficiaries; however, under the Ujjwala Plus Scheme, the Government will provide free LPG connections to more targeted beneficiaries. The aim was to make gas connections available to 1.5 *crore* people in 2017 and to provide 50 million gas connections over the next 3 years. Under the PMUY scheme, many people were left out and could not claim the benefit because they did not provide a family name at the time of the Socio-economic Caste census. This situation ought to be rectified by the Ujjwala Plus Scheme.

"Give It Up" or "Giveback" scheme

The Government has asked well-to-do households to voluntarily give up their LPG subsidy as part of the "Give It Up" programme, any many well-to-do families have done so. Further, the Government decided that the LPG subsidy cannot be claimed by consumers if they or their spouse had a taxable income of Rs 1 000 000 or more during the previous financial year. This decision took effect from 1 January 2016. The main objective of the scheme is to provide LPG to poor households and replace traditional fuels such as kerosene, coal, fuelwood and dung. It is estimated that nearly 1 *crore* LPG consumers have voluntarily given up their LPG subsidy, thus helping the Government to better target subsidies to poor households and to encourage use of clean fuel for cooking in both urban and rural areas *(3)*.

SAHAJ

SAHAJ is a digital initiative intended to provide a straightforward way for consumers to apply for a new LPG connection. The oil marketing companies launched the facility for the release of an LPG connection with online payment and issuance of an electronic subscription voucher, "e-SV", under the Digital India Initiative, and the facility is now available throughout India. The e-SV records the number of cylinders and the pressure regulator lent to the consumer against a security deposit. The document is emailed to the customer upon release of the LPG connection online. An online payment facility for booking refills and paying bills is also included. Online inter-company de-duplication is also made possible with the e-SV. It should eliminate the need for multiple visits to distributors showrooms by prospective consumers to complete the formalities and deal with any problems. It will also reduce the time for release of connections. The Indian Oil Corporation started pilot-testing the SAHAJ scheme in Delhi on 1 May 2015, with 308 distributors. A total of 550 SAHAJ e-SVs were released for online registration and payment, and almost 98% of the connections registered online were released within 7 days of registration. After the success of this pilot study, the facility was extended to cover states and distributors across India *(4)*.

Emergency helpline

A multilingual LPG emergency helpline was dedicated to the nation on 1 January 2016 by the MoPNG. Assistance is available around the clock, with two shifts of 12 h each, for attending to emergency LPG leakage complaints. The call centre has a web-based application for logging

and monitoring calls and updating the contact details of mechanics and field officers

Smart Delivery Management System

The Smart Delivery Management System was introduced to make the supply and distribution of LPG transparent by promoting a friendly mobile application for delivery personnel, with features like smartcard-based delivery options, real-time delivery, confirmation of deliveries made, better control of delivery staff and the supply chain and capture of the geographical coordinates of every delivery.

Facility for online payment for refill booking

To promote cashless transactions, consumers have been provided with a facility to make online payments for booking a refill. Thus, consumers can arrange for delivery of a refill to their homes without having to be present and addressing the potential issue of overcharging.

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Annex 2. Nongovernmental and civil society organizations concerned with energy and health in India

Name of organization	Category	Work related to household air pollution	Website
Chest Research Foundation	Research	Conducts research on airway diseases, specifically asthma and COPD; clinical evaluation of drugs	www.crfindia.com
KEM Hospital	Medical facility	Conducts research on maternal and child health, communicable and noncommunicable disease. Conducting a trial of introduction of LPG to pregnant women	www.kemhrcpune.org/vadu-hospital
Kalpvriksh Environment Action Group	NGO	Work on environmental and social issues	http://www.kalpavriksh.org/
Applied Environmental Research Foundation	NGO	Work on community-based conservation and natural resource management	http://www.aerfindia.org
Seva Mandir	NGO	Provides clean energy cookstoves to households in Udaipur and Rajasthan	www.sevamandir.org
SEWA	NGO	Provides solar lanterns and energy-efficient cookstoves by guaranteeing bank loans for its members	www.sewabharat.org
Public Health Foundation of India	NGO	Conducts research, training and capacity-building, implementation, policy advocacy in public health	www.phfi.org
Grameen Greenway Infra	Social enterprise	Stove manufacturer	www.greenwayappliances.com
Envirofit	Social enterprise	Stove manufacturer	www.envirofit.org
PRAYAS	NGO	Research and intervention in policy and regulatory in the energy sector; offers training and support to civil society groups	http://www.prayaspune.org/
Gram Oorja	Social enterprise	Provides renewable energy to meet electricity, cooking fuel and water needs of tribal communities using photovoltaic microgrids, biogas-based cooking grids and solar pumps	www.gramoorja.in
Samuchit Envirotech	Social enterprise	Promotes clean cooking technologies	www.samuchit.com

Name of organization	Category	Work related to household air pollution	Website
Barefoot College	NGO	Provides solar cooking and lighting solutions	www.barefootcollege.org
Clean Energy Access Network	NGO	Work to improve clean energy access for rural and urban poor	www.cleannetwork.org
Tata Trust	NGO	Supports various clean energy projects, such as popularization of solar-based irrigation pumps, facilitating access to energy through community off-grid solar systems, facilitating lighting systems for individual homes, installing rooftop solar systems, popularizing clean cooking systems and biogas	www.tatatrust.org
Infosys Foundation	NGO	Supports clean cooking programme as part of their carbon offset projects	https://www.infosys.com/infosys-foundation/
Shakti Sustainable Energy Foundation	NGO	Promotes policies that encourage renewable energy and energy efficiency	http://shaktifoundation.in/
Council for Energy, Environment and Water	NGO	Conducts policy research on energy issues including cooking	http://ceew.in

For further information please contact:

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