



Global Alliance for Clean Cookstoves

India Cookstoves and Fuels Market Assessment

Dalberg Global Development Advisors
February 2013



Introduction

- The “India Cookstoves and Fuels Market Assessment” was conducted by Dalberg Global Development Advisors on behalf of the Global Alliance for Clean Cookstoves (“the Alliance”).
- It is **one of a series of country assessments** completed by the Alliance to:
 - Enhance sector market intelligence and knowledge;
 - Contribute to a process leading to the Alliance deciding which regions/countries it will prioritize; and
 - Support the Alliance in developing its strategy and approach to country level interventions.
- This document is meant **to provide a snapshot of the cookstoves sector in India** in terms of the overall trends in supply and demand, and emerging opportunities and challenges. It can and should be used in conjunction with a number of research papers, consumer surveys and other sources (most published on the Alliance’s website) to enhance the sector’s understanding of the market.
- In this study, a team of Dalberg consultants overseen by the Alliance staff led the data collection and analysis in India over a period of 5 weeks conducting a combination of primary sources (through expert interviews and the Alliance-sponsored stakeholder consultations) and secondary research as well. The process was designed to build on and synthesize the research that has already been conducted in the sector.

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Executive summary (1/2)

India has grown to be the third largest economy in the world (in PPP terms) and its population of 1.2 billion presents an enormous market opportunity for emerging businesses.

However, growth has not been equal and large challenges remain: ~35% of its population lives on less than \$1.25 a day, health and educational outcomes remain on average low, physical infrastructure is weak, and access to energy is a challenge for the majority of the population.

Solid fuels remain a critical part of the energy formula for many households. ~67% of households in the country (equivalent of ~166 million households) remain wedded to solid fuels as their primary source of cooking fuel. While conversion to modern fuels has accelerated in urban areas, populations in rural areas have been slow to move away from solid fuels. Given that the majority of India's population is likely to remain young and rural over the next 10 years, solid fuels will continue to play an important role in the energy mix of households.

The use of solid fuels and inefficient cookstoves has had significant impacts on health outcomes and livelihoods, particularly for women. ~400 million people in India (of which 90% are women) are exposed to the negative health impacts associated with indoor air pollution from inefficient cookstoves, resulting in respiratory, pulmonary and vision problems. It is estimated that household air pollution is the leading cause of DALYs in South Asia leading to ~875,000 premature and avoidable deaths. In addition to the health impacts, inefficient cookstoves and practices entails that women spend up to ~5-8 hours per day on cooking activities, with ~20% of that time devoted to the collection of fuel.

Based on the overall population, fuel practices, and income segments, there is a very large market for cookstoves including both easy and challenging to address segments. The overall market size in India is ~235 million households, more than the total market sizes of many other developing countries combined. The easiest consumer segment to target would likely be the low and mid-high solid income solid fuel purchasers – a market of ~33 million (or 14% of the overall market). A larger and more challenging market would be rural solid fuel collectors who could benefit most from cookstoves, and make up ~45% of the market – however, given that they don't have a history of paying for fuel, it would be harder to break into. However, a key challenge for all segments will be to ensure that the cookstove is affordable enough for the end-consumer (either by bringing down the price point or by enhancing the availability of consumer financing options)

Executive summary (2/2)

Despite the large market potential, there are a limited number of players in the market and few have reached scale. There are a wide variety of cookstove technologies on the market today – ranging from basic improved cookstoves to renewable energy solutions. While there is a thriving and growing set of private sector actors (and NGOs) in the sector, the majority of them are small and have yet to scale up to meet the magnitude of the problem. Key challenges include: lack of awareness of the problem among consumers, a dearth of sustainable financing sources, variable government policies which can spoil the market by introducing subsidies, and challenges in identifying effective partners to conduct rural distribution.

While the government has been slower to re-enter the cookstove policy sector, donors and multilateral agencies are scaling up their efforts in this area. The government's experience with the National Program on Improved Cookstoves (NPIC) met with some successes at a state level (i.e., Gujarat) but faced challenges nationally. New initiatives such as the National Biomass Cooking Initiative and National Clean Energy Fund have sought to incorporate lessons learned from the prior policy initiatives and are focused on enhancing the role of the private sector, but have been slow to start. However, cookstoves have become a popular focus area for donor agencies and multilateral programs and new programs on supporting research, financing and implementation are beginning to emerge.

Overall, there is a high potential for cookstoves to become an attractive opportunity for the private sector and an impactful mechanism by which to improve health outcomes and livelihood opportunities for millions of households. However, in order to scale up both the supply and demand for cookstoves, support is required in four areas: (i) facilitating greater partnerships between stakeholders and sharing of knowledge within the sector, (ii) developing and promoting acceptable and minimum standards for stove performance, (iii) promoting awareness of cookstoves and the positive benefits they hold, and (iv) providing and promoting a wider base and diversity of financing options available to both consumers and suppliers.

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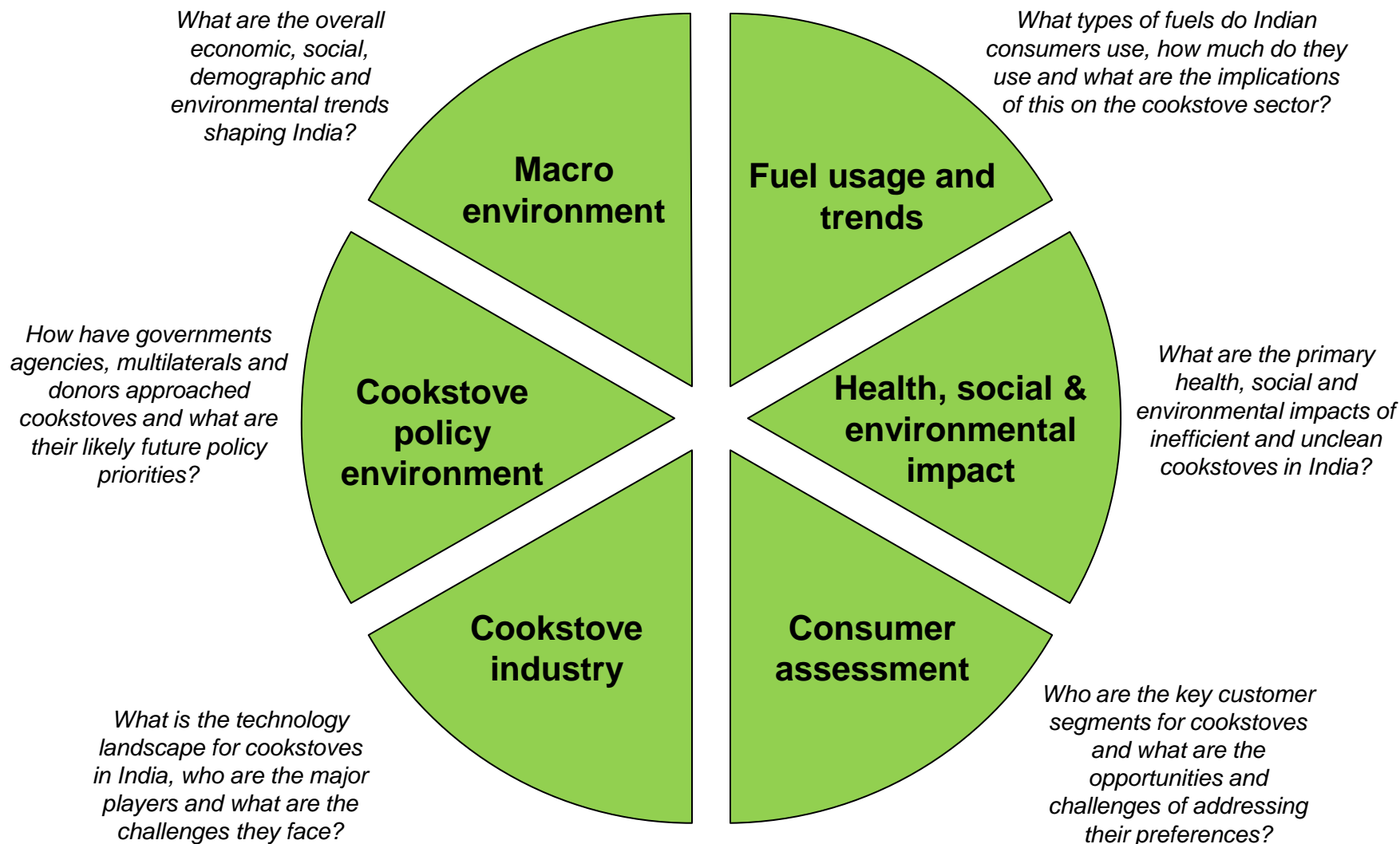
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We conducted a sector mapping of the Indian cookstove industry across six dimensions



We used a combination of primary and secondary research to inform our findings

This market assessment was undertaken over the course of 5 weeks. It builds on *existing* work in the sector and seeks to consolidate rather than to create and re-invent the wheel.

Key sources for the market assessment include:

- **Primary data** from a variety of surveys including information on household size, demographics, cookstove use, fuel use, etc. Key sources included: Census of India, National Sample Survey Organization, WHO Demographic and Health Survey, etc.
- **Secondary research** from academic papers, dissertations, and industry briefs
- **Interviews with stakeholders** including academics, experts on the industry, and select manufacturers/distributors

Some notes on the data and analysis:

- For a detailed understanding of the Indian market, we used the most comprehensive source of data available: the 2011 National Census as well as the 2009 National Sample Survey Organization report. We accept that there may be errors and variance in this data set and this analysis can be updated with improved data if/when it comes available
- In some analyses, totals may not add up exactly (i.e., percentages may not add up to exactly 100%) due to rounding.
- All geographic maps have been taken from the Government of India. Depiction of boundaries is not and should not be considered authoritative.

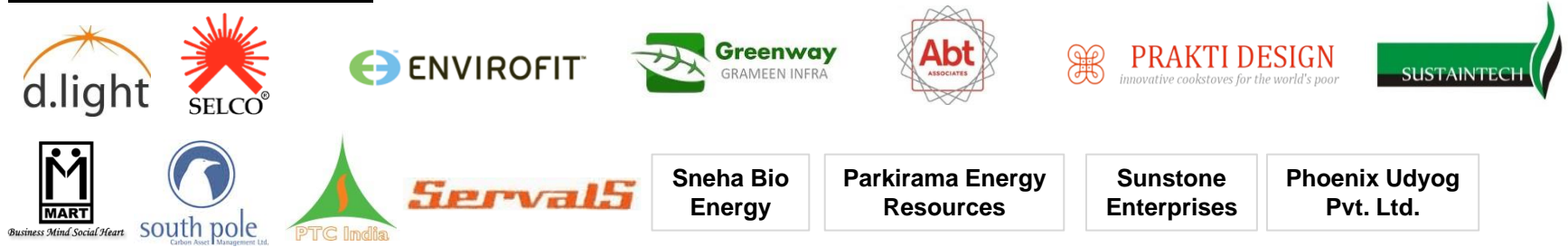
We validated and refined our findings through a series of stakeholder consultations in Chennai and Delhi

Participants at GACC stakeholder consultations in India

Government:



Manufacturers and distributors:



Donor agencies, Non profit sector, advocacy organizations and research organizations:



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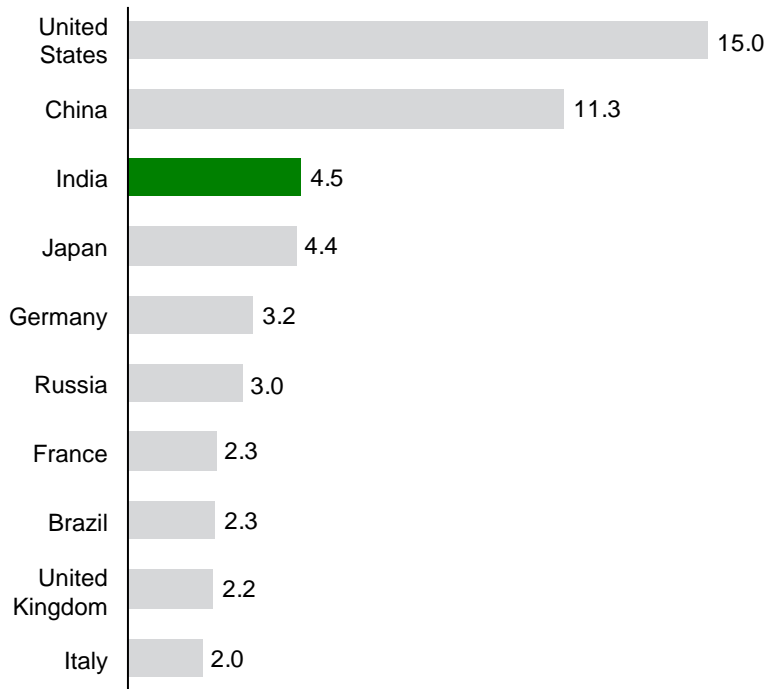
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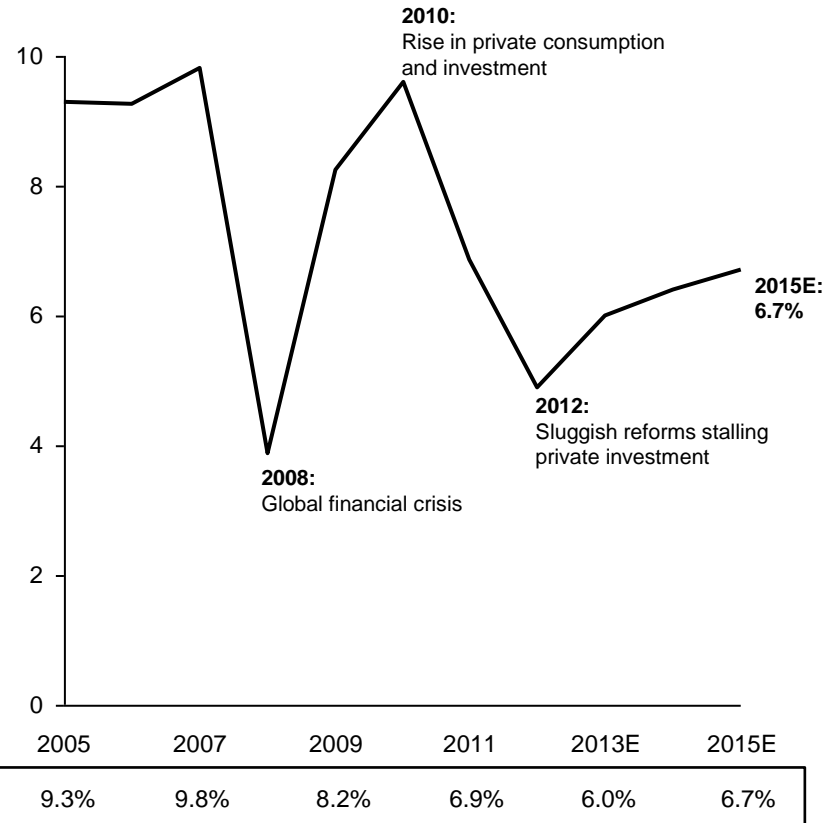
Appendix

India is the world's third largest economy. The country's growth is likely to slow down but will remain high at ~5-7% GDP growth

GDP of 10 largest economies (PPP adjusted, 2011)
(current international \$, trillion)



India's GDP growth rate
(annual %)



Growth rate:

9.3% 9.8% 8.2% 6.9% 6.0% 6.7%

The country is led by a coalition government and therefore regional parties play a significant role in influencing central policy decisions

Political structure

- India is a parliamentary republic with a multi-party system
- The Constitution of India serves as the country's supreme legal document
- The President is the head of the state and appoints the Prime Minister who serves as the head of the government
- Parliamentary elections are held every five years with the last elections held in 2009

Administrative structure

- The country is divided into 28 states, 7 Union Territories, 640 districts
- Power is divided between central and state governments with a Governor serving as the head of state and the Chief Minister as the head of a state government
- Majority of the population is spread across the 640,867 villages in rural India
- New Delhi, Mumbai, Bengaluru and Hyderabad are the four most populous cities in the country

Current government

- The Indian National Congress (INC) is the dominant party leading a coalition government with 38% of the legislative seats
- Other members of the coalition include regional parties such as National Conference (Jammu and Kashmir), National Congress Party (Maharashtra), Dravida Munnetra Kazhagam (Tamil Nadu)
- The second largest national party is the Bharatiya Janata Party (BJP) with 21% of the seats

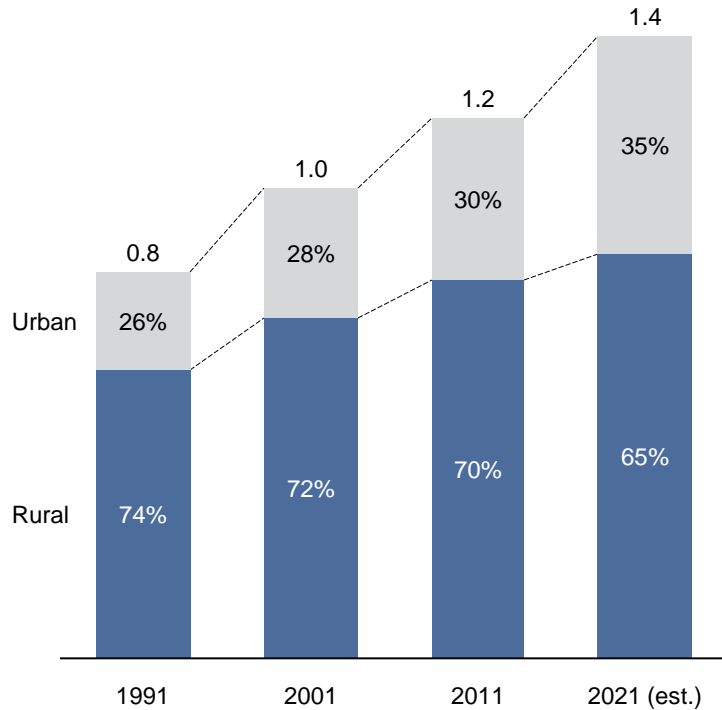
Working with the government

- Partnership with a cooperative government agency (national as well as local) is critical to navigating the complex political and regulatory environment of India
- Most legislations are enacted by the central legislature with the state legislature having legislative power on certain issues such as public health, communication, agriculture and electricity
- Several initiatives related to energy access and climate change have been tabled but may be vulnerable to lack of consensus amongst parties of the coalition government

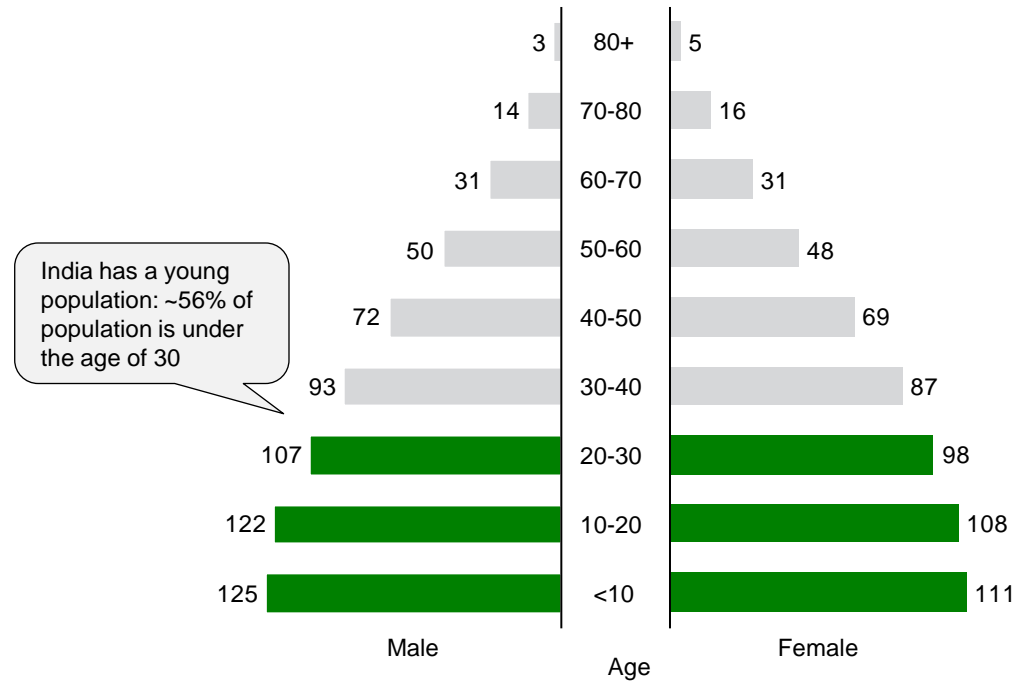
Success of development interventions often depends on government buy-in and alignment with existing programs, particularly at the local level

India's population is likely to be primarily rural and largely young over the next 10 years

Rural vs. urban population breakdown
(% of population, total population in billions)



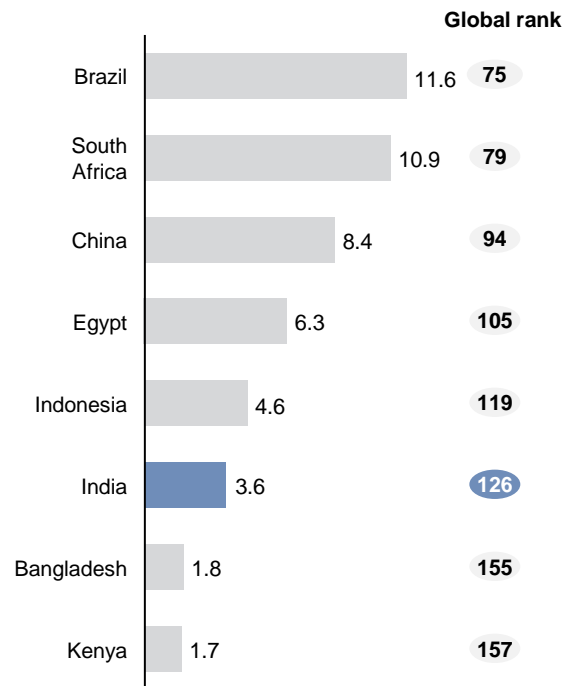
Population pyramid, 2011
(millions of people)



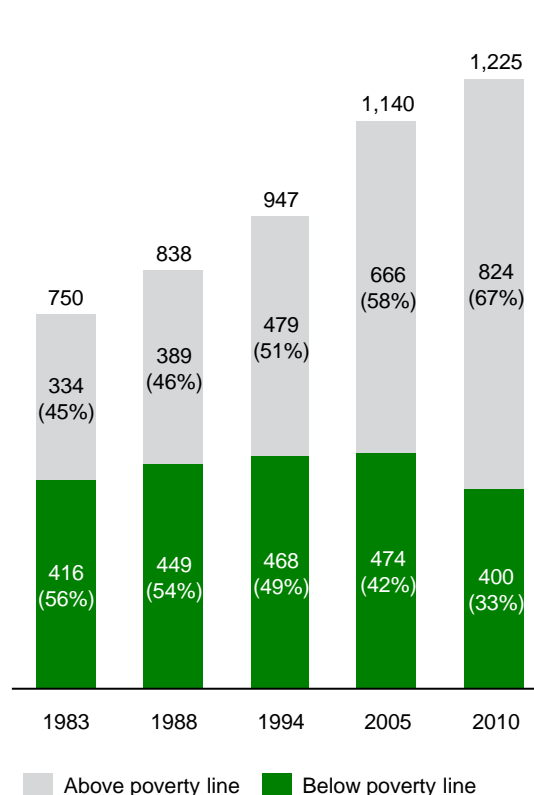
India's large and growing population is a key reason why its current development pathway may not be socially or environmentally sustainable

Despite substantial economic progress, growth has not been inclusive and a large swathe of India's population remains poor

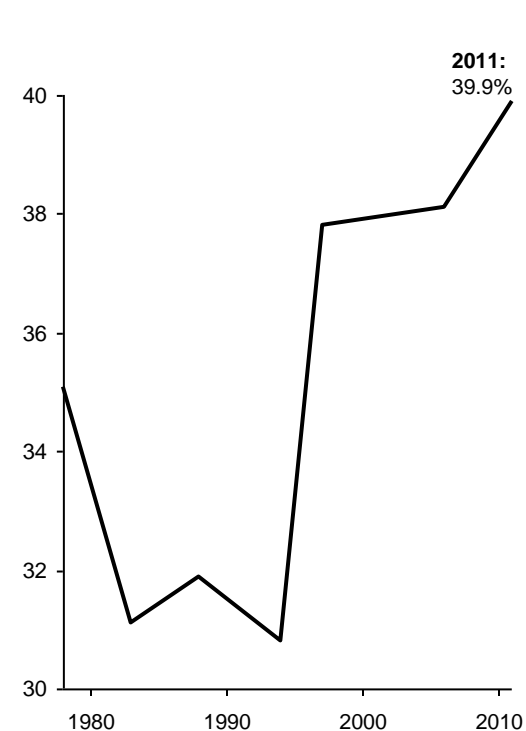
GDP per capita, PPP
(current international USD, thousand)



Population below poverty lineⁱ
(in millions)



Gini index - Indiaⁱⁱ
(%)



Note: (i) \$1.25 per day (PPP) is treated as poverty line; In 2009, methodology for calculating India's official poverty estimates was changed and revisions were made to the official poverty line; (ii) Gini index represents distribution of income or consumption expenditure; an index of 0 implies perfect equality and an index of 100 implies perfect inequality

Source: World Bank Data; Euromonitor International

While progress has been made, women in India tend to remain marginalized and score lower on many key development indicators

Gender equality statistics					
UNDP gender inequality index		129 out of 146 countries (2011 index)			
% of women in national government		11%			
Internet gender gap (weighted) ⁱ		27.4%			
		Rural	Urban		
Sex ratio (Number of females per 1,000 males)		947	926		
Adolescent fertility rate (births per 1,000 girls aged 15-19)		43	20		
Infant mortality rate (per 1,000 births)		51	31		
		Male	Female	Male	Female
Literacy rate (Age 7 & above)		79%	59%	90%	80%
% of children attending school	6-10 years	89%	86%	91%	90%
	11-13 years	88%	82%	90%	88%
	14-17 years	66%	55%	73%	71%

- Average age of women at marriage is 20.7; the figure is 20.2 in rural areas and 22.2 in urban areas
- Female participation in labour force remains low at 36% overall, and only 19% in the organized sector. Of the women working in the organized sector, 70% are employed by the government
- Marital status often dictates the autonomy and empowerment of women
- The National Policy for Empowerment of Women aims to bring about advancement, development and empowerment of women in all spheres of life through by:
 - a) creating a more responsive judicial and legal system sensitive to women
 - b) mainstreaming a gender perspective in the development process

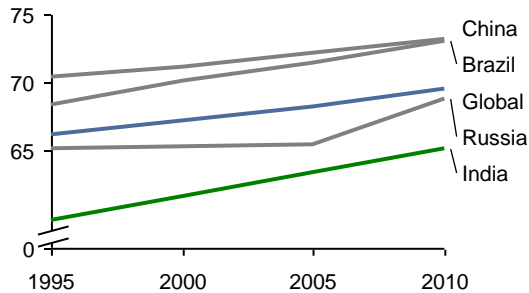
Across most of India, women tend to not play decision-making roles in the household – cookstove initiatives should consider this when conducting marketing and awareness campaigns

Note: (i) Internet gender gap represents the gender gap in likeliness to access internet, meaning a women is that percent less likely to have internet access than a man
 Source: Census of India 2011; Government of India; Women and the Web: a study by Intel & Dalberg; UNICEF Statistics; UNDP Gender Inequality Index; World Bank Data; Women in National Parliaments 2012; Inter-Parliamentary Union; An Overview of Women's Work and Employment in India 2010; Ministry of Health and Family Welfare Statistics India

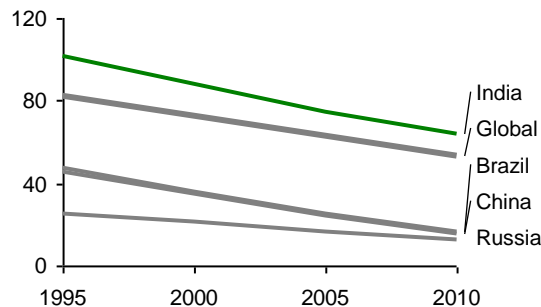
The overall health landscape in India lags when compared to other developing countries, but it is a key priority in national policy

While improving, key health indicators in India are lower than other developing countries...

Life expectancy at birth
(in years)

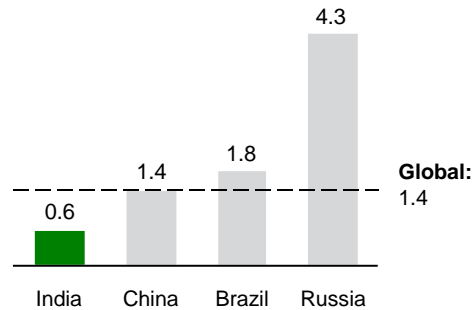


Mortality rate – under age 5
(per 1,000 live births)

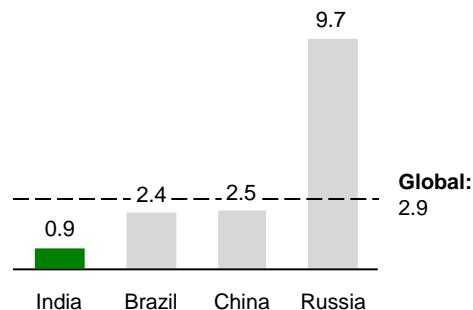


... and the infrastructure required to address these issues remains inadequate

Physicians
(per 1,000 people)



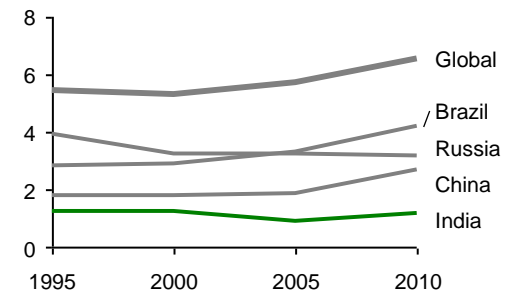
Hospital beds
(per 1,000 people)



The government has made health a national priority area:

- Commitment to increase health expenditure from 0.9% to 2.5% of GDP by 2017, with a focus on chronic diseases, infrastructure and data management

Public health expenditure
(% of total GDP)



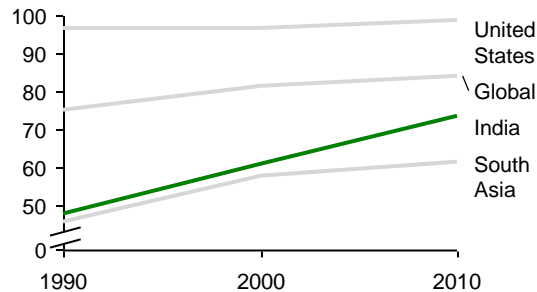
- Strong focus on maternal and child health in rural areas through national community healthcare worker program (ASHA program)

Cookstove initiatives can help improve health outcomes in India, but the lack of infrastructure raises challenges for consumer awareness.

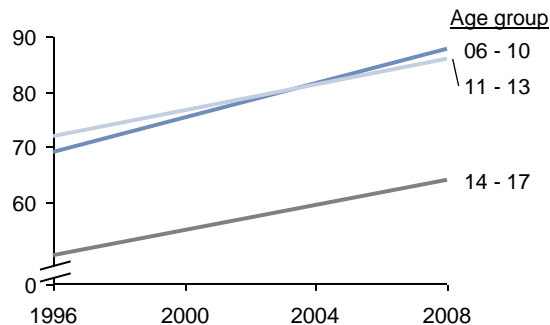
While it is improving, illiteracy and a lack of proper education infrastructure continue to hamper India's growth trajectory

Although it has significant illiteracy, India is catching up fast by educating its younger generations...

Adult literacy rate (%)

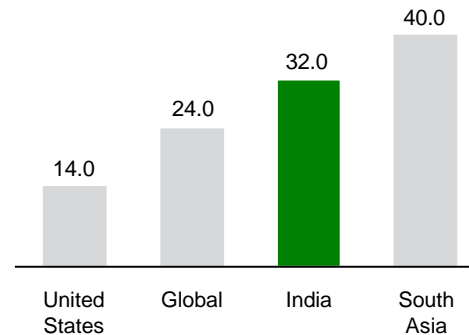


Age specific attendance ratio (% of children in that age group)



...however, the infrastructure to support the change is inadequate

Pupil teacher ratio in primary schools - 2010



- **Lack of teachers:** 10% of schools have single teacher and teacher absenteeism is high
- **Lack of basic infrastructure:** 12% of schools do not have drinking water facility; 25% of schools do not have adequate furniture
- **Lack of enough schools:** 53% of children in rural areas and 9% of children in urban areas travel more than 2 kilometres to attend secondary school

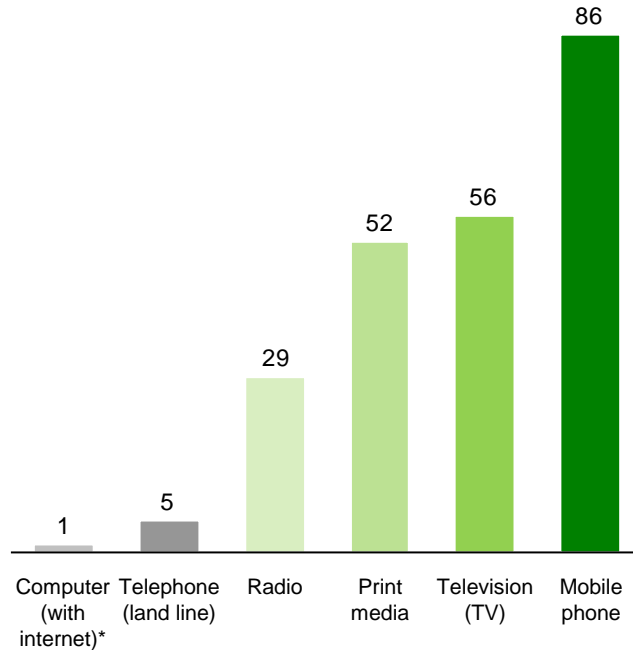
Government has stepped up its pace on improving education outcomes:

- Education spending as a % of GDP is now 3.2% (as compared to the South Asian average of 2.7%) and up from 2.9% in 1997
- Right of children to free and compulsory education act (RTE) is added to fundamental rights granted by Constitution of India in 2009
- Sarva Shiksha Abhiyan (SSA) seeks to provide access to quality elementary education to all children of 6-14 years age group
- The Mahila Samakhyia program aims to empower women in rural areas through education

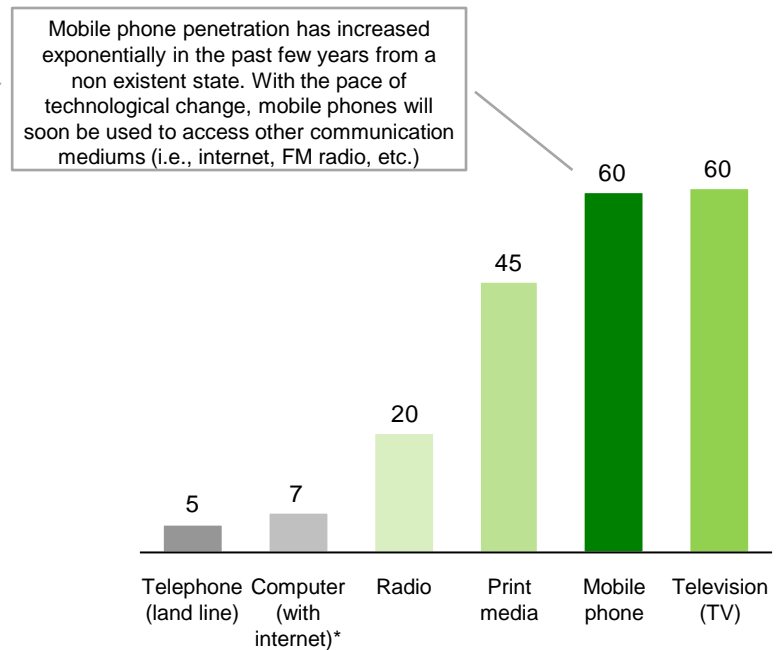
Low levels of literacy is a challenge for consumer awareness. However, given that India's population is primarily young, cookstoves initiatives can potentially use schools as a way to raise awareness in the youth population

India has a well developed communications infrastructure, with mobile phones, television and print media playing a crucial role

Access to mass communication modes - Rural
(in millions of households)



Access to mass communication modes - Urban
(in millions of households)



Mode	1	3	17	31	33	51	6	8	25	57	76	77
% of total Households:	1%	3%	17%	31%	33%	51%	6%	8%	25%	57%	76%	77%

*Number of households with access to internet is expected to be higher as other modes, especially internet cafes and mobile phones, are also used to access internet

Increasing awareness of cookstoves can be achieved through either short and targeted messages on TV and mobile phones, or through longer more nuanced messages in print media

Note: (i) Households that can be reached via mobiles also include households that can be reached via both telephone (land line) and mobile; (ii) Households that can be reached via computer includes only households that have computers that are connected to internet; (iii) Estimates related to print media are arrived upon by using Indian readership survey and census data. Hence, precise accuracy of data may vary when compared with other modes of communication
Source: Census of India 2011, Indian readership survey 2011Q2, Internet and Mobile Association of India (IAMAI), Dalberg analysis

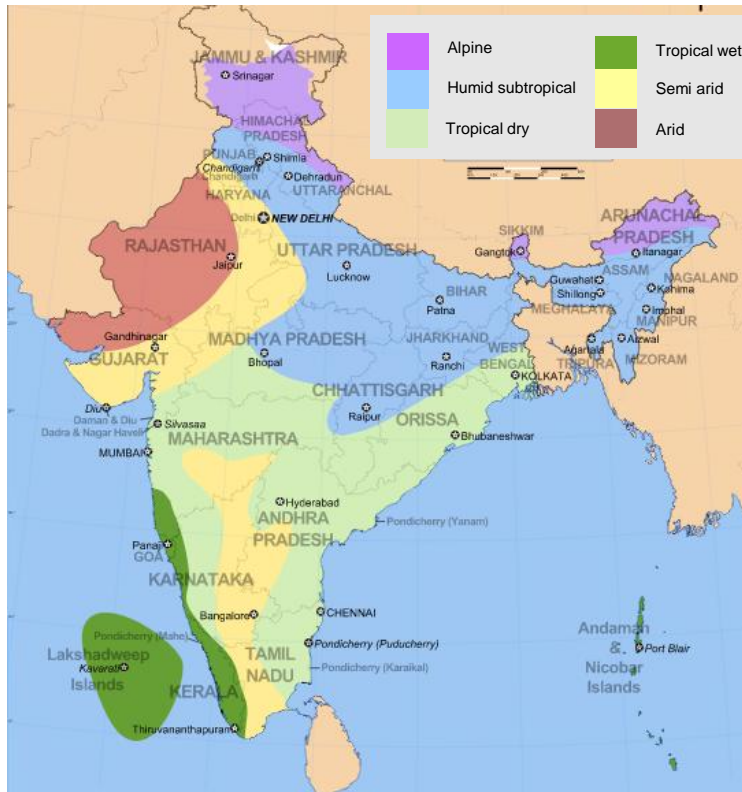
While India has an extensive infrastructure, low quality and uniform access remain challenges that the government is seeking to address

	Roadways	Railways	Waterways	Airways
Current situation	In terms of quality of trade and transport related infrastructure, India stands 54th out of 153 countries , below China, Brazil and many other developed and developing nations (World Bank)			
	<ul style="list-style-type: none"> • About 60% of India's freight and 88% of passenger traffic is carried by road • India has ~3.8 km of road per every 1,000 people, which is much lower than that of USA (20.8); The figure is further low in rural areas of India (2.2) • But only 54% of Indian roads are paved 	<ul style="list-style-type: none"> • ~927 million tonnes of freight is transported every year via railways and ~21 million passengers travel every day via railways • But railways are under severe capacity constraints and are unable to meet the demand 	<ul style="list-style-type: none"> • ~1 billion tonnes of freight is handled by ports • India stands 21st out of 154 countries in terms of shipping connectivity • But India stands 83rd out of 141 countries in terms of quality port infrastructure 	<ul style="list-style-type: none"> • ~2.3 million tons of freight & ~150 million passengers were carried via airways • Both passengers and freight traffic has been growing at 20% annually, placing a heavy strain on airport infrastructure
Government priorities	<ul style="list-style-type: none"> • Pradhan Mantri Gram Sadak Yojana (PMGSY) aims to provide all weather road connectivity in rural areas of the country 	<ul style="list-style-type: none"> • The government has initiated construction of dedicated freight corridors in western and eastern high-density routes 	<ul style="list-style-type: none"> • National maritime development programme (NMDP) aims to meet the future needs through efficient and more infrastructure 	<ul style="list-style-type: none"> • 21 airports are either being renovated or developed in Public Private Partnership (PPP) model
	Infrastructure is one of the key priorities of Indian government and is encouraging public private partnership (PPP) models through various incentives which include tax incentives			

Despite difficulties and challenges in physical infrastructure, cookstove initiatives can leverage the road and railway network in “hard to reach” rural areas as other consumer goods companies have done

India has a diverse ecological and environmental profile with six climatic zones

Climatic zones in India



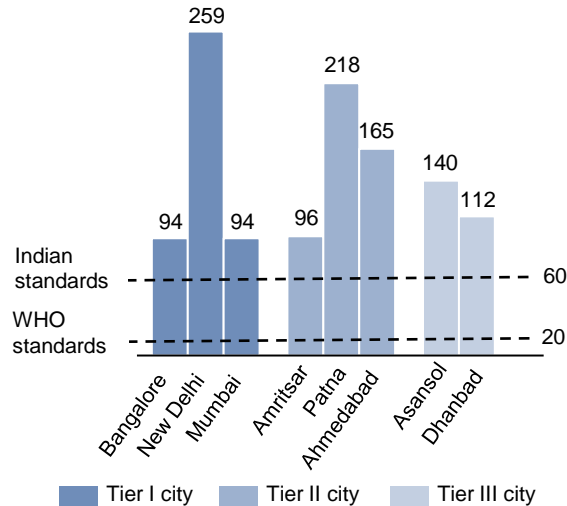
- **Ecological zones:** India has 6 climatic zones ranging from tropical in the south to temperate and alpine in the Himalayan north
- **Mineral resources:** Major mineral resources include (i) coal (fourth-largest reserves in the world), (ii) iron ore, and (iii) petroleum.
- **Water:** India has a total water surface area of 314,40 km² and receives an average annual rainfall of 1,100 mm
- **Cultivable land:** India has large swathes of agricultural land estimated at ~180 million hectares and this has remained constant
- **Forest cover:** According to official statistics, India has actually grown its forest cover by an average of 0.5% a year and forests are now 23% of the country's land area
- **Overall performance:** India ranked 122 out of 132 countries on environmental performance, ranking very low on air quality, agricultural sustainability and water management

However, natural resources are being depleted, air quality is decreasing and GHG / carbon emissions are increasing

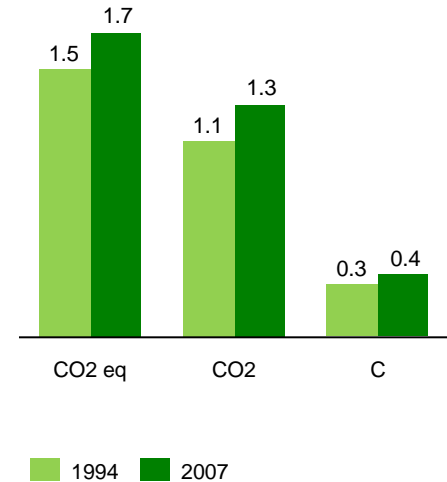
Natural resources depletion
(% of GNI)



PM 10 concentration in ambient air
in $\mu\text{g}/\text{m}^3$ (annual)



Per capita GHG emissions
(tons/capita)



- Rising soil erosion leading to decreased agricultural yields
- Heavy dependence on fossil fuels for energy generation
- Mismanagement of mining and infrastructure projects

- Nationally, particulate matter (PM) 2.51 level is nearly five times the recommended threshold, denoting unsafe conditions for human beings
- According to a 2012 study, India was ranked last of 125 countries in its air quality
- Between 10 and 20% of air pollution in major urban centers is caused from domestic sources as well as waste burning

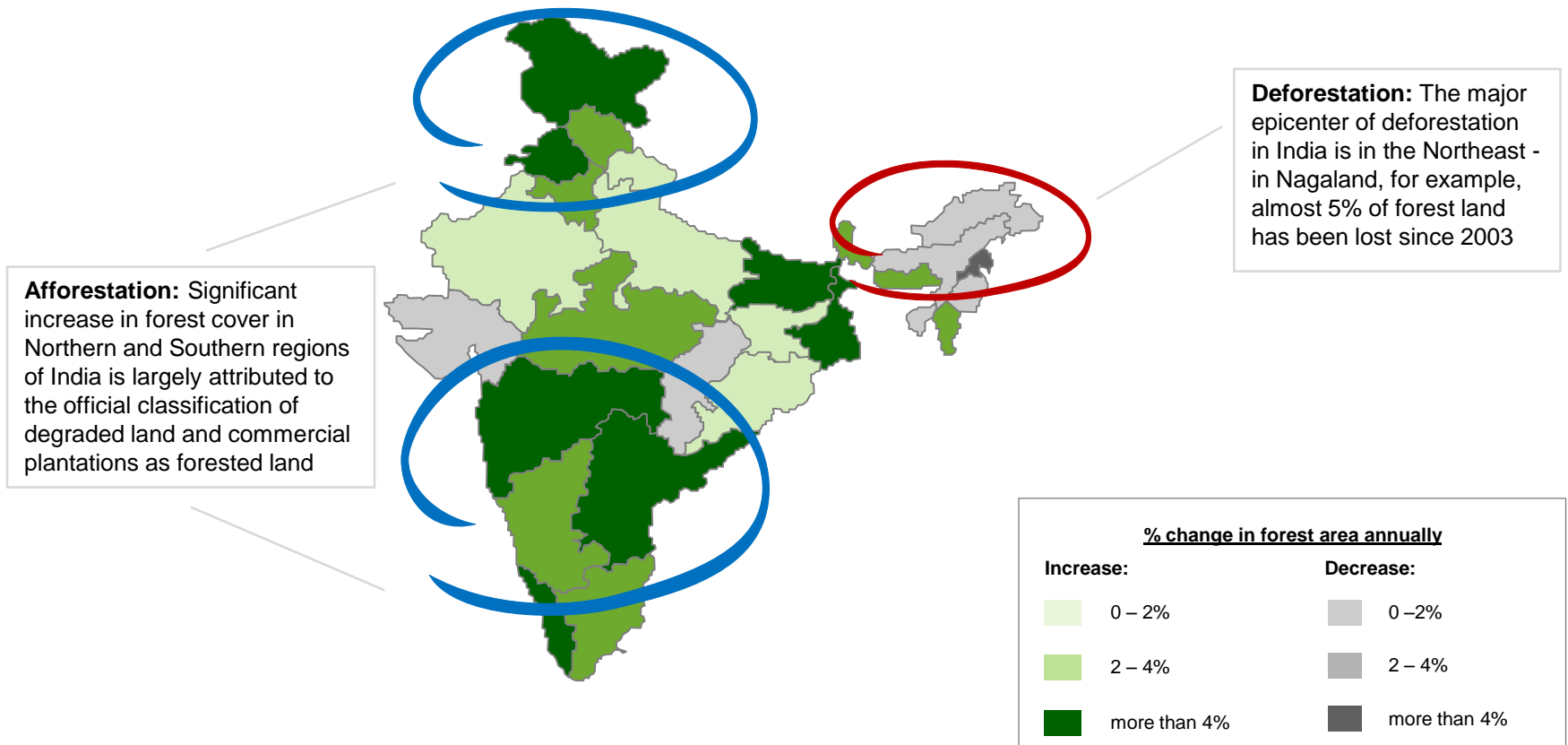
- GHG emissions have been steadily rising for the past five years
- India produces 6% of global black carbon emissions, making it the third largest emitter worldwide. 40% of these black carbon emissions are estimated to come from household solid fuel combustion

Note: Particulate matter less than 2.5 micron size

Source: World Bank Data; India State of Forest Report - 2011 by Ministry of Environment and Forests; EIA; Greenhouse Gas Emissions 2007; Ministry of Environment and Forests; 2012 Environmental Performance Index by Yale University; Urban Emissions - Urban Air Pollution & Co-Benefits Analysis for Indian Cities 2012

Official figures state that forest area grew by ~2% annually, but afforestation quality is poor and deforestation persists in the east

Change in forested area, (Official estimates, 2003 – 2009)
(% change, sq. km)



By encouraging use of non-solid fuels, improved cookstoves can play a crucial role in preventing land degradation and deforestation, particularly in areas with negligible or negative afforestation rates

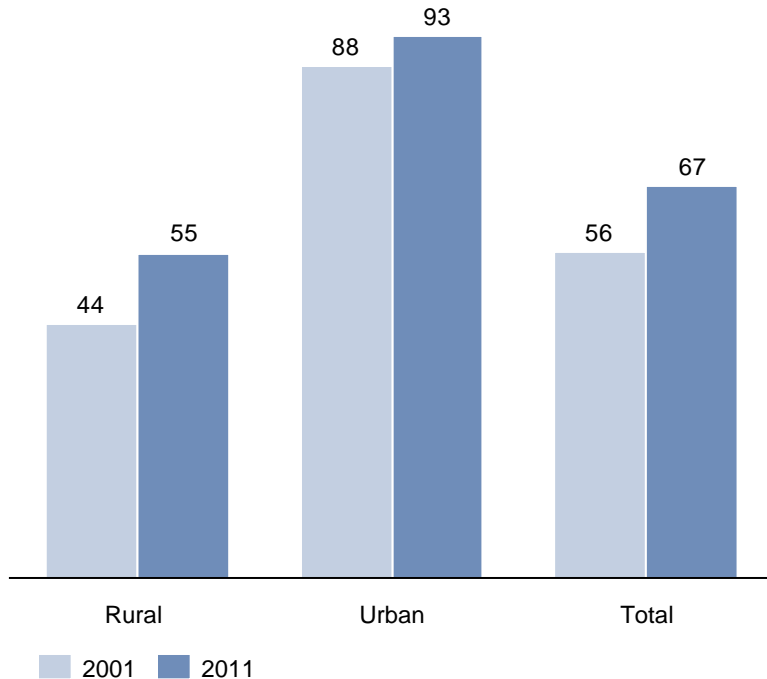
Note: National data on forest area is disputed over the inclusion of wasteland and commercial plantations

Source: India State of Forest Report- 2011; Ministry of Environment and Forest; Deforestation and forest degradation in India – implications for REDD+; Dalberg analysis

Access to energy is a challenge for many households, and India is largely reliant on fossil fuels

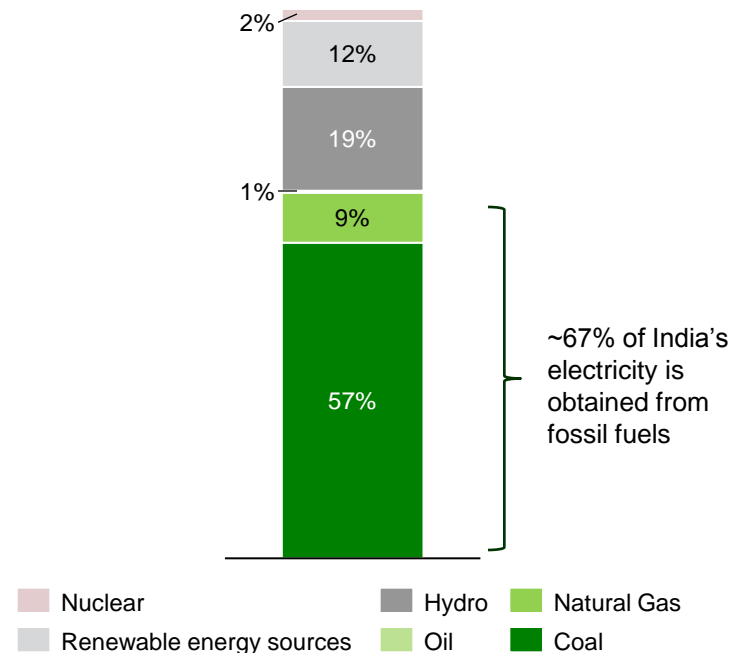
Access to electricity

(% of households with access to electricity)



Source of electricity

(% of Megawatts)



Access to electricity may actually be overstated given biases in the data and the frequent power outages

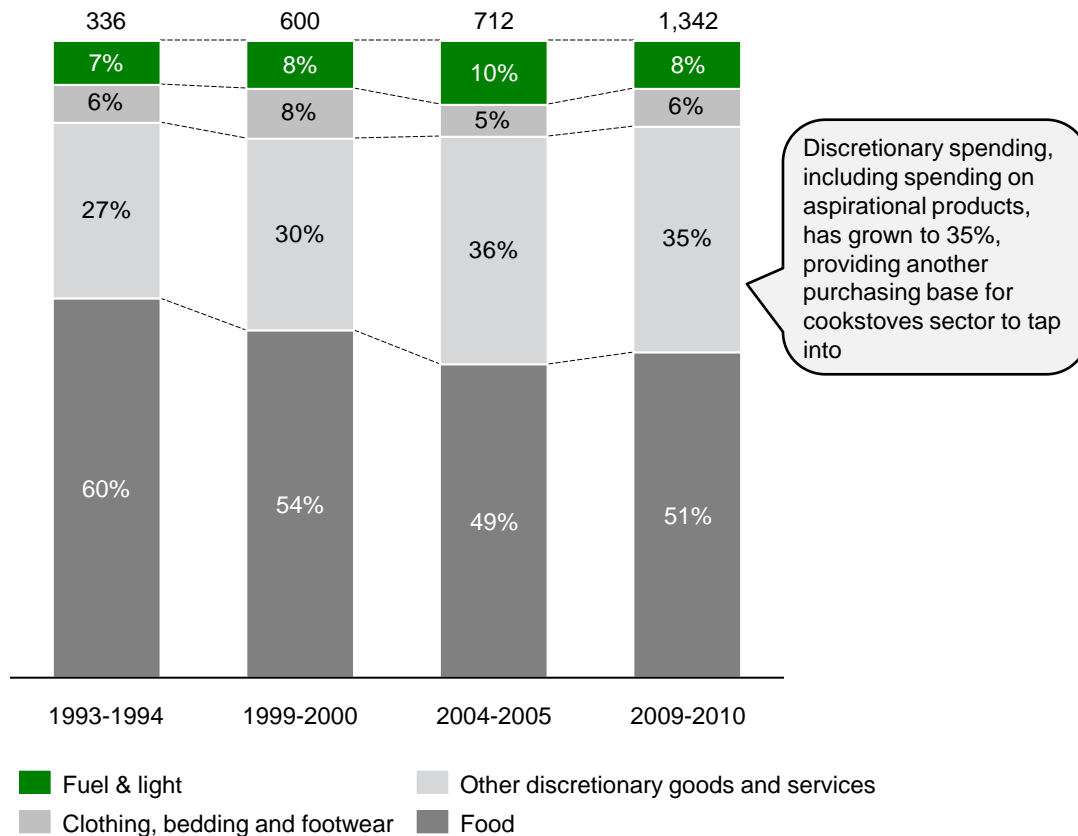
India continues to rely on fossil fuels as its main source of electricity which is exacerbating its energy deficit

Note: (i) Hydro stations with installed capacity less than or equal to 25 MW are indicated under renewable energy sources; (ii) Renewable energy sources include wind energy, solar power, small hydro project, biomass power, urban & industrial waste power

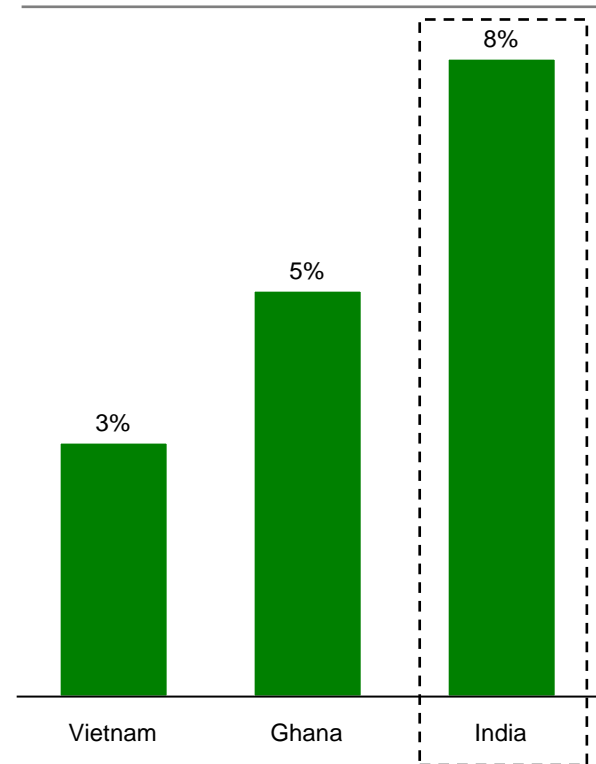
Source: Central Electricity Authority of India; Census of India 2011

Indians spend ~7-10% of their total expenditure on fuel & light, significantly more than households in other developing countries

Monthly household expenditure, India
(% of total expenditure, INR)



Household expenditure on fuel & light
(% of total expenditure, 2010)



Given household spending patterns, cookstoves can be targeted at two potential markets: (i) as fuel cost-saving devices, or (ii) as aspirational products that are a part of discretionary spending

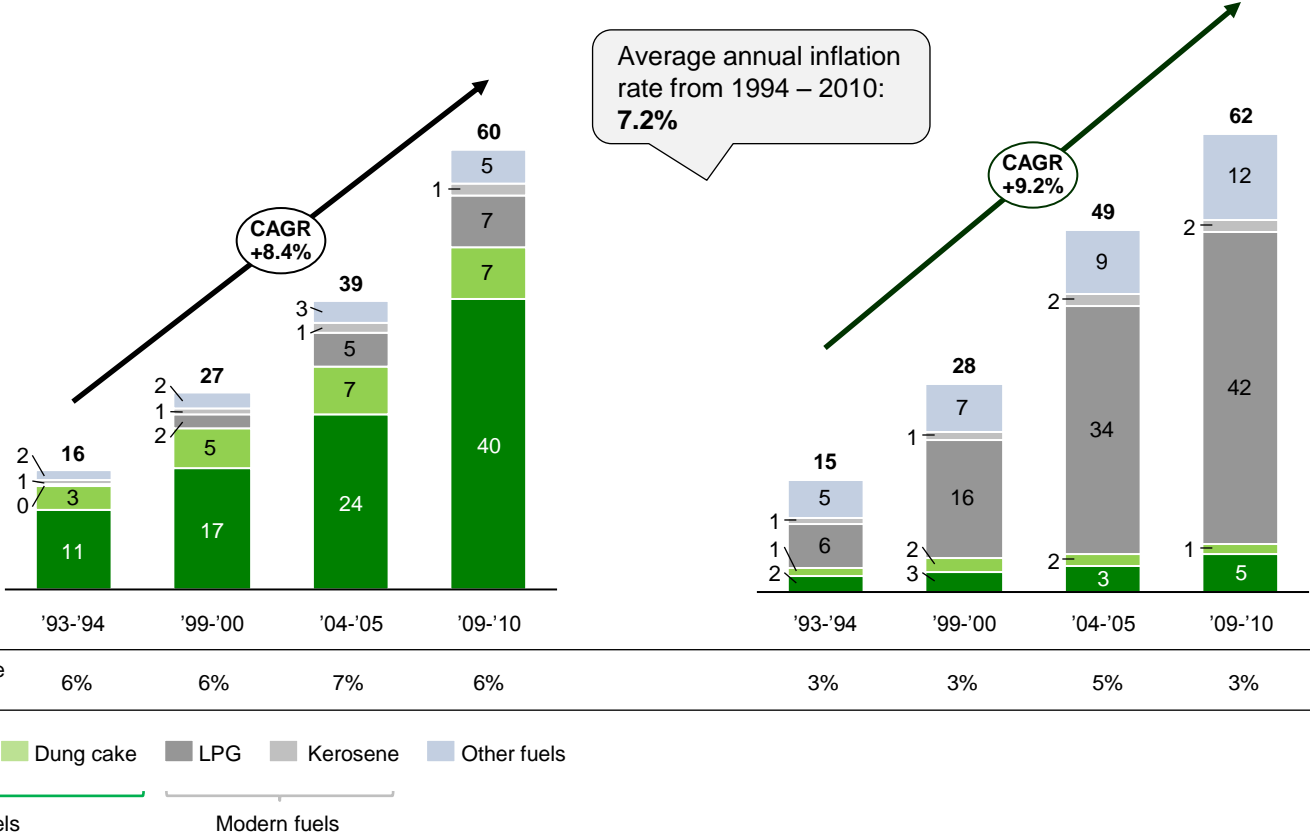
Note: Expenditure on fuel and light does not include expenditure on fuel for motor vehicles and other transport vehicles

Source: Dalberg analysis; National Sample Survey Rounds – 51, 55, 61 & 66; GACC market assessment studies – Vietnam and Ghana

Expenditure on cooking fuels has been growing at ~8-9% per annum, above the average inflation rate of 7%

Average per capita monthly expenditure on cooking fuels - *rural areas* (in INR)

Average per capita monthly expenditure on cooking fuels - *urban areas* (in INR)



The growth in expenditure on cooking fuels may indicate a broader purchasing power base from which to develop a cookstove initiative

Note: (i) It is estimated that Kerosene is used by households for cooking and lighting in the ratio of 20:80 (ii) Other fuels include coal, electricity and any other fuels
 Source: Dalberg analysis; National Sample Survey rounds – 51, 55, 61 & 66

There is great diversity in food types, flavors and preparation styles, but there are several common cooking habits across the country

Food types

- Significant variation in diet preferences due to diversity in topography and demographics
- Food preferences are influenced by historical traditions, local resource availability and climate conditions
- Even within a state, the food preferences may vary based on the location or other factors e.g., coast vs. inland, hills vs. plateau, etc.
- Despite the differences, there are some elements which are common across different food types, including:
 - *Roti* – a bread made of wheat flour, often as a staple of the meal
 - *Rice* – a staple food eaten along with side dishes such as meat, vegetables
 - *Dal* – a preparation of pulses
 - *Vegetables* – prepared in gravy or dry form to consume with rice or *roti*

Cooking habits

- Most cooks are women and girl children
- Many families prefer traditional stoves due to habit
- Fixed traditional stoves are the standard, and often placed in a semi enclosed annex to shelter it from rain & sunlight
- Biomass use is incredibly diverse with families using whatever they can collect or store
- Generally people cook seated and do not prepare more than one dish at a time but would prefer to do so if an option is available
- Heat-wasting saucepans, often without lids, and flat pans are used regularly
- In certain households, it is not uncommon to have a 'backup' stove choice where gas supply is unreliable or product quality is questionable











NOTE: See Appendix for detailed breakdown of food types and cooking habits at a regional level

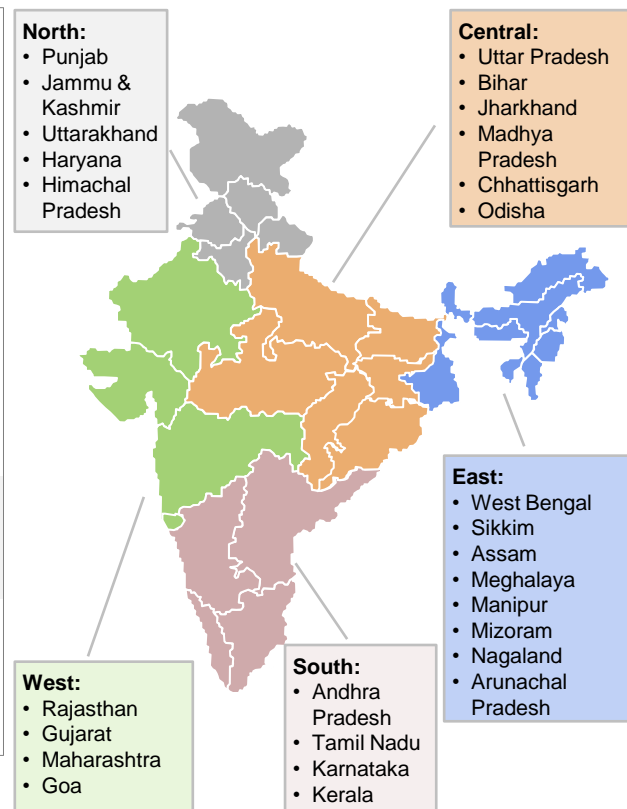
India's diverse cooking preferences suggest that manufacturers may need to have multiple stove designs in order to cater to various needs and preferences

India can be classified to five broad “food zones” based on preparation of staple foods

“Food zone” classification in India

Note: Given the diversity of India’s population, there will certainly be variations of cooking style and food preferences within these zones. This categorization is meant to provide a **high-level view** only. Further research will be required before any cookstove initiative is developed

Zone	Staple food	Accompaniments	Key cooking activities	Equipment	Heat intensity
North 	<ul style="list-style-type: none"> • Thick rotis (tandoori rotis, naan, paratha) 	<ul style="list-style-type: none"> • Meat • Vegetables • Dairy products 	<ul style="list-style-type: none"> • Baking • Boiling • Frying 	<ul style="list-style-type: none"> • Kadhai • Tava • Smoke oven 	
Central 	<ul style="list-style-type: none"> • Thin rotis (roti and chapati) 	<ul style="list-style-type: none"> • Dal • Lentils • Vegetables 	<ul style="list-style-type: none"> • Baking • Boiling • Frying 	<ul style="list-style-type: none"> • Tava • Kadhai 	
East 	<ul style="list-style-type: none"> • Rice 	<ul style="list-style-type: none"> • Fish • Meat • Vegetables 	<ul style="list-style-type: none"> • Frying • Grilling • Steaming 	<ul style="list-style-type: none"> • Pots • Kadhai • Smokehouse 	
West 	<ul style="list-style-type: none"> • Thick rotis (chapati, millet rotis) 	<ul style="list-style-type: none"> • Vegetables • Lentils • Seafood • Dairy products 	<ul style="list-style-type: none"> • Baking • Boiling • Frying 	<ul style="list-style-type: none"> • Tava • Kadhai 	
South 	<ul style="list-style-type: none"> • Rice • Dosa (rice pancake) 	<ul style="list-style-type: none"> • Dal • Lentils • Vegetables • Dairy products 	<ul style="list-style-type: none"> • Boiling • Frying • Steaming 	<ul style="list-style-type: none"> • Pots • Tava • Kadhai 	



See Appendix for detailed breakdown of food types and cooking habits at a regional level

Note: (i) States are grouped into these categories for ease and may not necessarily be according to the official definition/popular perception; (ii) Kadhai: A semi spherical pan, Tava: flat pan
 Source: Dalberg analysis

At a high level, common and regionally specific stove characteristics can be identified to suit each food zone

Ideal common characteristics for stoves across regions:

- Ability to refuel a stove while cooking (i.e., entryway for fuel is not blocked by the cooking pot)
- Flame that can be partially controlled, particularly to ensure wide flames to cook breads/staples
- Ability to vary heat, even if crudely, throughout the cooking process to vary between different foods
- Portability (i.e., light weight and/or can be disassembled easily) and durability over a long period of time

Potential regional characteristics:

Northern India:

- High heat potential to cook breads
- Portability given rugged environment, particularly in very northern states

Central India:

- Compatibility with various utensils given diversity of foods prepared
- Lower stoves as people generally cook seated

Eastern India :

- Grill to smoke food (particularly seafood and meat)
- Flame and heat control adaptable to higher altitudes
- Portability given rugged environment

Western India :

- Temperature variability to shift between cooking bread and green vegetables
- Ability to sustain longer cooking periods
- Stability to withstand heavy stirring

Southern India:

- Compatibility with a wider variety of utensils, given diversity of foods
- Wide flame in order to cook staples such as dosa

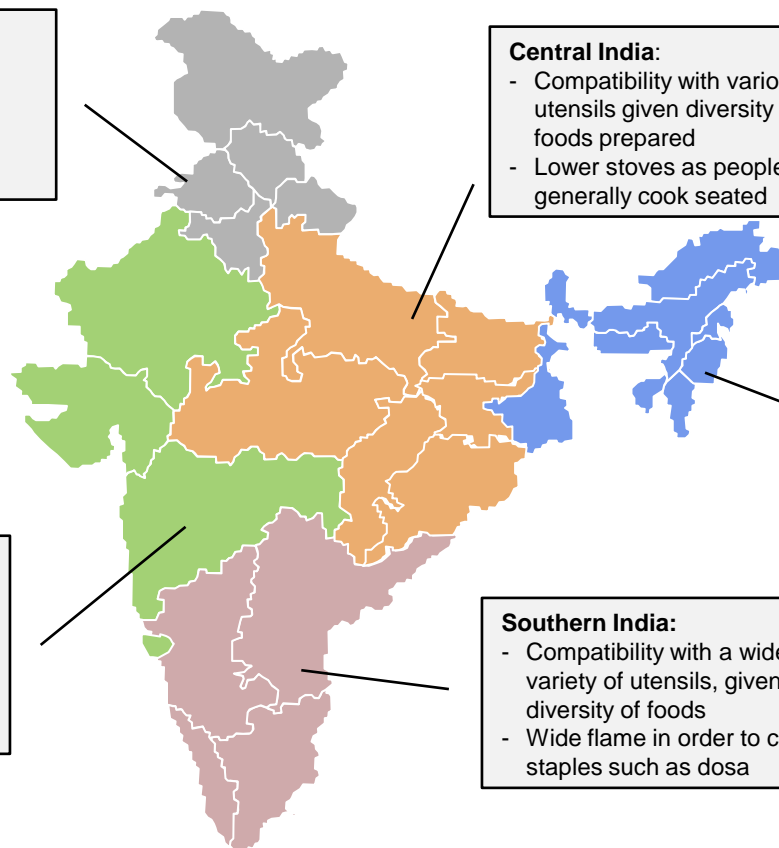


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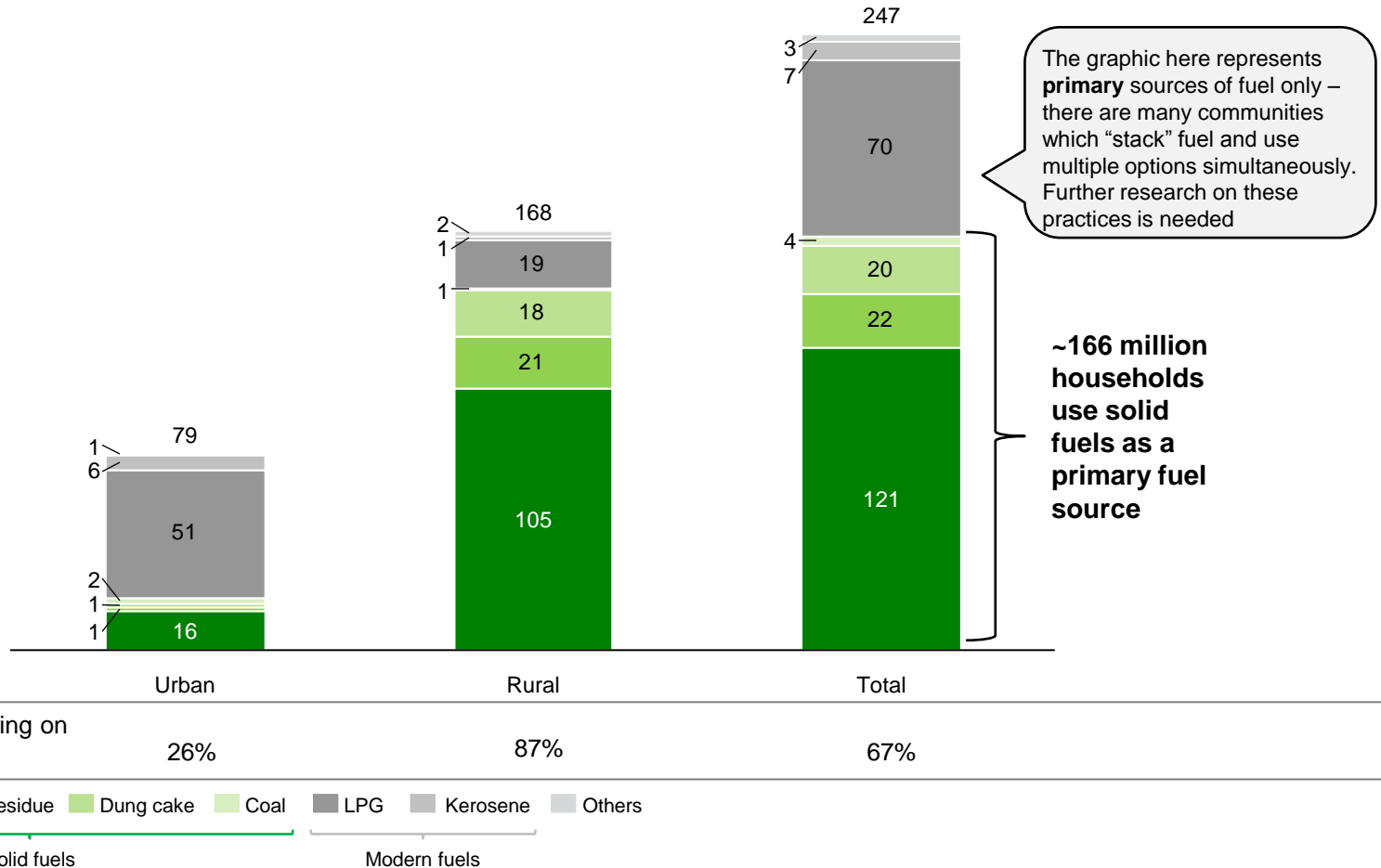
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Appendix

~67% of overall Indian households rely primarily on solid fuel for cooking; in rural areas, this figure is much higher at ~85%

Primary fuel usage breakdown (2011)

(millions of households)

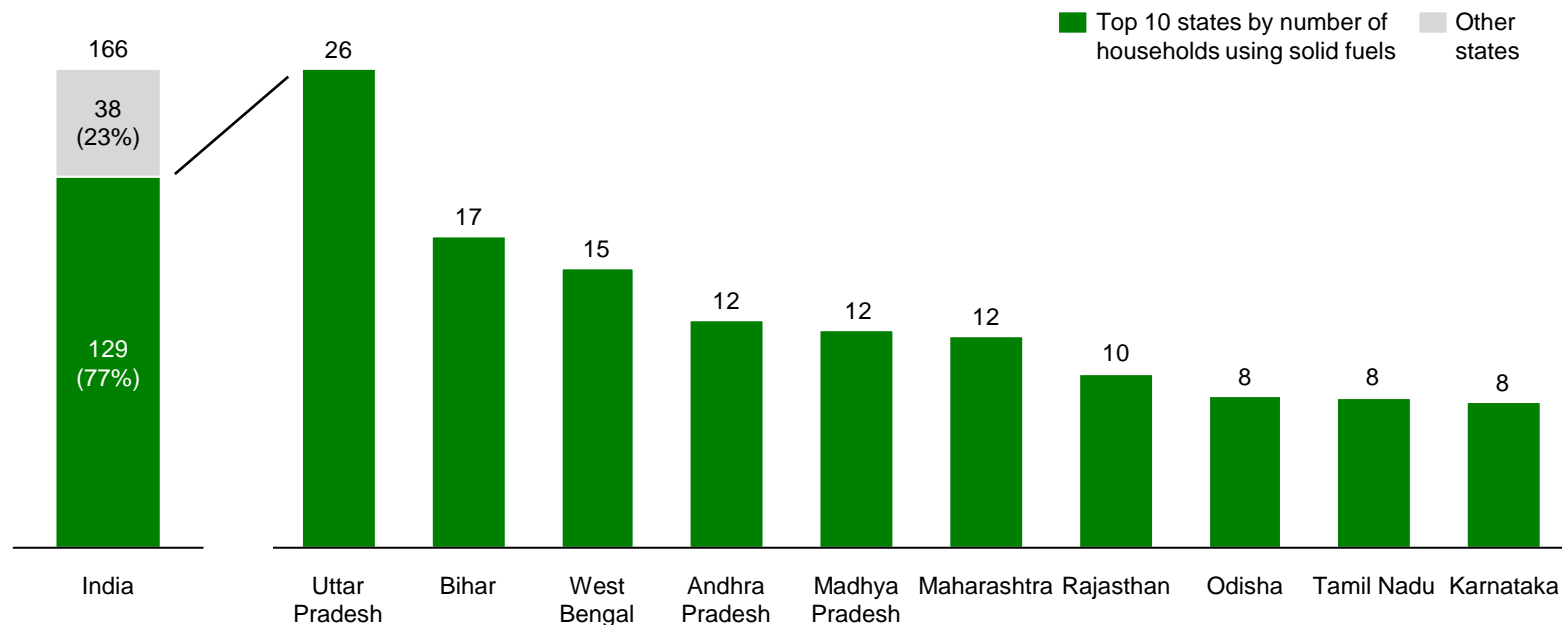


Note: (i) Households which use “other fuels” represent households which use electricity, biogas and other fuels (according to census authority) and the households that do not cook; (ii) Individual values may not add up to total values due to rounding off error

Source: Census of India 2011; Dalberg analysis

Ten states account for nearly ~75% of all household solid fuel use in India

Number of households using solid fuels as primary source for cooking
(millions of households)



% of households using solid fuels	67%	80%	90%	77%	59%	80%	49%	76%	86%	44%	61%
Per capita GDP (in USD)*	1,180	595	419	1,057	1,392	714	1,941	939	894	1,670	1,327

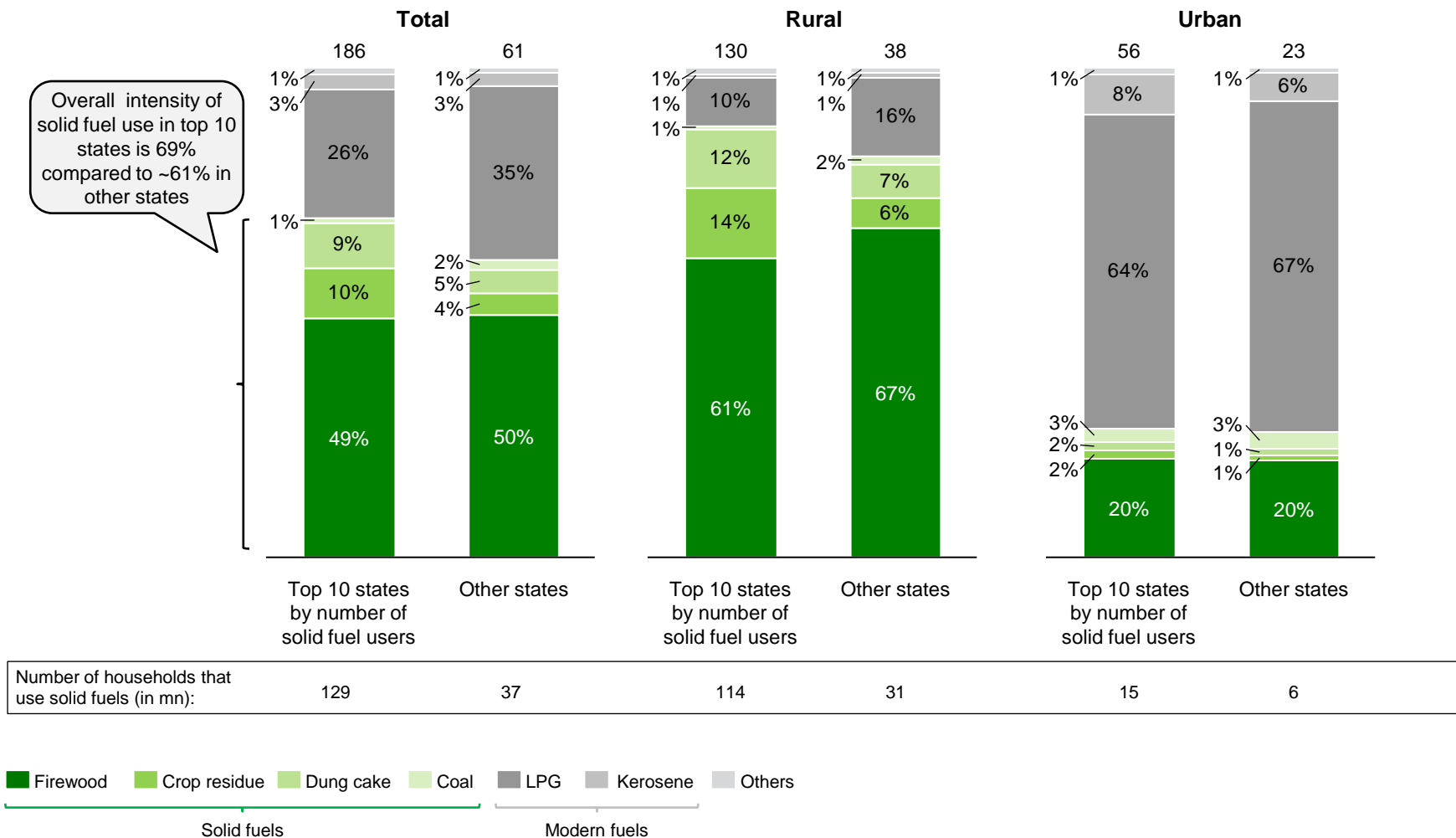
*Bolted per capita GDP figures are those which are below the Indian average

Cookstove initiatives targeted at these ten states can (i) have a significant impact on improving the efficiency of solid fuel use in India, and (ii) help address development objectives in some of the poorest states in India

In the ten states with the most solid fuel users, the *intensity* of reliance on these fuels is also higher, particularly in rural areas

Breakdown of households by primary cooking fuel

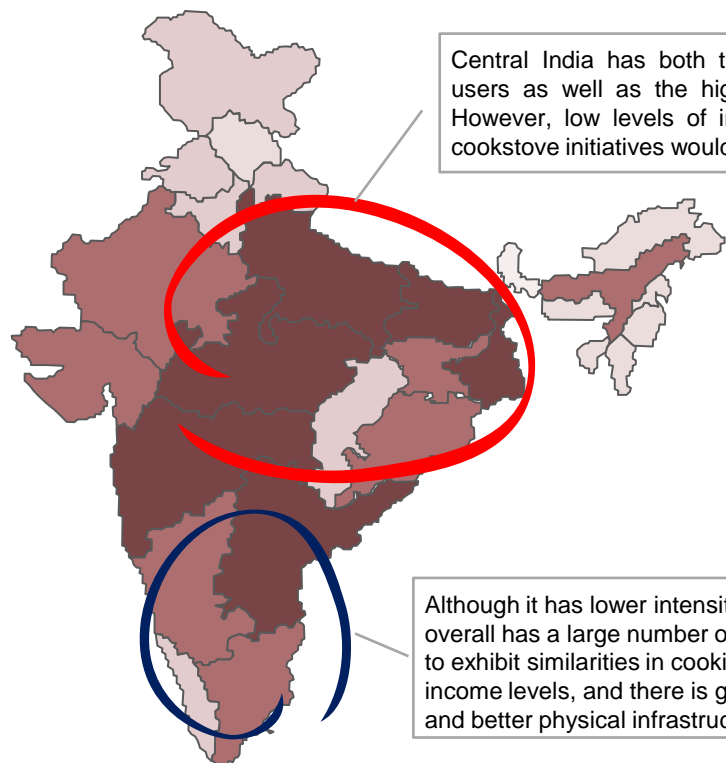
(millions of households)



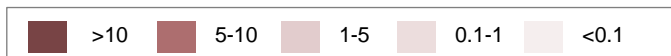
Note: Households which use "other fuels" represent households which use electricity, biogas and other fuels (according to census authority) and the households that do not cook
 Source: Dalberg analysis; Census of India 2011

There is a critical need for cookstove initiatives in Central and South India as the scale and intensity of solid fuel use is high

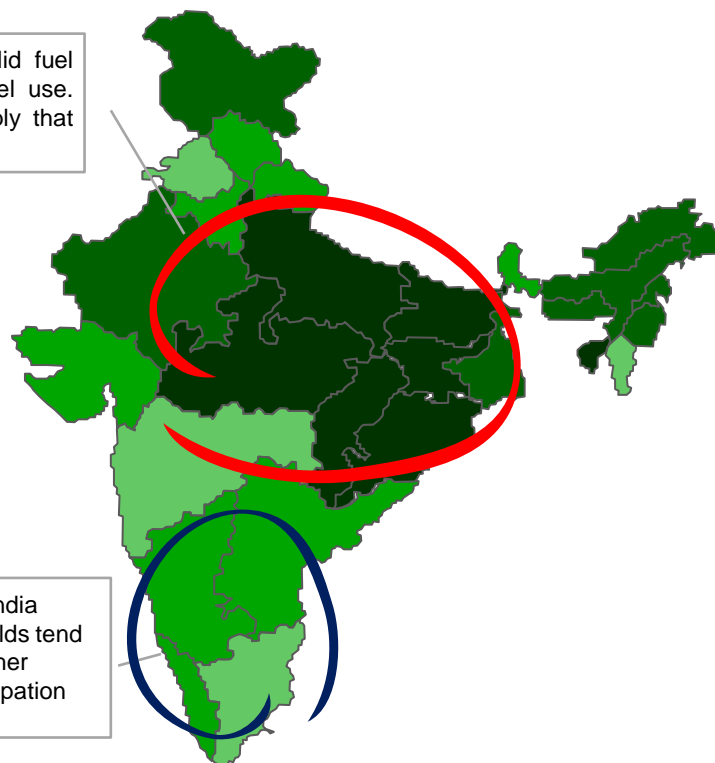
Distribution of solid fuel users in India
(millions of households)



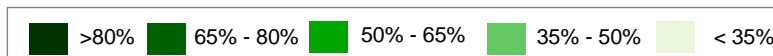
Millions of households dependent on solid fuels:



Intensity of dependence on solid fuels
(% of households)



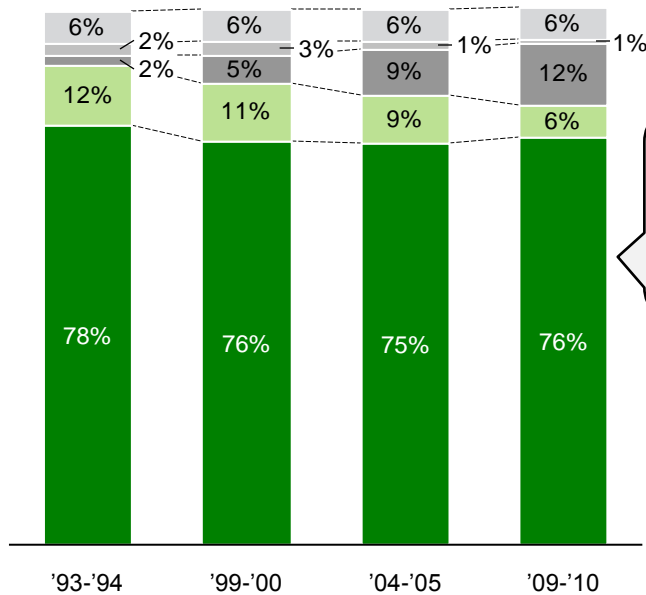
% dependence on solid fuels:



Employing a regional approach can enable players in the cookstove sector to focus their efforts and still make an impact on environmental and social outcomes

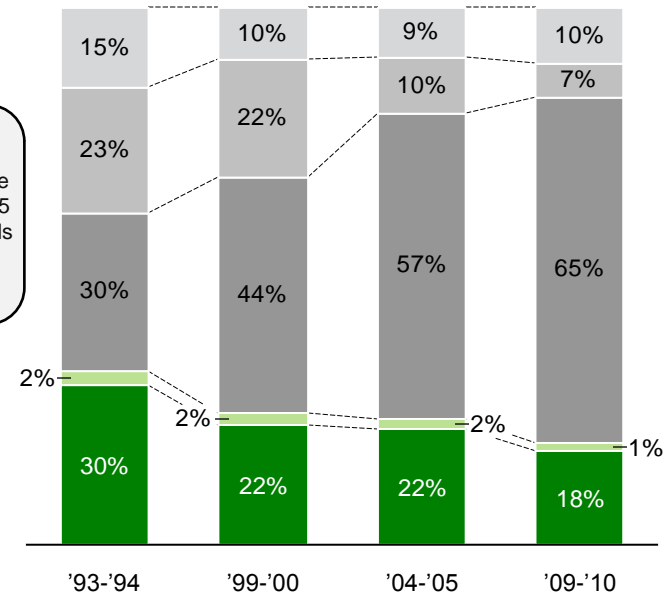
Although conversion from solid fuels to LPG and kerosene has been slow in rural areas, it has been significant in urban areas

Breakdown of fuel use: rural India
(% of households)

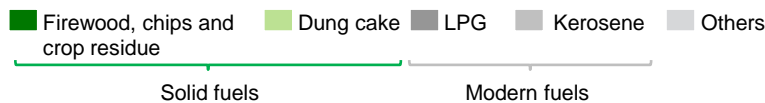


As a result of a high population growth at and low conversion rate to non-solid fuels, ~23.5 million **more** households use solid fuels in 2011 when compared with 2001

Breakdown of fuel use: urban India
(% of households)



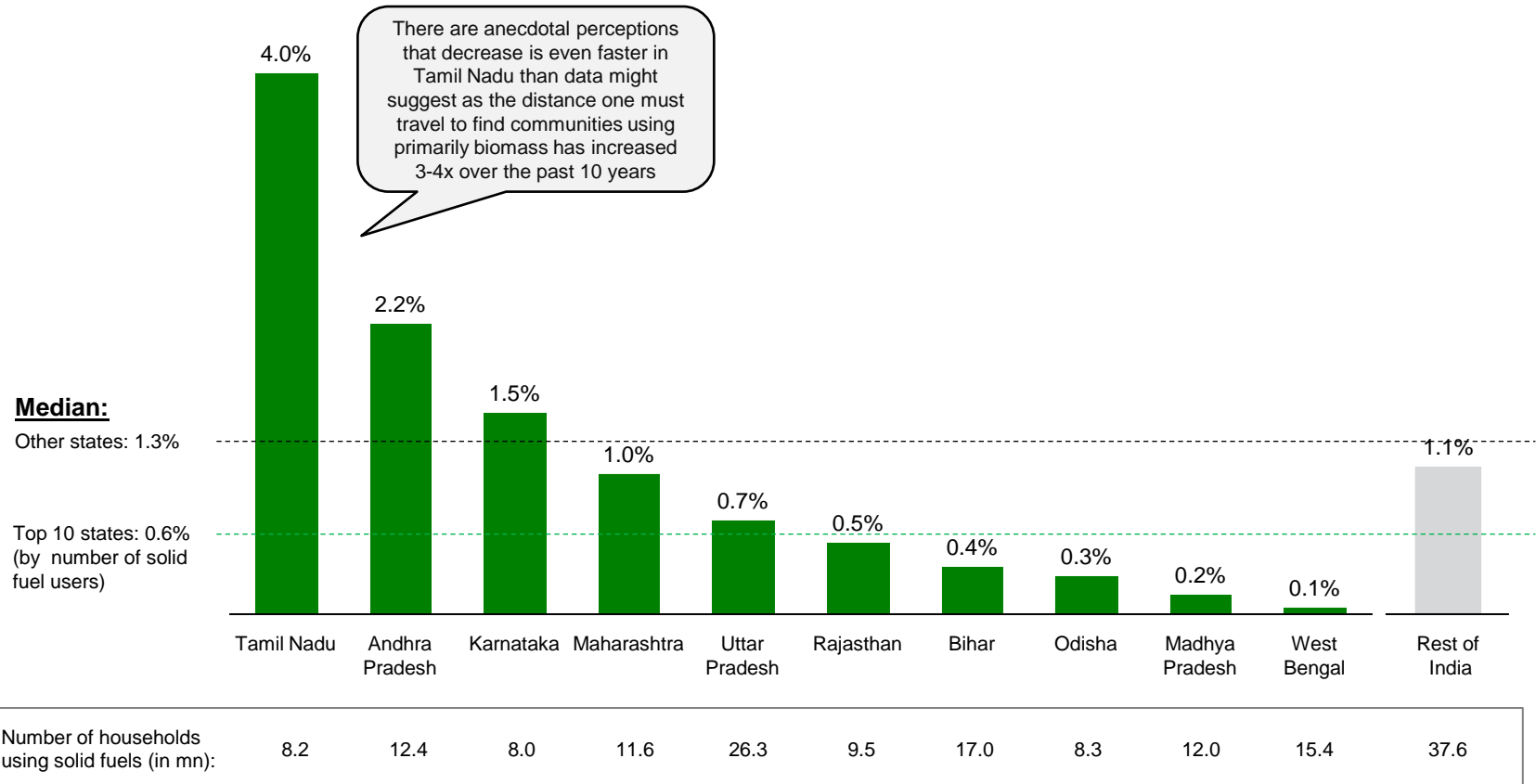
% of households relying on solid fuels	'93-'94	'99-'00	'04-'05	'09-'10
	90%	86%	84%	82%



Given that India's population is going to remain predominantly rural over the coming 10 years, addressing the use of solid fuels in rural areas should be a major focus of cookstove initiatives in the country.

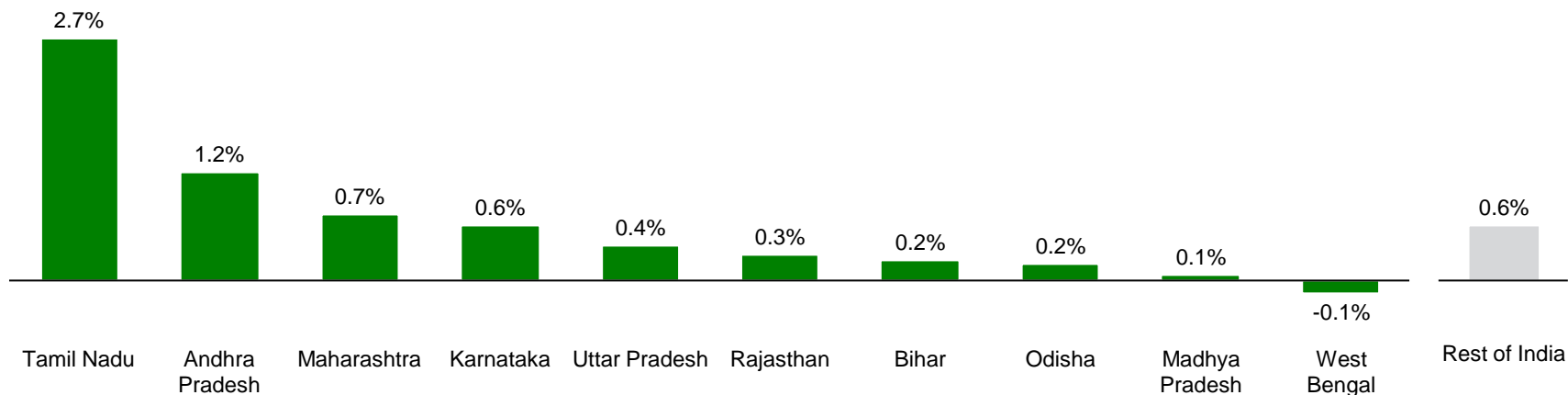
The rate of conversion remains low in states with high usage of solid fuels

Annual decrease in % of households using solid fuels for cooking (2001-2011)

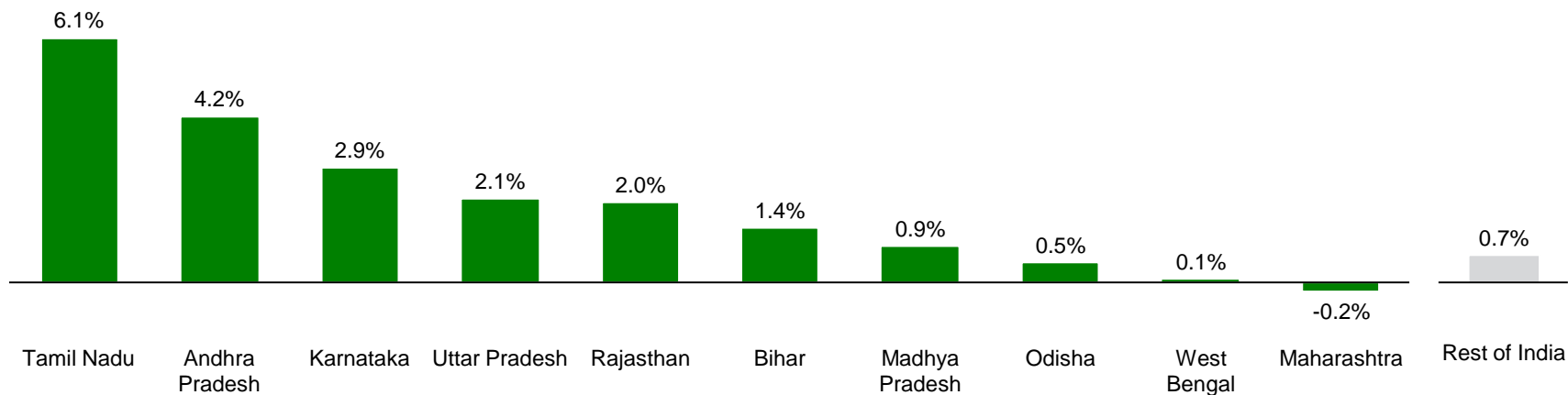


Rate of conversion to modern fuels is uniformly lower in rural areas than in urban areas

Annual decrease in % of households using solid fuels for cooking (2001-2011) – *Rural*



Annual decrease in % of households using solid fuels for cooking (2001-2011) – *Urban*



Comparing across these ten states, states in Central India have the highest need but tend to have less hospitable business environments

State	Cooking habits		Demographic features		Business environment		
	Food zone	% of households using solid fuels	Human Development Index (HDI)	Per capita income (in USD)	Attractiveness to businesses	Key physical infrastructure ⁱⁱ	Penetration of similar products ⁱⁱⁱ
Bihar	Central	90%	0.37	419			
Odisha	Central	86%	0.36	894			
Madhya Pradesh	Central	80%	0.38	714			
Uttar Pradesh	Central	80%	0.38	595			
West Bengal	East	77%	0.49	1,057			
Rajasthan	West	76%	0.43	939			
Maharashtra	West	49%	0.57	1,941			
Karnataka	South	61%	0.52	1,327			
Andhra Pradesh	South	59%	0.47	1,392			
Tamil Nadu	South	44%	0.57	1,670			
India	-	67%	0.47	1,180	-	-	-

Below aggregate India level

Quartile: Bottom Second Third Top
(Relative to all 28 states of India)

Note: (i) Based on India competitiveness ranking 2011 which signifies competitiveness of state in attracting and facilitating businesses by considering policy environment, infrastructure and various other parameters (ii) Based on roads in rural areas (km per 1,000 people) as they are the key infrastructure to reach target customers (iii) Based on penetration of mobile phones as most of the mobile phones used by our target customers and improved cookstoves are in the same price range and also require similar distribution networks. Hence, albeit not to the exact level, penetration of mobile phones signify consumer's ability to purchase cookstoves and company's ability to build effective distribution model in that state (iv) With the exception of HDI, all other indicators correspond to year 2011; HDI scores correspond to surveys conducted in 2007-08; Source: Dalberg analysis; Stakeholder discussions; Census of India 2011; Provisional road statistics of India - 2010-11; Indian Human Development Report 2011; Reserve Bank of India; India Competitiveness Report 2011

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Collection of and heavy exposure to traditional fuels have significant health consequences, particularly for women and children

Observations

Collection of fuels



- In India, families spend ~5-8 hours or more per week, collecting fuel. Collection often entails carrying loads weighing 20-30 kgs of traditional biofuels, especially firewood, on the head/shoulders
- Women frequently leave the safety of their communities to search for firewood and other traditional biomass fuels

Cooking



- Burning solid fuels causes indoor air pollution (IAP) due to emission of harmful substances such as carbon monoxide, particulates, benzene and formaldehyde at levels up to 100 times higher than the recommended limits set by WHO
- Women and young children spend several hours near cookstoves to prepare meals and to study/play by the weak light of an open flame

Health impacts

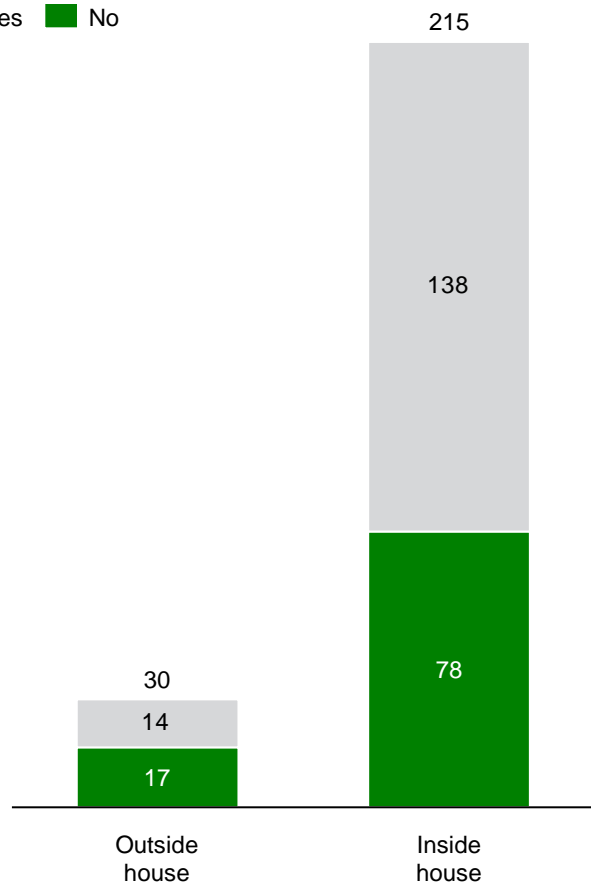
- Regularly carrying heavy loads for long durations can expose them to head and spinal injuries, pregnancy complications, and maternal mortality
- Leaving safer abodes to collect fuel from fields and other far locations, increases exposure to bites, bruises and attacks
- Chopping wood can lead to allergies, chapped hands and limb deformation in certain cases
- Inhalation of toxic fumes emitted by traditional cookstoves causes acute lower respiratory infections (ALRI), chronic obstructive pulmonary diseases (COPD), lung cancer, cataracts and other illnesses
- Burns from open fires and unsafe cookstoves are another risk – more than 500,000 women suffer moderate to severe burns every year, primarily due to unsafe cookstoves. The lack of access to immediate medical assistance further exacerbates the situation.

The health impacts from indoor air pollution are caused primarily by the burning of solid fuels in poorly ventilated or cramped conditions

Cooking location (households, millions)

Kitchen facility:

Yes No



- For households with indoor kitchen facilities, the majority of them are poorly lit and ventilated, increasing the risk of inhaling harmful smoke, gases and particulates
- For households without indoor kitchen facilities, cooking is usually done in the corner of a room, sometimes separated by a half wall, leading to smoke filling the entire house and impacting other members of the family as well

It is estimated that at least ~400 million people in India are exposed to the impacts of indoor air pollution

Indoor air pollution (IAP) is now definitively linked with causing five major diseases: lung cancer, chronic obstructive pulmonary disease (COPD), pneumonia and other acute lower respiratory infections (ALRI), lung cancer, loss of vision including cataracts, and heightening risk of cardiovascular disease IAP can cause these illnesses both directly and indirectly

Direct exposure

Estimates suggest that at a minimum, ~360 million people, primarily women, are directly impacted by IAP

Rationale:

- ~150 million Indian households use cook stoves that cause Indoor Air pollution (IAP)
- Majority of the cooking activity is conducted by women and girl children in Indian households
- Each household have an average of 2.38 women

Indirect exposure

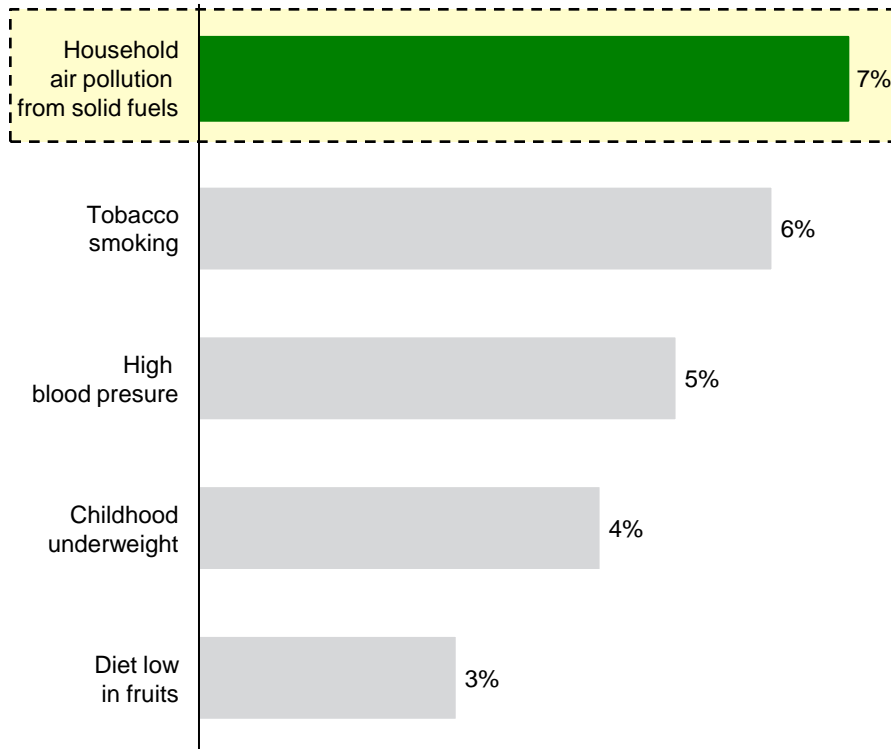
Estimates suggest that ~48 million others, particularly babies, are affected by IAP as well

Rationale:

- For every 1000 women, ~22.2 are pregnant
- As such, ~8 million babies are prone to ill-effects caused by IAP
- Majority of Indian women keep their children, who are below 5 years of age, near by them while cooking. Hence ~40 million additional children under 5 are also indirectly affected

Air pollution from households is the leading cause of DALYs in South Asia, causing ~875,000 deaths annually in India

Primary causes of DALYs in South Asia (% of total DALYs in 2010)



Deaths and DALYs

Estimates suggest that ~875,000 deaths and 16.9 million DALYs occur annually in India due to IAP

- ~875,000 deaths occur every year in India due to IAP which accounts for 1/4th of the deaths caused globally
 - ~525,000 deaths can be attributed to Acute Lower Respiratory Infections (ALRI)
 - ~350,000 deaths can be attributed due to Chronic obstructive pulmonary diseases (COPD)
- ~16.9 million disability-adjusted life years (DALY) are lost due to IAP caused by use of solid fuels due in large part to losses in productivity due to illnesses
- ~140,000 children under five die annually due to IAP-induced illnesses. This accounts for ~8% of under-five deaths in India
- Household air pollution contributes to 16% of OAP globally, therefore being responsible for an additional 500K deaths annually

Despite limited awareness of the issue, IAP is a major public health concern and clean cookstoves can be a component in any public or private initiative to address these health issues

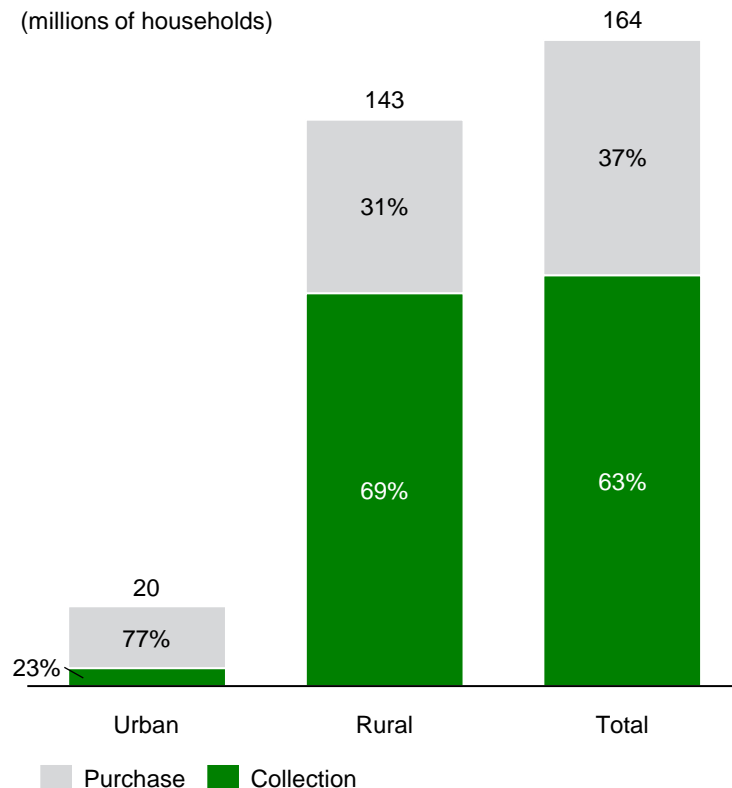
Note: (i) The ratio of deaths caused due to IAP in India to the ones caused globally is assumed to be the same in 2007 & 2012 as there is no significant decrease in number of people using solid fuels in India and globally (ii) Deaths to DALYs ratio was assumed to be the same in 2004 & 2012 as DALYs is a function of deaths and diseased days which in turn are proportional to each other

Source: Global and Indian Burdens of Disease from Household Air Pollution - the GBD 2010 Study; HAP Expert Group and Indian Institute of Technology, 2013

~63% of solid fuel users collect part or all of their fuel and all households spend significant time on cooking activities

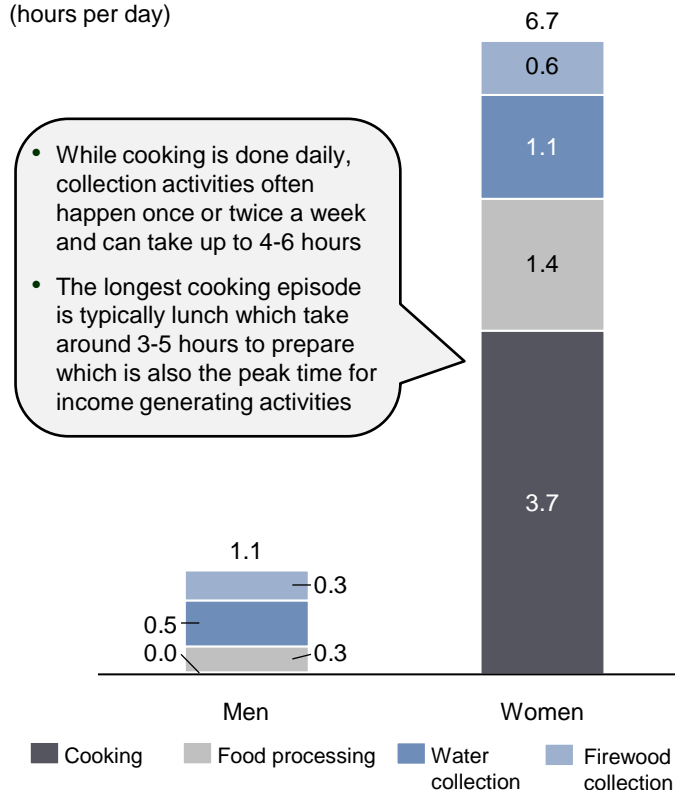
Collection vs. purchase of solid fuels

Source of firewood
(millions of households)



Time spent on cooking activities

Time spent on cooking activities (2004-05)
(hours per day)



While cleaner and more efficient cookstoves can result in significant time savings when compared to existing cooking practices, this messaging needs to be tailored based on household distribution of cooking activities

Note: "Purchase" includes those households procuring those exclusively purchasing solid fuels as well mixing collection and purchase of solid fuels.

Source Dalberg consumer segmentation database; NSSO 2004/2006 and 2009/2010 database; Census 2011; Planning Commission of India; IHDS; "Human Development in India"; Elizabeth Cecelski - "The role of women in sustainable energy development".

Women are the primary users of cookstoves, but are often restricted from making household expenditure decisions

Women can play an important role in the cookstove sector...

- **As decision makers:** Up to 43% of female headed households chose to use modern fuels such as LPG (as opposed to the average of 29% across all households)ⁱ. In a clean cookstoves program, run by an Indian cooperative, women were able to use savings from reduction in fuel use to provide two meals a day, instead of one, for their families
- **As beneficiaries:** Exposure to IAP is greatest among women and young children, who spend the most time along with their mothers near open fires or traditional cookstoves
- **As stakeholders:** Many NGOs, such as SSP (Sakhi Retail), SEWA and TIDEⁱⁱ, train local female entrepreneurs to build & sell cookstoves and employs women in their door to door selling activities

...but several barriers prevent their increased involvement

- Men are often responsible for making household expenditure decisions such as purchasing of cookstoves while women play a insignificant role through the decision process. However, there are regional variations (i.e., women in South India tend to have more decision-making power than their counterparts in northern states such as Rajasthan and Uttar Pradesh) which should be considered
- Cultural barriers limit the mobility of certain segments women and restrict their participation in the cookstove sector

Improved cookstoves can significantly improve the quality of life and offer livelihood opportunities for women, but marketing and awareness campaigns should consider existing gender dynamics and identify to work within or around them

BP's experience in rural Maharashtra suggests that the success of the direct agent model is highly dependent on the status of women

CASE STUDY

BP "jyoti" model in rural Maharashtra

- In 2005, BP initiated a for-profit partnership with Swayam Shikshan Prayog (SSP), an NGO, to develop an innovative business model in rural India, where women, "jyotis" would be trained to sell the Oorja stove and pellets
- BP envisioned that the "jyotis", poor rural women who would serve as village-level, entrepreneur agents, would proactively travel around her village to make sales and host product demonstrations in rural Maharashtra
- From 2006-2010, the partnership sold 45,000 Oorja stoves and 520k bags of 5kg pellets
- The program generated income opportunities for ~800 women but business was sold in 2009 due to performance pressure
- Business was purchased by ex-BP-India CEO and National Expansion Manager, and the company is now run as a separate entity known as First Energy

Observations

SSP's SHG members faced many labor market disadvantages, which had initially motivated many to become jyotis, but then hindered most from employing effective sales practices. These included:

- 1) Social constraints on female mobility for commercial purposes
 - Unmarried women not permitted to leave for commercial purposes and married / widowed women only allowed to leave if family is very poor and desperately needs money
 - If women not permitted to leave; mother-in-law takes over, but sales made by older women are much lower than sales made by younger women
- 2) Stigma that only poor women engage in sales outside the home, making non-poor agents reluctant to sell stoves and pellets in the public domain
- 3) Husbands taking over their business outside the home

Caste dynamics may also limit interaction between upper and lower caste individuals

CASE STUDY

Observations

- Caste and socioeconomic status prevented women from truly having access to the entire village
- Caste posed an obstacle to females visiting each other's homes to make sales – higher caste customers, e.g., were not willing to visit customer houses and would expect the customer to come to them
- Little differential between commission rates by caste group, due to two factors which cancel each other:
 - a) Higher castes have greater access and greater ability to influence households
 - b) Low caste agents are usually lower income and more likely to be permitted to leave their homes for sales, making them more motivated to make sales

Summary of barriers to exchange across caste

	If customer is:	If agent is:
High caste	May not buy from low caste agents because she perceives the agent is polluting the product	May think it is beneath her to approach the home of a low caste customer
Low caste	Willing to buy from a high caste agent, but is unlikely one would come to her home	Often uncomfortable approaching a high caste customer's home

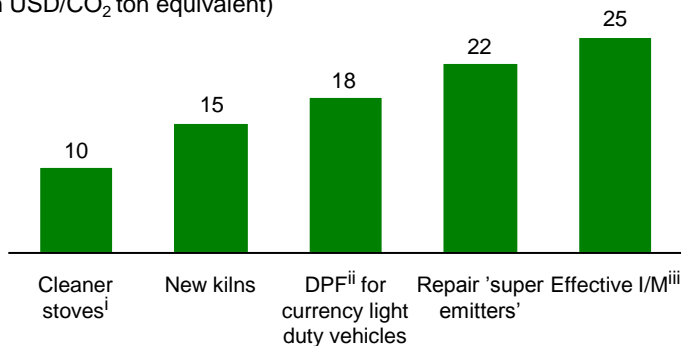
While caste may not be an issue in all communities, local traditions, community structures and religious beliefs will all play a role in the acceptance of cookstoves and these should be included as part of any cookstove initiative

Reliance on solid fuels is having significant impact on the environment, primarily through increased carbon emissions

Black Carbon emissions

Mitigation cost-effectiveness

(in USD/CO₂ ton equivalent)



- Household fuel and stove interventions are the most effective mechanisms to reduce CO₂ emissions per unit cost
- Wider use of cleaner cookstoves is estimated to be able to reduce India's black carbon emissions by about 0.15 million tonnes annually -- one-third of the total black carbon emissions in India. However, black carbon is not a traceable asset so its reduction could not be monetized

Deforestation

- Historically, procurement of fuelwood from forests has been a major contributor to deforestation throughout India
- However, procurement of fuelwood has shifted from forests to non-forest areas with a lot of fuelwood being procured from trees planted along roads, canals, farmlands and wasteland
- Currently fuelwood is only directly contributing to deforestation in north-eastern Indian states

While improved cookstoves can significantly reduce India's carbon emissions in a cost-effective manner, it will likely have a more limited impact on deforestation rates

Note: (i) This is an average value; cost-effectiveness of coal, wood and biomass stoves can range from ~USD 7 to ~USD 12/CO₂ ton equivalent; (ii) Diesel particulate filter; (iii) Inspection and maintenance

Source: India State of Forest Report - 2011; Forest Situation of India - INSEDA; Global Forest Resources Assessment (FRA); Status Report on use of Fuelwood in India - MSSRF; Energy for Sustainable Development; Reducing Black Carbon Emissions in South Asia - US EPA; Black Carbon Emissions in Asia - USAID

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The consumer landscape in India can be segmented using four criteria

1

Geography
(Rural / Urban)

2

Household fuel type
Solid fuel: Firewood / chips, dung cake and coke / coal
Modern: LPG, biogas, kerosene, electricity

3

Sources of fuel
(Purchase / collection)

4

Income level
(Income deciles – lowest 10% to highest 10%; classified as “very low”, “low” and “mid-high”)

The following assumptions form the basis of our analysis

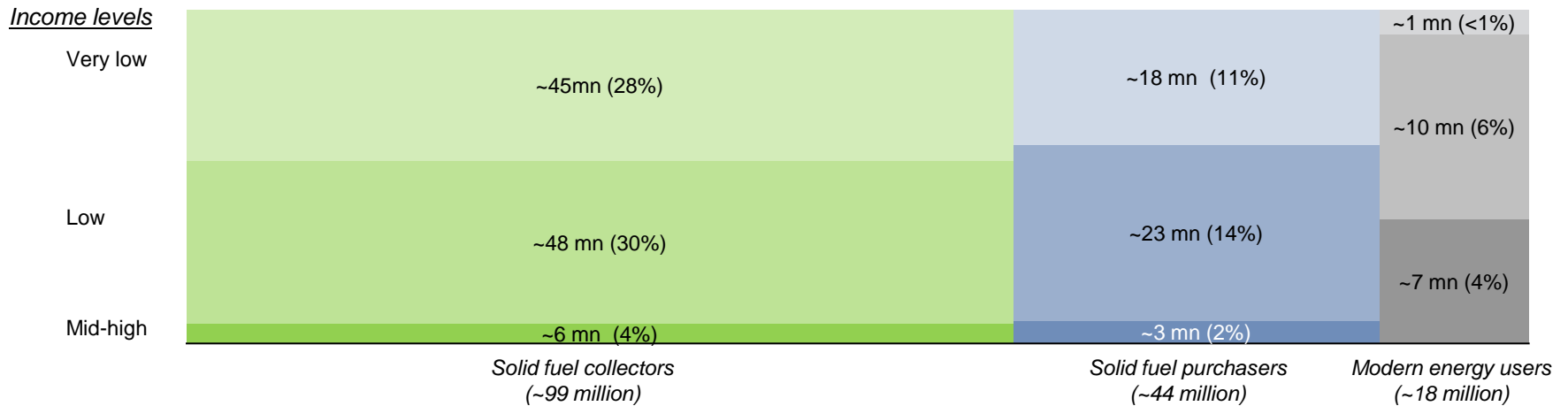
The customer segmentation in this section is an illustrative example of how the Indian market could be grouped. They are based on the following assumptions:

- The customer segmentation is designed to provide a high-level view of the market and strengthen the understanding of the customer base in India
- The customer segmentation is based on a preliminary market assessment and has used a combination of both primary and secondary research. Further refinement of customer segmentation and customer profiles will be required for specific programmes and regions.
- This customer segmentation calculations were derived based on the following mathematical assumptions:
 1. **Population:** 1.21 billion, 69% rural, 31% urban, ~4.9 people / household
 2. **Fuel use:** Broken down into use by income decile and rural / urban status
 3. **Purchase vs. collection of fuels:** Based on available data from NSSO 2009 / 2010
 4. **Income levels:** Rural and urban populations based on income decile. “Very low income” classified as population with expenditure less than Planning Commission’s poverty line guidelines, for rural and urban India, respectively. “Mid-high” income population is calculated based on the population with the power to use LPG year round or afford a \$30-\$50 stove. The “low income” population is calculated as the balance of the population.
- Available data was compiled from the World Bank and National Census Data from 2004/2005 and 2009/2010. The analysis excludes ~12 million households which use “other” fuels that are not identified by Census of India 2011

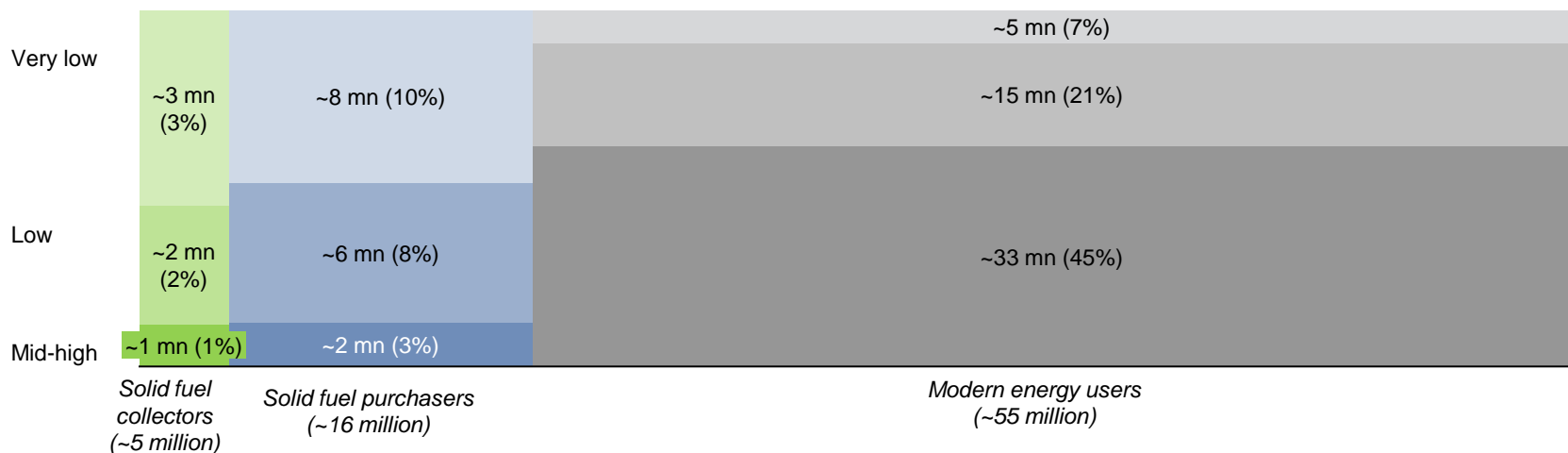
The potential rural market for cookstoves is twice as large as urban markets, but they tend to have much lower income levels

Indian households by customer segment (100% = 235 million households)¹

Rural market (~161 million households)



Urban market (~74 million households)



Note: Excludes ~12 million households which use "other" fuels that are not identified by Census of India 2011

Source: Dalberg consumer segmentation database; NSSO 2004/2006 and 2009/2010 database; Census 2011; Planning Commission of India

There are eight key customer segments in the Indian market (1/2)

	Size ⁱ	Description	Primary characteristics	Challenges
Very low income solid fuel collectors	47 mil (20%)	<ul style="list-style-type: none"> • Predominantly rural (95%+) • 88% wood, 12% dung 	<ul style="list-style-type: none"> • Limited interest and ability to pay for stove • Demographic profile likely skewed towards low education, marginalized populations • Likely to use more open fires than enclosed stoves 	<ul style="list-style-type: none"> • Requires subsidy approaches due to lack of disposable income • Requires higher investment in awareness and consumer behavior • Need to convince them of “aspirational” value of stove as well as time savings value
Low and mid-high income solid fuel collectors	56 mil (24%)	<ul style="list-style-type: none"> • Predominantly rural (95%+) • 89% wood, 11% dung • 89% low-to-mid income, 11% mid-to-high income 	<ul style="list-style-type: none"> • Can afford improved solutions and for higher income group, additional financing not needed • Have higher education and awareness levels • May not appreciate opportunity cost of fuel collection as much 	<ul style="list-style-type: none"> • Distribution challenges in reaching rural population • Identifying which marketing message which works best (i.e., opportunity cost? health?)
Rural very low income solid fuel purchasers	18 mil (8%)	<ul style="list-style-type: none"> • Predominantly wood collection (~94%) and remainder are coal and dung cake 	<ul style="list-style-type: none"> • Live in areas of biomass scarcity so collection not an option • Consumers may partly collect and partly purchase based on seasonal availability and income fluctuation 	<ul style="list-style-type: none"> • Under a lot of income pressure, so may not be an attractive segment to target • Would require financing/subsidy approaches for enhanced and higher end biomass solutions • Hard to reach with modern fuel options
Urban very low income solid fuel purchasers	8 mil (3%)	<ul style="list-style-type: none"> • Wood collection (81%) and coal (15%) are primary fuel sources • Urban disadvantaged and marginalized populations heavily represented 	<ul style="list-style-type: none"> • Primarily slum dwellers with limited access to modern fuel solutions and likely have low education • High levels of fuel purchasing behavior despite very low incomes 	<ul style="list-style-type: none"> • Require financing options (i.e., targeted subsidies or cash transfers), but move to modern fuels might be possible • Need to consider crowding/space issues, portability and property rights as a key part of appropriate technologies

Note: (i) The poverty line is INR 26 / day for rural India and INR 32 / day for urban India. The bottom 40% of rural households and bottom 20% of urban households fall into this category (overall ~34% of India falls into this category); (ii) For LPG, assumes maximum affordability is 5% of total expenditure and that LPG consumption requires 50L-200L / HH / year; for stove purchase, assumes households are at most willing to spend 25% of one month's income on an improved stove. The analysis yields per capita monthly expenditure of INR 1,700, which is the 90th percentile for rural and 70th percentile for urban India.

Source: Dalberg consumer segmentation database; NSSO 2004/2006 and 2009/2010 database; Census 2011; Planning Commission of India

There are eight key customer segments in the Indian market (2/2)

	Size ⁱ	Characteristics	Primary characteristics	Challenges
Rural low and mid-high income solid fuel purchasers	26 mil (11%)	<ul style="list-style-type: none"> Predominantly wood collection 90% low income; 10% mid-to-high income 	<ul style="list-style-type: none"> Has some disposable income and already pays for fuel so can be a key segment to target Higher levels of education likely Appropriate segment for biogas, LPG conversion (if in peri-urban areas) and enhanced and advanced biomass solutions 	<ul style="list-style-type: none"> Market can be quite fragmented across country – need to identify effective distribution strategies Need to leverage existing awareness initiatives Need to identify message that will resonate most strongly with the consumers
Urban low and mid-high income solid fuel purchasers	8 mil (3%)	<ul style="list-style-type: none"> 81% wood, 15% coal and remainder as dungcake ~75% low income, 25% mid-high income 	<ul style="list-style-type: none"> High levels of fuel purchasing behavior despite lower incomes for majority of this segment Cultural factors likely leading to continued use of solid fuels Education and awareness is likely to be higher, particularly among mid-high income segment 	<ul style="list-style-type: none"> Focus on consumer education and commercial models for the mid-high income segment Need to consider crowding/space issues, portability and property rights as a key part of appropriate technologies
Rural modern energy users	18 mil (8%)	<ul style="list-style-type: none"> Predominantly low and mid-to-high income (~95% of total) ~90% LPG, ~7% kerosene 	<ul style="list-style-type: none"> Majority of the segment can afford fuels and cooking solutions Many, possibly most, do fuel stacking (i.e., using solid fuels for secondary cooking needs) Has already changed cooking behavior so likely easier to reach and lower burden of persuasion 	<ul style="list-style-type: none"> Convincing consumers to change their <i>secondary</i> stove away from an unimproved chulha can be difficult Understanding and being able to manage government policy changes in LPG and kerosene
Urban modern energy users	53 mil (23%)	<ul style="list-style-type: none"> ~90% LPG, 10% kerosene 62% mid-to-high income, 29% low-to-mid income; 9% very low income 	<ul style="list-style-type: none"> Majority of the segment can afford improved cooking solutions There is likely a lot of fuel stacking in this segment as well as well as an opportunity to move kerosene users towards cleaner and safer solutions 	<ul style="list-style-type: none"> Identifying key message that resonates with the consumers Understanding and being able to manage government policy changes in LPG and kerosene

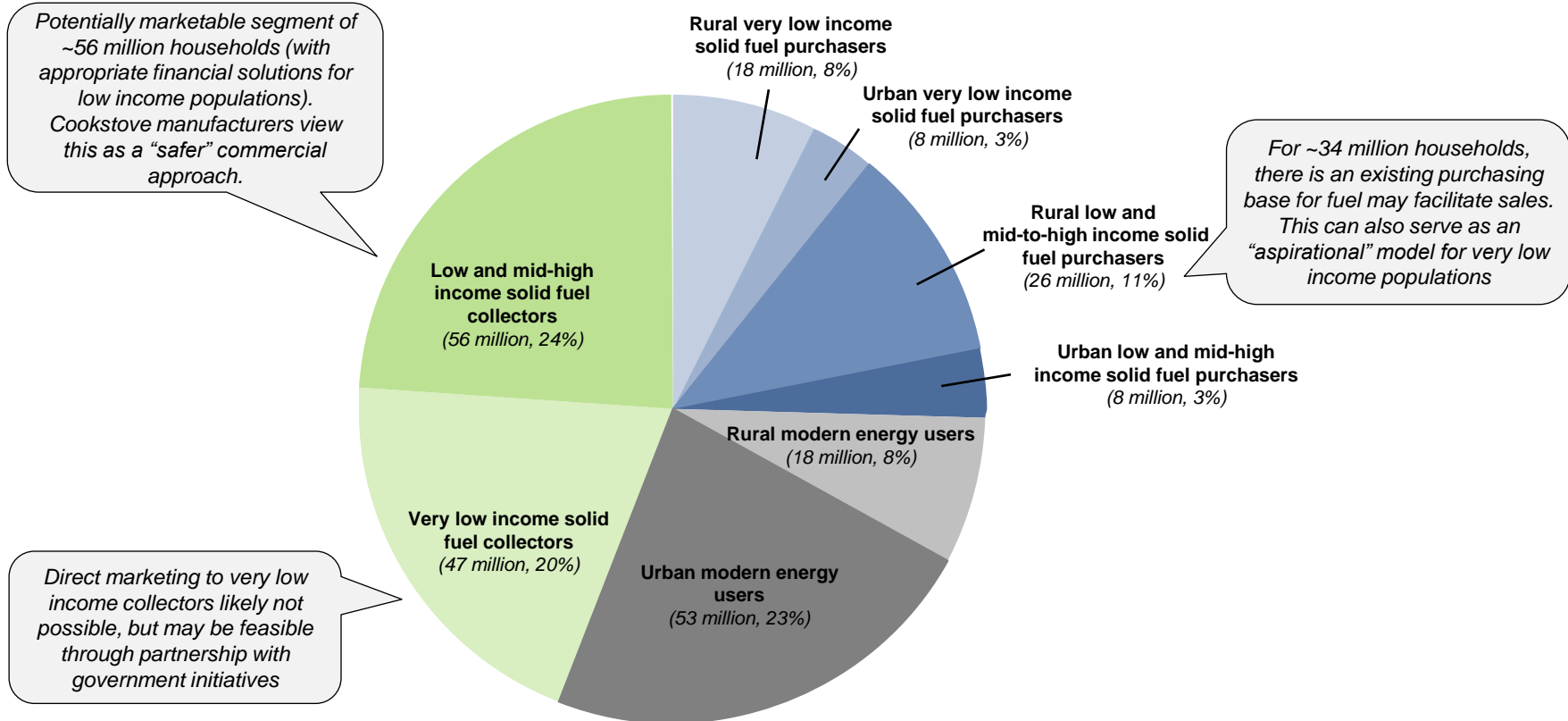
Note: (i) The poverty line is INR 26 / day for rural India and INR 32 / day for urban India. The bottom 40% of rural households and bottom 20% of urban households fall into this category (overall ~34% of India falls into this category); (ii) For LPG, assumes maximum affordability is 5% of total expenditure and that LPG consumption requires 50L-200L / HH / year; for stove purchase, assumes households are at most willing to spend 25% of one month's income on an improved stove. The analysis yields per capita monthly expenditure of INR 1,700, which is the 90th percentile for rural and 70th percentile for urban India.

Source: Dalberg consumer segmentation database; NSSO 2004/2006 and 2009/2010 database; Census 2011; Planning Commission of India

Very low income groups may not be addressable, but those with low and mid-high incomes may increasingly purchase improved stoves

Indian households by customer segment (2011)

100% = 235 million householdsⁱ



The customer segment to be targeted is critical in determining the design, price point and distribution strategy of any cookstove initiative

Note: Excludes ~12 million households which use "other" fuels that are not identified by Census of India 2011

Source: Dalberg consumer segmentation database; NSSO 2004/2006 and 2009/2010 database; Census 2011; Planning Commission of India; Shrimali, G., et al., Improved stoves in India - A study of sustainable business models; Energy Policy (2011); GACC stakeholder consultations

The market size for cookstoves in India is very large – individual segments are bigger than the total market potential of other countries

Potential market for cookstoves

In total households in country, millions



Note: Excludes 13 million households who use "other" fuels which are not described by Census

Source: Dalberg consumer segmentation database; NSSO 2004/2006 and 2009/2010 database; Census 2011; Planning Commission of India; GACC market assessment studies

Consumers' willingness to pay will vary depending on the customer segment

“Willingness to pay” drivers

Economic savings: monetary savings due to decreased need for fuel (greater efficiency) lower cost of fuel (due to fuel switching) or more durable stove (limited replacement costs)

Time savings: recouped time from time not spent collecting fuel or from decreasing long cooking times (through more efficient stoves)

Health concerns: key issues include ensuring healthier children and mitigating chronic health issues such as eye irritation, difficulty breathing etc

Cleanliness: improving the look and overall cleanliness of the kitchen, utensils and home

Aspirational technology: improving the look and overall cleanliness of the kitchen, utensils and home



Likely target audience

- Solid fuel purchasers (primarily male as the economic decision maker)
- Educated consumers
- Commercial/institutional buyers

- Higher income/educated rural consumers (with opportunities for alternatives livelihood)
- Solid fuel collectors (primarily female who have the most time burden from cooking)

- Female consumers (as primary caretakers of the house and children)
- Donor agencies and “mission-driven” institutional purchasers

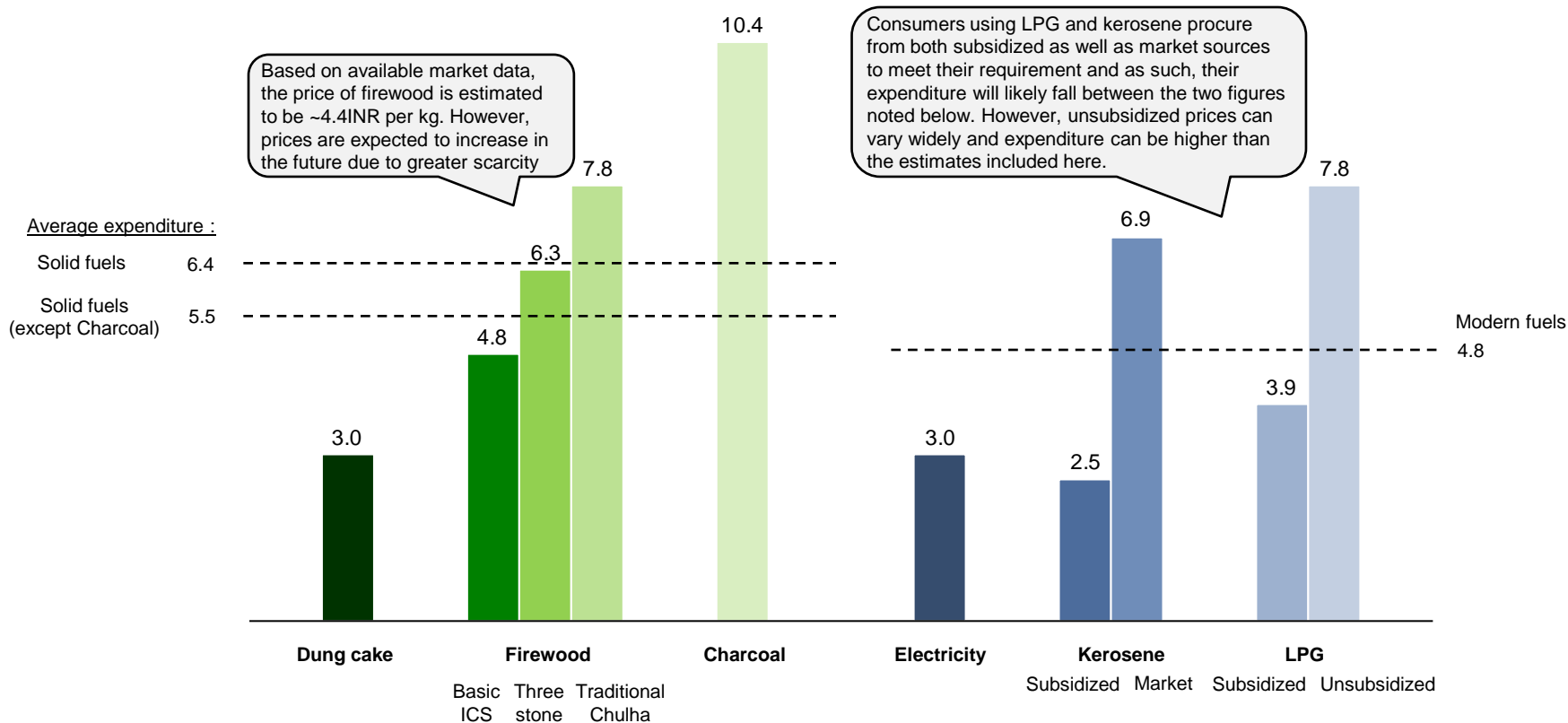
- Female consumers (as primary cooks and presence in the kitchen)

- Female consumers (as primary cooks and presence in the kitchen)

The customer segment to be targeted is critical in determining the design, price point and distribution strategy of any cookstove initiative

On an average per meal basis, purchased solid fuels are more expensive than modern fuels, but the difference is marginal

Indicative fuel expenditure (in INR per meal per household)



In situations where cost savings from switching from solid fuels to modern fuels is minimal, other benefits of cookstoves (i.e., health benefits, time savings, aspirational technology, etc.) should be emphasized

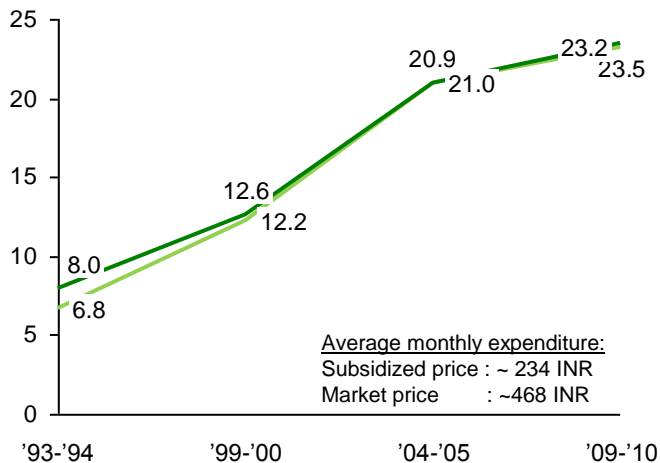
Note: (i) Expenditures are indicative and will vary by region as they were calculated by using aggregates; (ii) A typical meal composition for the study is Rice, *Ragi mudde* (finger millet) and *saru* (similar to soup); (iii) A typical household size is ~4.91 according to Census of India 2011; (iv) The price of kerosene in market vary from 30 -80 INR/litre as they are not controlled by government and hence, 40 INR/Litre, average of prices available from popular media and research was used

Source: Dalberg proprietary database; Energy options for cooking in India - N. H. Ravindranath and J. Ramakrishna; IHDS; National Sample Survey Office

However, prices of subsidized LPG & kerosene have grown annually by ~7-9% and future costs remain uncertain in light of policy changes

Average price of LPG (subsidized)

(in INR/Kg)

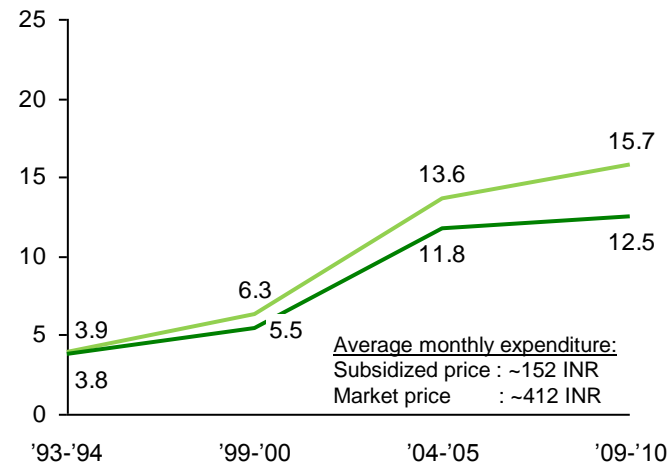


CAGR: Urban 8% Rural 7%

A household used to receive unlimited subsidized LPG cylinders. But recently, the government has restricted the number to 9 per year. The rest of the requirement must be procured at market price, which is double the subsidized price

Average price of kerosene (subsidized)

(in INR/ liter)



CAGR: Urban 9% Rural 8%

Government provides a quota of kerosene per family based on income level. The rest of the requirement is usually procured from informal markets where prices are usually double or triple the subsidized price. In addition, there is a movement to ban kerosene in households which could lead to massive price fluctuations

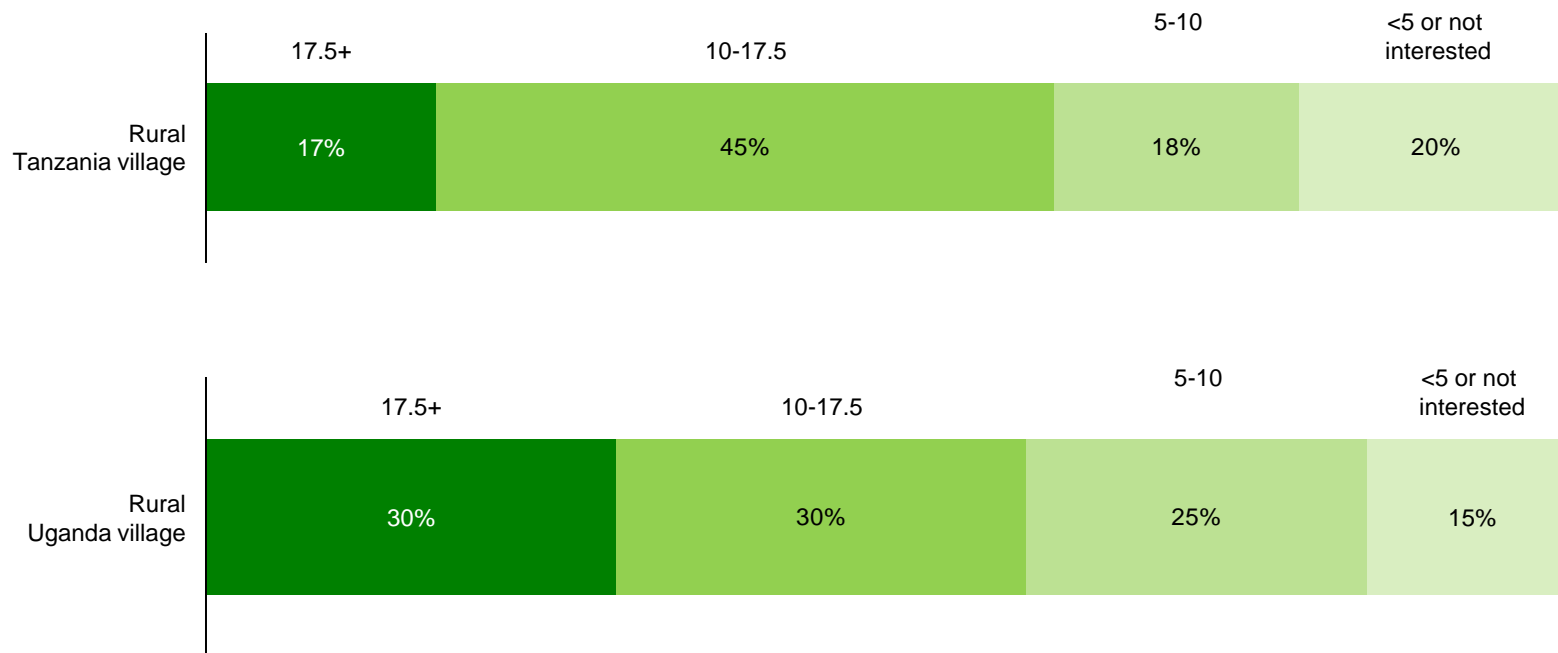
While the average price is kept artificially low by subsidies, the burden on the consumer is expected to fluctuate given the government's policy changes to limit the availability of subsidized fuel. This will in turn have an impact on the price variability in the informal market

Cookstove initiatives should be wary of changes in household costs of purchasing modern fuels because:

- (i) existing modern fuel users may revert back to solid fuels and**
- (ii) cost savings resulted by switching to modern fuels may no longer be a selling point**

Initial evidence from other countries suggests that the segment not interested in ICS is small, but further validation for India is required

Willingness to pay (USD)ⁱ



While it is likely that there is a subset of the Indian consumer base that is also unwilling or uninterested in purchasing a cookstove, further research is required to define and size this population

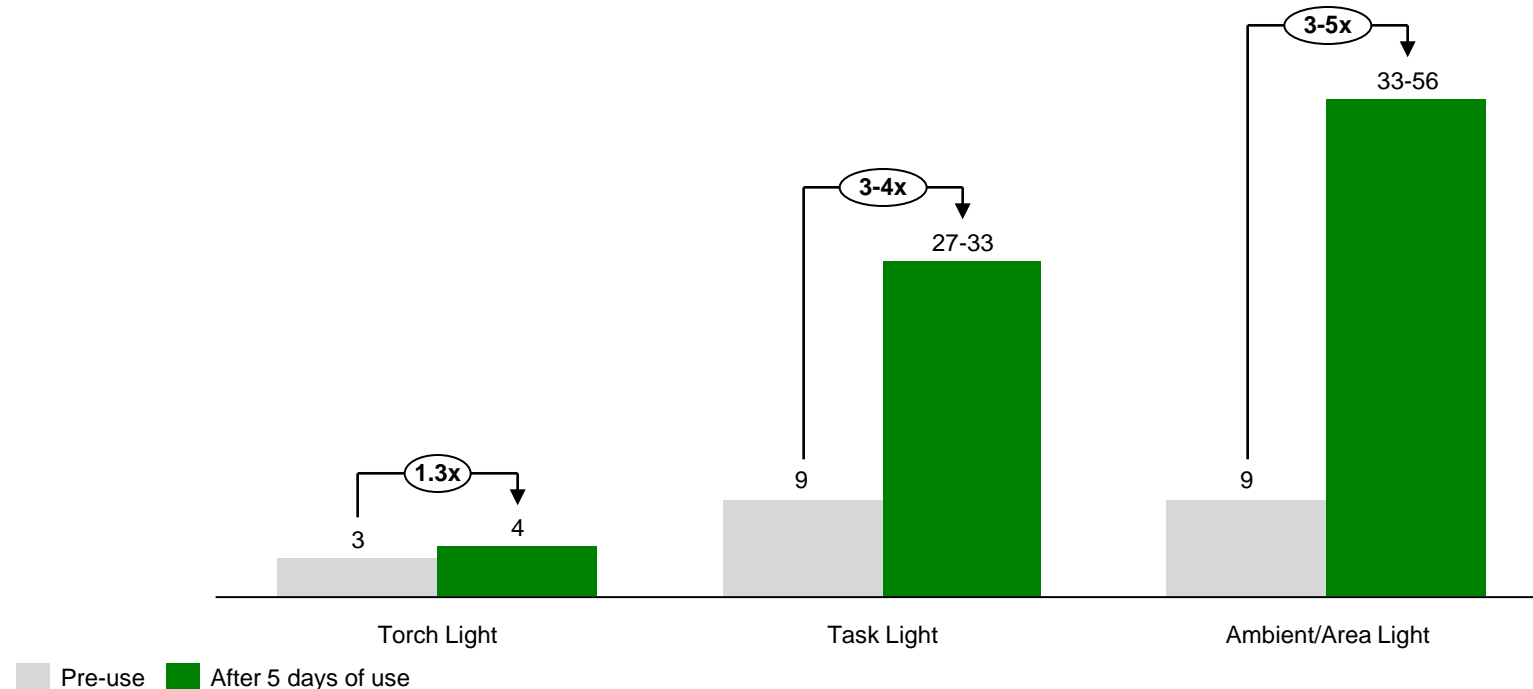
Note: (i) Data extrapolated from Atkins et al. (2010) reflects willingness to pay for improved rocket stoves; (ii) Data for specific MVP villages not available; (iii) Uganda and Tanzania collector data based on GVEP assessment of rural areas in each country; (iv) Mid-income collector share set at 40% to reflect 30-50% range in studies of wood collector demographics in Chad/Sudan/Nepal/Guatemala

Source: Atkins et al. 2010; GVEP 2010; Dalberg fuel collection database; Dalberg analysis

Demand and willingness to pay are likely to increase after consumers have been exposed to and educated about the stove

Much like solar portable lanterns (SPLs), cookstoves are “experience goods”: their value and worth increase significantly after a period of usage

Customer willingness to pay for quality SPLs (USD)



Cookstove manufacturers and distributors can consider using a “trial period” to enhance the consumer’s perception of the cookstove and increase willingness to pay

Indian cook stove sellers have not emphasized consumer finance, but are increasingly considering it in order to increase sales

Financing solution	Overview	Reach	Challenges	Examples in Indian context
Carbon finance (CDM)	USD 10-25 carbon credit claimed by the manufacturer as income or passed through to the consumer in lower prices.	Present, but not prevalent; a handful of companies have reported revenues from carbon credits	Carbon credits tend to create significant volatility in revenue flows due to regulatory risk and carbon price fluctuations.	Envirofit with Shell Foundation
Non-carbon “buy-down” performance based grants	Performance based subsidies provided directly by donors/ governments to lower upfront cost of the stove to the end user either as a lower overall price or through a voucher	Not yet tried in the market	Hard to monitor the “performance” and use of the stove and can distort the market for cookstoves	N/A
Microfinance	Small loans for stove purchase disbursed through MFIs/SACCOs and typically bundled with distribution arrangements	Present, particularly to help distributors buy stoves, and in cases where cook stoves are bundled with other products	Need to create a “top up” loan as ticket prices for cookstoves are too low; MFI’s are not allowed to endorse products;	SELCO India, Prakti Design Labs; Grameen Greenway
Installment / pay as you go models	Consumers can pay for a stove in installments in order to diminish upfront costs for consumers	Limited, as implementation is difficult, but a few players are considering it	Transaction costs of collection are high and difficult to scale	N/A
Mobile-enabled utility model	Potential for mobile financing and utility based models with remote stove activation/deactivation (cookstoves)	Not prevalent for cook stoves yet, unlike solar lanterns	Upfront investment in technology infrastructure required	N/A
Fuel amortization and cross subsidy models	Stoves offered for free, at cost, or with partial subsidy but funds collected from fuel revenue stream. Stoves offered for free in return for fuel collection services	Fairly prevalent in the past, particularly due to the NIPC, the previous government program	Hard to monitor and can distort the market for cookstoves in the long run	NPIC
Corporate/ institutional financing	Sell stoves in bulk to a corporation who will then resell to the consumer at or below cost	Becoming more prevalent, but still in infancy	Need to identify institutions which understands value of cookstoves and has large consumer market	Envirofit

Source: Carbon credits to bring down costs of clean stoves for rural poor, Business Line; Cookstoves and Markets – Experiences, Successes and Opportunities, GVEP International; Improved stoves in India – A study of sustainable business models by Shrimali et al.; Dalberg analysis

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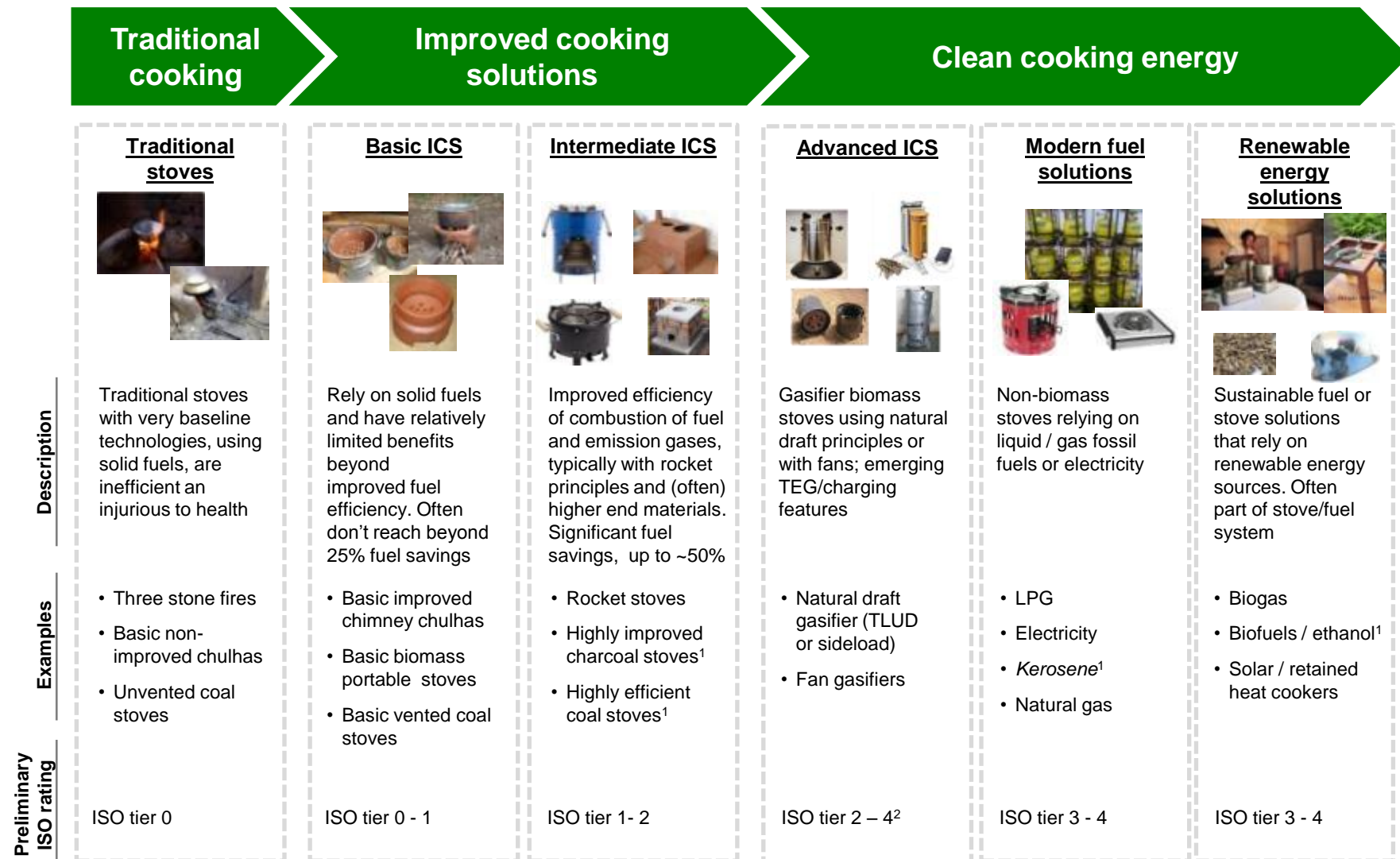
Cookstove industry

Cookstove policy environment

Sector mapping summary









Appendix

There are six categories of cookstove technologies





















Note: (i) The vast majority of kerosene stoves are unlikely to be considered clean under WHO health emission standards but are included here as a modern fuel solution; (ii) Excludes low quality natural draft gasifier that perform at a standard lower than ISO tier 2. Only household-suitable stoves are included in this analysis.
Source: Dalberg analysis; Expert interviews

Here are a few basic and improved ICS solutions currently in the market; their prices range between \$2-\$35

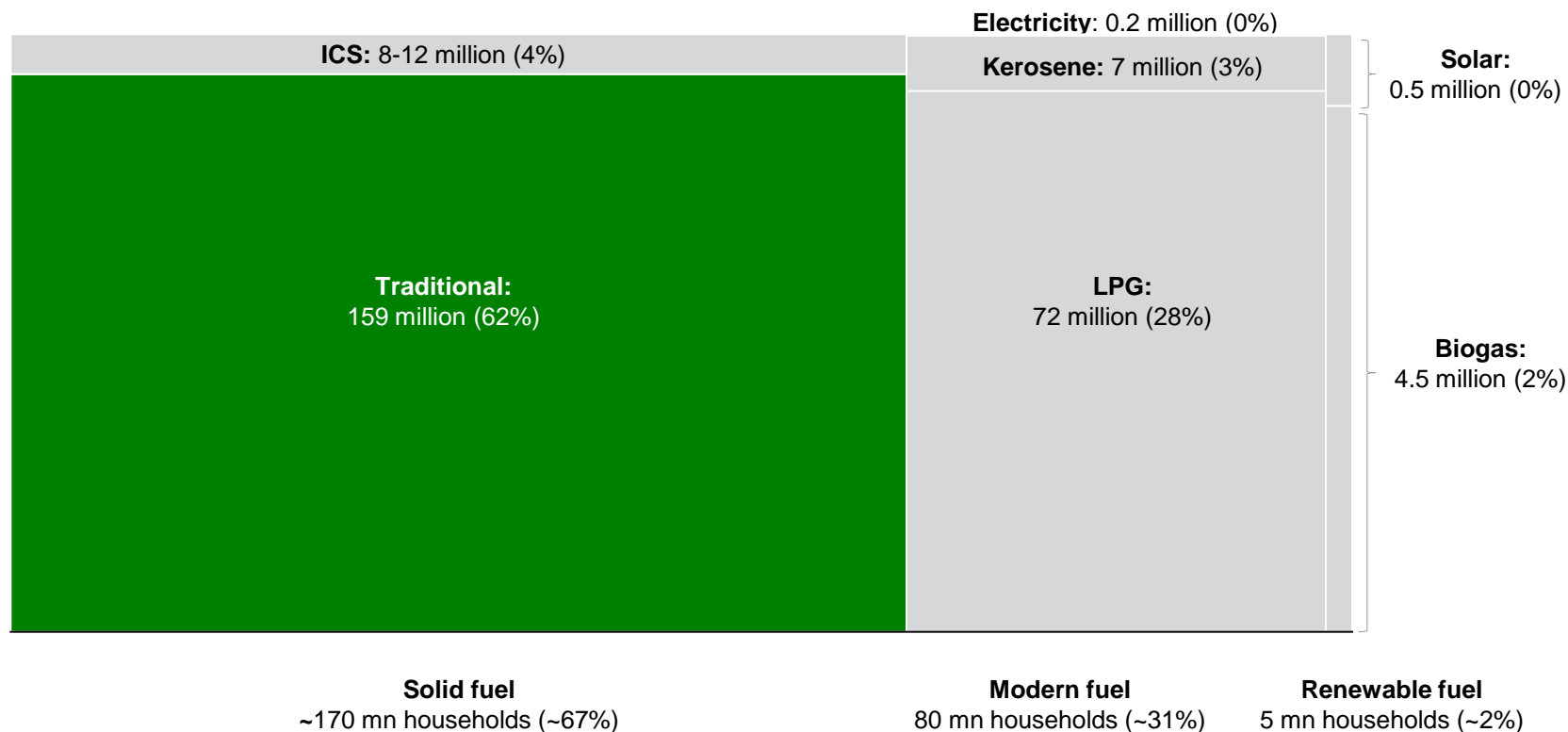
	Product	Key players	Price range	# of HH using stove
Basic ICS	• Chimney solid fuel stoves	  	\$2 - \$10	~8 million
	• Portable wood and charcoal stoves	 	\$1 - \$5	~3 million
Intermediate ICS	• Portable wood rocket	  	\$25 - \$35	<0.5 million

There is a broad range of clean cooking solutions available, but the products are significantly more expensive than basic ICS stoves

	Product	Key players	Price range	# of HH using stove
Advanced ICS	• Natural draft gasifier	  	\$20 - \$35	} <0.5 million
	• Forced draft gasifier	  	\$20 - \$75	
Modern	• Liquid petroleum gas (LPG)	  	\$30 - \$100	~70 million
	• Kerosene		\$15 - \$25	~7 million
	• Electricity	  	\$50 - \$100	<0.5 million
Renewable energy	• Biofuels / ethanol	  	\$30 - \$35	~4 million
	• Solar / retained heat cookers	 	\$70 - \$90	<0.5 million

Nearly two-thirds of India's population continues to rely on traditional cookstoves

Cookstove penetration by type (% of households)



While LPG use is high (28%), nearly 75% of users are in urban areas and availability is low in rural areas. Rural cookstove initiatives will need to focus on moving traditional cookstove users to improved cookstoves.

Within the ICS market, estimated to be 9 million – 13 million stoves, nearly all are basic improved chimney chulha stoves

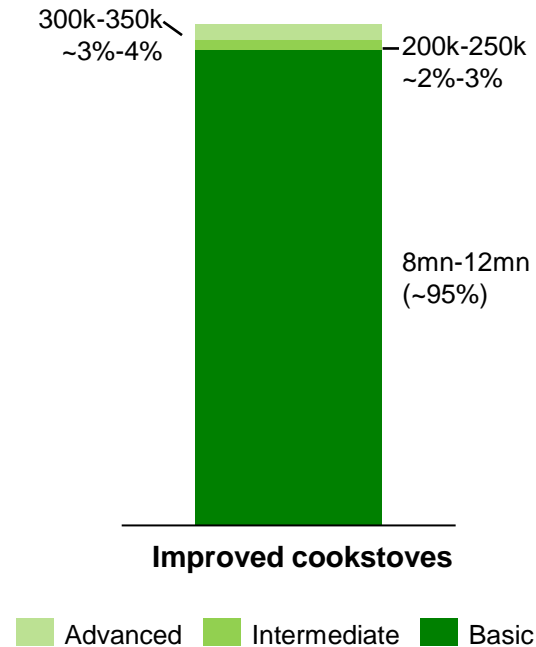
Improved cookstoves penetration model:

Sources and methodology

- **8-12 million basic cookstoves:** These figures are based off of improved chimney chulhas from IHDS (2005-2006) and WHO DHS (2004) surveys . This does *not* include portable improved stoves (such as the Priagni) which can increase the estimate to 9-13 million basic improved cookstoves
- **200-250K intermediate stoves:** This includes stove sales from the major players (Envirofit Greenway Grameen, Prakti) as well as some smaller rocket stove manufacturers which comprise the majority of the market
- **300k-350K advanced stoves:** Based on sales reports of major manufacturers (i.e., BP Oorja / First Energy) report and scaled for actual usage and adoption. This includes an estimated number of draft gasifiers

Estimated ICS penetration

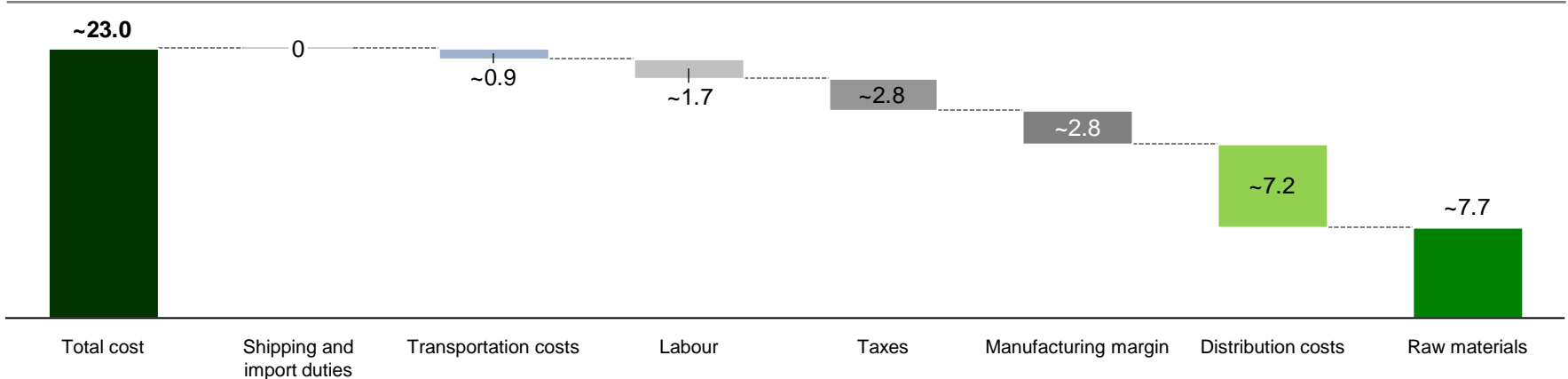
(millions of stoves, % of ICS market)



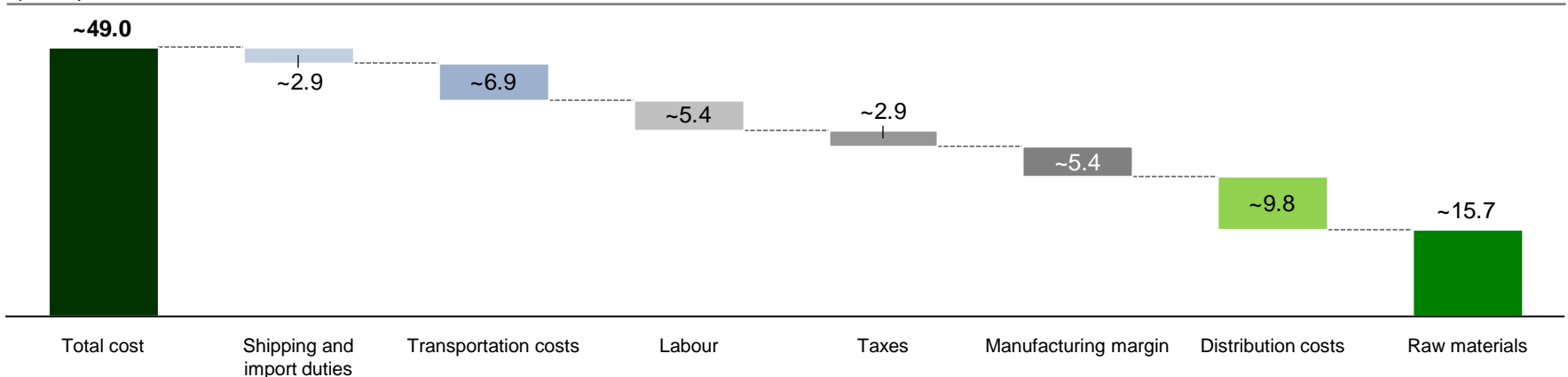
There may be room within the ICS market to move users from older and poorer quality basic cookstoves to newer and / intermediate or advanced cookstoves

Raw material and distribution costs represent between 50 – 60% of the costs of intermediate / advanced stoves

Indicative cost breakdown of a rocket stove [intermediate ICS]
(USD)









Indicative cost breakdown of a fan draft gasifier [advanced ICS]
(USD)



Expert interviews indicate that distribution and taxes may be two sources of potential cost savings for manufacturers

Note: Rocket stove and fan draft gasifier costs are based on the costs from one manufacturer of each category
Source: Dalberg analysis

Commercial efforts have had limited success: of 10 sampled organizations, none have achieved both scale and profitability

Company (years in business)	Stoves sold ⁱ	Financial sustainability ⁱⁱ	Relative successes	Relative weaknesses
Company A (1 year)	0	Unknown	Too early to assess	Too early to assess
Company B (40 years)	0 (sold 0.15Mn in Africa)	Closed India operations	Great track record in Africa	Not operating in India due to loss of funder
Company C (2 years)	120,000		Technical design Partnership with an university, NGO and a foundation Innovative marketing & supply chain practices	N/A
Company D (4 years)	450,000		Cross subsidizing from commercial sales Support from parent company in past Innovative marketing & supply chain practices	Must manage both fuel and stove supply Loss of support from parent MNC
Company E (11 years)	450		Revenue from fuel sales Primarily commercial customers	Challenges in setting up a supply chain; Heavy reliance on carbon financing
Company F (1 year)	1,000	Unknown	Support from the parent company, a large consumer appliances multinational	Prone to major strategy changes enforced by parent company
Company G (2 years)	5,000		Competitive advantage over LPG stoves in the wake of LPG prices increase	Lack of total control on distribution channel due to third party partners
Company H (5 years)	25,000		Support from the parent NGO	Funding unavailability Lack of total control on distribution channel due to third party partners
Company I (1 year)	40	Unknown	For-profit company by same founder as Company J; Targets street vendors who spend more on fuels	Funding unavailability
Company J (10 years)	7,000		Support from donor agencies	Sales decreasing; funding unstable Lack of control of distribution channel due to third party partners

 Unlikely  Possible  Likely  Proven

Note: (i) Sales as of June 2010; (ii) Per the estimation of the authors of the study

Source: Shrimali, G., et al., Improved stoves in India: A study of sustainable business models. Energy Policy (2011)

Across private sector players, there are some common characteristics as well as differences in their business models (1/2)

Common characteristics

Differences

Design / manufacturing

- **Developing local production capacity:** Most businesses have some or all manufacturing located in India to take advantage of proximity to customers, government incentives for local manufacturing and to take advantage of lower costs. Southern India was cited as a particularly promising place to locate a manufacturing plant. Others also emphasized locating in rural areas to take advantage of cost savings (in wages and transportation costs to final consumer)
- **Tailoring product design:** The majority of cookstoves in the market aim to provide a more advantageous cooking experience without requiring a fundamental change in user cooking habits. Consumers are willing to adopt new cooking approaches, but the product must be cost-competitive with existing solutions such as LPG stoves

- **Centralized vs. decentralized production facilities:** While some cookstove manufacturers prefer centralized manufacturing in order to bring down cost and facilitate quality control, others which are more “mission oriented” tend to prefer decentralized models which emphasize employment generation, empowerment and more micro-tailored design solutions.
- **Outsourcing vs. controlling manufacturing:** Some companies have the comparative advantage to control the entire value chain including manufacturing. However, others choose to “outsource” the manufacturing to others in order to save on costs

Human capital

- **Leveraging “business” skills:** Greater depth of experience in certain key business skills (e.g. supply chain) has helped companies build out more effective operations, as opposed to companies with an NGO heritage, which may struggle to commercially disseminate even a strong product

- **Unskilled vs. skilled labor for manufacturing:** For more basic technology designs, companies prefer to use unskilled labor. However, for more complex designs, more skilled workers (both in technical design as well as oversight of tools/machines) are required

Across private sector players, there are some common characteristics as well as differences in their business models (2/2)

Common characteristics

Distribution and service strategy

- **Managing variance in demand:** Companies who are able to effectively predict consumer behaviors and demand patterns can vary their manufacturing/ distribution strategy accordingly and can avoid large inventory costs
- **Focusing on building supply channels:** Companies that have achieved volume have focused significant attention on strengthening scalable supply channels and have remained actively involved in managing the channel. This includes heavy partnership with women's self help groups to develop core village level entrepreneurs (explored further

Financing sources¹

- **Securing upfront financing:** Enterprise finance, particularly capital to support the upfront customer research, stove design and establishment of a supply channel is a key differentiator of success
- **Identifying stable and diverse funding sources:** The magnitude and stability of enterprise funding was most important to achieving scale than whether the source was private or charitable in nature. Generous corporate backing can be one route to creating a large-scale energy business serving the poor

Differences

- **Provision vs. non-provision of after sales service.** There are mixed opinions on the viability of after sales service because some companies don't see the demand for it and it takes away resources from more immediate threats to their business. There are some who seek to minimize their role in this area and test goods upfront to ensure no defects, while others are moving more to an after sales service model, particularly as other consumer goods for the BOP (i.e., lanterns) have them as well

- N/A

Note: Explored in further detail on the following page

Source: Shrimali, G., et al., Improved stoves in India: A study of sustainable business models. Energy Policy (2011)

Private sector players employ a number of different approaches to identifying, targeting and serving a customer base

Model #1: Micro-targeting

- Identify communities primarily based on *need* (i.e., based on income levels, solid fuel use, health impacts, etc.)
- Work closely with the community to develop and design a stove that meets their specific needs in terms of cooking practices, foods etc. This design may not be applicable outside of the single community
- Focus on developing stove technologies that will meet the needs of the very BOP populations as well as those with slightly more disposable income
- Emphasis on lowering the cost to meet affordability targets, but ultimately can seek to use subsidies to ensure it reaches the end consumer
- Model is not necessarily designed to be scalable beyond 1-2 immediately proximate communities

Model #2: Community sales

- Identify communities on the basis of existing professional and personal networks
- Use an existing design of a cookstove (developed through other participatory design) and adapt it to the specific needs of the community as needed
- Understand the community income dynamics and “reverse engineer” the segment that can afford the cookstove (i.e., not the very BOP consumers)
- Use local community leaders and “changemakers” to drive sales

Model #3: “Broad net” approach

- Engage in an upfront long-term testing process to broadly understand consumer preferences and design a cookstove accordingly
- Focus on lowering the cost where possible, but don’t seek to target the very BOP populations as they will not be able to afford the solution
- Conduct broad based marketing strategy to target consumers across a variety of regions

Targeting BOP consumers (as per model #1) is very challenging for companies seeking to achieve financial sustainability – many employ models #2 and #3 and target “higher income” segments of the population in order to achieve financial profitability


A critical element of a successful business is the approach and actors used to generate awareness and disseminate cookstoves

Awareness raising strategies


- **Product demonstrations and user trials:** these are known to be the most important driver of the stove's adoption in the marketplace, particularly if it includes testimonials from credible consumers
- **National/regional “message-driven” campaigns:** private sector companies can try “piggy-back” on government campaigns on health issues (i.e., smoke inhalation) and environmental issues around the country
- **Celebrity endorsements:** while not employed yet in India, this has seen success in other spheres (i.e., in other fast moving consumer goods and charities) so there is scope for it to be applied to the cookstove industry

Key actors

- **Social and community networks:** neighbors, community leaders and “changemakers”, and self-help groups (particularly for women) are *extremely* influential in spreading the word and facilitating sales
- **Retail shops:** India has many *kirana* stores which sell basic needs in outlets across the rural parts of the country. They are important elements in the cookstove distribution chain and can be used to bundle cookstoves with other innovative goods (i.e., solar portable lanterns) to increase ticket price and impact
- **Medical and insurance facilities:** Doctors and insurance workers can also play a role in promoting cookstoves as part of a healthier lifestyle, and in the case of life/health insurance, as a potentially premium cost-reducing measure
- **Pharmacy and health shops:** There are examples of cookstoves being bundled with other health goods (child health products, oral medication, etc.) as part of a comprehensive health strategy
- **Financial institutions:** Rural banks and microfinance institutions have played important roles in (i) spreading awareness and (ii) providing the loans to enable the consumer to finance the purchase
- **Cooperatives and unions:** There are creative examples of working directly with the heads of cooperatives (i.e., dairy) and worker unions (i.e., tea plantation workers) to generate awareness and make bulk purchases which can then be distributed (subsidized or at cost) to its members








The success of any given cookstove depends on the combination of its merits and success of the company in developing a viable supply channel that can bring a large number of people into personal contact with the product



Existing players use one or two of these actors at the most as part of their distribution strategy – further coordination amongst stakeholders will broaden the scope of opportunity for scaling up distribution and supply channels

Several alliances have been formed in order to improve distribution to end users

Direct sales channel	3 rd party dealer-distributor networks	Micro-franchisees	Social sector partners	Institutional sales
<p>Manufacturer staff, commission-based door-to-door agents, proprietary stores</p>	<p>Distributor / dealer networks including both large and small retailer formats</p>	<p>Micro-franchisee agents empowered and incented to distribute products</p>	<p>Sales/order fulfillment via MFI / NGO / gov't extension agents</p>	<p>Bulk purchases and redistribution by institutional clients (e.g., relief agencies)</p>
				

Despite the breadth of enterprise financing options, only a few are in practice today

Financing solution	Overview	Reach	Challenges	Examples in Indian context
Commercial loans	Manufacturer already sufficiently “credit worthy” through other business lines or is able to provide enough collateral and to access commercial credit – interest rates often high	Very rare	Must first establish commercial viability; banks unwilling to make risky loans	N/A
Credit guarantees	A third party provides a guarantee on the credit provided by private banks, in order nullify the risk	Moderate, particularly for cook stove selling organizations that would on lend to provide consumer financing for the cook stove purchase	A complex structure to set up and as such, has only been tried once in India	N/A
Social impact investment	Funds seeking to pursue impact-driven goals alongside traditional investment targets provide both equity and working capital to players in the cook stove value chain.	Some players have already made investments	Only a few players in social impact space and they still tend to view cookstoves as a “frontier market”	BioLite
Subsidized loans	Commercial credit is “subsidized” by donors, or loans provided by “impact investor” with longer time horizons and lower rates. Also may involve innovative structuring of collateral requirement, and/or incorporate capacity building and training	Moderate, particularly as start up funding for cook stove selling enterprises, before they reach scale	Lends itself to complexity as multiple financier stakeholders need to be managed	SELCO India, Greenway Grameen Infra
Grant funding	Funds from foundations, NGOs and government, that seek to provide a start to cook stove sellers before they are able to commercialize and become sustainable enterprises	Prevalent, particularly in initial stages, as most cook stove enterprises reaching BoP households are not commercially viable	Susceptible to shifting donor priorities and funding cuts; may not be sustainable in the long run	Envirofit, Vikram Stoves

Note: carbon financing is explored in further detail on the following page

The infrastructure of the Indian carbon credit market is developed, but few players are able to take advantage of it

Overview of Indian carbon finance market

- One of the largest markets in the world , similar in size to Brazil, behind only China
- Two commodity exchanges trading in carbon credits, as well as futures trading in carbon credits, resulting in a better trading platform and prices for CERS generated by Indian companies
- Commercial banks like IDBI and HDFC provide comprehensive carbon credit services
- Public sector has very low involvement in the Indian carbon market , while SMEs are the major driving factor in the market

Barriers to scaling up in the cookstoves sector

- **Data irregularities:** much of the benefits of carbon financing are derived from carbon emissions data and projections – few of which are directly applicable to cookstoves
- **Lack of applicability to small manufacturers:** Because there is a lack of aggregation of large number of small SME projects, reducing attractiveness for purchasers. In turn, it makes it harder for smaller manufacturers (i.e., cookstove players) to engage with the market
- **Lack of knowledge and transparency:** many players in the market are not aware of the steps and methodology to follow in order to access carbon financing
- **High transaction costs:** for smaller firms in particular (i.e., the majority of the private sector players in the cookstove market), the transaction costs of understanding and applying carbon finance to their business models is overwhelming

If carbon financing is to be scaled up in the cookstove sector, external technical support, advice and guidance is critical in order to support cookstove players through the process

A sample of 10 firms reveals that grant funding remains important and consumer and carbon financing options are limited

Financing scenario of 10 companies surveyed

- 6 of them had been funded initially through grants, primarily from foundations and the government
- Only 1 of them received venture capital financing
- 3 of them grew out of other entities such as NGOs, non-profits or as the offshoot of another parent company
- 2 of them had successfully taken advantage of carbon credit sales while 1 was still exploring its viability to its business model
- None had developed any consumer financing options



Key takeaways

- **Patient capital is required at the outset:** upfront financing without expectation of returns for multiple years (1-4 years) is needed as players need time to conduct the necessary research and create a business model that can reach the consumer
- **Consumer financing is not noted as a barrier:** Basic affordability is important but none of the companies dedicated to household stoves saw lack of consumer finance as a major obstacle
- **Lack of government funding:** The government has not been a significant source of enterprise financing, and a number of companies have reported that Indian government subsidy programs have caused significant problems for business
- **Carbon financing still uncertain:** Carbon financing could be a potential revenue stream that makes the finances of an enterprise more viable; however transaction costs are high and carbon credits could create volatility in revenue flows due to regulatory risk and carbon price fluctuations

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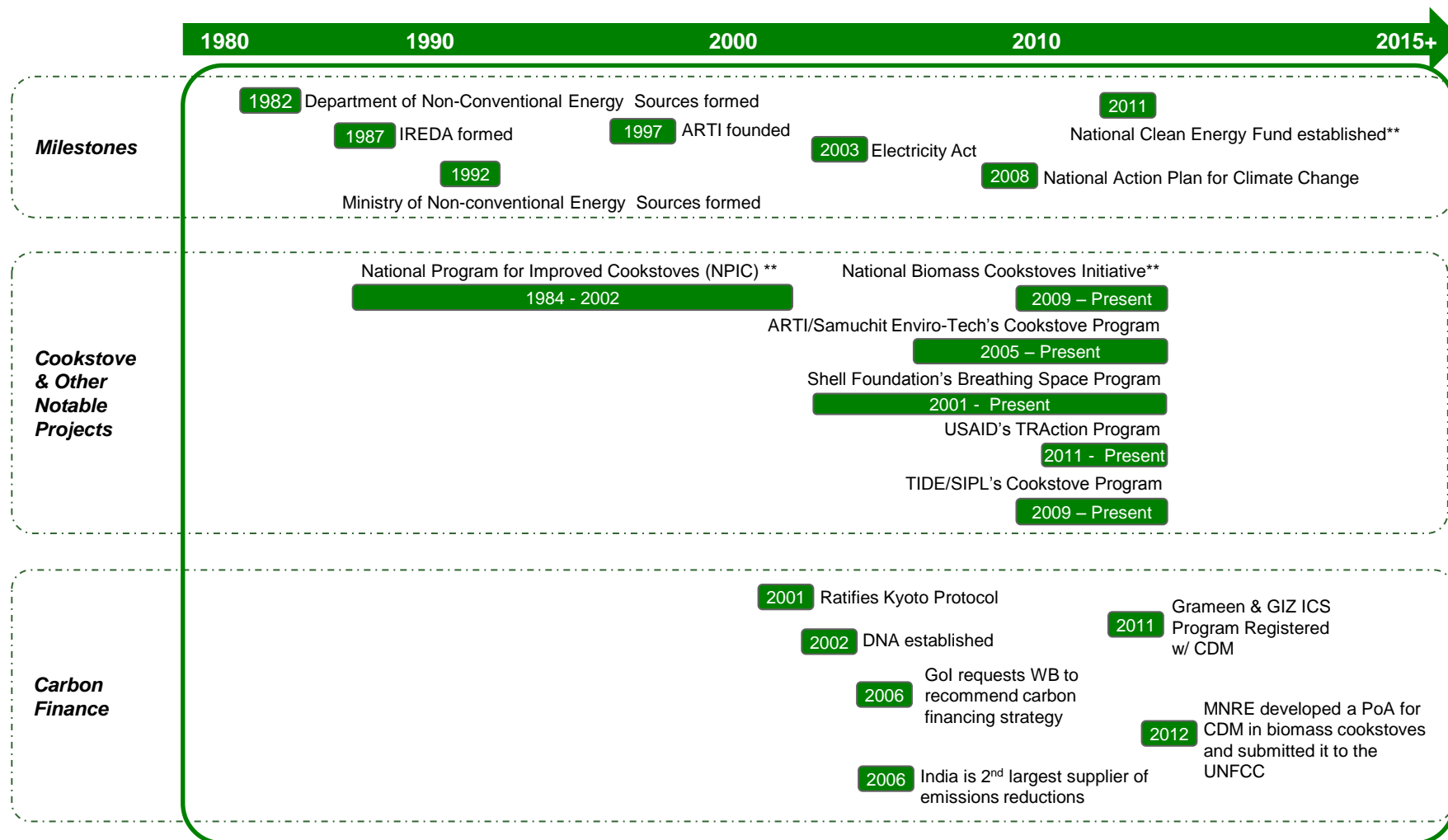
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Appendix

While cookstove programs have been in existence since the 1980s, there has been a surge of activity in the past decade

Non-Exhaustive



** Detailed profiles included on following pages

Source: USAID; Ministry of New and Renewable Energy, India; Ministry of Environment and Forest, India; Development of Renewable Energy Technologies (RETs) in India; Scaling up Carbon Finance in India, World Bank

The NPIC distributed more than 30 million improved cookstoves but faced challenges with stove quality and program management

Program overview

- **Objective:** NPIC aimed to disseminate improved cookstoves to ~120 million households relying on traditional and biomass stoves, particularly in rural areas
- **Structure:** NPIC was implemented in 23 states and 5 union territories through a multi-model, multi-agency approach.
 - **National level:** Annual chulha installation targets determined nationally and disaggregated at the state level
 - **State level:** Program implemented by nodal departments and agencies of the respective state governments through their district and block-level cells. In addition, some national level governmental and non-governmental organizations were given separate targets
 - **Village level:** At the village and household level, the approach was to implement the program through NGOs and self-employed workers
- **Product source:** >60 varieties of improved clay and chimney based mud stoves were sourced from private companies, NGOs and research institutes, with the government bearing half the cost of stoves
- **Marketing:** Ten-day demonstration camps were held to encourage and engage villagers, local government collaborators and students in distributing stoves
- **Price:** Cost of stoves varied between \$2 – \$6 with an additional 50-75% direct cash subsidy depending on the region and social status
- **Impact:** 33.8 million stoves, ~27% of target, distributed in rural India

Key challenges

- Issues with stove quality and usage because of low durability, poor long-term performance and sub-optimal usage as the user was not included in the design process
- Government based subsidy mechanisms were not sustainable in the long run and provided disincentives for entrepreneurs to develop their own improved stoves initiatives
- Government failed to target regions where fuel scarcity were severe, or where firewood was very expensive
- Negligible monitoring of the program, making it difficult to evaluate and develop needed corrections in design and distribution

Government initiatives are keen to learn from the challenges of the NPIC program and implement “best practices” in future policy initiatives

Karnataka was relatively successful in implementing NPIC and is now working with a broad set of players to increase stove uptake

CASE STUDY

NPIC (1985-2002)

- ~440,000 improved stoves were installed across the state in 1988-95 as part of the national program

Strengths of the program:

- Effectively partnered with various players, especially technical institutions and utilized their services and designs
- Effectively coordinated with various stakeholders, including private sector, technical institutions, foundations, NGOs and masons
- Effectively utilized the services of village level and other local level bureaucracy, particularly in identifying demand and in transferring technologies developed by local engineers through mason trainings

Lessons learned: Action plans should have emphasized:

- Phasing out of subsidies
- Monitoring and after-sales service
- Quality control
- Technical training of users and producers
- Greater interaction between designers, producers and users

Post-NPIC

Since the withdrawal of central funding in 2002, the state government has continued cookstove related activities under three key umbrellas:

- **Swacha Grama Yojana:** Distributes improved cookstoves with higher priority to promoting biogas technology and LPG
- **Jal Nirmal project (funded 85% by World Bank):** Focuses on awareness, household demand, and commercialization via mechanisms and institutions capable of meeting demand in order to increase the likelihood that beneficiaries will permanently adopt the improved stoves
- **Support to foundations & other players:** Actively assisting other foundations and players, such as Shell Foundation, by providing support of administration and suitable policies

Gujarat was successful in implementing NPIC, but despite initial efforts, was unable to sustain its program after NPIC discontinuation

CASE STUDY

NPIC (1985-2002)

Strengths of the program:

- Leveraging organizational synergies through integrated rural development: Integrated the national program with rural housing schemes for families below the poverty line generated tremendous organizational synergies
- Enhanced targeting: Targeted households below the poverty line ensured that the national program benefited those who were most in need and least likely to access LPG, kerosene, or other superior fuel distribution networks
- Organizational flexibility: Three-tier system ensured that accurate demand estimated by local staff were communicated to the top tier, and ability to use local NGOs permitted swift adaptation of strategies to village realities

Lessons learned: Action plans should have emphasized:

- Phasing out of subsidies
- Need for after sale inspection
- Quality control – lack of standardization for stove construction and approved dealers
- Need for financial performance incentives for NGOs responsible for distribution

Post-NPIC

- Since the withdrawal of central funding in 2002, the state government made a significant effort to continue a scaled down state program
- Continued with subsidy levels similar to those of the national program, targeting only marginalized communities and has continued with the strategy of integrating with housing schemes
- Between 2002 and 2005, around 40,000 improved stoves were distributed
- In 2005, the government of Gujarat discontinued the program due to lack of funding, resulting in the NGOs abandoning their efforts as well

The National Biomass Cookstove Initiative (NBCI) is an innovation-focused initiative that aims to learn from the lessons of NPIC

Overview

Context:

- In 2009, the Ministry of New and Renewable Energy launched the National Biomass Cookstove Initiative to enhance the use of biomass cookstoves. Learning from the lessons of the NPIC, the project aims to use several existing commercially-available and better cookstoves and different grades of process biomass fuel

Priorities:

- State-of-the-art testing, certification and monitoring facilities and strengthening R&D programs in order to design and develop the most efficient, cost effective durable and easy to use device
- Innovation: development of cleaner combustion units and improved biomass processing technologies, delivery models and partnerships with academia/private sector/NGOs

Technology:

- Focusing on community cookstoves (through mid-day meal schemes in government schools) and family sized portable cookstoves (currently in pilot phase)

States (9):

- West Bengal, Odisha, Uttar Pradesh, Uttarakhand, Rajasthan, Jharkand, Madhya Pradesh, Karnataka and Andhra Pradesh

Government role:

- Ministry's responsibility is only until certification and field testing programs, after which manufacturers will be free to sell and promote their products

MNRE certified
manufacturers
(7 to date)

Natural draft



Harsha



Forced draft



The National Clean Energy Fund was launched in 2011 to fund innovation in clean energy technologies

Objective

To fund research and innovative projects in clean energy technology

Eligible projects and funding

Up to 40% of project cost for any project/scheme for innovative methods to adopt to clean energy technology and research & development, including those:

- Sponsored by a Ministry/Department of the Government
- Submitted by individual/ consortium of organizations in the government/public sector/private sector in the form of a loan or viability gap funding

Key challenges

Delay in utilizing and disbursing budget: Rs. 8.2 crore collected to date, with only ~Rs. 1 crore disbursement

Misalignment between programs and mandate: Certain approved projects could have been funded by the respective ministries under regular schemes

Challenges in operationalizing approvals: Lack of clearly defined priorities and no clear process to evaluate proposals from different ministries. There is also criticism that the Inter Ministerial Group that evaluates proposals is not acting fast enough in order to effectively spur R&D in clean energy












While there are also several other government initiatives focused on clean energy, there is great uncertainty around the quality, depth and scope for impact of these programs

There are other policy initiatives which can also be used to enhance the supply and/or demand for cookstoves

Sector	Policy / Strategy	Description	Relevance to cookstoves sector	<i>Non-Exhaustive</i>	
				May assist in increasing Supply	Demand
Energy	National Mission for Enhanced Energy Efficiency	Aims to promote and support efficient energy usage. One of its focuses is to assist energy efficient appliances through innovative financing measures	Explore potential areas of partnership. E.g., availing financing facility	✓	
Health	National Rural Health Mission (NRHM)	Aims to improve health care scenario across rural India through better health care delivery and better awareness on health issues	Enter into a partnership to create awareness on negative health effects due to solid fuel usage		✓
	Indira Awaas Yojana	Social welfare program to provide housing for rural poor in India through financial assistance	Enter into a partnership to incorporate improved cookstoves in the designs of houses		✓
Social	National Mission for Empowerment of Women	Aims to bring about advancement, development and empowerment of women in all spheres of life through a host of policies and partnerships	Enter into a partnership to create awareness on solid fuel usage and to provide loans for purchasing improved cookstoves	✓	
	Mahatma Gandhi National Rural Employment Guarantee Act (NREGA)	Aims to create 100 days of employment every year to adult members of rural households	Include construction of community biogas facilities and other open source models of improved cookstoves under the type of activities of NREGA	✓	✓

While promising, partnerships with government policy priorities needs to be explored in further detail

Donor and multilateral initiatives targeted at the Indian cookstove market are relatively new and there is opportunity for growth

Organization	Overview	Key implementing partners
 USAID	<ul style="list-style-type: none"> • Timeframe: 2011-2020 • Budget: USD 12.3 million (Global) • Approach: Works in tandem with other US government departments and various partners in India to increase supply and demand; and to create supporting environment 	 Others
 DFID	<ul style="list-style-type: none"> • Timeframe: 2011-2015 • Budget: GBP 11 million • Approach: Supporting TERI to research and pilot innovative or improved technologies and private sector-led business models which will increase supply and demand of cooking and lighting solutions that can be replicated in India, Africa and elsewhere 	
	<ul style="list-style-type: none"> • Timeframe: 2002-Present • Budget: USD 3.5 million (Global, 2007- Present) • Approach: Through its flagship Breathing space program, tackles Indoor Air Pollution via cookstoves sales, creates strong rural finance and distribution chains and conducts pilot projects to raise awareness in Bihar, Maharashtra and Karnataka 	 Government of Karnataka
 UNDP	<ul style="list-style-type: none"> • Timeframe: Quarterly • Budget: Not available • Approach: Quarterly publication on biomass energy 	Ministry of New and Renewable Energy
	<ul style="list-style-type: none"> • Timeframe: 2012- Present • Budget: USD 5 million • Approach: Partial credit guarantee for \$5 million loan that ICICI is providing to SEWA to give members \$100-\$200 loans 	
 GIZ	<ul style="list-style-type: none"> • Timeframe: TBD • Budget: N/A • Approach: Works with partners to increase supply and demand; and to create supporting environment through various studies and innovative projects and models 	 Ministry of New and Renewable Energy

Note: (i) With the exception of USAID, the budgets do not include contributions made to GACC at global level (ii) Information presented above is obtained from secondary research and therefore, it may not represent all the activities undertaken by the agencies mentioned above

Source: Donor agency websites; Media; Donor agency representatives; GACC stakeholder consultations; Dalberg analysis

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Summary of cookstove and fuels market assessment in India

Macro	Fuel usage and trends	Health, social & environmental impact	Consumer	Cookstove industry	Cookstove policy
<ul style="list-style-type: none"> + Very large potential market which is only beginning to be scratched + Improving education and communications infrastructure although it is limited now + Coalition government and federal structure makes government ownership challenging - Physical infrastructure remains weak and a critical challenge to distribution 	<ul style="list-style-type: none"> + Significant number of solid fuel users which is expected to grow as the population remains rural and young + There are clear regional trends in central and south India which allow for a regional approach - Movement away from solid fuels has been slow indicating there can be resistance to new cookstove technologies 	<ul style="list-style-type: none"> + High number of IAP related deaths creates a strong case for change + Cookstoves can be an effective way to combat the rising black carbon emissions in the country + Significant livelihood improvement opportunities, particularly for women - Role of women remains marginalized and there is challenge to truly empower them 	<ul style="list-style-type: none"> + Very large potential market with a diverse set of segments to target + Growing consumer purchase behaviour (although still very low) - Government policies for modern fuels are in flux which could diminish attractiveness of cookstoves 	<ul style="list-style-type: none"> + Diverse cookstove sector in terms of technologies present + Entrepreneurial culture with many active community organizations - Market may still be recovering from subsidies and “donations” of government policy through national program - Limited overall number and scale of manufacturers, given size of potential market - Consumer and enterprise financing remains a critical challenge to scaling up new enterprises 	<ul style="list-style-type: none"> + Increasing number of multilateral and donor initiatives related to cookstoves and promising levels of coordination - Government policy on cookstoves and fuels is fragmented and has had limited impact to date - Stated need for greater coordination on standards, testing and certification

There is a large and growing market for efficient cookstoves in India and this can improve health and livelihoods of millions. However, the industry is still small compared to the magnitude of the problem and government policy has yet to comprehensively support market-based solutions to the cookstove sector

Implications for Intervention Options

From the market assessment and stakeholder consultations, a clear set of needs were identified that the sector needed in order to scale up and meet the magnitude of the problem in India:

- 1 Facilitating partnerships and collaboration within the sector:**
 - There is a wide variety of research and “lessons learned” that private and public sector players are conducting which is not being shared effectively. Greater coordination and sharing of research and results would help strengthen the sector as a whole
 - Many manufacturers are seeking to widen their network of distributors and target consumers in order to be able to tackle a larger “chunk” of the problem. Further work on bringing potential partners together from across the value chain and facilitating their discussions is a key need.
- 2 Developing and promoting accepted standards:**
 - A lack of transparent information on the minimum standards that cookstoves are required to pass is allowing sub-par technologies to reach the consumer. More stringent performance standards (i.e., on design, emissions, etc.) is urgently needed
 - Part and parcel of this is the need to increase the availability of and access to testing centers – these are currently prohibitively expensive and is a very lengthy process. Improving testing centers will help to incentivize players to invest in ensuring their products are up to standard
- 3 Generating greater awareness of the problem:** despite the fact that the health, social and environmental impacts of inefficient cookstoves is a pressing development issue, there is little awareness of the positive impacts that clean cookstoves can have. Improving general awareness of the issue will help to boost demand and sales
- 4 Supporting a greater variety and amount of financing available to the sector**
 - Overall, a greater amount of low-risk funding (particularly at the start-up stage) is required for new players to break into the sector – scaling up financing options overall would help to incentivize new players to enter
 - Carbon financing remains an elusive option for many private sector players as there is limited information on how to access it. Improving transparency, information and “know-how” on first steps will help to unlock a new source of financing for private sector players

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APPENDIX 1: Detailed regional breakdown of food types and cooking habits

Diet preferences and cooking habits (1/5)

Western India (Rajasthan, Gujarat, Maharashtra and Goa)*

Food types



- **Rajasthan:** influenced highly by availability of ingredients, especially water and green vegetables, in this arid region. Food that could last for several days and could be eaten without heating is preferred. Dal Baati, a hard and unleavened bread, is the most prepared dish and is known for its long shelf life and less water requirement
- **Gujarat:** largely vegetarian and slightly sweet. A typical meal consists of *roti* (bread made from wholemeal flour), rice, sweets and different combinations of vegetables and spices which may be stir fried, spicy or sweet
- **Maharashtra:** The coastal areas are known for coconut based dishes with seafood where as the interior have more frugal cuisine which uses dry coconut. Staple foods tend to be rice and bread prepared from wheat or millets
- **Goa:** Rich, piquant food strongly flavoured by coconut, red chillies and vinegar with a strong emphasis on seafood

Cooking habits

- Most cooks are women, and the majority cook outdoors to be able to multitask and have conversation with neighbours
- Many families prefer traditional stoves due to ease of use & habit
- In certain households, it is not uncommon to have a 'backup' stove choice where gas supply is unreliable or product quality is questionable
- Fixed traditional stoves are the standard, and often placed in a semi enclosed annex to shelter it from rain & sunlight
- Biomass use is incredibly diverse with families using whatever they can collect
- People generally cook seated and do not prepare more than one dish at a time
- Heat-wasting aluminium saucepans often without lids are used

Improved cook stoves should have: higher heat efficiency (especially in Rajasthan), ability to generate both high and low intensity heat, ability to sustain longer cooking periods and ease of use, especially for heavy stirring

Diet preferences and cooking habits (2/5)

Northern India (Punjab, Haryana, Himachal Pradesh, Jammu & Kashmir and Uttarakhand)*

Food types



- **Punjab:** Diverse range of dishes. Dairy and assortment of breads have huge presence in the cuisine. Tandoori *roti* and *naans* (bread made in a clay tandoor oven), stuffed *parathas* and *kulchas* (flaky Indian bread with different kinds of vegetarian and non-vegetarian fillings) form the major part of food
- **Jammu & Kashmir:** Huge influence by Hindus, Buddhists and Central Asians cuisine. Staple foods are: rice, meat and vegetables
- **Uttarakhand:** Known to be wholesome to suit the high-energy necessities of the cold region and tends to be slightly spicy. Most consumed foods are: rice, lentils, pulses, vegetables and dried cereal balls (winter)
- **Haryana & Himachal Pradesh:** Similar to cuisine of the other northern Indian states. Dairy products are more preferred in Haryana due to abundant cattle. Where as in Himachal Pradesh, non-vegetarian food is preferred

Cooking habits

- Most cooks are women, and the majority cook outdoors to be able to multitask and have conversation with neighbours
- Many families prefer traditional stoves due to ease of use & habit
- In certain households, it is not uncommon to have a 'backup' stove choice where gas supply is unreliable or product quality is questionable
- Fixed traditional stoves are the standard, and often placed in a semi enclosed annex to shelter it from rain & sunlight
- Biomass use is incredibly diverse with families using whatever they can collect
- People generally cook seated and do not prepare more than one dish at a time
- Heat-wasting aluminium saucepans often without lids are used

Improved cookstoves should have: higher heat efficiency (especially in mountainous regions), ability to generate both high and low intensity heat, ability to sustain longer cooking periods and ease of use for heavy stirring

Diet preferences and cooking habits (3/5)

Central India (Uttar Pradesh, Bihar, Jharkhand, Madhya Pradesh, Chhattisgarh and Orissa)*

Food types



- **Uttar Pradesh:** Vast majority of the state is vegetarian and prefers *dal* (cereal), *roti*, lentils, rice and vegetables
- **Bihar:** Wholesome and simple. Predominantly vegetarian food and milk products. Staple foods are rice, *roti*, pickles, *dal*, lentils and vegetables
- **Jharkhand:** Mix of vegetarian & non-vegetarian food. Low on oil and spices. Staple foods are: rice(major), *roti*, *dal* and vegetables
- **Madhya Pradesh:** Varies regionally. Wheat and meat are common in north and west, where as rice and fish are common in south and east. Staple foods are: rice, *roti*, *dal*, other cereals, lentils, vegetables, meat and fish
- **Chhattisgarh:** Consists of many foods not found in the rest of India. Staple foods are rice, bamboo vegetables, mushrooms and fish
- **Orissa:** Relies heavily on local ingredients. Delicately spiced and sweets form a significant portion. Staple foods are: rice, *roti*, sweets, lentils, fish and other seafood

Cooking habits

- Most cooks are women, and the majority cook outdoors to be able to multitask and have conversation with neighbours
- Many families prefer traditional stoves due to ease of use & habit
- Fixed traditional stoves are the standard, and often placed in a semi enclosed annex to shelter it from rain & sunlight
- Biomass is abundantly available
- People generally cook seated and do not prepare more than one dish at a time
- Heat-wasting aluminium saucepans often without lids are used for preparing gravy dishes and sweets
- Flat pans are used to prepare *rotis*

Improved cook stoves should have: higher heat efficiency, ability to generate both high and low intensity heat, ability to sustain longer cooking periods and compatibility with various pans

Diet preferences and cooking habits (4/5)

Eastern India (West Bengal; Sikkim; Assam; Meghalaya; Manipur; Mizoram; Nagaland; Arunachal Pradesh)*

Food types



- **West Bengal:** Contains significant amount of sweets, fish and other sea food. Use high amounts of spice. Staple foods are: rice, fish, vegetables and lentils
- **Sikkim:** Various ethnic groups have their own distinct cuisines. Rice is the staple food; meat and dairy products are also widely consumed.
- **Assam:** Mixture of different indigenous styles. Staple foods are: rice, fish, endemic herbs and vegetables
- **Meghalaya:** Different from other north-eastern Indian cuisines. Staple foods: spiced meet, rice, bamboo vegetables and momo dumplings
- **Manipur:** Spicy food; Staple foods: rice, leafy vegetables and fish.
- **Mizoram:** Blend of Chinese and north Indian cuisines. Staple foods: rice, pork, bamboo vegetables and leafy vegetables
- **Nagaland:** Staple foods: pork, fish, bamboo shoots, soya beans and rice
- **Arunachal Pradesh:** Staple foods: rice, fish, meat and leafy vegetables

Cooking habits

- Most cooks are women, and the majority cook outdoors to be able to multitask and have conversation with neighbours
- Many families prefer traditional stoves due to ease of use & habit
- Fixed traditional stoves are the standard, and often placed in a semi enclosed annex to shelter it from rain & sunlight
- In some states such as Nagaland, kitchens are situated outside the house to serve also as smokehouses
- Biomass is abundantly available
- People generally cook seated and do not prepare more than one dish at a time
- Dishes are cooked in closed utensils as most of the food items are boiled

Improved cookstoves should have: higher heat efficiency, ability to work efficiently in cooler regions, ability to sustain longer cooking periods and ease of use, and ability to smoke and grill food

*States are group into this category for ease and may not necessarily be according to the official definition/popular perception

Source: Dalberg analysis

Diet preferences and cooking habits (5/5)

Southern India (Andhra Pradesh, Tamil Nadu, Karnataka and Kerala)*

Food types



- **Andhra Pradesh:** In spite of variations across the state, the food is known for its spicy taste with rice as the major staple food. Vegetables, *dal*, lentils, poultry and dairy are other staple foods
- **Tamil Nadu:** Characterized by use of rice, legumes, lentils and dairy products. Uses a blending of spices and involves elaborate process
- **Karnataka:** Reflects influences from three neighbouring states: Andhra Pradesh, Tamil Nadu and Maharashtra. While the majority of cuisine is vegetarian, coastal regions consist of significant amount of seafood and uses coconut oil. Staple foods are: rice, lentils, vegetables, legumes, poultry and dairy products
- **Kerala:** Seafood, spices and coconut products have significant presence. Like other coastal south Indian cuisines, staple foods are: rice, fish, coconuts, vegetables, poultry and dairy products
- *Dosa* (rice pancakes), *idli* (steamed rice cakes) and *vada* are most prepared dishes across this region

Cooking habits

- Most cooks are women, and the majority cook outdoors to be able to multitask and have conversation with neighbours
- Women generally cook seated and prepares lunch immediately after preparing breakfast
- Many families prefer traditional stoves due to ease of use & habit
- In certain households, it is not uncommon to have a 'backup' stove choice where gas supply is unreliable or product quality is questionable
- Fixed traditional stoves are the standard, and often placed in a semi enclosed annex to shelter it from rain & sunlight
- Biomass use is incredibly diverse with families using whatever they can collect or using the stored crop waste
- Heat-wasting aluminium saucepans often without lids are used
- Flat pans are used to prepare dishes such as *Dosa*

Improved cookstoves should have: higher heat efficiency, ability to generate both high and low intensity heat, ability to sustain longer cooking periods and compatibility with various cooking utensils

*States are group into this category for ease and may not necessarily be according to the official definition/popular perception

Source: Dalberg analysis



APPENDIX 2: Detailed classification of cookstove types

Traditional stoves: Burn inefficiently and produce harmful toxins

Three stone fire





- Burning is highly inefficient and does not remove any particulate matter
- Materials always available and stove is simple to construct
- Any biomass fuel can be used
- **Key manufacturers:** Construction by consumers or masons

- Use 
- Availability 

Traditional biomass chulha





- Usually hand made from clay in a distinctive U shape, with a coating of dung around it
- Inefficient burning, producing harmful particulate matter
- Can be adapted to multiple pots of different sizes
- Any biomass fuel can be used
- **Key manufacturers:** Construction by consumers or masons

- Use 
- Availability 

Traditional coal/charcoal stove



- Traditionally used by communities for whom coal is the primary fuel source
- Extremely inefficient burning and very harmful as a result of high levels of smoke produced
- Simple bucket style structure with an opening to insert the coal
- **Key manufacturers:** Construction by consumers or masons

- Use 
- Availability 

Key |  Minimal  Low  Medium  Medium-High  High

Basic improved cookstoves: Better cooking efficiency than traditional stoves but do not reduce negative health outcomes

Chulha with chimney



- Similar to a traditional chulha, but incorporates a chimney to increase efficiency
- Durability issues with chimney when it is not cleaned frequently
- Widely disseminated as part of National Improved Chulha Program
- Any biomass fuel can be used
- **Key manufacturers:** primarily technological institutes

- Use 
- Availability 

Portable chulha



- Portable, single pot stove without chimney
- Is usually constructed from metal
- Can be constructed at the village level by local artisans
- Can be adapted to multiple pots
- Any biomass fuel can be used
- **Key manufacturers:** N/A

- Use 
- Availability 

Portable charcoal stove



- Portable, single pot stove without chimney
- Stove is metal clad and lined with ceramics in order to increase thermal efficiency
- Metal clad material helps ensure strength during use and transport
- Stove can be produced at village level by potters and small sheet metal shops
- **Key manufacturers:** N/A

- Use 
- Availability 

Key |  Minimal  Low  Medium  Medium-High  High

Intermediate and advanced cookstoves: Burn efficiently but do not have significant cost-savings over traditional cookstoves

Rocket stove



- Portable, single pot stove with insulated vertical chimney
- Durability issues with the combustion chamber if not cleaned frequently
- Is usually constructed from metal
- Any biomass fuel can be used
- **Key manufacturers:** Greenway Grameen Infra, Envirofit

- Use ○
- Availability ◐

Natural draft gasifier



- Portable, single pot stove without chimney
- Is usually constructed from metal
- Any biomass fuel can be used
- High durability as it consists of no moving parts
- Airflow cannot easily be regulated to change heat setting
- **Key manufacturers:** Samuchit Enviro Tech

- Use ○
- Availability ◐

Fan draft gasifier



- Portable, single pot stove without chimney
- Is usually constructed from metal
- Durability issues with the fan
- Generally runs on battery or biomass
- Precise regulation of air-flow for different heat settings
- **Key manufacturers:** Biolite, First Energy

- Use ○
- Availability ◐



Key | ○ Minimal ◐ Low ◑ Medium ◒ Medium-High ● High

Modern fuel solutions: More efficient, more convenient to access and good for health

Gas stove (LPG)





- Is usually constructed from stainless steel
- High durability and easy to clean
- High regulatory control over the prices and supply of LPG cylinders
- **Key manufacturers:** Prestige, Padmini

- Use 
- Availability 

Electric





- Is usually constructed from stainless steel
- Increasing use in urban areas due to rising gas prices and unpredictable gas supply
- Limited access to electricity in rural and peri urban areas
- **Key manufacturers:** Prestige, Glen India

- Use 
- Availability 

Kerosene



- Is usually constructed from brass
- High regulatory control over the price of kerosene
- Very harmful as a result of high levels of smoke produced
- Cause of several household fire incidents
- **Key manufacturers:** Maharaja, Everyday

- Use 
- Availability 

Key | ○ Minimal |  Low |  Medium |  Medium-High |  High

Renewable solutions: Efficient but accessibility and high prices are key concerns

Biogas



- Is usually constructed from stainless steel or cast iron
- High efficiency and zero emissions associated with gas stoves
- Limited availability of biogas pipelines for stoves
- **Key manufacturers:** Padamavati, Rupak

- Use
- Availability

Solar cooker



- Is usually constructed from metal
- A reflective mirror of polished glass, metal or metallised film concentrates light and heat from the sun on a small cooking area
- Portability is limited due to the heavy weight of the stove
- **Key manufacturers:** Rudra Solar

- Use
- Availability

Briquettes/Pellets



- It is made by compacting biomass waste and used as fuel
- Can be moulded into uniform size
- Can be tailored to particular usage.i.e. long burning time, stove types (institutional or households), smoke and ash levels among others
- **Key manufacturers:** Guru Kirpa

- Use
- Availability

Key | ○ Minimal | ◐ Low | ◑ Medium | ◒ Medium-High | ● High