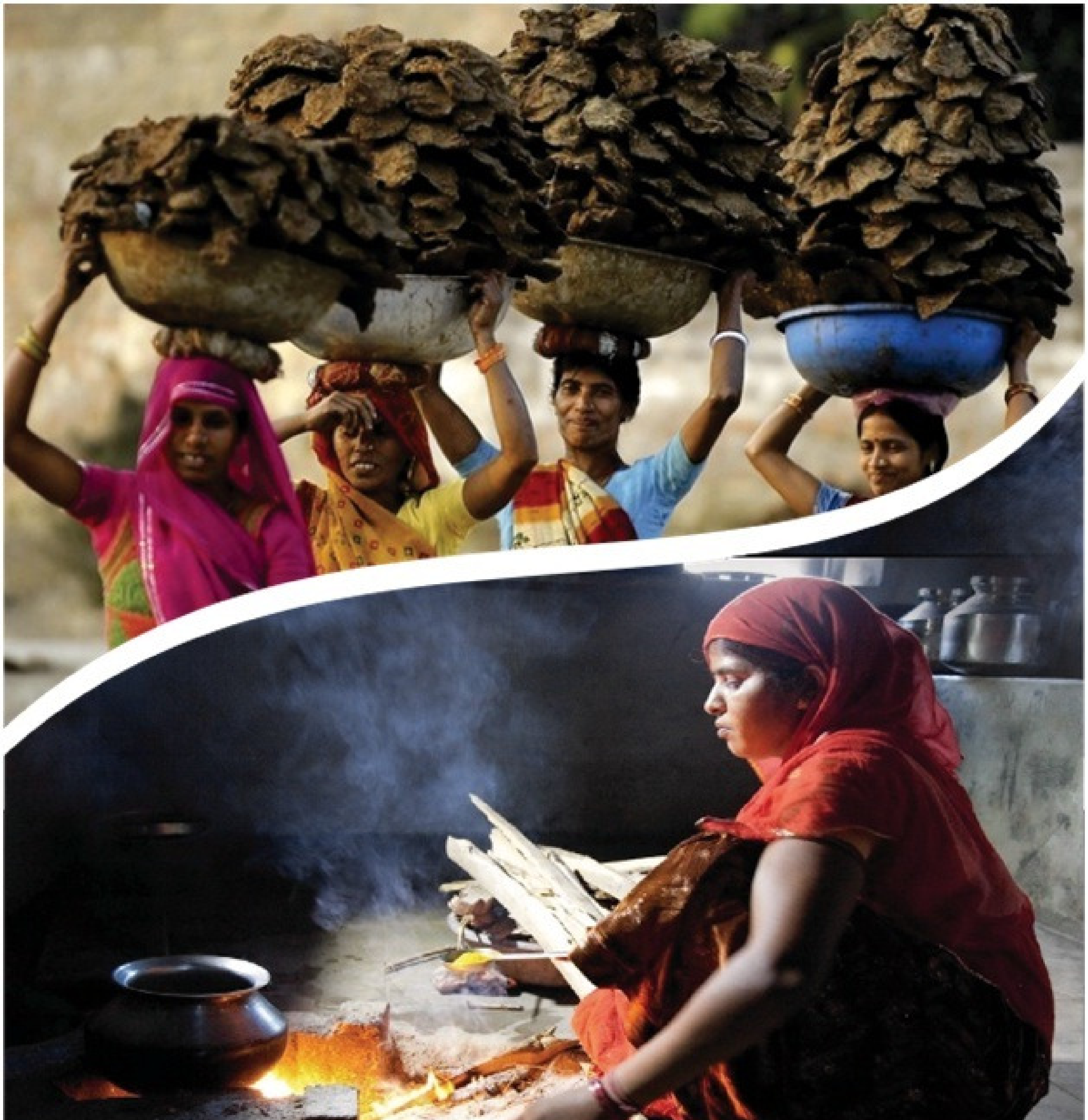

Improved Cook Stoves for Rural India: Issues and Recommendations

TERRE Policy Centre

Future of Cook stoves: Review and recommendations

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Abstract

After 3 decades of organized efforts, the widespread use of improved, smokeless and energy-efficient cooking stoves still remainsa distant dream. One of the oldest and technologically most simple cooking methods ever developed by civilization continues with its perennially archaic status quo for billions of its users, mostly poor. Consequently, health and social impacts from cook stoves continue to adversely affect the underprivileged. Women and children are the most suffered section of the society due to their time lost in collecting the fuel as well as due to local and indoor pollution.

The small emissions from each of the millions of cooking stoves now form into what is known as “Atmospheric Brown Cloud (ABC) ". It is a layer of air pollution containing micro- particulate matters emanating from incomplete combustion. Such mass of soot or dust formed in atmosphere travels around the globe like a cloud and absorbs as well as scatters incoming solar radiation, leading to climate change, global warming and other impacts.

The changing world scenario that includes rising population and drastic degradation of the ecosystems has renewed the demand for much needed transformation of technology of cooking stoves. This paper, developed by an authorand the guide who themselves were the users of various types of cooking stoves in their childhood and who have interacted with the present users, technology suppliers and decision makers, assesses the situation in respect of the cooking stoves, identifies the barriers-many of which are overlooked by zealous technocrats- and makes recommendation to overcome those barriers.

Key Words: Improved cook stoves, Black carbon, Atmospheric brown clouds (ABC), Biomass Chula, Climate Change

1. Introduction

Energy is a vital input for economic and social development. In most of the developingcountries, wood and other biomass fuels are still the primary source of energy for the majority ofpeople, particularly the poor for cooking, heating and their small cottage business. In the last few decades, these developing countries have experienceda dual challenge i.e. rise in population and rapid depletion of natural forest resources that has resulted in hardship for the people living inrural areas, especially women and children who spend a considerable part of their time and energyin search of fuelwood and biofuels and often have to cover long distances. Besides, deforestationhas also led to many negative ecological consequences.

This paper deals with the cooking stoves and the challenges and opportunity they offer.

Cooking practices may be divided into three main categories; 1) by the use of an electric/LPG/Kerosene cookstove, 2) by the use of a cookstove based on cleaner natural fuels (biogas, methane, ethanol solar), and 3) by the use of a cookstove designed to burn biomass inputs (wood, charcoal, other biomass) which causes indoor and outdoor pollution and now need more efficient burning through cleaner and near complete combustion compatible with cooking practices.

Use of an electric cookstove represents the cleanest alternative for cooking but seldom used in developing countries due to the high costs of electricity and limited access in rural areas. Similarly, LPG and Kerosene are costly option and its distribution in the developing countries like India is inadequate and limited in quantity. The second best alternative, cookstoves based on clean fuels, these technologies are largely unavailable in poor areas, due to the high investment costs and/or fuel prices, as well as their inaccessibility in rural areas.Efficient biomass cook stoves with improved combustion technology is currently the only available and affordable clean cooking alternative mainly due to wider availability of free or cheaper biomass (wood, cow dung, saw dust, compacted briquettes from dried biomass of leaves etc). Therefore the focus of the paper will be on biomass ‘cook stoves ‘(also called as Chulha in India) and technology referred to as “improved cook” stoves for rest of the paper.

1.1 Biomass as fuel for Chula and issues:

In many rural contexts of the developing world, important sources of fuel used for cooking are:

a. Shrubs, bushes and forest wood-fuels including sawdust and its briquettes
b. Cow dung cakes after drying
c. Post harvest agricultural residues and compacted briquettes
d. Charcoal, coal and mixed with a, b and c above

In a way, all above can be grouped as a fuel generated by agricultural residues and organic waste. It is normally burned in open-air for cooking, clear the lands or just to dispose them. Fires set to clear the land generate uncontrolled emissions, while wasting a potential energy resource. In the developing world, most agricultural residues that are burnt as fuel are used in their natural state with some pre-treatment like drying, cutting. Or compacting (briquetting) Compared to wood-fuels, crop residues typically have a high content of volatile matter and ash, lower energy values. Conventional ‘stoves’ are mostly designed to burn firewood or charcoal. The direct use of unprocessed solid biomass waste for cooking in wood-fuel stoves has some advantages and disadvantages.

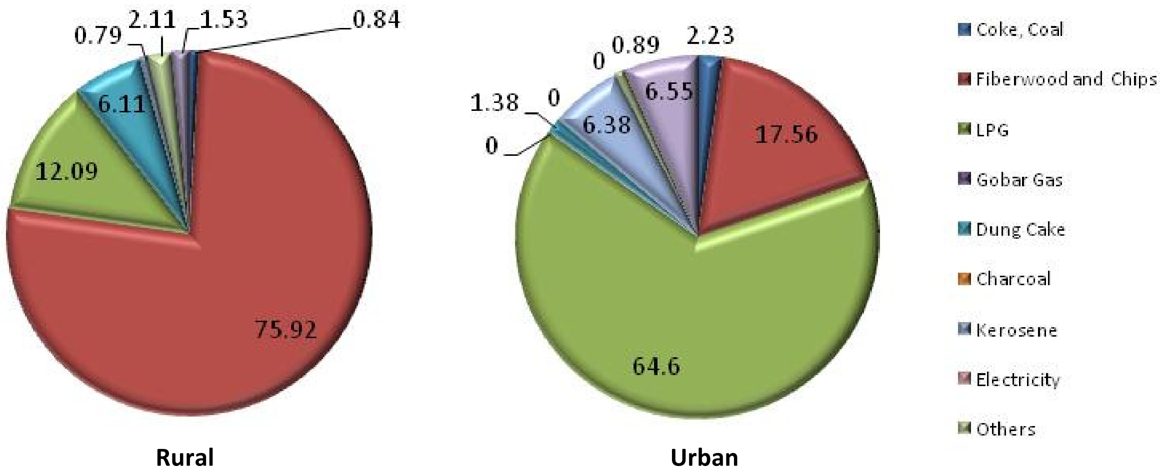
Advantages and disadvantages of the use of agricultural residues as household fuel:

Advantages	**Disadvantages**
Available almost free of cost to the poor rural families	Indoor and outdoor Air pollution when burned in open fires or traditional improved stoves
Useful way to dispose of the crop residues in the field, instead of burning them in situ	The seasonal availability of crop residues can be a limit for its use
Easy to handle and transport	Shorter burning time, loss of heat
Low impact on women‘s time for harvesting	Very bulky device (concerns in transport and storage)
The ash can be used for pre-sowing/planting seasons	Contribution to global warming

Pictures: Rural house hold fuel option in India

1.2 Household fuel use pattern in rural Vs urban India

Biomass is used as the primary cooking fuel in 58.68 % of households. As seen in fig., 82% of the rural households use biomass for cooking (76% firewood and chips, 6 % dung cake). LPG is used by 12% and kerosene by only 0.79%. In the urban areas, the situation is different. LPG is the most common cooking fuel used by 64.6% of households, followed by biomass (19%) and kerosene (6.4%).In India, 74% households have access to electricity (66% of the rural household and 94% of the urban).



Percentage distribution of types of cooking fuels used in A) rural and B) urban India, 2009-10

(Source: NationalSample Survey(NSS), Government of India(66th Round NSSO, 2010)).

1.3What Is an Improved Stove?

Defining an improved stove, generally regarded as a relative concept, dependson several factors: the type of traditional stove considered; the aim of thedesign improvement; and issues of affordability, compatibility with cooking practices, type of food to be cooked which change in India every region and sub-region. Traditional stoves can rangefrom three-stone open fires to substantial brick-and-mortar models and oneswith chimneys. In addition, the nature of the improved status has variousdimensions. For example, stoves can be designed to improve energy efficiency, remove smoke from the indoor living space, or lessen the drudgery ofcooking duties modified to suit the cooking traditions and type of food to be cooked.

1.4 Types of Cook Stoves and Improved versions:

A) Natural Draft Improved Cook stoves

Conventional designs are basically open flames and do not incorporate any advanced principles of combustion. The conventional stoves are modified to reduce the energy lost. Improved system would trap the heat inside the stove and direct it to the pot, thereby increasing thermal efficiency and combustion qualitysignificantly.There is no insulation in the stove design and therefore the fire has more of tendency to smoke due to cooling near the walls and at the same time the direct contact of the flame with the walls allows heat to conduct out of the system decreasing the thermal efficiency.

Advantages:

• Simple, cheaper to build

• Cheaper to operate as no batteries are used

• No moving parts, so less likely to break down

Disadvantages:

• Airflow cannot easily be regulated to change heatsetting

• Potentially less efficient

B) Forced Draft Improved Cook stoves

Forcing air into a fire is anestablished and effective way to raise flame temperature and intensity and also to reduceemissions by encouraging complete combustion.Alternative designs exist where airflow is forced using a fan. Batteries most often power such fans.

Advantages:

• Precise regulation of air-flow for different heat settings

• More efficient, due to control of air flow

Disadvantages:

• More expensive to build and operate (e.g. replacing batteries)

• May break down rendering it useless, especially in rural setting where support services are minimal.

C) The Improved cookstove may be of different types:

• Natural Draft Side Continuous Fed

• Natural Draft Top Continuous Fed

• Natural Draft Top Batch Fed

• Forced Draft Side Continuous Fed

• Forced Draft Top Continuous Fed

• Forced Draft Top Batch Fed

• Forced Draft Self Power Generating

1.5 The value of Improved stove

1.5.1 Indoor air pollution due to conventional cooking stove/Chulha

Nearly 3 billion people worldwide rely on solid fuel combustion to meet basic household energy needs. The resulting exposure to air pollution causes an estimated 4.5% of the global burden of all the human diseases.

In these households, solid fuels are often burned in inefficient, poorly vented combustion devices (open fires, traditional stoves). The incomplete combustion of these solid fuels results in much of the fuel energy being emitted as potentially toxic pollutants, including particles of varying sizes, carbon monoxide (CO), nitrogen dioxide, volatile and semi-volatile organic compounds (e.g., formaldehyde and benzo[*a*]pyrene), methylene chloride, and dioxins. Combustion of coal, in addition to the above pollutants, releases sulfur oxides, heavy metals such as arsenic, and fluorine.

The use of solid fuels, primarily for cooking, has been estimated to be responsible for> 3.5 million premature deaths per year (plus an additional 0.5 million deaths from outdoor air pollution due to household fuel use).

1.5.2 Health impact on woman

There are many epidemiology studies that have addressed the direct health effects of ABC-relevant pollution sources, such as wildfire, indoor biomass and coal smoke and dust events. These studies have documented a variety of acute and chronic health effects, including premature deaths, hospital admissions and chronic respiratory disease.

Available information about adverse health effects of airborne fine particles from studies conducted in many areas of the world suggests that ABC exposure is very likely associated with significant adverse health effects.Respiratory effects, such as pulmonary inflammation, have also been observed in response to ABC-relevant pollutants in controlled human studies. Toxicity outcomes associated with individual ABC-relevant pollutants include cardiovascular and respiratory disease, cancer, and reproductive and/or developmental alterations.Cardiovascular effects, including the up-regulation of cardiac factors associated with vascular remodeling, have been noted in mice exposed to gasoline emissions, while atherosclerotic lesions and other vascular changes were enhanced in animals with repeated exposure to concentrated particulate matter.Using improved cook stoves could prevent adverse impacts on health of women and children

1.5.3 Impact on Women Education:

It is very evident that the wood collection for burning is one of the major activities in rural area mainly done by women of the villages. The young girls alone or accompanied by mothers or most of the time young girls are being asked to collect the wood for cooking. This affects their schooling and ultimately affects their education.

Half of the rural population consisting of women can be empowered to contribute to the growth and well being of the society by utilizing their time in more productive work.

1.6 Why improved cook stoves are needed in India:

The use of open fires and traditional stoves leads to incomplete combustion of fossil fuel, causing high Black Carbon (BC) emissions. Furthermore, open fires and traditional stoves have low combustion efficiency, leading to higher cooking times and inefficient use of fuelwood.

Black carbon (BC) exists as particles in the atmosphere and is a major component of soot.Black carbon results from the incomplete combustion of fossil fuels, wood and other biomass.

Complete combustion would turn all carbon in the fuel into carbon dioxide (CO2). In practice, combustion is never complete and CO2, carbon monoxide (CO), volatile organic compounds (VOCs), organic carbon (OC) particles and BC particles are all formed.On a global basis, approximately 20% of black carbon is emitted from burning biofuels, 40% from fossil fuels, and40% from open biomass burning.The largest sources of black carbon are Asia, Latin America, and Africa. Some estimates put that China and India together account for 25-35% of global black carbon emissions.

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1.6.2 Impact on Climate change:

Black carbon influences climate in many ways, both directly and indirectly, and all of these effects must be considered jointly. Black carbon contributes to climate change in two basic ways: by absorbing sunlight in the atmosphere and, subsequently, by falling from the atmosphere onto snow and ice – causing these normally-reflective surfaces to absorb more heat and melt more quickly. In addition, many sources of black carbon also emit other particles whose effects counteract black carbon, providing a cooling effect. BC also contributes to surface dimming, the formation of Atmospheric Brown Clouds (ABCs), and changes in the pattern and intensity of precipitation. Ramanathan et al. (2005) stated that “Large reduction of solar radiation at the Earth’s surface simultaneous with lower atmospheric warming increases atmospheric stability, slows down hydrological cycle and reduces rainfall during monsoon

Reducing current emissions of BC may help slow the near-term rate of climate change, particularly in sensitive regions such as the Arctic.It has been called the second greatest greenhouse pollutant as the magnitude of its direct radiative forcing exceeds that due to methane. This, in combination with its short lifetime of a few hours to a few days, could make the control of its emissions from fossil fuel, one of the quickest and the most effective ways of slowing global warming

1.6.3 Public Health Effects:

BC contributes to the adverse impacts on human health, ecosystems, and visibility associated with ambient fine particles. Short-term and long-term exposures to BC are associated with a broad range of human health impacts, including respiratory and cardiovascular effects as well as premature death. The World Health Organization (WHO) estimates that indoor smoke from solid fuels is among the top ten major risk factors globally, contributing to approximately 2 million deaths annually. Women and children are particularly at risk.

Indoor air pollution major cause of illness and mortality for women and children inhaling BC

- 1.6 million premature deaths annually worldwide (400,000 annually in India alone)
- Childhood pneumonia, lung cancer, bronchitis, cardiovascular disease are among effects (Venkataraman 2010)

Although combustion of biomass and fossil fuel is the only form of BC production, BC effects vary distinctively depending on its different forms. It can store carbon for the long terms in soils and sediments but it can also cause severe health problems and contribute to global warming. It is an atmospheric pollutant with high global warming potentials. However, it is also an integral part of the global carbon budget and, if properly utilized, can play a crucial role in mitigating climate change impacts. Any mechanism targeted toward reducing soot BC should aim at all combustion activities within humankind’s control and at large geographic scales since its climate and pollution effects are far reaching.

1.6.4 Atmospheric Brown clouds: From Local Air Pollution to Climate Change due to biomass burning

Atmospheric brown clouds are atmospheric accumulations of carbonaceous aerosol particles spanning vast areas of the globe. They have recently gained much attention, from the scientific community and from the general population, as they severely impact several aspects of everyday life. Aside from affecting regional air quality and negatively impacting human health, these clouds affect biogeochemical cycles and profoundly influence the radiation budget of the Earth, resulting in severe climatic and economic consequences. Carbonaceous aerosol particles are generated primarily by combustion processes, including biomass and fossil fuel burning.

1.6.4.1 Composition of ABCs:

ABCs are a complex mixture of gases, vapors, and particulates.Carbonaceous aerosol particles are inherent andmajor components of all ABCs, along with inorganicspecies, such as sulfates, nitrates, and mineral dust. Theyare largely responsible for the brown color of ABCs,although in some cases NO2 and hematite in mineral dustmay also contribute to the color.The principal components of carbonaceous aerosol particlesare organic matter (OM) and elemental carbon (EC).The resulting mixture has anextremely complex composition made up of organic speciesfrom various compound classes, such as alkanes, aromatics,alcohols, carbonyls, carboxylic acids, and multifunctionalcompounds. Certain organic constituents are toxic andpose a risk to human health.

Biomass burning constitutes the largestsource of carbonaceous aerosols, as the practice is widespreadaround the world and involves the burning ofsubstantial amounts of plant material (biomass) for avariety of purposes.

1.6.4.2 Role of black carbon in ABCs:

As inefficient combustion is a key feature of all major sources of ABCs, an essential component is black carbon (BC), or “soot.” Soot is virtually equivalent to elemental carbon in aerosol. Black carbon does not normally occur as discrete particlesin ABCs, but is intimately mixed with other aerosol species,such as sulfates, nitrates, OM, mineral dust, and sea salt. A universal feature of BC isthat it effectively absorbs energy across the entire solarspectrum, from the ultraviolet to the infrared.

1.6.4.3 ABCs and climatic and economic impact:

According to radiocarbon analyses, biomass burning produces two-thirds of the carbonaceous aerosol particles in the region, whereas biofuel and fossil fuel combustion accounts for one-third. Black carbon particles aloft directly absorbboth the incoming solar radiation and the radiation reflected by the Earth’s surface and low clouds. This lendsa brownish color to the sky and heats the lower atmosphereby as much as 50–100% while reducing solar radiation atthe surface by about 10% compared to clear-sky conditions.

Such a significant redistributionof energy between the Earth’s surface and the atmosphereeduces evaporation from the ocean, because approximately50–80% of the radiative heating at the surface isbalanced by evaporation. Moreover, this energy redistributionmay shift the monsoonal circulation southwards, aswell as reduce rainfall over land in the region.

1.7Past efforts for the improved cook stoves in India

It is interesting that though the organized efforts at national and sub-national levels for improved cook stoves started nearly 30 years back, their widespread use and success has not been adequate and consistent. The social scientists, voluntary organizations , academics, policy makers have all done their bit and pieces for the improved cook stoves.

The list of main manufacturers of the Improved cooking stoves is in Annex 1.

1.7.1National Programme on Improved Cook stoves (NPIC) and other efforts

It was started in 1983, to conserve and optimized the use of firewood, alleviate deforestation and to bring improved household sanitation and general living conditions, as a demonstration programme in India.Later,in 1985, the programme was converted into a nationaldissemination programme by the Ministry ofNon-Conventional Energy Sources (MNES) of Governmentof India. The programme was implementedthrough state nodal agencies, women organizations,KhadiVillage and Industries Commission (KVIC),and Non Governmental Organizations (NGOs) as a20-point programme and minimum needs programmeof Government of India. Atotalof33.8 million improvedchulhashadbeeninstalledwithvaryingdegrees of successand finally,thisprogramwasformallydeclaredclosedin the year2004 without achieving its desired goals.

Number of other initiatives to improve the cook stoves have been undertaken at State level, voluntary basis, funded by business and international organization. The issue remains on the top of the agenda for number of agencies. Based on the experiences and discussion with number of experts, users and policy makers TERRE Policy Centre has assessed the situation to draw lessons and recommendation:

1.7.2 Reasons for limited successtill now.

a) The end-user wanted more versatility in the fuel usage and less time in cooking, while, the improved mud cook stoves were designed by the institutions by emphasizing on the objective of fuel economy and less smoke

b) The rural people were not concerned much about the cooking fuels and deforestation mainly due to lack of awareness and the alternative employment programme for women were not establishedat that time, as a result, the success was much below the expectation level with which it was started.

c)Apartfromthetraditionalcookingpractices,then on replacementoftraditionalcookstoveswiththeimproved cookstoveswasalsoinfluenced by socio-culturalfactorsandother benefits suchas,spaceheatingbytraditionalcookstoves.

d) Multiple levels of governmentbureaucracy made programme administration truly cumbersome and fragmented. In addition, the budget was insufficient for the level ofsupervision and assessment which theprogramme required. Problems werenot noticed and rectified in good time.Lastly, the programme was soonscaled down, being only one of severalnational campaigns occurring at thetime.

e) Stoveproducers were only concerned aboutgovernment specifications and did notrespond to the need for consumers

f) Failed to target regions where fuelscarcity were especially severe, orwhere firewood was a very expensive.

g) Another reason was the lack of interest of women towards maintenance, asthey did not perceive the usefulness ofthe stove.

1.7.3Barriers to dissemination and adoption of biomass cook stoves

A. Institutional barriers

A keyfactorinfluencing theimplementationof improved cookstoves programme, anywhere,istheexistinginstitutional infrastructure. Important issuesaretheavailabilityofR&D centers, awareness and training venues, technologyand information exchange, networking,multilevel monitoring mechanism(certification and quality control), promotional agencies andaftersalessupportandservices.

Fourtypes ofinstitutionalstructuresareinexistenceamongthe improved cookstoves programs:InstitutionledbyaGovernmentagency,NGO/privatepartnership, semi-governmentalstructure,andfullycommercialprivatecompanies.Engaginglocalgovernmentisimportant, from point ofviewofgeneralachievementofprogramme objectives. Such engagement hasaddedbenefits inpolicyformulation,coordinationatthe local level, effectiveawarenessraising,andmonitoring.Whereasthe role ofentrepreneursandNGOscanbehelpfulincreating awareness, establishingacommercialmarketandproviding aftersales support andservices. Institutional structure for alternative deployment of women-power is also important for weaning away women from their traditional role of wood collection.

B. Food habits and cooking practices:

India is a country of diversity in every sense so as the food habits of people in every part of the country. To classify in general the south Indian and north Indian food are prevalent and items people cook are dependent on the agricultural products belonging to that area. For example south Indian community prefers to eat rice based items and north Indian community prefers to have wheat based items and lentils. It is generally said after every 3km one travels one will get to taste different variety of food in India. Considering such diversity in cooking practices, requirement of need of energy is different, their cooking pots are different and cooking time varies drastically which needs to be considered before adoption of suitable cook stove for the people. So there cannot be one fit model for all.

C.*Improved cook stove is an integrated concept*

Cook stove does not operate in isolation and it is not only technology issue but is closely related to daily human practices. It is integrated part of thehuman development. The importance of well ventilated rooms, positioning of the cook -stoves in the house, behavior pattern of women who cook, the cooking methods and product to be cooked all play important part in making improved cook stoves. Letting the clean air in for combustion as well driving out post-combustion exhaust in most efficient way are the critical aspect of the improved cook stove. . The capacity building , awareness on these issues if not undertaken, the cook stove would remain simply a technology issue without 'human-dimension' to the issue.

D. Economic and financial barriers

Price of a clean stove is a major roadblock in successful implementation of the programme. Although in the end improved stoves save money, the initial investment required may prevent poor people from purchasing the stove.Lifetime of a cookstove is also an important factor for buyers. To tackle this issues various options such as microfinance services,loans, and financial incentivesand alternate employment for women are possible. Microfinance canhelp toovercomeinitialinvestmentcosts.Furthermore,themarketing channels ofexistingmicrofinance institutionsareusefulfor cookstovedistribution.Manyotherpotential key financing sources such as "Global EnvironmentFacility", "Climate Investment Funds", and "International FinanceCorporation" areavailable from where micro-financing packages can be designed.

For reduction in initial cost,incentives like tax waiver in manufacturing is required.Other measures could belike advancedsubsidypayment tothemanufacturer;micro-creditloanstoenterprises,entrepreneurs, andself-helpgroups,tomanufacture/sellcookstoves;and guaranteedadvancedpurchaseofcookstovesforgovernment's ownundertakings. Lifetime of a cookstove is also an important factor for buyers.

E. Policy barriers

Several governmentsprovidecapitalsubsidiesforcompetitivehouseholdfuels, suchasLPGandKerosene,whichleadstopricedistortion in the domestic fuel use. The distribution network for LPG and Kerosene is inefficient. Governments can assist in formulating a policy framework, which provides incentives to private sector operators, women's self help group to engage in the production, distribution, and sale of improved stoves. The elements of such a policy framework may include; technical support, training, and assistance in market research

F. Social and behavioral barriers

Developinghigh-qualitycookstovessuitable for mass productionisnecessary,butusersneedtobeinvolvedinthe earlystagesoftheprogramme,inordertoensurecompatibilitywith localpractices.Women's participationisanotheressentialcomponentof a successful programme. The village people have life cycle which they follow very religiously. Any intervention without understanding their habits, behavioral pattern and psychology will not lead to success of any project. It's very difficult to ask them to change their habits so any intervention should fit into their life cycle.

G. Technical and quality related barriers

The product quality is very important issue in order to achieve faster adoption and effective firewood saving. Technical faults duringand post implementation needs to be taken care of. Another technical barrier is the lack of tools and methods, to monitor and quantify the performance of the improved stoves in ways that are objective, systematic, cost-effective, and scalable.

H. Absence of testing laboratories

The testing laboratories are needed for various testing to check the efficiency of the cooking stove. Testing of their thermal efficiency and other operational factors needs to be ensured before any installation into field. Govt. did not have any laboratory back to its existing laboratories and no special personnel were appointed for this work.

I. Information and Interaction network Barriers

The factor that limits the technology diffusion in the society is informationand the consumer already using the technology is the most reliable source of information. Various reports by researcherssuggesta "people-centeredclose interaction approach", asameasureforeffectivedissemination. Theperformancemonitoringofstovesisan inevitable componentofany improved stove programme,asinformation relatedtostoveperformanceisessentialfordesigning next generationcookstoves.Forbettertechnologydiffusion, the government caninitiatecapacity buildingprogrammes;likeawareness information exchange and networking programmeswithincommunitiesforfuelresourceavailability, necessity ofsustainablefuelharvestingandbenefits of improved stoves.

2. Challenges and Research Priorities for Improved Cook stove:

Topic	Research Priorities
Adoption and markets	factors driving clean cookstove purchase, use, and broader aspirational change end-uses of traditional stoves (cooking and non-cooking) effectiveness of business models, social marketing, and consumer finance strategies cost-effective monitoring protocols documenting short- and longterm stove use patterns, including stove and fuel combinations
Cleaner fuels	impacts of fuel stacking and switching to gaseous, liquid, pelletized, and renewable fuels impacts and efficiency of fuel production processed biomass and biofuels, including efficient conversion of agricultural products and residues into pellets, biochar, charcoal, and gaseous or liquid fuels
climate and environment	impacts on short-lived and long-lived climate forcer emissions, global and regional radiative forcing, and non-radiative climate effects (e.g., aerosol effects on precipitation and snow/ice melt) impacts on deforestation, carbon dioxide uptake by forests, habitat, biodiversity
Gender and livelihoods	impacts of women employed in clean cookstove and fuel value chain on adoption impacts on consumers (time savings, income savings, education, and employment) case studies and best practice analyses of women’s empowerment in clean cooking project implementation
Health impacts	on indoor and outdoor air quality and air pollution exposures impacts on development and child survival impacts on adult disease, including respiratory health and

	cardiovascular disease incidence of severe burns and injuries
Humanitarian	impacts on refugees and other vulnerable populations in terms of meeting basic nutrition requirements, gender-based violence, livelihoods, income, and environment and health outcomes
Technology	improved stove design (materials, heat transfer, design tools), monitoring (sensors, mobile tools, etc.), and related devices (electric cogeneration, fans, cookware, etc.)
Testing and standards	laboratory and field testing to support voluntary industry consensus standards development of standards and test protocols, particularly for field testing research to support development of global testing infrastructure

3. Key Recommendations

A. Give human face to the Improved Cook Stoves and make them user friendly, affordable and accessible. :

Based on the overall population, fuel practices, and income segments, there is a very large market for cook stoves 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).

The technology improvement should consider the cooking methods, the food-menu, the user behavior considering that not every size would fit all.

B. Use of improved cook stove to be made mandatory under Indira AwasYojana (IAY)

IAY, a flagship scheme of the Ministry of Rural Development has since inception been providing assistance to BPL families who are either houseless or having inadequate housing facilities for constructing a safe and durable shelter. It is mandatory in this scheme that unless there is a toilet built near your house the applicant will not get the full payment installment. This compulsion is to promote the hygiene amongst the villagers. One of the success story of this is, the state of Sikkim which is the first state in India which is completely hygienic, having toilets to all the homes. Similar recommendation can be advised in case of clean cool stoves.

C. 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**. A detail survey be conducted to get feedback from users and initiating the programme for spreading the awareness, market incentives, use of mobile telephones and other media for the same be deployed.**

D. Need of new distribution model

A complete new model of distribution for improved cook stoves is needed. Different players can play a major role in distribution chain development such as Proprietary Distributor, Non-Governmental Organizations (NGOs), Cooperatives, Self Help Groups (SHGs), Microfinance Institutions (MFI), Rural Retail. Everybody has a role to play in this. Rural entrepreneurship can be developed through this programme and key role of woman can be identified. As distribution channels emerge as the vital links in reaching untapped rural markets,they must continue to stretch and evaluate their distribution capabilities.

E. 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.**The risk of over emphasis on the technologies, short term success, costly innovations and falls publicity need to be prevented though networking and authoritative monitoring.**

F. 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 financial a wider base and diversity of financing available to both consumers and suppliers.

G. No single solution will adequately address the cookstove challenge

Multiple stove designs will beneeded to accommodate a variety of cooking practices, fuels, and levels of affordability. Govt. willneed to balance efforts to improve existing stoves with research that could impact a range of stovetypes and regions.

H. At least 90% emissions reductions and 50% fuel savings are appropriate initial targets.

A limited number of improved stoves already meet these targets, but additional technical research and development can lower costs and make these successes more widespread for a range of laboratory and field conditions and for a variety of unprocessed and processed fuels. Measuring progress toward these targets will require clear definitions of baseline performance or absolute targets for emissions and efficiency based on health and climate impacts.

I. Technical R&D should guide and be guided by field research and implementation programs.

Technical research should be informed by health studies on appropriate emissions levels and by social science and field research on cooking practices. At the same time, new technical insights can be used to stimulate new stove designs, improve existing stoves, and support dissemination and testing efforts. Design guides and tools can make these insights accessible and relevant for downstream efforts. At every stage, laboratory and field work should be integrated into an iterative cycle of feedback and improvement. The research program should be organized to foster partnerships among researchers from the national laboratories, universities, and groups with significant field testing and dissemination experience.

J. Grampanchayats(local governing body in the villages) should encourage competition between villages

The local governance can prove to the higher officials in the government that they are ready and organized for a village-level switch to improved cookstoves. This approach helps identify those villages that represent households that have greater use for the stoves. Nirmal Bharat Abhiyan is the programme is demand-driven and people-centered based on the principle “From low to No subsidy". A nominal subsidy in the form of incentive can be given to the rural poor households for construction of improved cookstoves.

K.Monitoring the results :

All the stakeholders in distribution channel should **monitor the results** of the improved cookstove programand aim to complete **annual evaluation**son the progress of the program.

L. Setting up of Testing Facilities

It is expected that the groups doing fundamental research on combustion relevant to cookstoves, leading to new designs of stoves would need a well-equipped testing facility particularly for emission measurements for combustion research as well as for testing their own designs in-house for emissions as well as thermal performance.

These groups could also take up the task of evolving testing standards, for which such a facility would be essential or else, they could collaborate with others working on testing protocols sharing the testing facilities with them. These groups with state of the art equipment for testing could also carry out the training of personnel for certification centres as well as field testing centres. However, these groups should not be given the task of certification.

M.Financial Incentives to lower the Direct Subsidies on Capital Cost and replacement cost

Subsidies that continue to gradually decrease could make the stoves affordable for the poorer consumers while still allowing for commercialization over time.MNRE, with funding from the Government of India, could implement a small, continually decreasing subsidy for consumers. Eventually, when commercialization of improved cook stoves is achieved and cook stoves are more affordable, the subsidy should be removed completely.

O.Pellet stoves and boilers, using fuel made from recycled wood waste or sawdust, to replace current wood-burning technologies in the residential sector in industrialized countries.Replacing coal by coal briquettes in cooking and heating stoves.

P. Ban of open field burning of agricultural waste-providing alternate for open cooking by communities and nomads that use biomass.

The burning of agricultural field residue, such as stalks and stubble,during the wheat and rice harvesting seasons in the Indo-Gangeticplains results in substantial emissions of trace gases and particles. This pollution can have adverse health and climate impacts. There is a need to promote alternative methods to open burning and open cooking . Large scale awareness through government programmes with the productivity data is needed. Emerging technology in sustainable agriculture needs to be promoted amongst farmers.

Q. Use of CSR for developing need based cooking stove models and promoting them

New inclusive models of technology dissemination with financing to small organizations for development of need based clean cook stoves and promoting firms need to be backed through CSR funding. MNCs can work with local partners, university research laboratories, NGOs and microfinance institution to promote various activities. It can enable some of the lowest-income customers to purchase stoves and improve their livelihoods.In CSR terms, the creation of new technologies will hold the key to clean energy for the developing world.

R. Engaging women in supervision, implementation distribution. Participation of village women to evaluate technologies and develop better models

As women are the end users of the stoves, they need to be involved in all stages of development and promoting improved cook stoves. An awareness drive amongst women by the women can help in horizontal spread of this technology and sensitizing about the health impacts and other benefits from using the new stoves. END

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Annex 1

Approved Models of Portable Improved Biomass Cookstoves

Sl. No	Manufacturers	Model & Fuel used	Performance parameters as per test testing conducted in MNRE supported Test Centres
I.	**Natural Draft Cook stoves – Domestic Size**		
1	**UNICUS ENGINEERING PRIVATE LIMITED Bhubaneswar,**	Harsha(CSIR, IMMT Design)(Fuel-Wood)	Thermal efficiency: 26.7% CO : 5.10 (g/MJ_d) TPM : 272.07 mg/MJ_d Power output : 1.83 kW
2	**Vikram Stoves & Fabricators, Osmanabad**	Bio-classic(Fuel-Wood)	Thermal efficiency:26.01% CO : 4.54 g/MJ_d TPM:315.38 mg/MJ_d Power output:1.49 kW
3	**Greenway Grameen Infra Pvt Ltd, Navi Mumbai**	Greenway Smart Cook Stove(Fuel-Wood)	Thermal efficiency:24.1% CO : 3.0 g/MJ_d TPM : 320mg/MJ_d Power output : 0.8 kW
4	**M/s Ravi Engineering & Chemical Works New Delhi**	Firenzel(Fuel-Wood)	Thermal efficiency:26.62% CO/CO_2 : 0.041 TSP : 1.92mg/m^3 Power Output: 0.74kW

5	**Adarsh Plant Protect Ltd, ANAND**	Adarsh (Nirmal)(Fuel-Wood)	Thermal Efficiency : 22.40% CO : 3.81 (g/MJ_d) TPM :303.02 mg/MJ_d Power output :0.89 kW
6.	**iSquare D Charitable Trust Bangalore**	Chulika(Fuel-Wood)	Thermal efficiency: 29.77% CO :2.57g/MJ_d TPM :228.37 mg/MJ_d Power output : 0.74 kW
II.	**Forced Draft Cookstoves – Domestic Size**		
1	**First Energy Pvt. Ltd., Pune**	Oorja(Fuel-Pellets)-IISc -Design	Thermal efficiency :32.90% CO :3.956 (g/MJ_d) TPM :111.23 mg/MJ_d Power output : 0.7 kW
2	**The Energy and Resources Institute (TERI), New Delhi**	TERI SPT-0610(Fuel- Wood)	Thermal efficiency :36.84% CO : 2.25 g/MJ_d TPM :147.40 mg/MJ_d Power output:1.08 kW
3	**Alpha Renewable Energy Pvt. Ltd. Anand**	Eco chulha – XXL(Fuel-Wood)	Thermal efficiency: 31.50% CO : 1.90 (g/MJ_d) TPM :97.52 mg/MJ_d Power output : 1.10 kW
4	**Navdurga Metal Industries (Bharat), Faizabad,**	Agni Star(Fuel- Rice Husk)	Efficiency : 34.54% CO :5.23 g/MJd TPM :79.59 mg/MJd Power output:2.16 kW
5.	**Sacks Right Energy Innovations Bangalore**	OJAS(Fuel-Pellets)	Thermal Efficiency :35.33% CO :2.569 g/MJ_d TPM :78.82 mg/MJ_d Power output : 1.99 kWThermal Efficiency : 34.00% CO : 2.45 g/MJ_d TPM :99.01 mg/MJ_d

			Power output :6.39 kW
6.	**Ram Tara Engineering Company. Aurangabad**	RAMTARA(Fuel-Pellets)	Thermal Efficiency : 34.1% CO : 1.0 g/MJ_d TPM :86 mg/MJ_d Power output:1.0 Kw
III	**Forced Draft - Community Size**		
1.	**Alpha Renewable Energy Pvt. Ltd. Anand,**	Eco chulha-XXXL(Fuel-Wood)	Thermal Efficiency :32.28% CO :1.35 g/MJ_d TPM :79.77 mg/MJ_d Power output :3.32 kW
2.	**Sacks Right Energy Innovations Bangalore**	Ojas - M06(Fuel-Pellets)	Thermal Efficiency :35.11% CO :1.05 g/MJ_d TPM :69.01 mg/MJ_d Power output :5.43 kW
3.	**Sacks Right Energy Innovations Bangalore**	Ojas – M09(Fuel-Pellets)	Thermal Efficiency :34.00% CO :2.45 g/MJ_d TPM : 99.01 mg/MJ_d Power output : 6.39 kW

Annex 2.

Advantages and disadvantages of the use of biomass gasifier stove

Advantages	Disadvantages
Cleaner burning of solid biomass	Small-sized fuel needed. Further efforts for the users for chopping and splitting for the fuel preparation
More efficient use of biomass due to more complete combustion	Most micro-gasifiers are batch-loaded and cannot be refuelled during use. Thus cooking times are predefined by the size of the fuel container
Recovery of a wide variety of small-size biomass residues	Not easy regulation of the heat output, unless the stove is operated with a ventilator for forced convection

Performance similar to biogas (but not dependent on water and bio-digester) and approaching the convenience of fossil gases	Micro-gasifiers burn the biomass in two stages: first the gas-generator produces thewoodgas, which is a thick whitish 'smoke'.
'Gas' available on demand (unlike electricity or LPG that are dependent on local providers and imports, and unlike solar energy that is dependent on clear weather and daylight hours)	The gas-burner is basically a 'smoke-burner'. This is fine, if the gas-burner operates well. Shouldthe flame of the gas-burner go out (e.g. blown out by gusty wind), the gas-generatorwill still produce woodgas, which will not be burnt and then escape as thick white smoke from the stove
Pyrolytic micro-gasifiers can create charcoal which may be used for energy purposes or to improve soil productivity as biochar. The 'biochar' may also be used as soil amendment that can lead to improved water retention capacity and plant nutrient availability in depleted soils	