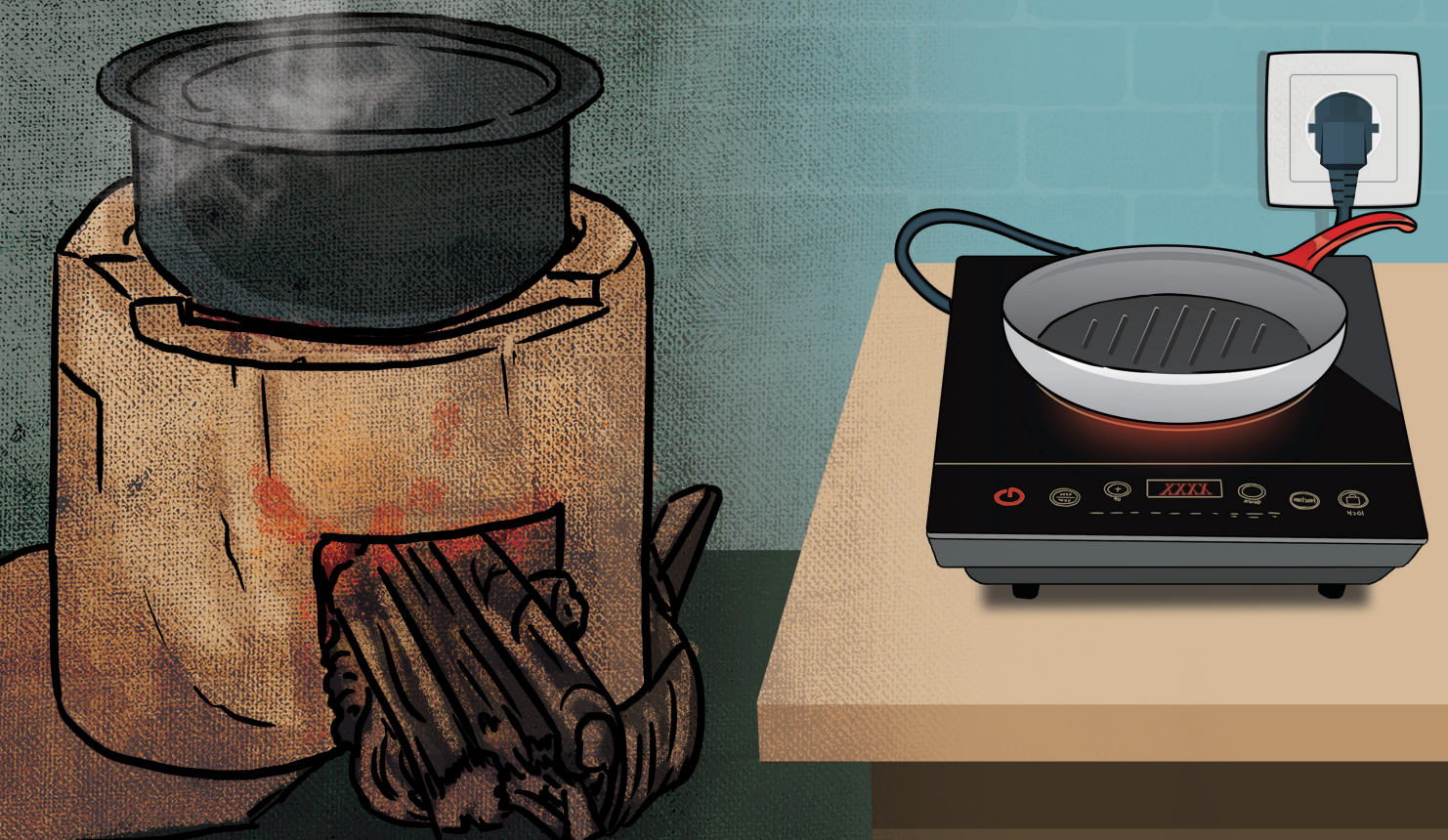
INDIA'S TRANSITION TO E-COOKING

Opportunities, Challenges and a Roadmap for Large-Scale Adoption



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Opportunities, Challenges and a Roadmap for Large-Scale Adoption

CONTENTS

List of abreviations

AIDS	Acquired Immune Deficiency Syndrome
AQLI	Air Quality Life Index
BaP	Benzo[a]pyrene
BCS	Bagepalli Coolie Sangha
BEE	Bureau of Energy Efficiency
BPL	Below Poverty Line
BSI	Bureau of Indian Standards
CAGR	Compound annual growth rate
CEA	Central Electricity Authority of India
CESL	Convergence Energy Services Limited
CMO	Chief Medical Officer
CO	Carbon monoxide
CO2	Carbon dioxide
CSE	Centre for Science and Environment
CSIR	Council of Scientific and Industrial Research
cu m	Cubic metre
CVD	Cardiovascular diseases
DALY	Disability Adjust Life Year
DBT	Direct Benefit Transfer
DISCOMS	Electricity Distribution Companies
DRDO	Defence Research and Development Organisation
DSM	Demand-side management
DT	Distributed transformers
E-cooking	Electric cooking
EESL	Energy Efficiency Services Limited
EPIC	Energy Policy Institute at the University of Chicago
ESMI	Electricity Supply Monitoring Initiative
EV charging	Electric vehicle charging
E-Waste	Electronic waste
FPO	Follow on public offer
FY	Financial year

ABBREVIATIONS

GDP	Gross domestic product
GHG	Greenhouse gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GW	Gigawatt
HIV	Human Immunodeficiency Virus
HT	High tension
IAP	Indoor air pollution
IARC	International Agency for Research on Cancer
ICS	Improved cookstoves
IEA	International Energy Agency
IISc	Indian Institute of Science
IIT	Indian Institute of Technology
ILO	International Labour Organization
IOCL	Indian Oil Corporation Limited
IOMC	International Programme on Chemical Safety
	Management of Chemicals
IPCS	International Programme on Chemical Safety
IRES	India Residential Energy Survey
ITI	Industrial Training Institute
kV	Kilovolt
kWh	Kilowatt hour
LFA	Load flow analysis
LPG	Liquefied petroleum gas
LT	Low tension
MDB	Multilateral Development Banks
MNRE	Ministry of New and Renewable Energy
MoP	Ministry of Power
MoPNG	Ministry of Petroleum and Natural Gas
MPCE	Monthly per capita expenditure
MW	Megawatt
NBFC	Non-Banking Financial Corporations
NCR	National Capital Region

NDC	Nationally Determined Contributions
NFHS	National Family Health Survey
NGO	Non-governmental organization
NISE	National Institute of Solar Energy
Nox	Nitrous oxides
NSSO	National Sample Survey Office
O&M	Operation and Maintenance
OEM	Original Equipment Manufacturer
OMC	Oil Marketing Companies
PAH	Polycyclic Aromatic Hydrocarbons
PM	Particulate matter
PMUY	Pradhan Mantri Ujjwala Yojana
PNG	Piped natural gas
PV	Photovoltaic
R&D	Research and Development
SCF	Smokeless Cookstove Foundation
SDA	State Designated Agencies
SDG	Sustainable Development Goals
SEWA	Socio Educational Welfare Association
SO	Sulphur oxides
TCO	Total cost of ownership
TERI	The Energy and Resources Institute
TPCODL	Tata Power Central Odisha Distribution Limited
UNEP	United Nations Environment Programme
WHO	World Health Organization

EXECUTIVE SUMMARY

Access to clean cooking has been on the radar of policymakers, state and Central governments, researchers and NGOs in India for several decades. Around a third of the world's population—2.4 billion people globally and about 500 million people in India—still lack access to clean cooking solutions. This causes untold damage to public health, the environment and economies.[1]

Approximately 3 million people globally and about 0.6 million people in India die prematurely every year because of indoor air pollution.[2] These deaths are mostly caused by wood-based cooking. There is a need to shift from burning wood, cow dung or other biomass for cooking to a cleaner, healthier substitute that will play the multiple roles of:

(a) providing energy access to the country's poor;
(b) reducing health problems and premature deaths;
(c) reducing associated medical costs and resource burden on the country's health infrastructure;
(d) helping India achieve its net zero targets by reducing carbon emissions at scale; and
(e) increasing GDP of the nation by reducing the economic burden of human-hours lost by women in collecting wood, cooking in inefficient wood burning stoves and cleaning soot filled kitchens.

Clean(er) cooking options are needed beyond the traditional fuels used in most parts of India as there are several problems stemming from their rampant and unmitigated use. Some of the health problems that stem from their use are respiratory illnesses and cancer; high infant and maternal mortality; significant greenhouse gas (GHG) emissions, including CO_2, CO, CH_4, NO_2; black soot and other dangerous pollutants; economic losses due to time spent in collecting wood, cooking and cleaning kitchens; and economic losses due to disability-adjusted life years lost as a result of health problems and infant mortality.

One notable health risk associated with polluting cooking fuel and indoor air pollution is the emission of pollutants such as benzo[a]pyrene (BaP), which is classified as a Group 1 carcinogen. Not only does it cause adverse and/or long-term health effects on humans, it also leaves its effect on future generations through mutations in the genes of affected people.

The Rajiv Gandhi Gram LPG Vitrak Yojana (also called the RGGLV Scheme) launched by the Union government in 2009, which was later renamed and relaunched as the Pradhan Mantri Ujjwala Yojana (PMUY) in May 2016, was a

good step in the direction of making clean cooking accessible in India. The scheme aimed to replace solid fuels and other biomass-based polluting cooking fuels with Liquefied Petroleum Gas (LPG) in many rural and urban households. Through the scheme, more than 100 million households in India received LPG cylinders by the end of March 2023.[3] India has a total of over 310 million LPG cylinder customers.[4] This roughly translates to 2,480 million LPG cylinders consumed yearly (assuming that a household uses an average of eight cylinders a year).

This rapid expansion in LPG access, however, has not guaranteed a sustained transition to clean cooking in households that received these cylinders. Unexpectedly, over 50 per cent of the households that received new LPG cylinders as part of the scheme did not choose to refill it even once. This was due to high costs of refill, cultural or behavioural beliefs, and a lack of significant LPG cylinder distribution networks where they lived.[5] As of March 2023, the average cost for a refill of an LPG cylinder (14.2 kg) was approximately Rs 1,100 across India;[6] the average Indian household requires eight such cylinders solely for cooking in a year.[7] That translates to approximately Rs 8,800 spent on cooking fuel alone per year. As per the NITI Aayog's Tenth Five-Year Plan, the average annual income of a Below Poverty Line (BPL) family is capped at Rs 27,000, which means an average BPL family (who are the primary beneficiaries of the PMUY scheme) have to spend one-third of their annual income on cooking fuel alone.

India's clean cooking problem is prevalent mainly in rural areas due their fuel usage practices. The rural population is also most affected by its negative impacts. Although the Ministry of Petroleum and Natural Gas (MOPNG) claims that the country's household LPG "coverage" stands at 99.8 per cent,[8] India's National Family Health Survey conducted in 2019–21 (NFHS-5) shows that 41 per cent of the population still cooks on biomass.[9] CSE's own calculations have found that this 41 per cent cumulatively emits—when it cooks on wood, cow dung or other biomass—around 340 million tonne of CO_2 into the environment every year, which is about 13 per cent of India's national GHG emissions. Interestingly, upon careful observation of India's last Biennial Update Report (BUR3) to the UNFCCC, this particular sectoral emission is not counted as part of national emissions.[10]

This, coupled with the lack of an extensive LPG distribution network in rural geographies, and the high gas import bill for India to meet its demand for LPG and PNG, make it evident that LPG cannot be the only clean cooking option for India in the coming years. Switching away from LPG, or a phase-down approach as we call it, over a period of 16–22 years can help India reach 100 per cent penetration of e-cooking in rural India. This not only coincides with the country's vision of

achieving the status of a developed nation but also enables the achievement of its net-zero ambition by 2070.

It is estimated that this will cost the country roughly Rs 1–5 lakh crore over the implementation period in subsidies (primarily for the procurement of e-cooking devices, utensils and electricity). Equally importantly, our analysis suggests that the initiative will also help to avoid an LPG import bill of Rs 25–65 lakh crore over a period of 15 years, even with a conservative increment of 5–15 per cent CAGR against a CAGR of 21 per cent over the past 15 years. To reiterate, the share of LPG consumption in rural and urban areas is not factored into the analysis, but the cost of the entire LPG import has been considered.

This report aims to understand and provide a roadmap for large-scale adoption of e-cooking for rural households, emphasizing that the intervention will have a relatively more significant impact compared to the urban counterpart for the following two reasons—i) rural India accounts for two-thirds of the total household number and; ii) access to other means of clean cooking such as LPG is very limited in rural areas. To put this into perspective, only about 57 per cent of the rural population has access to LPG while more than 90 per cent of urban households have access to LPG and possess the infrastructure to use e-cooking.

This report estimates a peak power demand of about 320 GW from e-cooking. This can be managed with effective load management measures as well as capacity addition of about 80 GW over a period of 16–22 years, following an aggressive to low penetration scenario. Nonetheless, a further deep dive into the implications of e-cooking on electricity generation and distribution capacity of the country is recommended. An analysis of Total Cost of Ownership (TCO) of the e-cooking system for rural consumers, which includes an e-cooking device and compatible cookware and utensils, indicates that it is comparable with the costs associated with LPG use in the first year but reduces thenceforth.

All of these make an excellent case for e-cooking in India. But given the polluting sources of India's power sector, e-cooking on a large-scale is more polluting than LPG, not that LPG is such a clean fuel itself.

Nonetheless, India needs a clear roadmap to adopt e-cooking on a large scale, where policymakers focus their resources and attention on rural India first. A large chunk of emissions, health problems and energy poverty are concentrated in rural areas and therefore need urgent attention. The urban population already has access to relatively cleaner cooking fuels and higher per capita energy access. They

will continue to switch to even cleaner cooking practices in the future as costs of devices and usage drops further and LPG/PNG prices rise further.

In addition, India also needs two other roadmaps for e-cooking to succeed. The first is a roadmap to phase down, and ultimately phase out, LPG from kitchens in India. The second is to strengthen and decarbonize the grid, keeping in mind future e-cooking adoption projections. Both need a variety of ministries to work in tandem to achieve near universal energy access and net-zero emissions goals for India.

And this can only happen when there is someone at the helm, leading the narrative, the discourse and the monitoring. If no entity is made responsible for the success of the programme, no entity will be held accountable for its failure.

According to our detailed stakeholder mapping, scoring and analysis, we suggest a specific ministry be given the charge to lead the e-cooking mandate in India. Different ministries for rural and urban India recommended.

In addition, large-scale e-cooking adoption will need the buy-in and investment of other ministries, such as the Ministry of Environment, Forest and Climate Change (MoEFCC), Ministry of Petroleum and Natural Gas (MoPNG), Bureau of Energy Efficiency (BEE), Ministry of Finance (MoF), Ministry of Health and Family Welfare (MoHFW), and Ministry of Human Resources Development (MoHRD).

Ultimately, the problem of clean cooking is a complex and multipronged, and has implications across multiple geographies, social classes, sectors and ministries. For India to be able to solve this much-wrestled-with problem any time soon, it needs to decouple it from political spin and entrust it to a specific ministry (if necessary, create a new one) that will collaborate with other ministries and bring them on board for specific objectives at various stages of implementation. Policymakers also need to include community-level organizations and women and/or women-led organizations as, at the end of the day, they are the ones most affected by their decisions.

E-COOKING IN INDIA—THE BIG PICTURE

- INDIA HAS COOKED WITH BIOMASS AND BIOMASS-DERIVED FUELS FOR SEVERAL HUNDRED YEARS.
- THERE HAS BEEN INCREASING FOCUS ON COOKING FUEL TRANSITION IN INDIA. HOWEVER, THESE EFFORTS HAVE NOT PRODUCED DESIRED OUTCOMES AS 500 MILLION PEOPLE STILL STRUGGLE WITHOUT ACCESS TO CLEANER COOKING FUELS.
- THIS REPORT PROVIDES INSIGHT INTO THE ILL EFFECTS OF BIOMASS-BASED COOKING. IT ALSO TOUCHES UPON KEY DETERRENTS—SOCIAL BARRIERS, AFFORDABILITY AND ENERGY ACCESS—TO LARGE-SCALE ADOPTION OF E-COOKING.
- ACCESS TO TECHNOLOGY AND CHOICE IN TYPE OF E-COOKSTOVES IS NEEDED TO OPTIMIZE THE ELECTRICAL AND FINANCIAL BURDEN FOR CUSTOMERS TO SWITCH TO E-COOKING.
- E-COOKING CAN NEITHER COMPLETELY REPLACE LPG NOR THE USE OF BIOMASS IN THE IMMEDIATE FUTURE, BUT A LONG-TERM OUTLOOK AND PLAN NEEDS TO BE FORMULATED.
- E-COOKING CAN RESULT IN MONETARY SAVINGS FROM AVOIDED LPG IMPORT OF Rs 25–65 LAKH CRORE OVER 15 YEARS.

Rationale

E-cooking, as the name indicates, is the practice of cooking using electricity as fuel. It is prevalent in developed economies, where the availability of electricity, along with relatively small population sizes, have resulted in its widespread adoption.

In India, on the other hand, where 65 per cent of its 1.4 billion people reside in rural areas, the traditional mode of cooking has been with biomass and biomass-derived fuels (such as *uple* made of cow dung and paddy straw). Although cooking practices have seen some changes over the years and people have switched to other fuels such as kerosene, LPG, charcoal and coal, the transition has only been partial and to this day, a significant population in rural areas still depend upon firewood to cook their daily meals.

In the wake of growing concerns on the multidimensional impact of biomass-based cooking, there has been an increasing thrust towards achieving a complete transition to clean cooking globally as well as in India. The SDG 7 framework lays out clear objectives and goals in this direction, and the achievement of these goals has been envisaged through collaborative action by governments and other development actors. Nonetheless, the efforts have not produced the desired outcome as 2.4 billion people globally are still struggling with lack of access to cleaner cooking fuels.[11] The impact or ill effect of biomass-based cooking is not limited just to the challenge of fuel availability, but spills over to several other ecosystems, directly and indirectly affecting climate, biodiversity, air quality, health, economic burden, agriculture and overall productivity. It implies that the magnitude of the underlying challenge lies not just in providing access to cleaner cooking options to 2.4 billion people but also to address these overlapping impacts.

According to the latest SDG 7 tracking report, 505 million people in India do not have access to clean cooking.[12] Considering the magnitude of the problem, India has demonstrated its intent to address this challenge. Recently announced subsidies for induction cookstoves is one of the many steps that are to be taken in this direction.

While it is clear that e-cooking is the way forward, it will take immense efforts from all stakeholders working together in multiple directions. Hence, an understanding of the roles and responsibilities of the variety of stakeholders is essential. Notwithstanding the fact that even the smallest actions from stakeholders can provide an impetus to large scale adoption of e-cooking, there are several challenges in the form of community awareness, technology development, manufacturing of affordable e-cooking devices and compatible cookware, O&M services, reliable

access to electricity, social and behavioural stigmas related to various class and cooking practices, diversity in eating habits and equally importantly the role of private sector. Overall, an entire ecosystem needs to be created with a very balanced approach to result in a win-win scenario for all the stakeholders along the value chain.

It is important to look at the long-term outcomes and impacts of e-cooking. This report provides insight into various ill effects of biomass-based cooking, the traditional mode of cooking widely practised in rural areas. Hence, focusing on mass-scale adoption of e-cooking in rural areas makes a stronger case from the perspective of achieving maximum instead of targeting urban consumers first and emulating the implementation model in rural areas. Urban consumers already have relatively easier access to clean cooking options in the form of reliable supply of electricity, LPG and PNG.

However, the technology for e-cooking needs to evolve to suit the needs of rural consumers. This is especially true for India as the target communities have unique cooking habits that differ across states and regions. Not only does the technology need to address community-specific cooking requirements and habits, rural consumers also need to be provided with choices in the types of e-cookstoves and cookware in terms of energy consumption (lower the better) and durability (higher the better). This will help optimize peak electrical load, especially during morning and evening hours, and the associated financial burden for consumers as well as the utilities for developing and strengthening electricity distribution infrastructure. Currently, the range of products available in the market is limited and do not offer such choices, either in terms of energy consumption or suitability for adoption/use in rural areas. Nevertheless, the cost of e-cooking is supposed to be at par with that of LPG, even with the current products and prices.

Some studies have been undertaken to understand the cost of e-cooking in terms of cost of ownership as compared to other modes of cleaner cooking such as LPG and PNG. Since we are focusing on mass-scale penetration of e-cooking in rural areas, we will delve into details pertaining to the cost of e-cooking and LPG; PNG has no footprint whatsoever in rural areas and is very unlikely to make a mark even in the distant future. The studies present a mixed scenario, with some arguing that the ownership cost of e-cooking is higher—marginally to significantly—compared to LPG-based cooking, while others favour e-cooking over LPG, basis the cost of ownership.

Based on preliminary analysis, we found that the cost of ownership of e-cooking over 10 years works out to be 30 per cent cheaper than LPG at its current price. Understandably, the sector will benefit in terms of reduction in cost as it achieves some scale along with technology advancements over the years. Ironically, even if e-cooking achieves 100 per cent replacement of LPG, continued consumption (albeit reduced) of biomass in rural areas might still be an issue to deal with from the standpoint of achieving 100 per cent smokeless cooking.

While the tangible social, economic and health benefits of large-scale use of e-cooking are widely acknowledged, intangible impacts on local environment and climate should also be recognized. These include improvement in local air quality, which has several public health benefits such as the prevention of certain respiratory ailments. It also results in reduced rate of deforestation, resulting in increased tree cover, which leads to overall improvement of soil health, agricultural output, resistance to droughts and floods and other environmental benefits.

A comprehensive stakeholder mapping has been carried out and presented in this report, which outlines the key stakeholders along with their respective roles. The efforts of the stakeholders need to be concentrated and channelled towards achieving the envisaged objectives. Therefore, we recommend that an appropriate institutional framework be developed to drive the initiative effectively and efficiently. Overall, the report attempts to understand the entire value chain in propagating smokeless electric cooking, including the role of a variety of agencies, government departments, institutions, private sector and other stakeholders, and their criticality in achieving the desired objectives; the institutional arrangement; cost and financial implications of e-cooking; barriers to its adoption; and, lastly, the way forward.

The road ahead

According to Census 2011, the rural population of India accounted for about 69 per cent of the total population and resided in 169 million households, which dropped to about 64 per cent in 2022.[13] A conservative estimate for 2023 based on the population growth projections provided by NSSO and an average household size of 4.5 persons as against an average household size of five in 2011 suggests that e-cooking needs to reach about 200 million rural households. Considering the scale, reaching 200 million households seems to be an uphill task. However, we wish to emphasize that the programme can be designed to reach every rural household, roughly 200 million, in a phased manner, over a span of 16–22 years, following an aggressive to conservative growth trajectory.

Our indicative analysis suggests that e-cooking can achieve 100 per cent penetration with regard to rural households in 16 years with a year-on-year coverage increment of 50 per cent (aggressive roadmap) beginning with covering only 0.1 per cent (200,000) of total rural households nationally in the first year and adding 50 per cent annually of the preceding year's coverage. This translates to an average of 5,500 households per state or Union Territory in the first year. A more granular roadmap of adoption/coverage at the district and village levels indicates the feasibility of e-cooking penetration relatively more clearly.

For example, in the first year, every district (considering a total of 766) in the country will be required to connect about 260 rural households to e-cooking, increasing the number by 1.5 times every year, reaching 11,5000 rural households in the sixteenth year. A more granular plan at the village level suggests a clearer way forward. In the first year of this plan, every third village will be required to connect one household to e-cooking. In the second year, one household in every two villages will be connected to e-cooking. One household per village will be connected to e-cooking in the fourth year, adding 50 per cent more annually thereafter to reach 134 households per village in the sixteenth year. Similarly, a medium trajectory with 40 per cent year-on-year growth can result in 100 per cent penetration in 18 years, and the lowest growth path with 30 per cent year-on-year addition will take 22 years. This coincides with the country's vision of achieving social and economic development transition goals by 2047. It implies that the e-cooking programme needs to be rolled out immediately to reach the target, even with the slowest transition roadmap among the three scenarios discussed here, by or before 2047.

Needless to mention, the programme would require a large capital investment from the private sector besides expenditure from the government. An estimate suggests that the aggressive scenario will require about a capital subsidy of about Rs 47,000 crore invested over 16 years towards supporting rural consumers, with 30 per cent of the cost of the e-cooking device along with compatible utensils (basic utensils required for cooking) at a subsidy of Rs 1,800 per household. However, the size and share of subsidy may reduce during the implementation period because of the economy of scale and technological advancements. In addition, because of very high peak power demand, the electricity for e-cooking can be anticipated to be very expensive. Therefore, to encourage adoption and continued usage of e-cookstoves, a fair amount of subsidy on electricity should be provided to rural consumers. Therefore, if 50 per cent electricity subsidy is provided to consumers in the first year of connection, about Rs 86,000 crore will have to be spent cumulatively over 16 years. If the subsidy needs to be continued for five years, it would cost the exchequer a whopping Rs 4.30 lakh crore to achieve 100 per cent e-cooking in the

sixteenth year, with the subsidy continuing till the twentieth year. For comparison, the subsidy on LPG amounted to Rs 2.5 lakh crore (US $36 billion) over nine years between the financial years of 2009–10 and 2017–18.

Furthermore, the cost of LPG imports for the last year alone was a whopping Rs 1.07 lakh crore. Over the past 15 years, LPG import has incurred a total cost of Rs 6.5 lakh crore. The dependence on LPG import thereby is causing a significant financial burden on the country's foreign reserves. This burden has increased substantially over the past 15 years at an average year-on-year increment of 27 per cent and at a CAGR of 21 per cent. If this trend continues, our analysis and most conservative estimates indicate that LPG import would cost a huge amount to the country's financial resources, amounting to Rs 25 lakh crore between 2023–24 and 2037–38, with an annual increment of 5.4 per cent and CAGR of 5 per cent on expenditure against the current CAGR 21 per cent. Alternately, if the year-on-year expenditure towards LPG import grows at 10.75 per cent and at a CAGR of 10 per cent, we will need Rs 40 lakh crore to meet the LPG demand of the country. If the dependence on the import of LPG can be curtailed to reduce financial burden, and the expenditure is limited to a CAGR of 15 per cent as against 21 per cent of the past 15 years, even then the estimated cost of LPG import for the next 15 years is a staggering Rs 65 lakh crore.

Regarding LPG access in the domestic segment, data from Petroleum Planning and Analysis Cell (PPAC)[14] indicates that the country had 314 million active domestic LPG connections at the end of 2022–23. Comparing this with the estimated number of households, both urban and rural, which is nearly 300 million,[15] LPG has seemingly reached 100 per cent of the households in the country. While the extent of penetration of LPG for domestic consumption is a good step in the direction towards clean cooking, 505 million people—roughly one-third of total households—still reportedly do not have access to clean cooking. According to the SDG 7 Tracking Report,[16] 57 per cent of the rural population had access to clean cooking in 2021, as opposed to 93 per cent in urban areas. This is the discrepancy in data, claim and information that requires further research from the perspective of deviation from one household-one connection model.[17]

However, as the e-cooking programme evolves and scales up, dependence on LPG will decrease. This will require building the capacity for more electricity generation and strengthening the electricity distribution system so that the power demand for e-cooking can be adequately met. The figures can, however, be debated and analysed further from the perspective of viability, and the cost

and need for developmental aspects. Clearly, a continued subsidy on electricity renders the initiative of achieving 100 per cent access to e-cooking a cost-intensive affair. Therefore, subsidy provision on electricity for e-cooking can be explored as an alternative option and limited to only a few initial months for each consumer.

Notably, the report does not aim to present grid complexities and associated economic implications in detail with regard to overall improvements in the infrastructure for electricity distribution, capacity addition and power generation required to meet the electricity demand from e-cooking. It is, however, estimated that a 100 per cent penetration of e-cooking with any of the recommended scenarios will present a peak electricity demand of about 320 GW, of which 75 per cent can be planned to be met and managed with adequate load scheduling, while a capacity addition of 80 GW would be needed to meet the balance 25 per cent of peak demand over a period of 16–22 years. The capacity can be scaled up gradually, beginning with an addition of 75 MW in the first year, 113 MW in the second year, 169 MW in the third year and so on until the sixteenth year, with a capacity addition requirement of 23 GW. However, a deep dive into the additional capacity requirement for electricity generation, transmission, and distribution with a significant share of renewable energy is out of the purview of this report and hence a detailed study is recommended.

In conclusion, e-cooking needs be seen against the backdrop of tangible and intangible costs and benefits. Seemingly and quite understandably, benefits far outweigh the cost.

2

HOW INDIA COOKS

- THE RAPID ADOPTION OF LPG DURING THE 90s ACROSS URBAN INDIA WAS FUELLED BY THE LARGE SUBSIDIES OFFERED BY THE GOVERNMENT, AND BENEFITED MIDDLE CLASS FAMILIES IN INDIA.
- ADOPTION OF LPG IN RURAL HOUSEHOLDS DURING THIS PERIOD WAS LOW AS THE INITIAL COST OF CONNECTIONS WAS RELATIVELY HIGH.
- ALTHOUGH LPG COVERAGE IS SHOWN AS 99.8 PER CENT IN INDIA IN 2021–22, THIS IS NOT A TRUE REFLECTION OF THE CURRENT REALITY. NSSO DATA SHOWS THAT 41 PER CENT STILL USE BIOMASS AS THE PRIMARY COOKING FUEL.
- IN THE LAST TEN YEARS ALONE, THE GOVERNMENT HAS SPENT ABOUT Rs 3.21 LAKH CRORE IN LPG SUBSIDIES FOR URBAN AND RURAL INDIA.
- DEPENDENCE ON LPG IMPORTS ALSO CAUSES SIGNIFICANT FINANCIAL BURDEN ON THE COUNTRY'S FOREIGN RESERVES.

According to the fifth National Family Health Survey 2019–21 (NFHS-5)[18] carried out by the Ministry of Health and Family Welfare, 88.6 per cent of urban households use LPG or piped natural gas (PNG) as their primary cooking fuel, while only 42 per cent of rural households use LPG.[19] According to the same survey, about 56 per cent of the population cooks on polluting fuels like wood, biomass, animal dung cakes, agri-residue or kerosene. Over the years, however, we have seen significant transition in cooking fuels from traditional methods to LPG- and PNG-based cooking as a clean cooking fuel.

Transition to clean cooking and role of LPG in India

LPG was first introduced in India way back in 1955 by Bharat Petroleum (BPCL), then known as Burmah Shell[20] before it was nationalized due to energy security concerns arising out of the 1971 India-Pakistan War. Today, the Indian packaged LPG market is dominated by three national energy companies—BPCL, which sells under the brand name Bharatgas; Indian Oil (IOCL), under the brand name Indane; and Hindustan Petroleum (HPCL), under the brand name HP Gas. Of these, Indane holds approximately 50 per cent market share while the rest is equally split between the other two.[21]

In 1965, there were only 2,000 Indane LPG connections in India.[22] By the 1970s and 1980s, LPG stoves, even though they were initially regarded warily by consumers due to safety concerns, started replacing kerosene stoves in Indian kitchens.[23] In 1977, there were about 3.2 million connections across India (i.e. covering 2.5 per cent of the population),[24] which grew to 8.8 million (5 per cent) in 1984,[25] and 19.6 million (11 per cent) by 1990.[26] The primary driver behind this growth was the enormous subsidy offered by the government that amounted to roughly half the cost of a cylinder.[27] Adoption in rural India though was comparatively low as the initial cost of the connection was high for rural households. In the 1990s, getting an LPG connection was more a privilege reserved for wealthy households rather than a public good made available to all.[28]

All of this, of course, changed when the Rajiv Gandhi Gram LPG Vitrak Yojana (also called the RGGLV Scheme) was launched by the Union government in 2009. The RGGLV Scheme was renamed and relaunched as the Pradhan Mantri Ujjwala Yojana (PMUY) in May 2016. Under the scheme, cheaper LPG connections and cylinders were guaranteed for poorer households in both urban and rural geographies. The scheme, which guaranteed LPG cylinders to over 100 million additional households (as of March 2023),[29] although successful at first glance, has shown some glaring gaps on deeper assessment. Over 50 per cent of new households, when surveyed, chose not to refill cylinderd, primarily due to LPG's high inherent costs and lack of LPG distribution networks.[30]

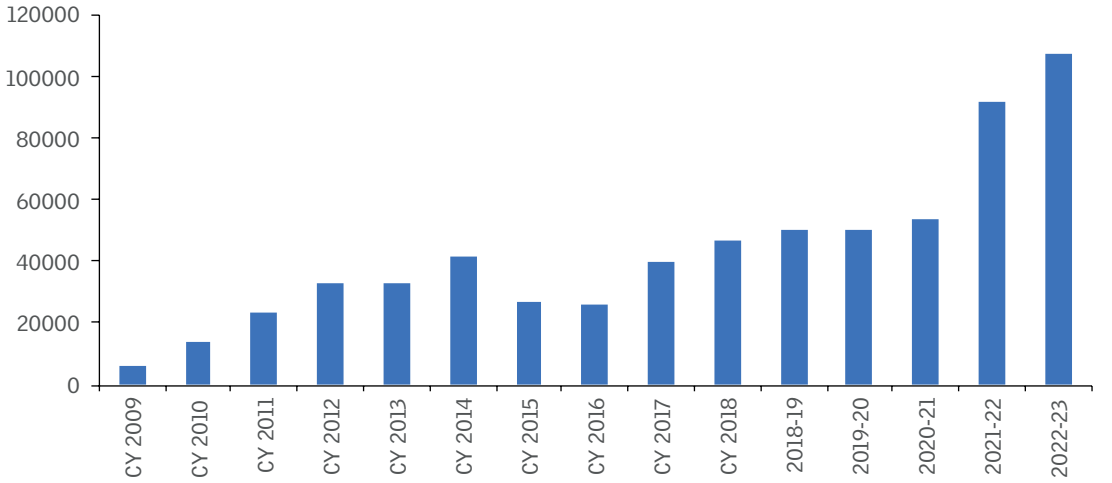
The lack of an extensive LPG distributor network, especially in rural geographies, is also evident. The 31 crore active LPG consumers in India are serviced by only 25,326 distribution centres spread across rural and urban geographies.[31] This means that on average, 95,000 LPG cylinders are distributed yearly, or over 250 cylinders daily, by each registered distributor in India. For urban geographies, this might not seem like an unattainable number, but in rural geographies, the distances involved make it particularly difficult to ensure the widespread adoption of LPG.

This, coupled with the additional costs involved in transporting the cylinders themselves given the poor distribution infrastructure in rural areas, and the cheaply available alternative that is wood or cow dung, helps us understand why PMUY's LPG distribution scheme has not taken off as expected.

But according to India's Ministry of Petroleum and Natural Gas (MOPNG), the country's household LPG "coverage" apparently stands at 99.8 per cent.[32] This claim should be taken with a pinch of salt, as it was arrived at by simply dividing the total number of household LPG connections in India by the total number of households in the country. The number of households in India is an extrapolation from 2011 Census data, as well as population projections from NSSO, both of which point to approximately 300 million currently. Of these, approximately 200 million are rural households, where the need for clean cooking is critical. It is based on the false assumption that LPG connections are equally distributed among households and that the claim (and need) of one household-one connection is unequivocally true. It also ignores the sad truth about fuel stacking, wherein households stock multiple kinds of fuel for their various energy needs, which includes LPG, wood, and/or cow dung for their cooking needs. The truth is that many households have multiple LPG connections, with 11 per cent of urban households and 58 per cent of rural households in India still using biomass as their primary cooking fuel.[33]

LPG has been one of the most subsidized commodities in India since it was introduced in the 1970s. It is also one of the most expensive commodities for the national exchequer. Data from only the last 10 years indicates that the government has spent approximately Rs 3.21 lakh crore in LPG subsidies for urban and rural populations. These numbers include the Direct Benefit Transfer (DBT) under the PMUY scheme for households. Moreover, in March 2022, the Cabinet Committee on Economic Affairs (CCEA) announced an additional subsidy on domestic LPG for up to 12 refills per year. An expenditure of Rs 6,100 crore was earmarked for 2022–23 and Rs 7,680 crore for 2023–24.[34]

Figure 1: Annual cost of importing LPG to India



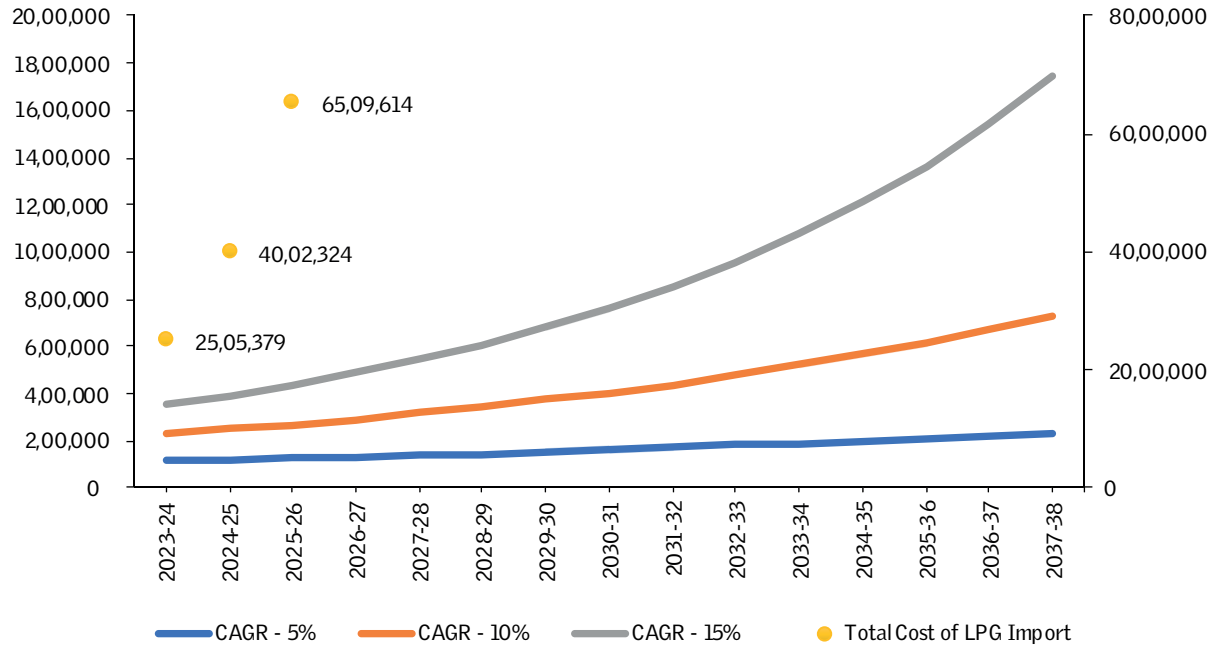
Source: Compiled from annual reports of MoPNG and PPAC

Furthermore, the cost of LPG import for the last year (2022–23) alone was a whopping Rs 1.07 lakh crore.[35] Since 2009, LPG import worth Rs 6.5 lakh crore has been incurred by the national exchequer.[36, 37] Dependence on LPG imports results in a significant financial burden on the country's foreign reserves, with costs increasing substantially over the last 15 years—at an average year-on-year increment of 27 per cent and CAGR of 21 per cent.

It is also to be noted that over the last decade, the dependence on LPG imports has increased at a relatively slower pace—at a CAGR of just 10 per cent. The trends in import expenditure on LPG over the past five years, however, suggest a significant increase in import of LPG, with an average year-on-year expenditure increment of 20 per cent and CAGR of 16 per cent.

If the trend continues, our analysis, as shown in Figures 1 and 2, show that with the most conservative estimates, LPG import would cost the country up to Rs 25 lakh crore during 2023–38, with an annual increment of 5.4 per cent and CAGR of 5 per cent on expenditure against the current CAGR of 21 per cent. Alternatively, if the year-on-year expenditure towards LPG import grows at 10.75 per cent and at a CAGR of 10 per cent, Rs 40 lakh crore will be needed to meet the LPG demand of the country. If the dependence on import for LPG requirement can be curtailed to

Figure 2: Total cost of LPG import projected over the next 15 years



SOURCE: CSE analysis based on past consumption trends

reduce the financial burden and can be limited to a CAGR of 15 per cent as against 21 per cent over the past 15 years, even then the estimated cost of LPG import for the next 15 years is a staggering Rs 65 lakh crore.

As regards penetration of LPG in the domestic segment, data from the Petroleum Planning and Analysis Cell (PPAC)[38] as of April 1, 2023 indicates that the country has 314 million of active domestic LPG connection (as on the end of FY 2022–23). Comparing this with the estimated number of households, both urban and local, which is nearly 300 million,[39] LPG has seemingly penetrated to 100 per cent of the households in the country. While the extent of penetration of LPG for domestic consumption is highly heart-warming, 505 million people—roughly one-third of total households—still reportedly do not have access to clean cooking. According to SDG 7 Tracking Report,[40] 57 per cent of India's rural population had access to clean cooking while 93 per cent did in urban areas in 2021. The discrepancy in data, claim and information requires further research.[41] This observation implies significant deviation from the premise of one household, one connection.

Given increasing prices of oil and gas across the globe and the fact that India imports about 84 per cent of its gas needs, this subsidy and import expense is only going to increase. Affordability is one of the prime factors that determine the success of any clean cooking solution, and therefore LPG cannot be the sole clean cooking solution for India in the long term.

Women of the community have been trained in handling operations of biogas and processing vermicompost out of bio-slurry.

In terms of estimated benefits, the project is expected to reduce firewood use from 5.2 kg per day to 1.4 kg per day for every family. This would mean that 462 trees are saved every year. The total reduction of carbon footprint is estimated to be 239,878 tonne per year. The use of the bio-slurry will enhance soil quality and increase total produce. The elimination of indoor smoke could result in a 36 per cent decrease in respiratory disorders, and add 1.7 years to life expectancy. A woman could save up to 70 minutes per day by using biogas as cooking fuel. As a result, the annual income of households could increase by Rs 75,000 (from vermicompost sales).

3

SCOPE OF THE PROBLEM

- DESPITE THE BEST EFFORTS OF THE GOVERNMENT, OVER 56 PER CENT OF HOUSEHOLDS IN RURAL INDIA STILL USE SOME FORM OF BIOMASS TO COOK FOOD.
- THIS RESULTS IN ENVIRONMENTAL PROBLEMS SUCH AS INDOOR AIR POLLUTION, WHICH POSE SERIOUS HEALTH RISKS FOR WOMEN, PRIMARY CAREGIVERS AND UNDERAGE CHILDREN.
- THESE COOKING FUELS ARE ALSO A MAJOR GLOBAL WARMING CHALLENGE, RELEASING CARBON DIOXIDE, METHANE, NITROGEN OXIDE AND GREENHOUSE GASES MORE POTENT THAN CO_2.
- THESE EMISSIONS ARE NOT ACCOUNTED FOR IN THE NATIONAL GHG INVENTORY SUBMITTED TO UNFCCC AS PART OF THE COUNTRY'S CLIMATE PLEDGES.

Pollution and associated health problems

Despite the best efforts of the government, rural India continues to burn highly polluting fuels in traditional inefficient cooking stoves. Over 56 per cent of households in rural India—i.e. around 505 million people—still use wood, charcoal, kerosene, coal, agricultural residue, animal waste or other biomass to cook food.[42, 43, 44]

The resulting indoor air pollution in rural households poses serious health risks for women who do the cooking and are the primary food preparers in India, as well as underage children who accompany them during their household activities. They are the silent victims of the adverse effects of using these fuels.[45]

Exposure to long-term air pollution is the fourth leading cause of death globally after high blood pressure, dietary risks and tobacco use. Death from exposure to long-term air pollution accounts for almost 7 million deaths annually. Its impact exceeds even those of high cholesterol and malnutrition put together. In India alone, over 1.6 million people die every year because of it.[46] A study done by the Air Quality Life Index (AQLI), produced by the Energy Policy Institute at the University of Chicago (EPIC), says that air pollution has reduced the life expectancy of Indians by five years,[47] and is comparable to that of smoking. It is three times more harmful to humans than alcohol use or unsafe water, six times more harmful than HIV/AIDS, and 89 times than conflict and terrorism.[48] In the capital's Delhi-NCR region, which regularly faces air pollution concerns due to traffic and stubble burning by neighbouring states, data from 2019 pointed to a reduced life expectancy of 10.7 years per resident due to air pollution.

Air pollution is catastrophic to human health, leading to multiple chronic as well as long-term health effects like cardiovascular diseases (CVD), lung cancer, respiratory illnesses (such as pneumonia), stroke, type 2 diabetes, cataract and a range of neonatal diseases such as low birth weight and preterm birth.[49, 50] Children are especially vulnerable when it comes to the ill effects of exposure to air pollution; studies indicate that they are prone to developing chronic respiratory illnesses such as asthma, bronchitis, impaired lung function development, impaired growth in brain size, and other developmental impairments caused by or related to exposure to air pollution.[51]

To compound problems, indoor air pollution, a direct result of burning any biomass or kerosene for cooking, lighting or heating purposes indoors, is far more hazardous than air pollution outdoors. This is because of factors such as close proximity that users have to maintain to the burning fuel (while cooking,

for instance), and inadequate ventilation that is prevalent in most rural Indian households (especially in winters in northern parts of India). This means that even with little to modest emission levels, the actual exposure to the pollution is significantly high, leading to higher rates of disease burden and lives lost or negatively affected.[52, 53, 54] In fact, indoor air pollution causes around 3 million premature deaths every year in the world—which is almost half of the total deaths attributed to air pollution at around seven million lives lost each year. Of these, over 200,000 lives were that of children under the age of five.[55, 56]

The reasons behind the devastating health problems associated with indoor air pollution are specific types of pollutants released when biomass is burned, especially in an indoor setting. Biomass burning releases carbon dioxide (CO_2), carbon monoxide (CO), nitrous oxides (NOx), sulphur oxides (SO) (principally from coal), formaldehyde, and an especially dangerous group of chemicals called polycyclic aromatic hydrocarbons (PAH), including phenanthrene, fluoranthene, pyrene, chrysene and known carcinogens such as benzo[a]pyrene (BaP).[57, 58]

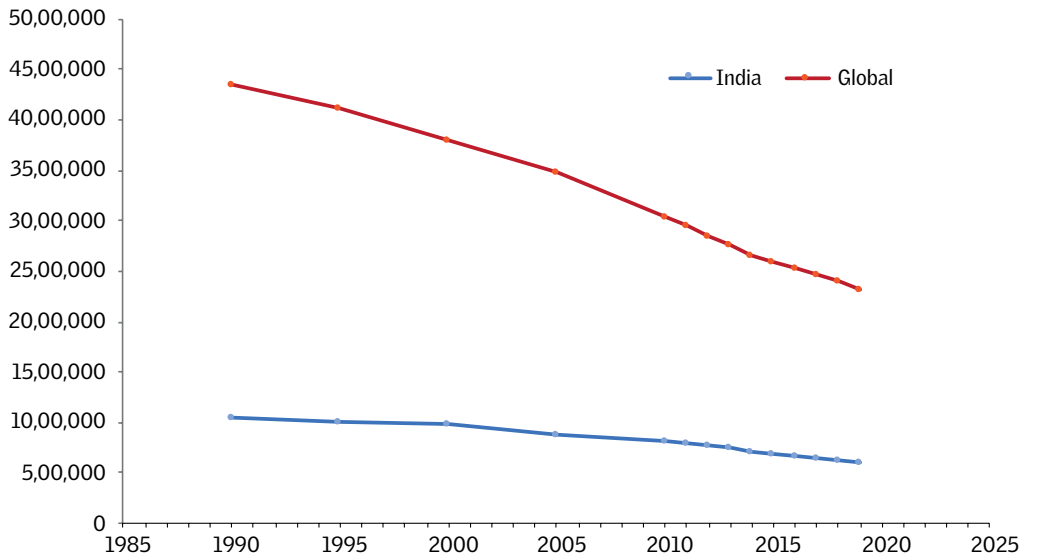
The International Agency for Research on Cancer (IARC) classifies BaP as a Group 1 carcinogen, which is the most dangerous kind of rating given by the agency. This rating essentially means that there is enough incriminating evidence present to conclude that a substance causes cancer in humans. IARC estimates that the lifetime risk of lung cancer increases by about 10–20 per cent for every one nano-gm/m^3 increase in BaP exposure in ambient air. Studies have shown that BaP concentrations in indoor air can be significantly elevated in households that use biomass for cooking—anywhere between 0.5 and 130 ng/m^3, with an average concentration found to be around 8.1 ng/m^3. However, concentrations varied widely across different households and cooking practices, with some households having BaP concentrations exceeding 50 ng/m^3.[59] Concentrations are even higher during cooking hours and usually decrease after cooking is completed, unless the houses are not ventilated, especially during winters, in which case it only exacerbates the effects.

These pollutants not only cause adverse and/or long-term health effects on humans, but also affect future generations through mutations in the affected people's genes. According to the International Programme on Chemical Safety (IPCS) and Inter-organization Programme for the Sound Management of Chemicals (IOMC)—both independent programmes set up by the UNEP, WHO, ILO and other international organizations—genotoxic effects were found in people exposed to PAH, in addition to impacts on their fertility.[60, 61] Burning biomass also releases particulate matter, including PM2.5 and PM10, which can penetrate deeply into lungs and damage human health considerably.[62, 63]

India has seen tremendous economic growth in the past three decades. Most indicators of economic growth are almost always linked to growth in energy access per capita and higher purchasing power parity of the public, which ultimately indicates a higher quality of life. Indoor air pollution (IAP) is a well-documented and widely acknowledged problem globally that finds roots in access and affordability to cleaner fuels and leads to significantly lower quality of life.[64] In other words, IAP is a result, and sometimes also the cause, of poverty and reduced quality of life in many populations.[65, 66] Several countries have taken steps to reduce the severe impacts related to IAP. Sadly, even though globally we have seen a significant decline in deaths and loss of productive life-years (DALYs) related to IAP over the last three decades, India has not progressed at the same rate.[67] (see *Figure 3: Number of deaths attributed to indoor air pollution—global versus India and Figure 4: Disability-adjusted life years (DALYs) attributed to indoor air pollution—global versus India*). Indoor air pollution still causes over half a million premature deaths every year in India—a third of the total deaths attributed to air pollution in the country.[68]

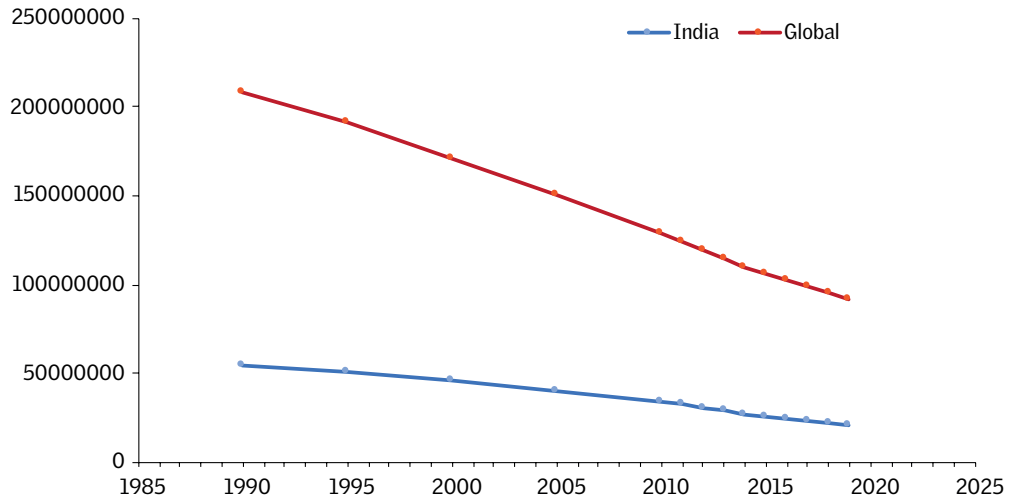
An additional ill-effect of burning polluting fuels for cooking, on top of the adverse effects caused due to inhaling the harmful smoke, is the long-term health impact of ingesting them while eating the food cooked on such fuels. In northern India,

Figure 3: Number of deaths attributed to indoor air pollution—global versus India



Source: State of Global Air, 2020

Figure 4: Disability-adjusted life years (DALYs) attributed to indoor air pollution—global versus India



Source: State of Global Air, 2020

where *roti* (traditional Indian flatbread) is the staple source of carbohydrates, this is a serious but less studied cause of disease and/or even death. The PAH compounds that are released when burning biomass, some of which are known carcinogens (like benzo[a]pyrene), have also been found to be as lethal to health if ingested in toxic quantities.[69] This aspect needs to be researched further in the rural Indian context to assess the additional burden of disease on the country due to burning biomass.

The problem of indoor air pollution is not limited to rural communities that use cooking fuels such as wood, biomass or kerosene. The urban population is also affected by indoor air pollution, albeit by a clean(er) cooking fuel, Liquified Petroleum Gas (LPG).

According to the National Sample Survey Office (NSSO), LPG is the second most popular cooking fuel, used by around 27 per cent of households in India. Kerosene is used by around seven per cent of households, and the remaining eight per cent use other fuels such as natural gas, electricity and biogas.

Household LPG combustion emits air pollutants such as nitrogen dioxide, carbon monoxide, sulphur dioxide, formaldehyde and ozone, which are known to be

associated with multiple adverse health effects in children, including impaired lung function development, asthma, bronchitis, low birth weight and even prenatal and infant mortality.[70, 71] Adverse effects were also noted in adults although more long-term research is needed to fully understand the direct health impacts of gas stove use in different settings, populations and adult age groups.

The climate change problem

The problem with polluting cooking fuels such as biomass and kerosene go beyond their adverse health impacts. When over 120 million households in India burn these fuels every day, twice a day for cooking, it also becomes a major global warming challenge, and an impediment to India achieving its Nationally Determined Contributions (NDCs). In addition to CO_2, inefficient combustion of wood, charcoal, animal dung and crop residues releases methane and nitrogen oxide, greenhouse gases that are more potent than CO_2 and other polluting agents.[72] Moreover, the traditional use of biomass also releases black carbon, commonly known as soot, which is a short- lived aerosol but with a global warming potential 1,500 times that of CO_2. It is estimated that 43 per cent of the global black carbon emissions are from household cooking and/or heating alone.[73]

According to the NFHS-4, polluting fuels are used by around 55 per cent of Indian households, which include mostly rural households (75 per cent) and a small part of urban households (16 per cent). These fuels include a mix of various solid fuels like coal and lignite (1 per cent of the population uses coal), charcoal (0.6 per cent of the population uses charcoal), wood (42 per cent of the population uses wood), straw, shrubs or grass (2.5 per cent of the population uses straw or grass), agricultural crop waste (3 per cent of the population uses this) and animal dung cakes (7.2 per cent of the population uses dung cakes).[74] However, GHG emissions associated with the prevalent use of these fuels is not included in the overall national GHG emissions inventory.[75] Even though India's solid fuel usage had declined to about 41 per cent by the time NFHS-5 (2019–21) was conducted, we have referred to NFHS-4 for comparison because India's last reported GHG emissions inventory (BUR3, 2021) used data from 2016.[76]

The overwhelming majority of polluting fuel users in India use wood, and the emission factors of most of these other fuels is less than wood.[77] According to the IPCC 2006 Guidelines for National GHG Inventories, solid cooking fuel use in households should come under the Residential sector, namely section *1A4b Residential*.[78] Currently, India's BUR3 reports a residential sector emissions contribution of around 7 per cent, or around 180 million tonnes of CO_2. This

does not include emissions from burning wood or other solid fuels for household cooking/heating purposes.

The climate impact of biomass use is not solely the result of combustion during the cooking process. There is an additional strain on the environment due to the effects of household fuelwood use. The current methods of collecting fuel feedstock from forests place a heavy burden on natural assets and also contribute substantially to the overall intensity of the fuel source. For example, traditional use of biomass, where the wood is unsustainably gathered from chopping down trees in forest areas is over seven times more GHG intensive than if the biomass were sustainably harvested alongside practising conservation and replanting programme.[79]

Even though improved cookstoves (ICS) have been distributed amongst rural populations as part of clean cooking programmes in the past, none of these cookstoves have completely cut out black carbon, CH_4 or NO_2 emissions. In fact, they don't even manage to bring the indoor air pollutant exposure levels to below WHO guidelines.[80] Adopting better clean cooking programmes, such as e-cooking solutions for rural India, will not only reduce India's CO_2 emissions, but also reduce black carbon, CH_4 and NO_2 emissions. These cumulative emission and green cover savings will have a positive climate impact for India.

4

POTENTIAL FOR E-COOKING IN INDIA

- INDIA IT IS UNIQUELY POSITIONED TO PUSH ELECTRIC COOKING BECAUSE OF ITS ELECTRICITY-SURPLUS STATUS.
- ALTHOUGH THE INDIAN MARKET FOR E-COOKING IS WELL MATURED, ONLY ABOUT 5 PER CENT OF THE INDIAN POPULATION HAS ADOPTED ANY KIND OF E-COOKING APPLIANCE.
- MULTIPLE DEVICES SUCH AS INDUCTION COOKTOPS, MICROWAVE OVENS AND ELECTRIC RICE COOKERS COMPRISE 60 PER CENT OF THE ELECTRICAL KITCHEN APPLIANCE MARKET IN INDIA.
- IN URBAN AREAS, EVEN HOUSES THAT ADOPTED E-COOKING DID NOT REPLACE THEIR PRIMARY FUEL LPG.

Current status of electrification in India

India's overall energy use varies considerably across states, due to differences in economic and demographic trends, resource availability and industrial profiles. As the country makes progress towards achieving universal household electrification, the use of electricity for cooking and heating is important to national policy towards clean cooking. With its status as electricity surplus, India is uniquely positioned to push electric cooking, with mass deployment of efficient induction cooking technology.[81]

According to National Family Health Survey 2019–2021 (NFHS-5), India reported remarkable progress in achieving near-universal access to electricity in the last half a decade. States in south India and Union Territories were the forerunners in this, with at least 99 per cent of their population having access to electricity. The state of Bihar has also shown phenomenal growth (increase to 96 per cent in 2019–20 from 60 per cent in 2015–16), followed by Assam (92 per cent from 78 per cent). Lakshadweep and Goa were the only two states where 100 per cent of their households had electricity. Also, the rural–urban divide in access to electricity has reduced significantly in all states except Meghalaya, Assam and Gujarat. Except for Meghalaya and Bihar, urban areas of all the surveyed states have almost achieved the SDG Target (SDG 7.1) of universal access to electricity.

Although access to electricity has reached close to 100 per cent, the problem of low electricity rates, poor quality of power and unreliable availability remains a significant challenge in rural India. Additionally, power theft and poor bill collection are also problems in these areas. DISCOMs however, are constrained in their ability to purchase power because of their poor financial health. As a result, they are keener to supply to industrial and commercial consumers who pay the highest tariff rather than improve infrastructure and customer base in rural areas. Moreover, higher tariffs help cross-subsidize the power supplied to residential consumers. This is the reason why industry is prioritized for supply, sometimes even at the expense of load shedding for residential consumers.

Given this current status, e-cooking can become the main alternative to LPG in the coming years. However, concerns around the availability of reliable and quality power needs to be addressed and acknowledged first. If done well, e-cooking presents the unique opportunity to achieve universal targets for both clean cooking as well as access to electricity.

Market for e-cooking devices in India

Although the market for e-cooking appliances is well developed in India—Prestige has been selling induction cooktops since 2008 and the first microwave ovens

appeared in the market in the early 90s—only about 5 per cent of the Indian population has adopted e-cooking till date. The difference is starker between urban and rural geographies. Roughly 10 per cent of the urban population uses some kind of e-cooking device as compared to only about 2.7 per cent of the rural population.[82]

In 2012, the market for small e-cooking appliances in India was valued at approximately Rs 5,500–6,000 crore, showing growth of approximately 25 per cent every year.[83]

There are multiple devices that come under the category of small electric kitchen appliances. Cooking devices such as induction cooktops, microwave ovens and electric rice cookers make up one subcategory. Together, they account for over 60 per cent of the electric kitchen appliance market in India. Food processing devices such as mixers, grinders and juicers are the other popular subcategory and make up the second largest share in electric kitchen appliances in India.

Besides these, other small electric kitchen appliances that are in demand include sandwich makers, toasters, kettles, steamers, grills, choppers, hand blenders, air fryers, grain grinders, waffle makers, coffee makers, egg boilers and roti-makers, among others.

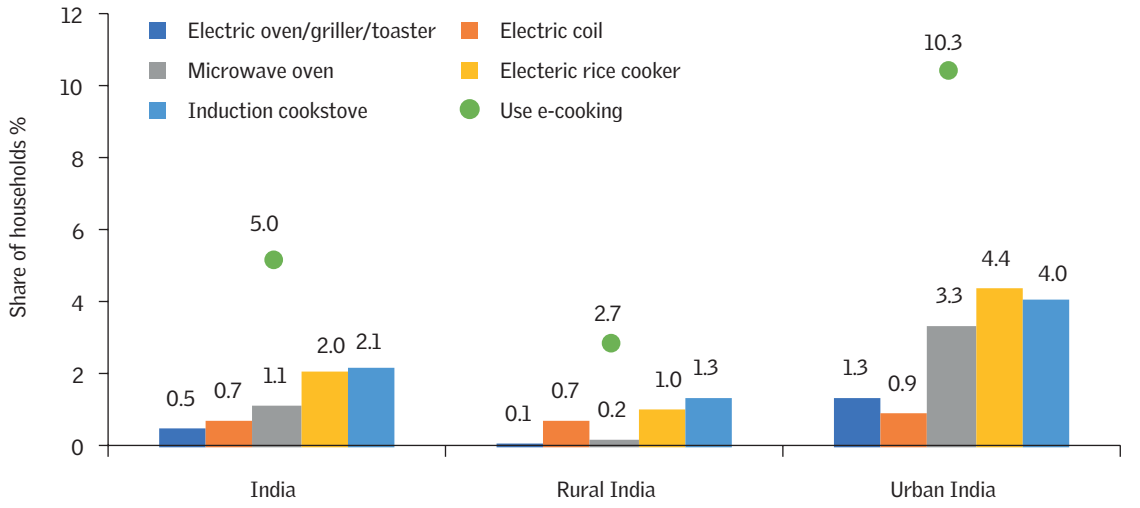
There are currently about 40 major local and international brands available in the Indian market, with TTK Prestige, Bajaj Electricals, Havells and Phillips leading the charge. Other popular brands include Crompton Greaves, Jaipan, Panasonic, Preethi, Morphy Richards, Usha and Wipro.

For the purposes of this paper, we shall focus on induction cooktops and their adoption in India, and the possible challenges in ensuring large-scale adoption across urban and rural geographies.

Induction cooktops are the largest product category within the small electric kitchen appliances category, accounting for approximately 45 per cent of the total demand for electric kitchen appliances. The growth rate for induction cooktops in 2020–25 is estimated to be 15 per cent.[84] When it comes to small electrical cooking appliances, induction cooktops are the most popular appliance as they are currently stocked by 90 per cent of Indian retailers.

Nonetheless, interest in this new way of cooking has been growing exponentially. A survey by GIZ in 2020–21 found that the market for induction cooktops has shown a compounded annual growth rate (CAGR) of 15 per cent year-on-year since 2014, and is expected to grow at a similar pace all the way to 2025.[85]

Figure 5: Adoption rates of e-cooking appliances in India



Source: India Residential Energy Survey (IRES) 2020, Council on Energy, Environment and Water

In India, the market for clean and electric cooking devices is quite limited and is currently mostly dominated by Chinese imports (up to 75 per cent).[86] But well-known Indian companies are progressively taking on the task of manufacturing electric cooking devices, and as a result, the Indian electric cooking market has accounted for around Rs 245 crores in 2020–21.[87, 88]

E-cooking usage across India

As per the Indian Residential Energy Survey (IRES) conducted in 2020, electricity use for cooking remains marginal in Indian homes, with only 5 per cent of households using any electric cooking appliance. As expected, the use of e-cooking is higher in urban India (10 per cent) than in rural areas (3 per cent).[89]

Because information about these appliances is not widely available, urban areas have a much higher prevalence of adoption (10.3 per cent) than rural areas (2.7 per cent). Since e-cooking is not very affordable either, adoption rates were also six times higher amongst the top five wealth deciles than the bottom five.

Unfortunately, both the IRES and the GIZ study found that even in houses that did adopt e-cooking, their primary fuel—which was LPG in this case—was not replaced, but only complemented. Nonetheless, most respondents did say that it was possible that e-cooking could become their primary means of cooking in the future.

5

BARRIERS TO ADOPTION IN INDIA (RURAL AND URBAN)

- E-COOKING HAS GENERALLY BEEN ASSOCIATED WITH WEALTHIER SOCIOECONOMIC SEGMENTS IN INDIA DUE TO APPARENT HIGH COSTS, AWARENESS AND ACCESS.
- BUT ACCORDING TO OUR ESTIMATES, E-COOKING IS CHEAPER TO OWN THAN LPG OVER A PERIOD OF FIVE TO 10 YEARS.
- BANKS AND RURAL NBFCS NEED TO BE WILLING TO TAKE RISKS WITH E-COOKING AS IT NEEDS MORE CAPITAL INVESTMENT FOR THE MANUFACTURING SECTOR AND ADOPTION IN RURAL HOUSEHOLDS.
- THE RECENTLY LAUNCHED NATIONAL EFFICIENT COOKING PROGRAMME BY EESL IS A STEP IN THE RIGHT DIRECTION.

Affordability

Affordability is one of the most critical factors in encouraging adoption of clean cooking solutions in India.[90] Unfortunately, because of apparent high costs and availability issues, electric cooking has been accessible to only the higher socioeconomic classes of people in India, in the recent past.[91]

A typical induction cooktop sold by the most popular brand in India, Prestige, which owns about 60 per cent of the market share,[92] costs around Rs 1,800–4,500 for a single plate model.[93] There is only one double-plate Prestige version in the market that costs over Rs 8,000. A traditional wood burner requires close to zero investment as most rural homes make it out of mud and stone. The cost of an LPG gas stove, with two to four burners on the other hand, can fall within the same range as induction cooktops.

Nonetheless, an induction stove is 5–10 per cent more efficient than conventional electric stoves and about two times more efficient than gas stoves.[94] And unlike the case with gas, it's also better for indoor air quality.[95] A traditional wood burning chulha, on the other hand, has been found on an average, to have only a 15 per cent thermal efficiency. These factors play an important role in determining the cost of ownership of each kind of cooking solution, as we have shown below.

Comparison of total costs of ownership

Given the predominant narrative that cooking with electricity can be expensive, we estimated and compared the costs of ownership of LPG, traditional wood stoves and electric induction cooktops over a period of one year, five years and ten years to get a better understanding. We found that over the course of five years and ten years, the cost of ownership of cooking with electricity was about 20 per cent lower than with LPG, but was comparable to it over the first year. Traditional wood burning cookstove was, as expected, the lowest cost in terms of ownership and usage.

For our estimations, we assumed that, in a typical year, an average Indian household across all geographies would need approximately the same amount of food and the same amount of energy to cook their food no matter what kind of fuel they used. Secondly, we looked at available information on LPG and calculated the amount of energy consumed in LPG cooking in a typical year to estimate the amount of energy needed if other fuels were used, which in this case were wood and electricity. We also included initial costs for each kind of cooking, namely, LPG stove (Rs 1,500), wood burning stove (Rs 200) and double-plate induction cooktop (Rs 4,000); utensil cost of Rs 1,500, Rs 250 and Rs 2,500 for each; and

an LPG connection cost of Rs 1,500. These were all one-time costs that affected one year of TCO.

A typical household in India that relies exclusively on LPG for cooking consumes somewhere between eight to 10 LPG cylinders (of 14.2 kg each) per year. This is equivalent to about 5.2 gigajoules (GJ) of energy. Assuming that the average LPG stove in an Indian household has a thermal efficiency of about 55 per cent, this translates to 2.9 GJ of cooking energy used per household every year. Based on this amount of energy used in LPG stoves, we calculated the amount of energy needed in traditional wood burning stoves and electric induction cooktops, and the costs associated with using them. Based on our calculations, we found that an average Indian household would need about 950 kWh (units) of electricity a year—or around 80 units a month, or around 2.7 units a day. For a household that cooks on a traditional wood stove, which is mostly rural households in India, they would need about 970 kg of wood a year, assuming a thermal efficiency of 15 per cent.

After factoring in initial costs of buying the stove, utensils and connection charges, as well as yearly maintenance for each kind of fuel and stove, at an LPG refill price of Rs 1,100 per cylinder (as of March, 2023),[96] the total cost of ownership (TCO) for LPG was found to be just over Rs 13,000 in the first year of ownership. Surprisingly, the TCO for e-cooking was also just over Rs 13,000 in the first year, assuming a power tariff of Rs 7 per kWh.

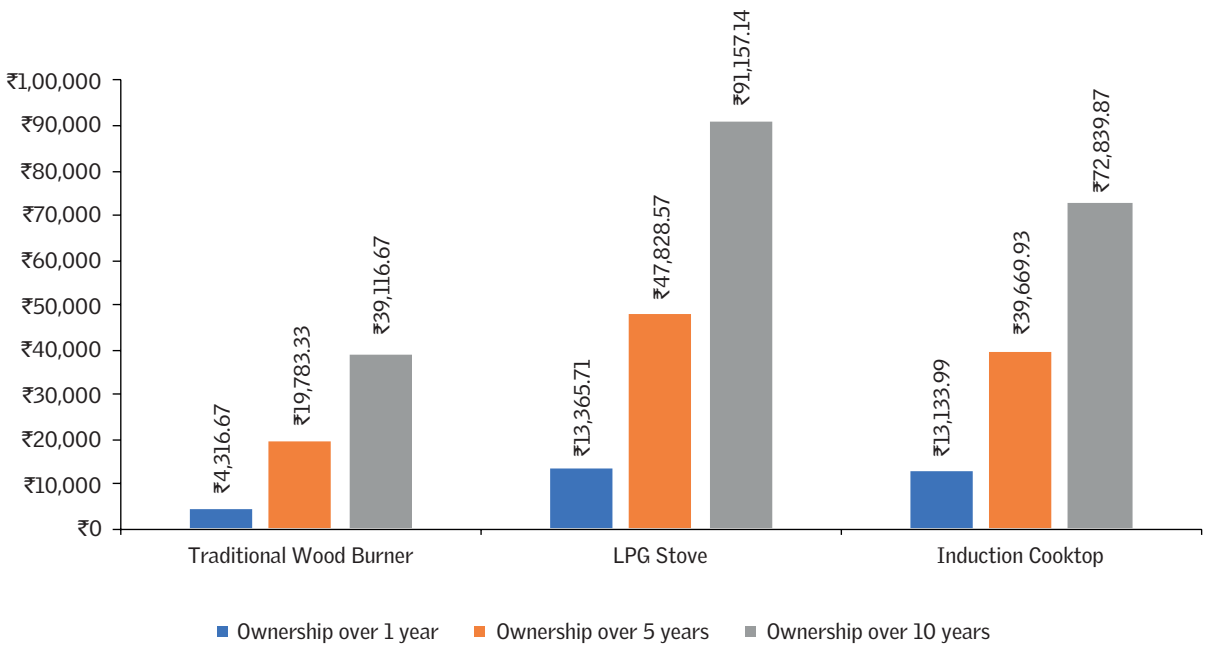
Costs drop significantly as usage continues over time, and e-cooking becomes 17 per cent cheaper than LPG over five years, and over 20 per cent in 10 years. However, it must be kept in mind that these projections have not factored in rising gas prices or inflation.

Financing schemes from PSU banks and other NBFCs

Although multiple government subsidies and financing mechanisms exist for the distribution and adoption of LPG for both rural and urban households, novel clean-cooking solutions like e-cooking have not found any buyers in India's small finance and other NBFC institutions.

Recently, EESL announced a subsidy on the distribution of induction cooktops for approximately 20,000 rural households. Unfortunately, this has not been replicated or adopted by any other government agency till the date of publication of this report.

Figure 6: Comparison of total costs of ownership (TCO) of the three kinds of cooking in India



Source: CSE analysis

Rural customers need subsidies, especially for rural consumers, for both the initial costs of purchase of e-cooking devices and associated utensils, but also in the electricity costs for running these devices on a daily basis. Moreover, if in a rural area the grid is non-existent or unreliable for the purpose of cooking, the government financing mechanisms are critical in the setting up and functioning of mini/micro-grids in villages, which can also be a way to enhance adoption of e-cooking in rural India.

Sociocultural challenges

India has a wide spectrum of sociocultural colours that affect cooking patterns every 40 km or so. Because of this, no one silver bullet solution can solve India's clean cooking problem, and therefore various clean cooking solutions, especially e-cooking solutions that are adapted to the specific sociocultural challenges of each geography and/or community, need to be encouraged by policymakers and industry.

Before we try to push a solution that we think is for the betterment of rural India, we need to make sure that it is caters to the unique needs of the community and is accepted by them easily. Manufacturers, policymakers, practitioners and development organizations need to understand these sociocultural aspects, and design their clean cooking (including e-cooking) solutions keeping this in mind.

Interviews with various stakeholders from the clean cooking field in India have given us an understanding of cultural practices that has presented unique and unexpected challenges to the adoption of clean cooking solution in rural India.

One such example was from a village in south India that had been identified as a potential beneficiary and was set to receive improved cookstoves (ICS) as part of a clean cooking project. The villagers were able and willing to accept improved cookstoves and change their cooking patterns accordingly. However, since the village head refused, the rest of the village did not follow through.

Another example is from another village in south India where upper-caste families did not want lower caste families to benefit from the ICS being distributed.

Access to financial instruments from banks and other financial institutions also plays a crucial part in the acceptance and sustained use of clean cooking solutions. Unfortunately, most banks do not lend for novel solutions or charge high interest rates which discourages poor rural families from adopting these solutions.

Rural to urban migration also plays a lesser known but significant role in the adoption of novel clean cooking solutions in rural India. In rural India, younger generations move to urban areas for job opportunities or studies. This leaves behind only the older generation who are habituated with the traditional modes of cooking and are resistant to switching to cleaner cooking practices. This presents a unique challenge in the adoption of clean cooking solutions as the older generation might find it difficult to adopt new cooking practices or afford expensive solutions.

These factors need to be kept in mind by manufacturers, implementing organizations and policymakers while designing a clean cooking revolution for the country. The clean cooking problem is first a sociocultural problem and only then an economic, public health or climate problem.

Grid complexities

The quality and reliability of power supply in rural India is one of the biggest impediments to the adoption of e-cooking in rural India. Several studies have documented frequent power outages across the country, including in major cities. Even in areas where government reports indicate minimal "deficits", there are power outages.[97]

CSE conducted a webinar to understand the various challenges to the large-scale adoption of e-cooking in India, where the issues related to improving the grid were also discussed. One of the key issues highlighted was the grid complexities of supporting large-scale e-cooking in a sample geography.

GIZ did an assessment of the impact of large-scale e-cooking adoption in urban and rural geographies on the existing grid infrastructure and the kind of mitigation measures that would be needed to support it. They partnered with Tata Power Central Odisha Distribution Limited (TPCODL) to receive data for simulation from the DISCOM for two feeders (urban and rural) based on certain criteria that had been pre-decided. Based on assumptions done to replicate e-cooking adoption, they used this data to simulate the impact an additional e-cooking load would have on the grid in multiple future scenarios and cases.

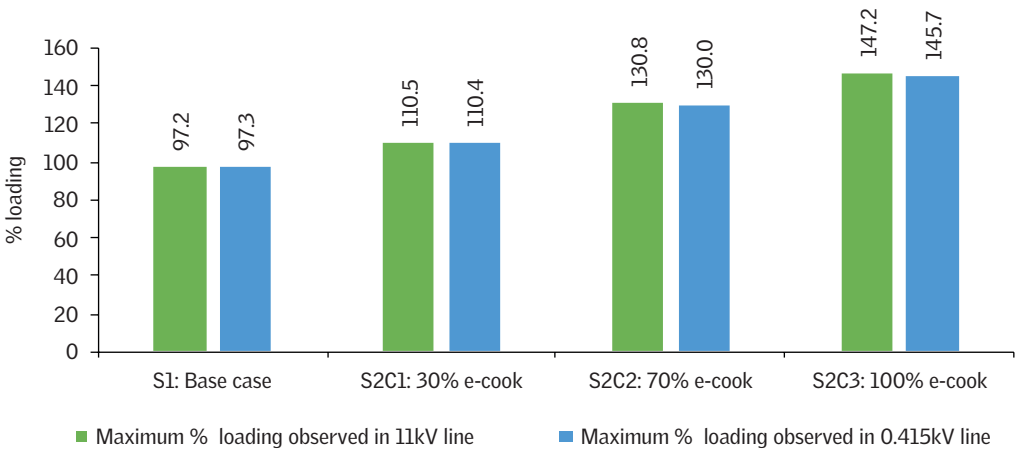
For both feeders, data was collected for the Load Flow Analysis (LFA) and Time Series Load Flow Analysis of a High Tension (HT) network (11 kV) up to the grid substation. The load profiles were constructed using fifteen-minute interval load data collected over four months. Load profiles were also extrapolated for a 0.415 kV Low Tension (LT) network where the data was not available. Based on existing research literature, GIZ also calculated that a typical household would consume around 4 kWh of energy a day (based on 8–10 LPG cylinders consumed annually per household) and that maximum power consumption would not exceed 2.67 MW for urban geographies.

One of the scenarios they modelled has been illustrated below:
Base load profile + e-cooking:
Case 1: Base load + 30 per cent of e-cooking, after 5 years
Case 2: Base load + 70 per cent of e-cooking load, after 10 years
Case 3: Base load + 100 per cent of e-cooking load, after 15 years

The following are the general findings and recommendations from the study:

- **Urban feeders** are almost fully loaded (current base load at 97 per cent per

Figure 7: Maximum projected loading of grid



Source: GIZ

cent) and do **not have much potential** to accommodate additional loads that will result from e-cooking adoption in the future.

- **Peri-urban/rural feeders** are not fully loaded and do have the potential to **accommodate the additional e-cooking load** at the feeder level.

- Peak load and losses will increase, overloading of the lines, dropping of tail end voltage of distributed transformers (DT).

- Potential of measure for additional load
  - **Solar PV**: Peak load and line loading reduction if peak usage coincides with solar generation hours, improvement of tail end bus voltages
  - **Storage**: Peak load reduction possible during battery discharging period, reduction in line loadings
  - **Demand-side management** (**DSM**): Peak demand shifting to off-peak hours will result in peak load and line reduction

- Additional e-cooking load offers potential financial benefits to DISCOMs.

Our own analysis indicates that 100 per cent penetration of e-cooking in India would lead to an additional peak power demand of about 320 GW, of which 75 per cent can be managed through a robust load management framework and the rest 25 per cent would need to be added on top of existing power capacity, to the tune of 80 GW over a period of 16 years. This also implies the need for strengthening the transmission and distribution infrastructure to manage the additional peak power demand.

In an ideal scenario, the additional demand can be met through distributed renewable energy generation using mini- or micro-grids at the local level, with local resources.

Considering 200 million rural households residing in about 6.5 lakh villages in India, an average village size is around 300 households. Mini- and/or micro-grids at the village level can be instrumental in meeting this electricity demand of 900 kWh per day per village in rural India solely for e-cooking. This can be done with a solar PV mini-grid of capacity of around 325 kWp and an energy storage system of appropriate capacity built in, in addition to other energy needs for the village. Since electrification has been achieved almost 100 per cent in India, this mini-grid can also be integrated into the grid, and the storage system can be built into the distribution network, thereby reducing CapEx costs.

If the cost of generation is Rs 5 per unit from a solar PV mini-grid and if the tariff can be subsidized/cross-subsidized by even 50 per cent, each household will only have to incur approximately Rs 3,000 per year for e-cooking.

6

STAKEHOLDER MAPPING AND ANALYSIS

- E-COOKING NEEDS STAKEHOLDERS FROM A WIDE ARRAY OF EXPERTISE TO WORK TOGETHER.
- TO UNDERSTAND THE ROLE OF EACH STAKEHOLDER AND THE VALUE CHAIN, WE MAPPED THEIR ROLES AND LINKAGES FOR THE SUCCESS OF THE E-COOKING INITIATIVE.
- A RELEVANT MINISTRY/GOVERNMENT DEPARTMENT NEEDS TO BE GIVEN CHARGE OF E-COOKING.
- INDIA NEEDS INDIGENOUS RESEARCH AND DEVELOPEMENT TO DEVELOP LOCALLY RELEVANT AND AFFORDABLE E-COOKING SOLUTIONS THAT ARE LOW ON POWER AND MAINTENANCE.
- ANY E-COOKING CAMPAIGN NEEDS BEHAVIOUR CHANGE TO BE A CRITICAL PART OF IT AS INDIA'S CULTURAL CONTEXT PRESENTS A BIG CHALLENGE.
- RECYCLING NEEDS TO BE INCLUDED IN THE E-COOKING ROADMAP TO MAKE THE WHOLE VALUE CHAIN CIRCULAR.

The complex and large spectrum of issues that are related to e-cooking that need to be solved for large-scale e-cooking adoption, especially for rural areas, need all relevant stakeholders from a wide array of expertise to work together towards this single cause. Therefore, it is essential to understand the role and contribution of each stakeholder along the value chain. This chapter attempts to map the various stakeholders and understand their roles in the success of the e-cooking initiative.

CSE deliberated with various stakeholders to understand and comprehensively map their interlinkages and their criticality to the success of e-cooking adoption in India.

In this exercise, we laid out all cross-functional stakeholders of the e-cooking sector in one place. The main benefit was to get a visual representation of all decision-makers/influencers who could impact e-cooking adoption in India, understand how they were connected to each other and how they could benefit themselves from the adoption of e-cooking. A scoring system was developed to categorize each stakeholder's importance to large-scale e-cooking adoption and each was scored on the basis of:

- Criticality to the success of the programme;
- Investment potential of the programme;
- Scale of influence over the programme;
- Scale of influence on other stakeholders to get their buy-in; and
- Alignment with their values and end-goals (including climate goals, energy goals, etc.).

All stakeholders have different roles to play at various stages of the programme. We have categorized the e-cooking programme into the following six stages throughout the adoption timeline of e-cooking in India:

- Research and development;
- Awareness building/behaviour change campaigns;
- Pilot/testing phase of new products;
- Manufacturing/importing and distribution/retail of e-cooking devices;
- Adoption/use and maintenance amongst urban and rural geographies; and
- Recycling such devices.

(see *Table 1: Stakeholder mapping and scoring* and *Figure 9: Impact analysis of components for promotion of e-cooking*).

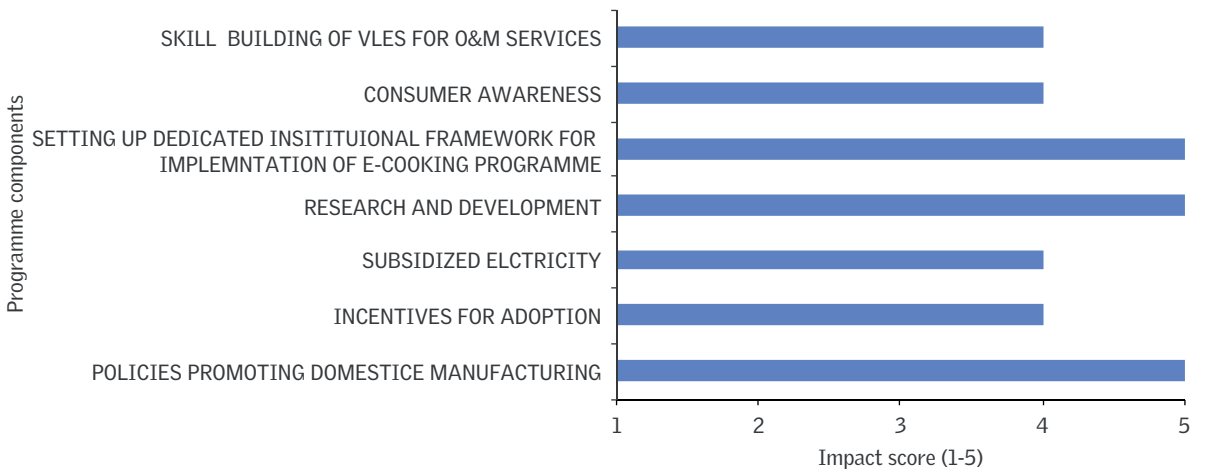
Table 1: Stakeholder mapping and scoring

Type of stakeholder	Stakeholders/role	Level of influence#	Level of interest^
Consumer			
Rural households	Adoption/usage	3	2
Urban households	Adoption/usage	3	5
Offices	Adoption/usage	1	3
Malls	Adoption/usage	1	2
Restaurants/dhabas	Adoption/usage	2	5
Hotels	Adoption/usage	2	4
Hospitals	Adoption/usage	1	1
Government entities			
MNRE/SNAs	Policies, incentives, implementation and monitoring	10	10
BEE	Pilot project, R&D, standards, labelling	8	8
EESL	Demand aggregation, procurement	9	10
Department of science and technology	Technical recommendations, r&d	7	4
MoP	Access to affordable electricity	10	9
MoRD	Awareness, implementation and consumer support	9	9
MoPNG	LPG distribution infrastructure can be clubbed with the distribution of e-cooking components and services	7	7
MoEFCC		7	10
Local administration/governance	Implementation of program, distribution of devices, monitoring usage, behaviour change campaigns		
Financial institutions (national/international/development FIS, NBFCs)			
World Bank	Technical and financial assistance for further studies Consumer finance Corporate finance	4	6
ADB		3	6
MECS		4	9
PSU banks			
Private banks			
Small finance banks		7	2
NBFCs		6	3
NABARD		6	3
SIDBI		6	3
PSUs/private businesses			
DISCOMs	Reliable and affordable access to electricity to consumers	6	3
OEMs	Manufacturing, distribution, R&D, O&M, recycling, awareness, training/skill building	10	5

Type of stakeholder	Stakeholders/role	Level of influence#	Level of interest^
IOCL (Indane)	Customer identification, acquisition and services	7	7
HPCL (Bharatgas)	Customer identification, acquisition and services	7	7
Retailers	Customer identification, acquisition and services	9	5
Authorized service centres	Customer identification, acquisition and services	8	5
Third-party service centres	Customer identification, acquisition and services	7	5
Authorised e-waste recyclers	Collection and recycling	7	7
NGOs/CBOs	Awareness and behaviour change campaigns, skill training		
Other Institutions			
IITs/ universities	R&D	5	5
CSIR	R&D	6	4

Source: CSE analysis

Figure 8: Impact analysis of components for promotion of e-cooking



Source: CSE analysis

Research and development

India needs a robust local manufacturing environment to enable faster, wider adoption of e-cooking devices in India. For this to happen, we need indigenous research for developing e-cooking innovations that are more suited to the Indian context, especially the rural context where cooking is done in much larger pots than is possible on current induction tops available in the market. We also need innovations that will lower both the costs of the device and the power requirements of induction tops and other e-cooking devices. Our rural geographies do not have the capability of supporting high wattage devices for households or the affordability for these devices.

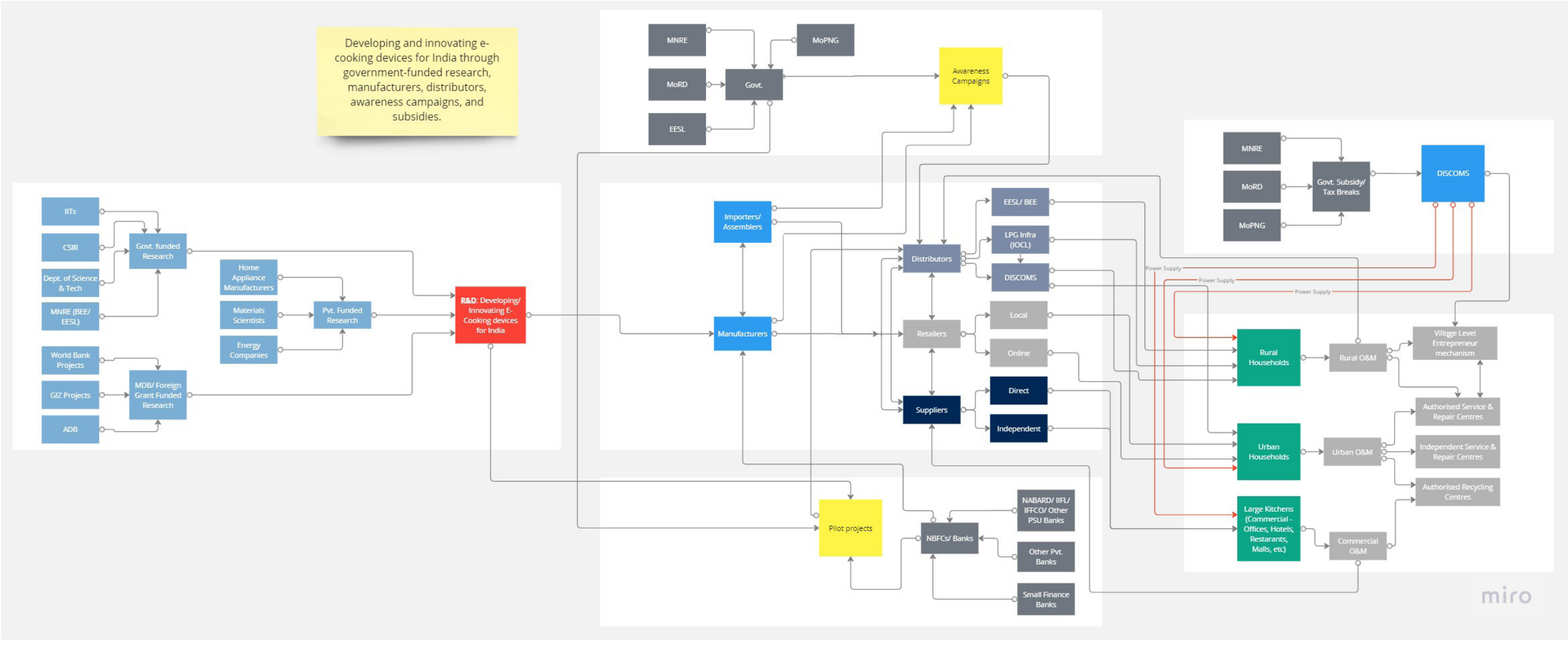
- This cannot happen unless the government steps in to encourage research in this field. Directing new funding into the centrally funded Council of Scientific and Industrial Research (CSIR) organizations is a first step. We also need encouragement from other premier **government-funded research institutions** in the country, including:

  a. Any/all of the IITs
  b. IISC Bangalore
  c. Indian Institute of Petroleum, Dehradun
  d. DRDO (for developing portable, sustainable cooking solutions for defence personnel in extreme conditions)
  e. Central Glass and Ceramic Research Institute, Kolkata
  f. Central Food Technological Research Institute, Mysore
  g. National Environmental Engineering Research Institute, Nagpur
  h. Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore
  i. Central Electrochemical Research Institute, Tamil Nadu

- Apart from this, research inputs from the **private sector** is significant for the success of locally relevant e-cooking devices. A prime example is Indian Oil Corporation Limited (IOCL), which has invested in developing an electric cooking system called *Surya Nutan*. This solar PV-connected and thermal battery-operated e-cooking system relies on heating up the proprietary alloy thermal battery that retains its heat for up to seven hours in the insulated box. Such solutions can be useful to the Indian context. However, the high price of the product—a single stove option costs around Rs 15,000—makes the product unviable for rural geographies unless the government offers steep subsidies.

- **International funding organizations or Multilateral Development Banks** can also be a useful way to encourage e-cooking in India over the long term.

Figure 9: Stakeholder map showing the major stakeholders who play a part in the adoption of e-cooking in India and how they link with each other while e-cooking adoption becomes more prevalent



Organizations like GIZ are already working in India on the subject of e-cooking and their presence can lead to opportunities to better understand the market as well as the policy frameworks required to encourage the adoption of e-cooking in India.

All three groups of stakeholders will play a critical role in the innovation stage of e-cooking, and will be needed to be brought in for varying degrees of investment, for the success of developing locally relevant and affordable e-cooking solutions.

Awareness building and behaviour change campaigns

Along with research and development, the country also needs dedicated campaigns for awareness building and behaviour change at the national scale. These can be similar to previous national-level campaigns such as the LPG schemes of the 1980s, 1990s and 2000s, the Bachat Lamp Yojna, run by the Bureau of Energy Efficiency (BEE), and the UJALA campaign by EESL.

These campaigns need to be driven primarily by government entities such as the Ministry of New and Renewable Energy (MNRE), BEE, Energy Efficiency Services Ltd (EESL), Ministry of Rural Development (MoRD), and the Ministry of Power (MoP) since the switch to e-cooking is most relevant to these particular ministries.

The private sector can also play a role in such campaigns. Running advertisements about the benefits of e-cooking, such as cost savings and other benefits, over biomass burning and LPG will encourage the sale of e-cooking devices across the country. However, the private sector will get involved only when they find it financially lucrative to invest in marketing and advertising campaigns, which is directly related to increased sales. Currently, we don't see focussed advertising related to e-cooking (especially induction cooking) as all the products available in the market are only single top devices that are meant for either single users or as additional cooking device for larger families.[98]

Pilot phase

Once locally relevant e-cooking devices are developed in the country, pilot projects will need to be run in various settings in order to determine the usage trends and patterns among Indian consumers, especially in the rural context. The feedback from these pilot projects will be required for developing the devices further.

1. Such pilot projects can be run by either the above-mentioned government entities, i.e.:
    - MNRE
    - MoP
    - BEE
    - EESL (e.g. The induction cooktop subsidy and distribution announced for 20,000 rural households in July 2023)

Or by

2. International development agencies/ MDBs; and
3. Partially/ fully private agencies, e.g. IOCL's pilot testing of 50 Surya Nutan e-cookers across India before its widespread launch and sale.

Manufacturing, importing and distribution, and retail

All the above three stages of the e-cooking adoption programme will eventually feed into encouraging local manufacturing and retail of e-cooking devices, especially induction cooktops developed for rural contexts. For urban areas, the following three stakeholders will be relevant:

- Urban retail outlets;
- Online retail outlets; and
- OEMs/commercial suppliers for supply to large kitchens, restaurants, hotels or malls.

For rural areas, there will need to be a mix of
- Private retailers;
- Government entities (such as BEE, EESL);
- Existing LPG distribution networks (such as Indane/Bharatgas distributors); and
- DISCOMs

Most or all of these distribution mechanisms will need to be coupled with some form of subsidy or finance scheme so that the adoption is consistent and widespread in rural households. For example, DISCOMs can take up free distribution of induction cooktops amongst rural households which will, in turn, lead to higher electricity consumption and therefore, higher incomes for them. Alternatively, DISCOMs can also adopt equated monthly payment mechanisms that are built into monthly electricity bills.

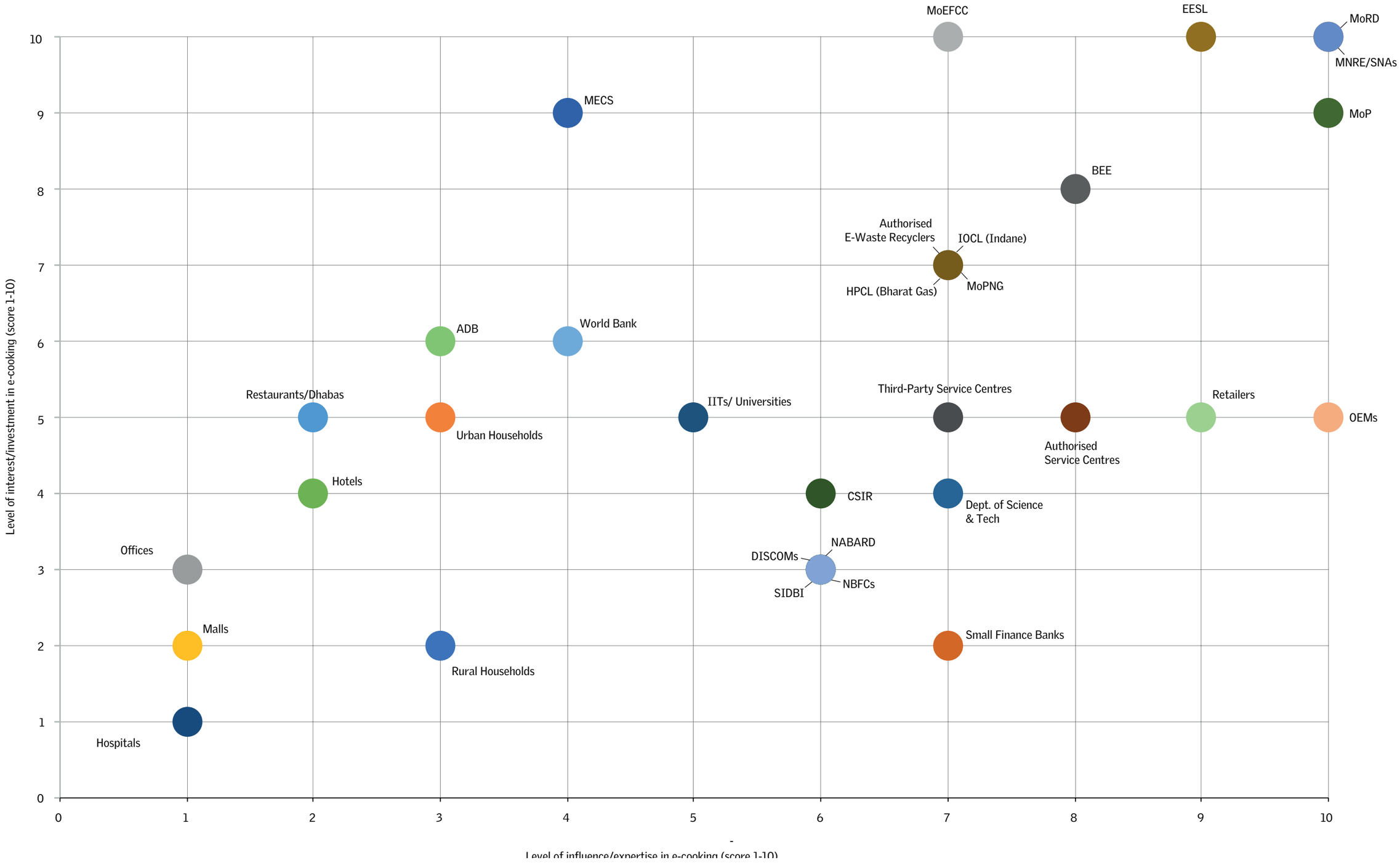
Adoption, use and maintenance

This report foresees the adoption of e-cooking in mainly the following three kinds of consumers in the long-term:
- Rural households;
- Urban households; and
- Large kitchens (commercial establishments like hotels, restaurants, mall, offices, etc.)

All of these three entities will need a separate strategy for not only encouraging adoption, but also maintenance of such devices. Urban households can be easily connected to service networks set up by OEMs or third-party servicers. This will also be a source of job creation in this new sector since e-cooking devices, like any other small electrical home appliance, needs maintenance and repair from time to time.

Rural households will need a different strategy for encouraging usage and maintenance. The government will have to provide tariff subsidies that DISCOMs can give to rural consumers. If, in the future, peak tariff policies come into place, then the government can also encourage the adoption of smart metering

Figure 10: Stakeholder scoring by level of influence and level of interest



Source: CSE analysis

in partnership with DISCOMs so that the energy consumed by cooking devices can be viable for subsidy. For maintenance/repair of the devices, a multipronged strategy needs to be adopted, including:

- Setting up dedicated service centres by OEMs in rural areas.

- Training and capacity building of rural population so that household repairs can be done locally and cheaply. This training can either be done by the government or by the private sector by setting up dedicated training facilities for rural populations or by including e-cooking repair/maintenance in existing ITM academies.

- Leveraging LPG distribution chains and power substations as service facilities too. These places can become hubs for rural consumers to bring their appliances for repair maintenance, as well as centres from which trained personnel can visit households regularly for the upkeep of their devices (much in the same way as gas stove technicians visit check pipe leaks and stove maintenance; or like DISCOM personnel visit homes to check bills or metres)

Recycling

A less talked about but important factor that needs to be taken into consideration, even at this early stage, is recycling. Currently, India does not have any dedicated policy for e-cooking device recycling, and such devices fall under the E-Waste (Management) Rules of the country.

Thus, India first needs to develop a policy for recycling such devices, as well as put forth a roadmap for ensuring closed loop circularity in the e-cooking space.

The whole point of encouraging e-cooking is that India weans itself off polluting biomass or fossil fuels, reduces its GHG emissions and improves environmental and public health outcomes. This will be thwarted if, in the future, 300 million households start discarding their devices indiscriminately after use. The country's manufacturing environment also needs to be prepped so that they can, even at this early stage, put in mechanisms to include end-of-life e-cooking devices in their supply chains.

1. For urban areas, the existing service centres or India's approved e-waste recyclers can act as drop-off points for discarded household e-cooking devices. This can only happen if the e-waste management rules are enforced better.

2. For large commercial kitchens, the government must mandate circularity and proper recycling with penalty for non-conformers.

For rural areas, this is still an open question. The answer to this can lie in setting up dedicated e-cooking device waste collection centres in rural areas or by holding collection drives regularly. Both these options cannot succeed unless a robust supply chain is built into the e-cooking device environment that can ensure ensure that end-of-life devices are brought back into the recycling loop and precious metals are fed back into the manufacturing supply chain in India.

7

THE WAY FORWARD

- INDIA CANNOT ACHIEVE ITS NET-ZERO TARGET BY 2070 UNLESS IT TRANSITIONS 100 PER CENT TO E-COOKING.
- THIS UPHILL TASK, NEEDING AT LEAST 200 MILLION RURAL HOUSEHOLDS TO MAKE THE SWITCH, CAN BE ACHIEVED IN A PHASED MANNER.
- CONSISTENT GROWTH OF 30–50 PER CENT OVER 22 YEARS CAN ACHIEVE 100 PER CENT SUCCESS EVEN IF THE STARTING BASE IS AS LOW AS 0.1 PER CENT OF THE POPULATION.
- THE HIGH COST OF DEVICES AND ELECTRICITY TARIFFS WILL NEED SUBSIDIES TO THE TUNE OF Rs 47,000 CRORE AND Rs 4.30 LAKH CRORE RESPECTIVELY. BUT LPG SUBSIDY AND IMPORT BILL SAVED WILL BE ABOUT Rs 25–65 LAKH CRORE.
- THE PROBLEM OF CLEAN COOKING IS A SOCIAL PROBLEM FIRST, AND A CLIMATE PROBLEM SECOND, AND POLICYMAKERS NEED TO APPROACH IT AS SUCH.

India needs a clean, safe, affordable and sustainable cooking fuel option that is widely adopted by both rural and urban households, with rural penetration being the focus of policymakers and decision-makers. Rural India is both the main source of the problem of polluting cooking fuels, and also, the most impacted by it. Under the popular climate-centric narratives that underpin the iterated shift to clean cooking, the rural poor have because of biomass use been traditionally painted as perpetrators of household pollution rather than the victims of political, economic and social marginalization that leaves them with no other choice when it comes to fuel options.[99]

Policymakers need to therefore focus their resources and attention on this part of India first. This is where the chunk of emissions, health problems and energy poverty lie and therefore it needs the most urgent attention. The urban population already has access to relatively cleaner cooking fuels and higher per capita energy access, and will continue to switch to even cleaner e-cooking in the future as costs of devices and usage drop further and LPG/PNG prices keep rising.

Proposed roadmap

Aggressive, moderate and low growth scenarios

Our indicative analysis suggests that e-cooking can achieve 100 per cent penetration with regard to rural households in 16 years if a year-on-year coverage increment of 50 per cent (aggressive roadmap) is adopted by the country. In such a scenario, in the base year of 2024, a coverage of only 0.1 per cent (200,000) of total rural households is needed. Thereafter, each year, adding 50 per cent of the preceding year coverage annually, will help reach 100 per cent coverage before the end of 2039.

A more granular breakdown of this roadmap at state, district and village level shows the feasibility of e-cooking penetration more clearly.

At the state level, all three growth projections that we modelled, need to start with covering only an average 5,500 rural households per state or Union Territory in the first year. At a district level, every district (considering a total of 766) only requires about 260 rural households to adopt e-cooking in the first year. This number needs to increase by 1.5 times every year, ultimately reaching 115,000 rural households in the sixteenth year in the aggressive growth trajectory that we modelled.

At the village level, the roadmap is even more achievable. Only one household in every third village will need to be connected to e-cooking in the first year; one

household in every two villages in the second year; one household per village in the fourth year; and 50 per cent added annually thereafter to reach all households in all villages by the sixteenth year. Similarly, a moderate growth trajectory with 40 per cent year-on-year growth can result in 100 per cent penetration in 18 years; and the lowest growth path with 30 per cent year-on-year addition will take 22 years to cover all rural households. This implies that the e-cooking programme needs to be rolled out immediately to reach full coverage before 2047 even with the slowest transition roadmap among the three scenarios.

Subsidies

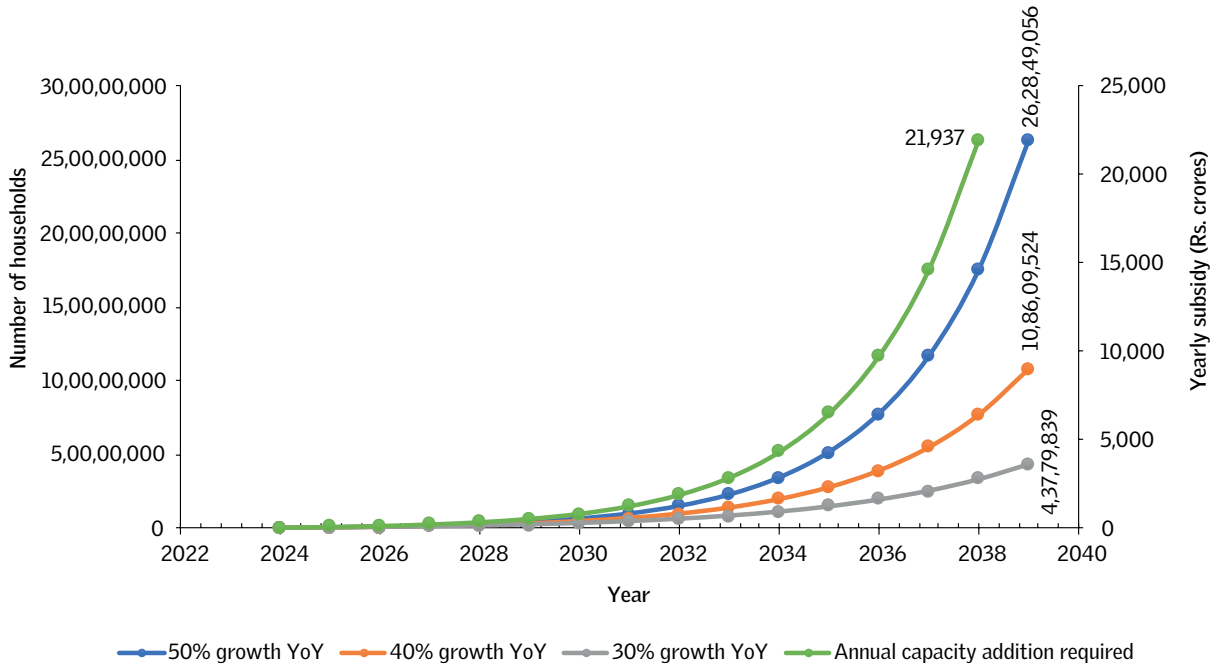
Needless to mention, the programme would require a huge investment and expenditure from the government as well as the private sector. According to our modelled projections, a conservative estimate suggests that the aggressive scenario will require a capital subsidy of at least Rs 47,000 crore over 16 years towards a 30 per cent subsidy on the initial cost of e-cooking devices and compatible utensils (basic utensils required for cooking). This comes to a subsidy of Rs 1,800 per household, and will be a one-time subsidy offered at the start. However, the size and share of subsidy may reduce during the implementation period because of price drops in e-cooking devices due to economies of scale and market innovations.

Additionally, because of the high demand for power needed for e-cooking, the electricity for e-cooking can be anticipated to be very expensive. Therefore, in order to encourage adoption and continued usage of e-cookstoves, a fair amount of subsidy on electricity should also be provided to rural consumers. Considering a 50 per cent electricity subsidy provided to consumers in the first year of connection, about Rs 86,000 crore will have to be spent over 16 years cumulatively. If the subsidy is continued for four more years, it would cost the exchequer a sum of Rs. 4.30 lakh crore for 100 per cent penetration of e-cooking in the sixteenth year. As mentioned in this report, this should be viewed from the perspective of increasing gas import bills for India and the LPG subsidies that have been doled out in the past 30 odd years cumulatively, which far exceed the subsidies needed for e-cooking in the next 16–22 years. For example, in India, subsidies on LPG amounted to Rs 2.5 lakh crore (US $36 billion) over just nine years (2009–2018).[100]

Improving and decarbonizing the grid

This report does not aim to present the grid complexities and associated economic implications in details with regard to the overall improvement in infrastructure for electricity distribution, capacity addition and power generation required to meet the electricity demand from e-cooking. Indicatively, however, according to our projections, it is estimated that a 100 per cent penetration of e-cooking with

Figure 11: Phasing the e-cooking achievement



Source: CSE analysis

any of the three growth scenarios will present a peak electricity demand of about 320 GW for 100 per cent rural coverage. Of this, 75 per cent can be managed with adequate load scheduling and demand management while an additional capacity of 80 GW would be needed to meet the remaining 25 per cent of the peak demand for over a period of 16–22 years, beginning with a capacity addition of 75 MW in the first year, 113 MW in the second year, 169 MW in the third year and so on until the sixteenth year.

Moreover, India's current power generation is mainly from coal-fired thermal power plants, which renders any transition to e-cooking moot if the grid itself is not decarbonized. Currently, according to the Central Electricity Authority's CO2 Baseline report, every unit (kWh) of electricity generated in India produces on average (weighted average) 0.960 kg of CO2e.[101] Therefore, any e-cooking roadmap is incomplete without also including a roadmap to decarbonize India's power sector fully. Since the scheduled times for cooking during the day is almost always around current peak electricity use hours, and since renewable energy sources are intermittent, this roadmap also needs to include energy storage systems like Battery Energy Storage Systems (BESS) at the utility scale or small-scale pumped hydro, or other similar storage systems. The grid, in its present

state, cannot support 100 per cent e-cooking in 100 per cent of India's households unless capacity is increased and energy storage is included. Detailed roadmaps for strengthening and/or decarbonizing the Indian power sector are beyond the scope of this report and therefore any e-cooking programme designed in the near future needs to take this aspect in consideration too.

Institutional framework

The success of any goal or project is only possible with good leadership and accountability. Unless there is someone responsible for the success of the project, no one can be held accountable for its failure.

As elaborated in the stakeholder mapping and analysis, there are various government entities that have differing levels of experience and expertise in implementing aspects of the e-cooking programme as well as varying levels of investment in it. No one entity in India has been successful in large-scale adoption of e-cooking, whether private or government. Therefore, the government needs to carefully decide which ministry or department needs to be charged with implementing e-cooking in India.

Our recommendation, according to our analysis, is that a relevant ministry should be charged with leading the e-cooking transition for rural and urban India.

Having said this, one thing to keep in mind is that any entity that is given the charge to lead e-cooking in India will not be able to succeed unless a variety of ministries, state departments, private entities and development organizations come together and work in tandem. The scope of the problem and the varying levels of solutions needed make it a gargantuan task, no doubt, but possible if the right entity is at the helm of the boat. This ministry or department will have to coordinate with multiple ministries to ensure each aspect, at various stages, is implemented smoothly. For example, the Ministry of Power (MoP) and state DISCOMs will have to be consulted regularly for improving and strengthening the grid wherever e-cooktops are being distributed. MoPNG and national OMCs will have to be consulted for using their LPG distribution network for e-cooking device distribution and maintenance.

Community and women's involvement

Last but not the least, the community needs to be involved from the start in distribution and monitoring mechanisms. Since the primary users of any such solution in rural India are women, solutions need to cater to their needs, both in terms of technology as well as policy.

For long, India's cooking fuel pollution has been viewed from the perspective of reducing GHG emissions and long-term health impacts, and improving the GDP of the state. Perhaps, future clean-cooking technologies, schemes and policy mandates need to be developed keeping in mind the end-user of those solutions, vis-à-vis the rural household, particularly rural Indian women.

For cleaner energy solutions to succeed, the emphasis needs to shift towards empowering the rural Indian woman first. These solutions should not limit her in terms of her available choices, her independence in the kitchen and her autonomy in conducting her daily household affairs. The issues of pollution control, reducing adverse health impacts and climate change need to come second in the agenda of policymakers and policy deliberators, even if it seems counterintuitive.

The problem of clean cooking is a social issue first and a climate issue second, and policymakers need to approach it from such a perspective. The Ministry of Rural Development (MoRD) needs to lead behaviour change campaigns aimed at encouraging e-cooking use and outlining the benefits as opposed to the cons clearly in the campaigns.

8

RECOMMENDATIONS

To promote electric cooking adoption in India, the following are the recommended next steps:

1. Assign a ministry/department to steer adoption of e-cooking in India or set up a new division under an existing ministry.

2. Improve the grid capability (in both urban and rural contexts—both of which have separate challenges related to e-cooking) to support at least 70 per cent e-cooking adoption in households over the next decade.

3. Decarbonize the grid quickly and include BESS to enable peak time cooking on electricity. It is recommended that a separate study be carried out focussing on the impact of e-cooking on the overall energy generation and supply system in the country. Recommended that MoP create a roadmap to decarbonize power sector that also includes e-cooking usage growth in the future.

4. Encourage and increase investment in indigenous R&D to develop India-relevant, affordable, low-power e-cooking devices to cater to various cooking needs.

5. Encourage local manufacturing by mobilizing NBFCs and banks to lend for e-cooking usage, adoption, retailing and manufacturing.

6. Mandate use of e-cooking in commercial establishments and large kitchens.

7. Integrating behaviour change campaigns at a national scale in any e-cooking programme implementation.

8. Include communities, especially women and women-led organizations, while designing any rural e-cooking implementation programme.

9. Implement standardization and labelling for e-cooking devices and recommendations on use by BEE/BIS.

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Despite Indian government efforts over seven decades to enable access to clean cooking fuels, about 500 million people in India still cook on polluting fuels such as wood, biomass, animal dung cakes, agri-residue and kerosene. The resulting indoor air pollution causes about 0.6 million premature deaths in every year, and untold damages in the form of serious health risks. This report found that it also leads to CO_2 emissions of over 350 million tonne every year in the country—which is more than India's transport sector or industrial sector's emissions.

This report aims to provide a roadmap for large-scale adoption of e-cooking for rural households in the country. As rural India accounts for two-thirds of the total number of households and access to other means of clean cooking, such as LPG, is limited in rural areas, this report emphasizes that the intervention will have more impact in rural households than its urban counterpart.

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