CLEAN COOKING IN INDIA

History, Current Scenario, Institutional Response, and the Road Ahead

A White Paper

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Table of contents

Disclaimer and Acknowledgements **1**

Table of contents **2**

Executive Summary **5**

1. The History of Cooking Technologies: India's Trajectory **7**

1.1 Early Fuel Transitions and Institutional Foundations (Pre-1980s) 7

1.2. The 1980s: Parallel State Programmes in Biomass, Biogas, and Solar 8

1.3. Market Reorientation and Experimentation (1994–2009) 9

1.4. Standardisation and Research (2009–2017) 11

1.5. The LPG Revolution (1950s–present) 12

1.6 Piped Natural Gas (PNG): Growth, Pricing and Its Relationship with LPG in India (1990s to present) 14

1.7. The Pivot to Electrification: Solar PV Cooking (2017–2023) 16

1.8. The Emerging Technologies (2020s) 17

1.9 The Enabling Ecosystem: Electrification and Rooftop Solar Policy (2019–present) 18

1.10. Global Frameworks and India's Place Within Them 18

1.11. Corporate Social Responsibility and Climate Finance (2010s to present) 20

1.12. Conclusion 21

2. Building a Case for DRE based Clean Cooking in the Present and Future **22**

2.1 The LPG Access-Adoption Paradox: affordability, supply gaps and where it stands today 22

2.1.1 LPG: High Coverage, Uneven Use 22

2.1.2 LPG as a transitional fuel 24

2.2 The Multi-Fuel Stacking 25

2.2.1 Harmful vs. functional stacking: a distinction worth drawing 27

2.3 The The Overlooked Thermal Energy Landscape and the untapped DRE resource 28

2.3.1 A scheme-design gap, not just a data gap 29

2.3.2 The untapped DRE potential 30

2.4 Indoor air pollution: the health and gender burden and the monitoring gap 31

2.4.1 Women and children: the unequal burden, and the co-benefits of transition 32

2.4.2 The monitoring gap 32

2.4.3 Beyond PM2.5: a fuller pollutant profile 34

2.5 The business model problem- across all stakeholders 34

2.5.1 For government 34

2.5.2 For deployers and enterprises 34

2.5.3 For consumers and households 34

2.6 The 2026 LPG crisis: a stress test for an LPG-centred model 35

2.6.1 Impact on India's LPG supply, prices and consumption 35
2.6.2 Government response 36
2.7 Reading the DRE Market: Insights from Providers 37
2.7.1 The crisis was a demand and an awareness shock 37
2.7.2 Demand is diversifying towards commercial and institutional users 38
2.7.3 Supply, not demand, is the bottleneck 38
2.7.4 Affordability is relative, not absolute 38
2.7.5 The sector moving from pilot to commercialisation, but adoption remains uneven 39
2.8 Key takeaways 39
3. Financing Architecture for Clean Cooking Technologies in India 40
3.1. End-User Finance 40
3.1.1 Government-Anchored Consumer Credit 40
3.1.1.1 The Ujjwala EMI Model 40
3.1.1.2 Government subsidy models for improved cookstoves and biogas 41
3.1.2 Microfinance Institutions and NBFCs 42
3.1.3 Commercial Banks, Regional Rural Banks, and NABARD Refinance 42
3.2 Enterprise Finance 43
3.2.1 Development Finance Institution Debt 43
3.2.2 Impact Equity and Venture Capital 43
3.2.3 Blended and Concessional Junior Debt 44
3.2.4 Grants, Accelerators, and Market-Building Facilities 44
3.3 CSR Projects 45
3.3.1 Corporate Foundations and Trusts 45
3.4 Carbon Markets 45
3.4.1 Mechanics and Methodologies 45
3.4.2 Companies and Specific Project Examples 46
3.4.3 Evolving Standards and Verification Requirements 46
3.4.4 India's Domestic Compliance Market 47
3.5. Financing Landscape of CLEAN's Member Organizations: Survey Findings 47
3.5.1 Current Sources of Financing 47
3.5.2 Types of Financing Required 48
3.5.3 Broader trends within the clean cooking sector 49
3.5.4 Future Financing Requirements 50
3.6. Conclusion: A Layered and Interdependent Architecture 50
4. CLEAN's Efforts in Promoting DRE based Clean Cooking Technologies 51
4.1 A User-Centred Approach to DRE based Clean Cooking Technology Promotion 51
4.2. Development of a Multi-Dimensional Performance Labelling System 51
4.3. Incorporating User Needs, Cooking Practices and Field Conditions 52

Heat-output controllability 52
Cooking versatility 52
4.4. Strengthening Consumer Information, Technology Quality and Stakeholder Decision-Making 53
4.5 Operationalisation, Stakeholder Engagement and Broader Significance 54
5. Policy Recommendations: Towards a Decentralised and Diversified Clean Cooking Energy System in India .. 56
5.1. Moving from a single-fuel model towards cooking-energy diversification 57
5.2. Electrification should complement, rather than replace, other cooking-energy sources 59
5.3. Promoting a portfolio of decentralised renewable cooking technologies 59
5.4. A strong policy-side behavioural and market push is needed from the Government 60
Action A: Make public institutional kitchens the anchor market 60
Action B: Build one technology neutral support window for households and enterprises 61
Action C: Build the service chain, not only the device 61
Action D: Communicate DRE as a practical cooking solution 62
Action E: Hold on to the 2026 demand with immediate measures 62
Safeguards 63
Suggested indicators 63
5.5 Strengthening R&D for user-centric and hybrid clean cooking technologies 63
5.6. Adopt a needs-based, location-specific and multi-device strategy 64
5.7. Institutional design, built environment integration and awareness creation 64
5.8. Employment generation and green livelihoods potential 65
Annexure 66

Executive Summary

India's clean-cooking journey has evolved through successive transitions. From traditional biomass, charcoal and kerosene to improved biomass stoves, biogas, LPG, PNG, solar cooking and increasingly, electric cooking. Over several decades, government programmes have pushed for large-scale access to cleaner cooking technologies. The most significant example is the rapid expansion of LPG connections under the Pradhan Mantri Ujjwala Yojana (PMUY), which brought millions of households into the formal clean-fuel system. However, the experience of India's earlier cooking-energy programmes as well as PMUY also reveals a persistent challenge: **access does not necessarily translate into sustained adoption and exclusive use.** Stoves have been distributed but later abandoned, biogas plants have remained underutilised, solar cookers have faced operational and behavioural constraints, and LPG connections have not always resulted in LPG becoming the primary or exclusive cooking fuel.

The current clean-cooking landscape is dominated by LPG, PNG and a growing policy emphasis on electric cooking. LPG has the advantage of a mature national distribution system and high consumer familiarity, while PNG provides a continuous cooking-fuel option in areas covered by city-gas-distribution networks. Electric cooking, particularly induction cooking, is gaining policy attention as electricity access has expanded. Yet each of these pathways has limitations. LPG remains substantially dependent on imports and exposes the cooking sector to international price, geopolitical and supply-chain risks. PNG is constrained by the geographical reach of gas-distribution infrastructure and domestic gas availability. Both of these being fossil fuels, are not aligned with the fossil-fuel-free future that the world aspires for in response to climate change. Electric cooking depends on reliable and affordable electricity and adequate household electrical infrastructure both of which are still not prevalent uniformly across India Furthermore, the proportion of non-fossil fuel based electricity generation is not adequate enough to make electric cooking 'clean' from environmental perspective. The 2026 LPG supply disruption demonstrated the vulnerability that can arise when there is widespread dependence on a single fuel and its associated international supply chains.

The evidence assembled in this paper therefore suggests that India's clean-cooking transition should develop a **diversified, decentralised and locally appropriate** cooking-energy system in which LPG, PNG, electricity and decentralised renewable-energy (DRE) technologies complement one another. DRE-based solutions including biogas, improved biomass and pellet-based systems, solar thermal cooking, solar-electric cooking and other emerging technologies such as hydrogen, DME etc. can utilise local resources, reduce dependence on imported fuels, create rural value chains and provide additional cooking options in locations where LPG or electricity may be expensive, unreliable or unsuitable.

The paper reveals an important gap in current clean cooking policy frameworks, which tend to focus narrowly on household cooking energy while overlooking a broader spectrum of thermal energy needs. Essential household requirements such as space heating and bath water heating are seldom considered in policy or programme formulation. Significant thermal energy demand exists beyond households in institutional and commercial kitchens, as well as in food-processing enterprises such as rice mills, dairies, jaggery units, tea-processing facilities, and bakeries. Despite their substantial energy requirements, these applications are rarely reflected in conventional clean cooking datasets and national statistics, resulting in inadequate recognition within policy and investment priorities. This highlights the need for a broader thermal energy perspective that extends beyond household cooking and recognizes the diverse thermal energy needs across sectors. Several decentralized renewable energy technologies, including biomass gasifiers, biogas systems, and solar thermal

solutions, are already well suited to address these demands but remain underrepresented in existing policy frameworks.

The paper also examines the emerging clean-cooking market and its financing requirements. Evidence from clean-cooking enterprises indicates that the principal financing challenge is not restricted to technology development. Manufacturers require capital for production, distributors need working capital, service providers need resources for installation and maintenance, and consumers require financing to overcome high upfront costs. Working-capital constraints, limited access to conventional commercial lending, high collateral requirements and the relatively small scale of many enterprises continue to constrain sectoral growth. Blended finance combining grants, concessional debt, equity, carbon finance and consumer financing therefore emerges as an important mechanism for supporting different stages of enterprise development and technology adoption.

The paper argues for **a stronger research, development and demonstration agenda focused on user-centric, multifunctional and hybrid thermal-energy technologies.** Rather than designing appliances around a single fuel, R&D should explore systems that can integrate multiple energy sources. For example, burners capable of using LPG, PNG and biogas; solar cooking systems with thermal or battery storage; and electric cooking systems capable of drawing from grid electricity, solar power and storage. The experience of Surya Nutan demonstrates the potential of targeted institutional support for such innovation. A broader incentive framework could extend this approach to universities, start-ups, manufacturers and public-sector R&D institutions working on DRE-based low power thermal-energy technologies.

The central policy message is therefore to avoid a single-source cooking-energy dependency. India should build a portfolio of technologies suited to different locations, users and end uses. This would involve capital support for durable assets, consumer financing, stronger local manufacturing and service networks. The transition should ultimately be measured not simply by the number of connections or appliances distributed, but by whether households and institutions have access to cooking energy that is affordable, reliable, non-polluting, low-carbon, culturally appropriate and sustainably used.

1. The History of Cooking Technologies: India's Trajectory

The history of clean cooking in India spans nearly eight decades, beginning with the reliance on charcoal, coal, wood fuels before 1940s, increasing access to LPG and kerosene in the 1950s and extending to the contemporary era of the growing spread of solar photovoltaic electrification and induction cooking. This trajectory encompasses successive phases of technological and policy intervention: the efficiency-oriented chulha and solar cooker programmes of the 1980s; the parallel promotion of biogas plants under the National Biogas and Manure Management Programme; the donor-driven market experiments of the 1990s and 2000s; the standards-based initiatives of the National Biomass Cookstoves Initiative and Unnat Chulha Abhiyan during the 2010s; the large-scale LPG expansion through the Pradhan Mantri Ujjwala Yojana from 2016 onward; and the recent pivot to electrification through solar-PV cookstoves, induction technologies, and enabling rooftop solar policies. Alongside these domestic programmes, India's clean cooking landscape has been shaped by global frameworks such as the Clean Cooking Alliance and climate-finance mechanisms, as well as corporate social responsibility initiatives. Taken together, this historical arc from 1945 illustrates both the continuity of state involvement and the recurring challenge of ensuring sustained household adoption across diverse technological pathways.

1.1 Early Fuel Transitions and Institutional Foundations (Pre-1980s)

Before cookstove programmes entered the policy lexicon, India's urban cooking energy landscape was shaped by charcoal and mineral coal, both of which accelerated deforestation and environmental degradation in and around cities.[1] Post independence, the Government of India consciously promoted kerosene (for urban poor and rural kitchens) and LPG (for urban middle- and high-income kitchens). Kerosene emerged as the dominant alternative for the urban poor and many rural households, prized for its low per-meal cost and its availability in small, affordable quantities.[2] It was considered a clean cooking fuel across the world at the time. By the 1980s, kerosene's drawbacks had become impossible to ignore: it was understood as a highly polluting fuel. One more reason that contributed to the downfall of kerosene is that it started featuring in a large number of 'accidental' deaths of young daughters in law - obvious dowry deaths. Subsequently, government subsidies for kerosene were progressively withdrawn, even as the fuel continued to serve rural lighting and cooking needs. While the traditional kerosene wick stoves were proving to be inefficient and polluting across the world, Indian Oil Corporation developed the Nutan wick stove in the 1980s which was more efficient and cleaner. It acquired world-wide acclaim for its performance. Also, the pressurised kerosene stoves (Primus stove) was another invention that showed that kerosene can be used far more cleanly than wick stoves. In spite of the barriers in accessing kerosene, both Nutan wick stove and pressurised kerosene stove continue to be manufactured, sold, and used across India. The use of LPG in urban kitchens was pushed aggressively through advertisements and demonstrations by the oil companies in the 1950s, and has also been supported by Government policies and subsidies in some form or other. There has been a steady increase in the number of LPG connections since then.

India's engagement with solar cooking also runs in parallel with this early fuel history, and at times ahead of global developments. An Indian engineer built one of the world's earliest commercial box-type solar cookers

[1]Indian Oil Corporation Limited [IOCL]. (2010). Surya Nutan – An indoor solar cooking system. Retrieved July 2026, from https://iocl.com/pages/SolarCooker

[2]Ibid

in 1945.(Yettou et al., 2014)[3] Government-linked laboratories carried this work forward: in the 1950s the National Physical Laboratory undertook early solar-cooker fabrication as part of the state's broader, though ultimately limited, efforts to address rural energy needs.[4] This early institutional research anticipated, by roughly three decades, the government's more systematic entry into renewable-energy policy- an entry triggered by the oil shocks of the 1970s, which exposed India's vulnerability to imported fuel and led the Department of Science and Technology to establish the Commission for Additional Sources of Energy (CASE) in March 1981, with a mandate to formulate renewable-energy policy and coordinate research and development.[5]

1.2. The 1980s: Parallel State Programmes in Biomass, Biogas, and Solar

In September 1982, CASE was absorbed into a new Department of Non-Conventional Energy Sources (DNES) within the Ministry of Energy- the institution that would later become, successively, the Ministry of Non-Conventional Energy Sources (1992) and the Ministry of New and Renewable Energy (2006).[6] DNES's first decade of work unfolded across three parallel tracks, addressing biomass, biogas, and solar cooking simultaneously.

On the biomass track, DNES initiated pilot projects on improved chulhas in the early 1980s, and grassroots organisations such as the Kerala Shastra Sahitya Parishad began experimenting with stove designs that reduced wood consumption.[7] The positive reception to these pilots led to the formal launch of the National Programme on Improved Chulhas (NPIC) in 1985, later folded into the government's 20 Point Programme for rural development.[8] NPIC was built on an assumption that would later prove only partially correct: that improving fuel-use efficiency would, by itself, deliver the desired health and sanitation outcomes. An "improved" chulha was defined narrowly, in terms of fuel efficiency of around 20 percent compared to the 5-10 percent efficiency of traditional stoves, with little early attention paid to emission of pollutants.[9] The programme operated through a layered institutional structure: the Improved Chulha Division at the Ministry of New and Renewable Energy (then DNES) set annual state-wise targets and subsidy levels, which were implemented through different departments at state level (rural development department in most cases), while Technical Back-Up Support Units in academic and research institutions developed regionally appropriate stove designs.

Implementation on the ground relied on state nodal agencies, NGOs such as the All India Women's Conference, and locally trained installers, often unemployed youth and women who fabricated and installed stoves at the district level.[10] Organisations such as Technology Informatics Design Endeavour (TIDE) in Karnataka and Appropriate Rural Technology Institute (ARTI) in Maharashtra and Goa, and relevant departments in agricultural, technical and academic universities in other states, contributed designs, while village-level actors including sarpanches, gram sevaks, potters, and women and youth stove-builders carried the programme into communities.

By the 1990s, it became evident that most NPIC stoves had achieved their efficiency gains through better heat transfer rather than cleaner combustion, meaning the underlying health objectives were not being met.[11] In

[3]Yettou, F., Malek, A., Madani, N., & Ferrouk, N. (2014). Solar cooker realizations in actual use: An overview. Renewable and Sustainable Energy Reviews, 37, 288–306. https://doi.org/10.1016/j.rser.2014.05.018

[4]Civilsdaily. (n.d.). Surya Nutan: A stove of green energy transition. Retrieved July 2026, from https://www.civilsdaily.com/news/surya-nutan-a-stove-of-green-energy/

[5]Ministry of New and Renewable Energy, Government of India [MNRE]. (n.d.). Introduction. Retrieved July 2026, from https://mnre.gov.in/en/about-department/introduction

[6]Ministry of New and Renewable Energy (MNRE), Government of India, n.d.; Wikipedia contributors, "Ministry of New and Renewable Energy," Wikipedia, The Free Encyclopedia, 2026.

[7]Ministry of Non-Conventional Energy Sources and Indian Institute of Technology, 1993.

[8]Ibid

[9]Ibid.

[10]Ibid

[11]Deshmukh, R., Wu, G. C., & Phadke, A. (2017). *Renewable Energy Zones for Balancing Siting Trade-offs in India*. Lawrence Berkeley National Laboratory. https://doi.org/10.2172/1366450

response, MNRE withdrew mud stoves without chimney from the programme, retaining only portable outdoor stoves and chimney-fitted fixed stoves for the final years of the initiative.[12] Even so, structural weaknesses proved difficult to overcome. World Bank reviews found that mud stoves lasted an average of only three years, and with weak market penetration, households frequently reverted to traditional chulhas once their subsidised stove broke down- a problem compounded by the fact that families had no mechanism for obtaining a second stove under NPIC once the one-time subsidy was used.[13] When central funding was withdrawn in 2002, more than 30 million improved chulhas across roughly 100 designs had been distributed, covering about a quarter of the programme's target households, but the programme's lasting impact was limited by the short lifespan of the stoves and the absence of any sustainable market for replacements or after-sales service.[14]

Running in parallel, the National Biogas and Manure Management Programme (NBMMP), launched in 1981-82, took a different technological route, promoting household biogas plants fuelled by cattle dung, biomass waste, or toilet waste. Administered by the Biogas Division at MNRE in coordination with state nodal agencies and the Khadi and Village Industries Commission, NBMMP has installed approximately 5 million biogas plants to date.[15] Yet a 2002 Planning Commission study found only 45 percent of these plants fully functional, with beneficiaries skewed toward relatively well-off farmers who often used biogas only as a secondary fuel.[16] Subsequent research attributed the programme's underperformance to feedstock shortages linked to declining livestock populations and inadequate maintenance support.[17] Notably, despite its modest success, NBMMP continued to receive central government funding even as NPIC funding was abruptly halted, illustrating an uneven policy commitment across the two flagship 1980s programmes.

The third track, solar cooking, followed a strikingly similar arc. From the early 1980s, DNES promoted a standardised box-type solar cooker: a square, flat-topped design with a single reflector, sized to hold four cooking pots. The central government offered a subsidy of around 30 percent, later reduced to 15 percent, and the scheme was implemented through State Nodal Agencies with support from local non-governmental organisations and women's groups.[18] The programme placed unusual emphasis, for its time, on quality standards and on recruiting entrepreneurs into manufacturing. Over twelve years of subsidy, roughly 340,000 cookers were sold, but adoption proved shallow: surveys found that more than 70 percent of owners were not actively using their cookers, citing unsuitable weather, time constraints, the lack of an appropriate outdoor cooking site, and the absence of any after-sales repair service. These findings led the government to discontinue consumer subsidies for box cookers in 1993-94.[19] The parallel failures of NPIC and the National Solar Cooker Programme, both undone by the absence of after-sales-service infrastructure rather than by the underlying technology, would prove to be a recurring pattern across four subsequent decades of Indian cooking-energy policies.

1.3. Market Reorientation and Experimentation (1994–2009)

The years following these programmes' discontinuation were not a policy vacuum so much as a period of experimentation led by international donors, manufacturers, and even multinational corporations such as British Petroleum.[20] On the solar side, from 1994 India's policy pivoted from direct consumer subsidies toward a

[12]Ibid
[13]Hanbar, R., 2002; Rehman, I. H. (Ed.), 2004.
[14]Rehman, I. H. (Ed.), 2004.
[15]Ministry of New and Renewable Energy (MNRE), Government of India, n.d.
[16]Programme Evaluation Organisation, Planning Commission, Government of India, 2002.
[17]Meena, P. K., Pal, A., & Gautam, S. (2024). *Zone-wise biogas potential in India: Fundamentals, challenges, and policy considerations*. *Environmental Science and Pollution Research, 31*, 1841-1862. https://doi.org/10.1007/s11356-023-31328-4
[18]Wikipedia. (2026). Solar cooker. https://en.wikipedia.org/wiki/Solar_cooker
[19]Ibid
[20]Thurber, M. C., Phadke, H., Nagavarapu, S., Shrimali, G., & Zerriffi, H. (2014).*'Oorja' in India: Assessing a large-scale commercial distribution of advanced biomass stoves to households*. *Energy for Sustainable Development, 19*, 138-150. https://doi.org/10.1016/j.esd.2014.01.002

market-development model: subsidies were redirected to manufacturers, on a 50 percent cost-sharing basis, to fund awareness campaigns, demonstrations, training and repair services, while interest-free loans were extended to wholesalers and institutions and states were supported in setting up renewable-energy showrooms "Akshay Urja" shops with attached repair facilities.[21] Average annual sales stabilised at around 25,000 units, concentrated among urban buyers who could absorb the higher, unsubsidised prices of improved models. This has led to on one hand informal communities of solar cooking enthusiasts including social circles on social media, and on the other hand, occasional users of solar cookers. Most if not all of the users are high income urban families, with a self-owned or controlled sunny terrace space.

This period also saw India move decisively into concentrating solar-cooking technology at institutional scale. German organisations EG Solar and the ULOG-Scheffler group began installing parabolic dish systems in Gujarat from 1990, and by the late 1990s India was host to some of the largest solar-cooking installations in the world: a Scheffler-dish steam-cooking system at the Brahma Kumaris ashram in Mount Abu, capable of preparing meals for 1,000 people, was commissioned in 1997; a still larger installation at a nearby Brahma Kumaris site in Taleti was built to cook for 10,000 people; and in October 2002 a facility in Tirupati, Andhra Pradesh, became at the time, the world's largest solar steam kitchen, with the capacity to prepare up to 30,000 meals a day.[22] India also hosted the Third World Conference on Solar Cooking in Coimbatore in 1997, organised under the leadership of Rajammal P. Devadas of the Avinashilingam Institute, cementing the country's role as a global hub for solar-cooking research and diffusion. By the mid-2000s, the Solar Cooking Archives listed 29 Indian manufacturers of box cookers and seven of parabolic cookers- more than in any other country.[23]

In India, solar cookers initially benefited from a tax-free regime, as they were exempt from sales tax and excise duty in the pre-GST era, reflecting the government's efforts to promote renewable energy adoption through fiscal incentives (MNRE, 2010)[24]. However, with the introduction of the Goods and Services Tax (GST) in July 2017, solar cookers were classified in a group of goods subject to a concessional 12% GST rate (GST Council, 2017)[25]. This marked a departure from earlier exemptions and raised concerns about affordability, particularly in rural markets where price sensitivity was high. Subsequent policy adjustments sought to balance fiscal needs with sustainability goals: in June 2024, the GST Council clarified that dual- energy source solar cookers remained under the 12% slab (GST Council, 2024)[26], while in September 2025 the rate was reduced to 5% for renewable energy devices, including solar cookers, to encourage wider adoption (GST Council, 2025)[27]. This transition from a tax-free regime to GST integration illustrates India's broader policy shift from direct subsidies toward market-based incentives, embedding clean cooking technologies within the national tax framework.

On the biomass side, the commercial logic of this era favoured factory-produced metallic stoves over locally fabricated mud stoves, prized for their ease of transport and minimal installation requirements. As policy emphasis shifted toward pollution reduction, natural-draft metallic "rocket" stoves and fuel-specific forced-draft gasifier stoves began to displace the simpler multi-fuel stoves of the NPIC era. Government-backed expansion of LPG connections to rural households also began in earnest around 2007–08, framed around health benefits and subsidy reform, running alongside continued NGO-led biomass-stove experimentation. Organisations such as Appropriate Rural Technology Institute (ARTI) and Samuchit Enviro Tech in Maharashtra and Development Alternatives in Madhya Pradesh received backing from the Shell Foundation, to try and develop a commercial market for improved cookstoves in the early 2000s, while British Petroleum introduced forced draft pellet fuelled metallic stoves to the Indian market around the same time. Technological

[21] Wikipedia. (2026). Timeline of solar cells. https://en.wikipedia.org/wiki/Timeline_of_solar_cells
[22] ibid.
[23] ibid.
[24] Ministry of New and Renewable Energy (MNRE). (2010). *Annual report on renewable energy programmes*. Government of India. Retrieved from https://mnre.gov.in
[25] GST Council. (2017). *Goods and Services Tax rates on renewable energy devices*. Government of India. Retrieved from https://gstcouncil.gov.in
[26] GST Council. (2024). *53rd GST Council meeting decisions*. Government of India. Retrieved from https://gstcouncil.gov.in
[27] GST Council. (2025). *56th GST Council meeting decisions*. Government of India. Retrieved from https://gstcouncil.gov.in

innovation diversified to include insulated rocket stoves, fan-assisted gasification stoves, battery-integrated designs, etc. during this period. Commercial entrants like Envirofit (also backed by the Shell Foundation initially) and First Energy (building on the foundation created by British Petroleum) emerged in the 2010s. Some of these manufacturers also benefited from the emerging carbon-credit markets.

Yet the persistent challenge across this period was last-mile connectivity for stoves, fuels, spare parts, and service support alike. Innovations such as partnerships with microfinance institutions, deployment of self-help groups as last-mile service providers, and instalment-based payment models through rural marketing companies were all attempted, but market penetration remained stubbornly low.[28] Most businesses in the sector found themselves selling not to end users directly but to donors and large-scale distribution programmes- a dynamic that one analysis has characterised as a "pseudo-market" approach: nominally commercial, but in practice still dependent on subsidy- or donor-driven push mechanisms, and therefore lacking the consumer choice and price competition that genuine markets would generate. A handful of commercial biogas companies, producing readymade plastic or fiberglass plants, emerged during this period as well, but they too relied predominantly on donor and government sales rather than open retail markets, with direct-to-consumer sales largely confined to urban and semi-urban areas. Where a more organic market did take hold was in the community and commercial cooking sector, where biomass stoves (wood burning with chimney, and/or using briquettes as fuel), and biogas plants running on food waste, found traction, driven chiefly by cost savings relative to firewood (purchased in open market) or commercial LPG. The climate-change dimension of biomass cooking also opened access to carbon finance for some non-profit and for-profit ventures, with biogas programmes finding more success in this regard than improved-cookstove initiatives.

1.4. Standardisation and Research (2009–2017)

The next major phase of government intervention reoriented the policy conversation around standards, testing, and certification rather than direct stove distribution. The National Biomass Cookstoves Initiative (NBCI), launched by MNRE in 2009, prioritised research and development aimed squarely at the broader "clean cooking" agenda, with health as the primary driver and climate change a secondary consideration. NBCI's central contribution was the development of test protocols and standards for both fuel-use efficiency and hazardous emissions- specifically carbon monoxide and PM2.5, alongside the establishment of testing and certification centres across the country.[29] These standards were calibrated against WHO guidelines while remaining realistic about the state of Indian cookstove technology, with the explicit expectation that thresholds would tighten as technology improved.[30] Targeting rural households reliant on firewood and agricultural residues, NBCI nonetheless struggled with durability, supply-chain, and user-acceptance challenges, and was phased out by 2014.[31]

NBCI's research foundation fed directly into the Unnat Chulha Abhiyan (UCA), launched in 2013-14 to fund R&D and pilot programmes for cookstoves meeting the newly established standards, spanning both household and institutional/community stove categories.[32] Between 2013 and 2017, UCA set a target of 2.75 million improved cookstoves; by the programme's end, 39 household stove designs and 15 community stove designs had been approved for financial support, with MNRE's supplier list intended to function as a quality benchmark for any organisation, governmental or otherwise, working in the cookstove space.[33] UCA's beneficiaries were

[29]Ministry of New and Renewable Energy. (2012). *National Biomass Cookstoves Initiative (NBCI): Guidelines and programme framework*. Government of India, New Delhi.
[30]Ibid
[31]Ministry of New and Renewable Energy. (2014). *Annual Report 2013-14*. Government of India, New Delhi.
[32]Ministry of New and Renewable Energy. (2016). *Unnat Chulha Abhiyan (UCA): Scheme guidelines and implementation framework*. Government of India, New Delhi.
[33]Ministry of New and Renewable Energy. (2012). *National Biomass Cookstoves Initiative (NBCI): Guidelines and programme framework*. Government of India, New Delhi.

predominantly rural and tribal households, with particular focus on reducing women's exposure to indoor air pollution. However as with its predecessors, adoption remained constrained by cultural preferences and behavioural barriers.[34]

1.5. The LPG Revolution (1950s–present)

India's dependence on imported liquefied petroleum gas (LPG) has evolved from a limited supplementary requirement into a structural feature of the country's cooking-fuel system (MoPNG, 2024)[35]. LPG was first introduced in India in 1955, when Burmah Shell launched Burshane in Bombay[36]. Public sector distribution began in 1965, with IndianOil launching the Indane brand; however, the country initially relied predominantly on domestic production from refineries and gas-processing facilities (IOCL, 2015)[37]. Importantly, available historical evidence indicates that India was still not importing LPG in 1982-83, when a World Bank assessment explicitly noted that domestic LPG was expected to substitute for imported kerosene (World Bank, 1983)[38]. By FY1985-86, however, LPG imports had emerged as a supplementary source of supply: Bharat Petroleum Corporation Limited (BPCL), then the canalising agency for LPG imports, reported the import of 32,052 tonnes of LPG during the year to supplement indigenous availability (BPCL, 1986)[39]. This places the emergence of regular LPG imports in the mid-1980s, rather than in the early decades of LPG adoption (MoSPI, 2007)[40]. The subsequent expansion of household LPG access, rising urbanisation and income, and later government programmes aimed at universalising clean cooking access caused demand to grow much faster than domestic LPG production (PPAC, 2023)[41]. LPG consumption increased from approximately 0.18 million tonnes in 1970–71 to 1.24 million tonnes in 1985–86 and 2.42 million tonnes in 1990–91, while production capacity expanded more slowly (MoSPI, 2007)[42]. Imports consequently became increasingly important through the 1990s and 2000s, particularly after the introduction of the parallel marketing system in 1993, which enabled private players to import and market LPG (Sahu, 2000)[43].

[34]Ministry of New and Renewable Energy. (2016). *Unnat Chulha Abhiyan (UCA): Scheme guidelines and implementation framework*. Government of India, New Delhi.
[35]Ministry of Petroleum and Natural Gas (MoPNG). (2024). *Annual Report 2023–24*.
[36]Bharat Petroleum Corporation Limited, "A pioneering approach," Our Journey, https://bharatpetroleum.in/about-bpcl/our-journey/a-pioneering-approach (accessed 6 October 2026).
[37] Indian Oil Corporation Limited (IOCL). (2015). *Indane: History and evolution of LPG in India*.
[38] World Bank. (1983). *India: Oil and Gas Sector Review*.
[39] Bharat Petroleum Corporation Limited (BPCL). (1986). *Annual Report 1985–86*.
[40] Ministry of Statistics and Programme Implementation (MoSPI). (2007). *Energy Statistics of India*.
[41] Petroleum Planning and Analysis Cell (PPAC). (2023, 2025). *LPG consumption and import data*.
[42] Ministry of Statistics and Programme Implementation (MoSPI). (2007). *Energy Statistics of India*.
[43] Sahu, G. (2000). *LPG marketing reforms in India*.

Box 1: The downfall of the Kerosene Era

From the 1990s onward, the expansion of LPG progressively displaced kerosene in urban cooking, while rural households continued to depend on it alongside biomass. Kerosene was historically treated as an essential household fuel and distributed through the Public Distribution System (PDS), giving it a distribution network capable of reaching low-income and remote households. However, the same system also demonstrated the difficulties of administering a heavily subsidised fuel when there are large differences between controlled and market prices. The Economic Survey 2014–15 estimated that 41% of PDS kerosene allocation was lost through leakage, while only 46% of the remaining quantity was consumed by poor households, illustrating how a subsidy intended to provide energy access could generate substantial diversion and weak targeting (Government of India, 2015). Diversion was not limited to parallel markets: subsidised kerosene was also used for adulterating motor fuels, prompting the government to introduce identification mechanisms. PDS kerosene was dyed blue so that its presence in non-PDS applications could be detected, while an additional chemical marker system was subsequently explored; the government acknowledged that an earlier marker had become ineffective because it could be removed or "laundered" (Ministry of Petroleum and Natural Gas, 2010; 2015). By the early 2020s, the government was actively phasing out PDS kerosene because of its environmental and health impacts, with several states becoming kerosene-free.

The year 2016 marked a genuine inflection point in India's clean-cooking trajectory. The Pradhan Mantri Ujjwala Yojana (PMUY), launched by the Ministry of Petroleum and Natural Gas, set out to provide free LPG connections including a stove, regulator, gas pipe, and first cylinder, to women in below-poverty-line households, building on the earlier Rajiv Gandhi Gramin LPG Vitaran Yojana.[44] The scale of ambition was striking: an initial target of 5 crore connections within three years, covering roughly half of India's BPL families, later evolving into a programme that has distributed over 10.56 crore connections to date, with an expansion phase, Ujjwala 2.0, launched in 2021.[45] India imported approximately 14.8 million tonnes (MT) of LPG in 2019–20, 17.0 MT in 2021–22, 18.5 MT in 2023–24 and 20.7 MTonin 2024–25, while domestic production remained broadly around 12–13 MT annually (PPAC, 2025)[46]. Consequently, imports supplied approximately 66% of domestic LPG requirements in FY2024–25, compared with a much smaller role in the early stages of LPG adoption (India Today, 2026)[47]. The geographical concentration of these imports has also been pronounced. In FY2024–25, approximately 92% of India's LPG imports originated in the Middle East, with the United Arab Emirates accounting for about 40.5%, Qatar 22.0%, Saudi Arabia 15.0% and Kuwait 14.7%, leaving only around 7.8% sourced from other countries (Dataful, 2026)[48]

[44]Indian Oil Corporation Limited. (2016, August 3). *Over 25 lakh LPG connections released under PM Ujjwala Yojana*. IndianOil News Release. https://www.iocl.com/NewsDetails/39975
[45]Ministry of Petroleum and Natural Gas. (2021). *Pradhan Mantri Ujjwala Yojana 2.0 launched for providing deposit-free LPG connections to poor households*. Government of India. Retrieved from https://www.pmuy.gov.in/
[46] Petroleum Planning and Analysis Cell (PPAC). (2025). *LPG consumption and import data*.
[47] India Today. (2026). *How dependent is India on imported LPG?*
[48] Dataful. (2026). *LPG import structure and country-wise dependence analysis*.

Box 2: International precedent: Indonesia's kerosene-to-LPG conversion

India's PMUY has a useful international example in Indonesia's 2007 LPG programme. The Indonesian government replaced kerosene subsidies with a free LPG starter package, including a 3-kg cylinder, first refill, stove, hose and regulator, for households in six provinces. As a result, LPG use increased from 1.9% in 2005 to 13.5% in 2013, while kerosene use fell from 18% to 1.8% (Toft, Beaton & Lontoh, 2016, cited in CEEW, 2019, pp. 55–56). The experience shows that replacing one fuel subsidy with another can accelerate the shift to cleaner cooking, but it also requires reliable last-mile distribution of cylinders and appliances. This is an important lesson for PMUY, particularly in addressing the challenge of sustained LPG refills.

PMUY's early implementation exceeded its initial target, with the original target of 5 crore LPG connections achieved in August 2018, well ahead of the March 2019 deadline. The target was subsequently revised upward to 8 crore connections, to be achieved by March 2020; this revised target was itself achieved in September 2019, seven months ahead of schedule.[49] Yet beneath these headline numbers, a more complicated picture has emerged. While rural households without LPG connections continued to rely exclusively on biomass fuels for cooking, even among households that had acquired LPG connections, traditional stoves and biomass fuels remained the dominant cooking energy sources, with LPG stoves typically relegated to supplementary use for quick tasks such as preparing tea or snacks. Anecdotal evidence has pointed to recurring problems of difficulties in accessing and affording refill cylinders, and a tendency among households to treat LPG as a supplementary rather than primary cooking fuel for cultural and economic reasons.[50] Over the last decade or so, the situation has improved with LPG becoming the primary cooking energy device in rural households in the more economically prosperous state. However, even in most of these households, use of the traditional cookstove has not totally stopped. In effect, Ujjwala succeeded spectacularly at solving the connection problem while leaving the deeper challenge of sustained, exclusive clean-fuel use only partially addressed- a gap that continues to shape policy debate today, and one that echoes the after-sales and sustained-use failures of the 1980s chulha and solar-cooker programmes.

1.6 Piped Natural Gas (PNG): Growth, Pricing and Its Relationship with LPG in India (1990s to present)

Piped Natural Gas (PNG) emerged as an important component of India's urban cooking transition, although its development predates the recent policy emphasis on city gas distribution (CGD). The earliest reported domestic PNG connection in India was provided in Vadodara in 1972, following the development of natural-gas resources in Gujarat; however, the large-scale institutionalisation of household PNG began with the development of metropolitan city-gas-distribution systems in the 1990s (India Today, 2025). [51] A major milestone was the establishment of MahaNagar Gas Limited (MNGL) in 1995 as a joint venture involving Gas Authority of India Limited (GAIL) and British Gas, with the objective of distributing natural gas in Mumbai and adjoining areas. MNGL commenced CGD operations in Mumbai in 1995, making Mumbai one of the first large urban markets for PNG in India (MoPNG, 2015; MGL, 2026).[52] This was followed by the establishment of Indraprastha Gas

[49]Mehta, N., 2017.
[50]Pandey, K., 2017.
[51] India Today. (2025). *Piped gas for cooking: Fuelling a clean future.* India Today Magazine, 24 January 2025.
[52] Ministry of Petroleum and Natural Gas (MoPNG). (2015). *Testing Norms of Gas Meter.* Government of India, Press Information Bureau. The release records that MGL commenced city-gas-distribution operations in Mumbai in 1995.
Mahanagar Gas Limited (MGL). (2026). *Company profile and history.* MGL. The company identifies 1995 as the year of its establishment and its pioneering role in Mumbai's natural-gas distribution network.

Limited (IGL) in 1998 through a partnership involving GAIL, BPCL and the Government of Delhi, accelerating the adoption of PNG in the National Capital Region. Subsequently, the Petroleum and Natural Gas Regulatory Board (PNGRB), established under the PNGRB Act, 2006, became the key regulator for CGD and progressively expanded the geographical areas authorised for PNG and CNG distribution. The expansion accelerated considerably after successive CGD bidding rounds, particularly the ninth and tenth rounds, which together covered 136 geographical areas and provided minimum-work commitments for more than 4.23 crore domestic PNG connections; by June 2019, however, only about 55.96 lakh domestic PNG connections had actually been established (PNGRB, 2019). [53] By January 2014, oil marketing companies reported that 3.26 lakh LPG connections had been surrendered by PNG users, indicating that some households shifted from LPG cylinders to piped gas PNG is primarily an additional urban clean-cooking pathway and a substitute for LPG in areas where CGD infrastructure is available. It does contribute by 'freeing up' some of the imported LPG for the expanding rural LPG distribution. . In terms of price, PNG has no uniform national retail tariff because prices vary by CGD operator, city, gas-sourcing costs and applicable taxes. As of August 2026, indicative household PNG prices were approximately ₹49.59 per standard cubic metre (SCM) in Delhi, ₹51.50/SCM in Mumbai and ₹55.27/SCM in Ahmedabad, although actual consumer bills also include applicable fixed charges and taxes (Goodreturns, 2026). [54]

The sector is currently receiving renewed policy attention because PNG can reduce dependence on imported LPG while providing continuous, metered cooking fuel. In August 2026, the Government introduced an incentive under which CGD companies receive an additional 200 SCM of lower-priced domestic gas for each new billed domestic PNG connection, signalling a renewed push to accelerate household PNG adoption and strengthen India's urban gas infrastructure (Ministry of Petroleum & Natural Gas, 2026)[55]. The 2026 West Asia conflict and the resulting concerns over LPG availability triggered an accelerated push towards Piped Natural Gas (PNG) as an alternative to LPG across India. On 14 March 2026, the Government amended the LPG Control Order to require consumers who had a PNG connection to surrender their domestic LPG connection and prohibited new LPG connections for consumers with PNG supply; consumers were also encouraged to shift to PNG wherever feasible (Ministry of Petroleum and Natural Gas, 2026a)[56]. The scale of the subsequent transition was substantial: by 10 May, approximately 6.79 lakh PNG connections had been gasified, infrastructure had been created for another 2.68 lakh connections, around 7.29 lakh customers had registered for new connections, and more than 52,300 PNG consumers had surrendered their LPG connections (Ministry of Petroleum and Natural Gas, 2026b)[57]. The push extended beyond households, as the disruption created strong demand for PNG among restaurants, hotels, industries and other large kitchens that depend heavily on commercial LPG. For example, in Pune city, more than 40 restaurants and over 20 industries reportedly shifted towards PNG during the early phase of the crisis (Indian Express, 2026a)[58].

Overall, the trajectory indicates that PNG has moved from a limited metropolitan fuel option in the 1990s to a nationally expanding urban energy network, but its future contribution to clean cooking will depend on further CGD infrastructure expansion, affordability relative to LPG, reliable domestic gas availability and the ability to extend piped-gas access beyond existing metropolitan markets.

[53] Petroleum and Natural Gas Regulatory Board (PNGRB). (2019). *City Gas Distribution in India: 9th & 10th CGD Bidding Rounds.* Government of India. PNGRB reported 55,96,155 domestic PNG connections as of June 2019 and commitments for 4.23 crore domestic PNG connections from the ninth and tenth bidding rounds.
[54] Goodreturns. (2026). *PNG Price in India Today.* August 2026.
[55] Ministry of Petroleum and Natural Gas. (2026). *Government incentive scheme for expansion of domestic PNG connections.*
[56] Ministry of Petroleum and Natural Gas. (2026a). *Updates on Key Sectors in View of Developments in West Asia: LPG Control Order amendment mandates surrender of LPG connections by consumers having PNG supply*. Government of India, 15 March 2026
[57] Ministry of Petroleum and Natural Gas. (2026b). *Updates on Key Sectors in View of Developments in West Asia*. Government of India, 10 May 2026
[58] Indian Express. (2026a). *LPG shortage hits Pune: Why hundreds of restaurants and factories are racing to switch to PNG*. 3 April 2026

1.7. The Pivot to Electrification: Solar PV Cooking (2017–2023)

By the late 2010s, the policy conversation had begun to shift once more, this time toward electrification. Pilot programmes on electric cooking, testing induction and solar-based solutions, emerged around 2018-19 under MNRE and various state energy departments, often integrated with decentralised renewable-energy projects and targeted at rural households in electrified villages already engaged in clean-energy livelihood programmes.[59]

India's shift from solar-thermal to solar-photovoltaic cooking was catalysed by a specific policy intervention: in 2017–18, the state-owned Oil and Natural Gas Corporation (ONGC), in partnership with Startup India, launched the "Solar Chulha Challenge," inviting entrepreneurs and researchers to design an indoor-safe, grid and off-grid-compatible solar cookstove capable of feeding a family of five at a target cost below Rs 10,000.[60] A team from the Indian Institute of Technology (IIT) Bombay won the challenge with its "SIX Cook-Stove" (Solar Intelligent Cooking with Storage), a 48-volt DC induction cookstove powered by PV panels and battery storage, developed in April 2018.[61] With roughly Rs 8.5 million in ONGC funding, IIT Bombay went on to convert the entire village of Bancha in Betul district, Madhya Pradesh, to solar PV cookstoves, distributing 86 units by January 2020 and beginning commercial sales that same year; the system paired four PV panels (about 1 kW) and four lead-acid batteries (roughly 7 kWh of storage) with one or two induction rings, enabling cooking at night and during a full day of cloud cover.[62] This was, in effect, India's first sustained real-world demonstration that solar-PV electric cooking could be engineered to match the performance, including the frying, roasting, and roti-making central to Indian cuisine of conventional LPG stoves.[63] Unfortunately, an induction cook stove in itself is expensive, and solar PV powered induction cooking is so expensive as to become totally unrealistic as a household cookstove, unless donor money supports the capital expense.

The 2020s saw India's public sector consolidate this shift toward solar-electric cooking. Energy Efficiency Services Limited (EESL), a joint-venture public-sector undertaking under the Ministry of Power, began developing three complementary models for scaling electric cooking: induction cook-stoves for urban areas, grid-connected solar-based induction cook-stoves for Tier-2 cities and semi-urban regions, and solar-based induction cook-stoves with battery storage for rural areas without reliable grid access.[64] This pilot phase culminated in the National Efficient Cooking Programme (NECP), launched in November 2023 by the Ministry of Power through EESL, setting an ambitious target of deploying 20 lakh induction cookstoves nationwide by 2026, promising cooking-cost reductions of 25-30% relative to LPG, and targeting both urban and rural households with reliable electricity access.[65] Running alongside it, the Energy Efficient Fans Programme sought to reduce overall household electricity demand, indirectly easing the path toward adoption of electric-cooking.[66]

[59]Ministry of Petroleum and Natural Gas. (2021). *Pradhan Mantri Ujjwala Yojana 2.0*. Government of India. https://www.pmuy.gov.in/ujjwala2.html
[60]Startup India, & Oil and Natural Gas Corporation Limited. (n.d.). *Solar Chulha Challenge: Innovation challenge for developing an indoor solar cooking solution*. Government of India. Retrieved from https://www.startupindia.gov.in/
[61]Solanki, C. (2018). *SIX cookstove (Solar Intelligent Cooking with Storage): A solar photovoltaic cooking solution developed at IIT Bombay*. Indian Institute of Technology Bombay, Mumbai, India.
[62]Engineering for Change. (2024). *Solar electric cooking in Bancha village: Lessons from India's first solar-powered cooking community*. Retrieved from https://www.engineeringforchange.org/
[63]Solanki, C. (2018). *SIX cookstove (Solar Intelligent Cooking with Storage): A solar photovoltaic cooking solution developed at IIT Bombay*. Indian Institute of Technology Bombay, Mumbai, India
[64]Press Information Bureau. (2023, November). *National Efficient Cooking Programme launched by Ministry of Power through EESL to promote electric cooking adoption*. Government of India.
[65]Energy Efficiency Services Limited. (2023). *National Efficient Cooking Programme (NECP): Programme framework and implementation strategy*. New Delhi: EESL.
[66]Ibid

In parallel, the Bureau of Energy Efficiency (BEE) launched a voluntary Star Labelling programme for induction stoves on 1 March 2023, intended to steer consumers toward more energy-efficient appliances.[67]

During the same period, research and development centre under the state-owned Indian Oil Corporation (IOC) in Faridabad developed "Surya Nutan," a stationary, rechargeable, always-kitchen-connected indoor solar-cooking system, in response to a challenge posed by Prime Minister Narendra Modi to design a sustainable cooking solution for middle-class households.[68] Surya Nutan draws electricity from a rooftop PV panel, converts it to heat through a purpose-built heating element, and stores the resulting thermal energy so that the system can continue cooking after sunset or during extended overcast periods; a hybrid mode allows it to draw on grid electricity when solar supply is insufficient. The system was formally endorsed by Prime Minister Modi at India Energy Week in Bengaluru in February 2023, with an ambition of reaching 30 million households. This stove is priced between roughly Rs 12,000 and Rs 30,000 depending on configuration.[69]

1.8. The Emerging Technologies (2020s)

Over the years, there were other technological interventions that were attempted locally, but did not get widespread support. A few innovators have attempted to introduce ethanol-based stoves[70]. While these stoves met efficiency and emissions standards of the day, the myriad of regulations around production, storage, transport and use of ethanol have prevented widespread use of these stoves. Currently, a few new DRE technologies are emerging. These are still in the testing stage, but are showing promising results, and can be game changers for the DRE cooking sector in the near future. For example, several researchers are experimenting with a green hydrogen cookstove concept, wherein the 'fuel' is distilled water mixed with an electrolyte, the electrolysis is powered by a solar PV charged battery, and the hydrogen produced is instantly used as a fuel in a specially designed burner to achieve cooking. The other approach is that of using methane as a precursor for manufacturing of dimethyle ether (DME), which can be filled into pressurised tanks, to be used on the same lines as LPG cylinders. If the methane is harvested from biomethanation systems, then this can be considered as a DRE cooking system.

Both green hydrogen and DME are non-polluting and nearly zero carbon approaches to cooking energy, wherein at the user end, the operation is very similar to that of an LPG stove. These stoves may be better suited for commercial/institutional applications to start with, due to the high cost, but eventually these may provide viable options for household cooking too. Such technologies do require funding support for R&D and financing and policy incentives for producting, marketing, distribution, etc.

CSIR-NCL has developed an indigenous DME production process and the *Aditi Urja Sanch* burner, which can operate on 100% DME as well as DME–LPG blends; the technology is designed to require relatively limited changes to existing LPG infrastructure and could potentially reduce dependence on imported LPG. (CSIR. 2020)[71].

Nimbkar Agricultural Research Institute (NARI) has developed stoves using low-concentration ethanol–water mixtures, while more recent work has explored ethanol as a clean cooking fuel for both households and commercial kitchens. Ethanol is particularly relevant to a DRE-oriented cooking strategy because it can be

[67]Press Information Bureau. (2023, March 1). *Bureau of Energy Efficiency launches voluntary star labelling programme for induction hobs/stoves*. Government of India.
[68]Indian Oil Corporation Ltd. (IOCL), n.d. Press Information Bureau (PIB), Government of India, 2023.
[69]Observer Research Foundation (ORF), 2024. Press Information Bureau (PIB), Government of India, 2023.
[70] For example: https://www.scribd.com/document/18475712/Ethenol-stove
[71] CSIR. (2020)#. Union Minister Dr. Harsh Vardhan launches eco-friendly, efficient and DME fired "Aditi Urja Sanch" Unit at CSIR-NCL, Pune. Press Information Bureau, Government of India.

produced from agricultural feedstocks and, in some models, through decentralised or micro-distilleries.(Rajvanshi, A. K., Patil, S. M., & Mendonca, B., 2007)[72].

Fluidline–Exacta International has been developing hydrogen-powered cooking solutions for domestic and commercial applications and has undertaken a dedicated *Design and Development of Hydrogen Stove* project with Fr. C. Rodrigues Institute of Technology. Its approach also emphasises distributed production of green hydrogen at or near the point of use, rather than depending entirely on centralised hydrogen production and long-distance transport. Exacta has specifically proposed the transition of commercial kitchens from LPG to green hydrogen, including the recovery and utilisation of oxygen generated during hydrogen production. (Fluidline–Exacta International, 2026)[73].

Examples include LPG/PNG/biogas-compatible burners, solar thermal cookers with battery or electric backup, biomass-gasifier–biogas systems, and combinations of solar, electricity and thermal storage. Such systems improve reliability where renewable resources or grid electricity are intermittent and allow households and institutions to shift between fuels according to availability and cost. Overall, these emerging technologies suggest that India's future clean-cooking transition to hybrid and fuel-flexible systems could provide greater resilience while reducing dependence on any single energy source. (Patnaik, S., Tripathi, S., & Jain, A., 2019)[74]

1.9 The Enabling Ecosystem: Electrification and Rooftop Solar Policy (2019–present)

The diffusion of solar-electric cooking in India has been underpinned by two broader policy shifts. First, the Saubhagya scheme's achievement of near-universal household electrification by 2019 created, for the first time, the grid infrastructure on which many grid-connected or grid-assisted electric-cooking appliances depend.[75] Second, the Pradhan Mantri Surya Ghar: Muft Bijli Yojana, launched in February 2024, has sought to install rooftop solar systems on ten million households, offering a central subsidy of up to Rs 78,000 for systems up to 3 kW and targeting 40 GW of cumulative rooftop capacity by March 2026.[76] While this scheme is framed primarily around household electricity consumption rather than cooking, it directly expands the distributed rooftop-PV base on which grid-connected solar induction cooking, of the kind envisaged by EESL, ultimately depends. Alongside these large infrastructure programmes, the India-focused work of the Modern Energy Cooking Services (MECS) programme has supported homegrown start-ups in the electric- and solar-cooking space and produced some of the first systematic studies of how well electric-cooking appliances suit Indian culinary practices.[77]

1.10. Global Frameworks and India's Place Within Them

India's domestic policy evolution has not advanced in isolation; it has been shaped and financed, at various points, by a parallel architecture of global clean-cooking initiatives. The Global Alliance for Clean Cookstoves

[72] Rajvanshi, A. K., Patil, S. M., & Mendonca, B. (2007). Low-concentration ethanol stove for rural areas in India. Energy for Sustainable Development, 11(1), 94–99.
[73] Fluidline–Exacta International (2026). Transition from LPG to Green H_2. World Hydrogen Summit 2026
[74] Patnaik, S., Tripathi, S., & Jain, A. (2019). Roadmap for Access to Clean Cooking Energy in India. Council on Energy, Environment and Water
[75] Press Information Bureau. (2023, March 16). *SAUBHAGYA electrification scheme: A total 2.86 crore households have been electrified*. Government of India, Ministry of Power. https://www.pib.gov.in/PressReleaseIframePage.aspx?PRID=1907728
[76] Ministry of New and Renewable Energy. (2024). *Guidelines for PM-Surya Ghar: Muft Bijli Yojana*. Government of India. https://pmsuryaghar.gov.in/
[77] Finovista, & Modern Energy Cooking Services (MECS). (2024). *Modern Energy Cooking Forum 2023 India report*. MECS Programme, Loughborough University. https://mecs.org.uk/wp-content/uploads/2024/01/Modern-Energy-Cooking-Forum-2023-India.pdf

emerged in September 2010 as a public-private partnership announced by then-U.S. Secretary of State Hillary Rodham Clinton at the Clinton Global Initiative annual meeting, subsequently hosted and led by the United Nations Foundation, and rebranded as the Clean Cooking Alliance in 2018, sought to build a global market for clean cookstoves and fuels, mobilising over US$25 million in enterprise support and US$17.8 million in research funding while targeting 100 million households worldwide by 2020.[78] The World Bank's Clean Cooking Fund, established in 2019 under the Energy Sector Management Assistance Program (ESMAP), took financing to a larger scale still, with a target of US$500 million intended to leverage up to US$2 billion in financing, and its first flagship project- targeting 500,000 households in Rwanda- explicitly linked financing to verified health, gender, and climate outcomes.[79] The UN Development Programme and World Health Organization have layered additional dimensions onto this architecture: UNDP integrating clean cooking into national climate and development strategies with an equity and livelihoods focus,[80] and WHO's Health and Energy Platform of Action, launched in 2016, framing household air pollution, responsible for an estimated 2.9 million premature deaths annually as fundamentally a public-health issue.[81] This global trajectory mirrors India's own- an arc moving from large-scale financing to integration within broader health, climate, and development agendas.

Within this global picture, solar cooking specifically illustrates a genuine divergence in national pathways. Globally, the shift toward photovoltaic-based electric cooking has been driven largely by humanitarian and off-grid electrification contexts, co-ordinated through international coalitions such as Modern Energy Cooking Services (MECS), Global Electric Cooking Coalition (GeCCo) and SOLCO (Solar-Electric Cooking Partnership), financed through blended finance, results-based financing, and carbon markets aimed at refugee settlements, smallholder communities, and last-mile populations across Sub-Saharan Africa, South Asia, and Latin America.[82] In India, by contrast, the pivot to solar-PV cooking has been driven chiefly by energy-security concerns tied to the country's heavy dependence on imported liquefied petroleum gas, and has been championed less by humanitarian coalitions than by state-owned enterprises-ONGC and Indian Oil-working alongside premier engineering institutions such as IIT Bombay.[83] India is also distinguished by the sheer duration and continuity of state involvement: decades of near-continuous central-government programming on cooking energy, from the 1982 National Solar Cooker Programme and NPIC through to Surya Nutan and NECP, a continuity matched by few other countries. India's earlier concentrating-cooker programme, exemplified by the Tirupati steam kitchen, demonstrated at institutional scale a capability that the newer global PV-cooking coalitions are only now attempting to replicate through mini-grid and school-kitchen pilots in Africa and Latin America.[84] The direction of technology transfer is thus increasingly two-way, with Indian innovations in solar-PV cookstove design informing, and being informed by, the wider global effort.

[78]Clean Cooking Alliance. (2018). *Clean Cooking Alliance: Strategy and impact report*. United Nations Foundation. https://cleancooking.org/
[79]World Bank, 2019. World Bank. (2019). *The Clean Cooking Fund prospectus*. Energy Sector Management Assistance Program (ESMAP). Washington, DC: World Bank.
[80]United Nations Development Programme. (2025). *Clean cooking as a catalyst for climate action, gender equality, and sustainable development*. New York: UNDP.
[81]World Health Organization. (2023). *Household air pollution and health*. Geneva: World Health Organization.
[82]UNEP Copenhagen Climate Centre (UNEP-CCC), World Food Programme (WFP), & UNITAR Global Programme of Action (UNITAR-GPA), 2025. *Solar electric cooking: Scaling modern energy cooking through humanitarian and development partnerships*. Copenhagen: UNEP Copenhagen Climate Centre.
[83]Startup India, & Oil and Natural Gas Corporation Limited. (n.d.). *Solar Chulha Challenge: Innovation challenge for indoor solar cooking solutions*. Government of India.
[84]UNEP Copenhagen Climate Centre (UNEP-CCC), World Food Programme (WFP), & UNITAR Global Programme of Action (UNITAR-GPA), 2025. *Solar electric cooking: Scaling modern energy cooking through humanitarian and development partnerships*. Copenhagen: UNEP Copenhagen Climate Centre.

1.11. Corporate Social Responsibility and Climate Finance (2010s to present)

A further thread in this story is the growing role of corporate social responsibility and climate finance in India's clean-cooking sector. CSR funding has provided another, more locally targeted channel for deploying DRE based cooking technologies. Tata Trusts' Clean Cooking Programme, running from 2013 to 2019, focused on market development and stove distribution across Gujarat, Rajasthan, and Uttar Pradesh, investing in awareness campaigns and NGO partnerships that ultimately disseminated more than 35,000 improved cookstoves to rural households, with objectives centred on reducing smoke exposure and easing the burden of fuelwood collection, particularly for women.[85] From 2020 onward, corporate CSR funding increasingly aligned itself with climate resilience and innovation financing rather than direct stove distribution, with programmes such as the HCL Tech Grant, the Infosys Foundation Aarohan Awards, and HDFC Bank's Parivartan SmartUp Grants supporting NGOs and start-ups working on renewable energy and household technologies that indirectly advanced clean-cooking adoption.

In biogas, CSR-supported projects have included, for example, the construction of 15 household biogas plants in villages around Kharagpur and Medinipur in West Bengal, with the plants using different organic waste streams to provide cooking fuel and biofertiliser to rural households (India Investment Grid, 2020; *Indian Express*, 2017)[86] Similarly, a CSR initiative in Sindhudurg, Maharashtra, supported the promotion of biogas plants among 500 marginal farmers in remote areas, illustrating the use of corporate funding to extend decentralised clean-cooking solutions to rural and livestock-dependent communities (CSRBOX, 2018–19). [87] CSR has also been used for solar cooking: an environmental sustainability initiative in Maharashtra included the distribution of improved cookstoves and solar cookers, while more recent philanthropic funding has supported pilots of indoor solar cooking technologies among rural communities dependent on biomass. A grant of approximately US$593,320 was committed in 2024 for a pilot promoting indoor solar cooking in India, with the programme intended to test adoption and health impacts among biomass-dependent rural communities (Solar Industries India Ltd., 2016; Bill & Melinda Gates Foundation, 2024). [88] A related 2024 programme has focused on deploying indoor solar cookers in selected districts of Madhya Pradesh, Uttar Pradesh and Maharashtra, further illustrating the predominantly geographically targeted nature of such interventions (EKI Energy Services Limited. 2024).[89]

Carbon finance has been used to support decentralised household biogas deployment in India, particularly by monetising the greenhouse-gas reductions achieved through replacing traditional biomass fuels with biogas. One early example was a Gold Standard voluntary emission reduction (VER) project developed by INSEDA and its grassroots NGO partners, covering household biogas plants in Kerala and Madhya Pradesh. The project sought to generate carbon credits from the displacement of firewood with biogas produced from cattle dung and other locally available organic waste, while simultaneously improving household energy access and reducing indoor air pollution and the drudgery associated with fuelwood collection (INSEDA/INFORSE, n.d.).[90] More recent carbon-financed activity indicates that this model continues to be explored at scale: a Gold Standard-registered household biogas project in Jammu and Punjab, for example, had a 2022–2025 crediting period and an estimated 40,129 tonnes of CO_2e in emission reductions, while another project in Madhya Pradesh has

[85] Tata Trusts. (2019). *Clean cooking*. Tata Trusts. https://www.tatatrusts.org/our-work/environment-and-energy/energy/clean-cooking
[86] The Indian Express. 2017. "NBCFDC opens biogas plants under CSR initiative." *The Indian Express*, 3 July 2017
[87] CSRBOX. 2018–19. *Promoting Usage of Biogas Plants – Maharashtra*. CSR Project by IRCON International Limited, implemented with Bhagirath Gramvikas Pratishthan.
[88] Bill & Melinda Gates Foundation. 2024. *EKI Energy Services Limited – Committed Grant*. Grant to promote indoor solar cooking stoves on a pilot basis among rural biomass-dependent communities in India.
[89] *EKI Secures Grant from the Gates Foundation to Expand IOCL's Solar Cooking Technology Rollout for Tribal, Underprivileged Regions*. 18 November 2024
[90] INSEDA/INFORSE. n.d. *Case: India – Household Biogas Plant: Carbon Credit for Household Biogas Plant of INSEDA Members and Partners under the Gold Standard*. Integrated Sustainable Energy and Ecological Development Association / INFORSE-South Asia

involved thousands of household and community biogas plants (Climate Projects Registry, 2026; Down To Earth, 2023).[91]

In 2023, The Asian Development Bank extended a US$6.5 million loan to Greenway Grameen Infra, backed by a US$3.25 million liquidity reserve from the Climate Innovation and Development Fund. The project aimed to distribute 1 million improved cookstoves across Madhya Pradesh and Odisha, with an explicit target of reducing 22.9 million tons of CO_2 emissions- a project structure that explicitly linked household cooking-energy access to carbon markets, signalling a maturing convergence between development finance, climate policy, and clean-cooking practice.[92]

1.12. Conclusion

Taken as a whole, the history of clean cooking in India defies any simple narrative of linear progress. It has intertwining threads of fossil fuel based and DRE based technologies. It is a story of repeated reinvention: from the efficiency-focused chulhas, biogas plants and solar box cookers of the 1980s, through a donor-driven "pseudo-market" hiatus, to standards-based research initiatives, a transformative but incomplete LPG revolution, and now a determined embrace of solar-photovoltaic electrification. Across each phase, the intended beneficiaries- rural women exposed to indoor smoke, below-poverty-line households burdened by fuel costs, and communities seeking sustainable livelihoods have remained remarkably consistent, even as the technologies, financing mechanisms, and institutional architectures built around them have changed dramatically. What has also remained consistent is a recurring gap between distribution and sustained use: stoves that broke down due to lack of service and maintenance support, biogas plants left underutilised, LPG cylinders too costly to refill regularly, and solar cookers abandoned for want of a repair technician. As India moves into the era of induction cooking and electrified kitchens, the central policy challenge from earlier decades persists in a new form: not simply getting clean-cooking technology into households, but ensuring it is affordable, culturally accepted, and used consistently enough to deliver the health, environmental, and economic benefits that have shaped this pursuit.

[91] Climate Projects Registry. 2026. *Household Biogas in Jammu and Punjab (HBJP)*, Gold Standard Project ID 11441. Climate Projects Registry. Down To Earth. 2023. *Forensic Dive into Carbon Trade*. *Down To Earth*, October 1–15, 2023.
[92] Asian Development Bank, 2023.

2. Building a Case for DRE based Clean Cooking in the Present and Future

Over the past decade, the Government of India has increasingly positioned LPG as the primary clean cooking fuel for rural households, while PNG has been promoted for urban households. This has been accompanied by substantial public support for LPG access and affordability through schemes such as PMUY and its associated subsidy measures. At the same time, electricity-based cooking for both rural and urban households seems to be gaining increasing attention in the last few years. As far as institutional and commercial cooking is concerned, there was a push towards commercial LPG, but in the face of the recent shortage of imported LPG due to geopolitical tensions, several urban local governments have shown willingness to ease the path of commercial PNG connections for commercial/institutional establishments.

Improved biomass cookstoves, biogas and solar cookers have all received programme support at different points; Chapter 1 traces this history in detail. However, these interventions have not developed into a sustained, large-scale clean-cooking pathway comparable to LPG, PNG and electricity. It must also be noted that support for improved biomass, biogas and solar cooking has remained fragmented and programme-specific, while the policy focus has increasingly shifted towards LPG, PNG and, more recently, electric cooking. This raises an important question for the clean-cooking roadmap: whether decentralised renewable-energy (DRE) technologies should be considered as part of the long-term mix of cooking energy technologies, particularly for households and applications where LPG or grid electricity may not be the most practical or affordable option.

2.1 The LPG Access-Adoption Paradox: affordability, supply gaps and where it stands today

The central analytical problem this paper foregrounds is what is termed as the Access-Adoption Paradox: India has substantially solved the access problem (a clean-fuel connection reaching the household) while the adoption problem (that fuel becoming the household's actual, sustained, and exclusive cooking energy source) remains only partially solved.

The paradox exists because "access" metrics (connections, installations, distributed units) are relatively easy for a government programme to achieve and report, while "adoption" metrics (refill rates, hours of actual daily use, share of meals cooked on the clean fuel) require sustained affordability, reliability, and behaviour change - all fundamentally harder to achieve and difficult to quantify for reporting. IEEFA's analysis is blunt on this point: coverage may exceed 100 per cent of households on a connections basis, yet 40 per cent of households may still depend at least partly on solid fuels like cow dung and firewood with traditional cookstoves.

2.1.1 LPG: High Coverage, Uneven Use

India has achieved near-universal household access to LPG, but access to a connection does not necessarily translate into sustained exclusive use. At the current price of around ₹942 for a 14.2-kg cylinder in Delhi, a household relying exclusively on LPG for cooking would spend roughly ₹6,600–₹7,500 per year, assuming 7–8 cylinders annually. For a typical four-member rural household, this represents approximately 3.3–3.8% of annual household consumption expenditure. Earlier estimates found a substantially higher burden when LPG prices were higher, with CEEW estimating that exclusive LPG use could require around 9.3% of monthly

household expenditure for rural households (CEEW, 2021)[93]. These estimates indicate that LPG can remain a significant recurring expense, particularly for lower-income households.

The PMUY subsidy has helped reduce this burden, but its coverage has narrowed over time. The ₹300-per-cylinder subsidy, which previously covered a larger number of refills, is now limited to four refills per year from FY2026–27. At the same time, PMUY households continue to have lower average refill consumption than households using LPG more regularly, with average annual consumption reaching about 4.7 cylinders in FY2025–26. This suggests that the key challenge is no longer simply providing an LPG connection, but ensuring that households can afford and reliably use LPG as their primary cooking fuel. A small proportion of PMUY consumers also report no refill use after receiving a connection, highlighting the gap between connection ownership and actual usage (Ministry of Petroleum and Natural Gas, 2026). [94]

Supply-chain constraints further reinforce this affordability problem. Rural distributors face greater delivery challenges than urban distributors, and the existing distributor commission structure provides limited incentive for deliveries to more remote households. Delays in obtaining refills can therefore push households temporarily/ repeatedly back to firewood, dung cakes and other locally available fuels (CEEW, 2023).[95] Consequently, multi-fuel use remains common, with households switching between LPG and solid fuels depending on affordability, availability and convenience. The gap between LPG connections and actual consumption is therefore an important indicator: while household LPG access has approached universal levels, growth in actual LPG use has been considerably slower (MECS, 2025).[96]

Another concern is that reported LPG consumption figures may not always represent household cooking use. A CAG audit identified instances of unusually high domestic-cylinder purchases, including multiple refills by individual beneficiaries on the same day, and noted that diversion of subsidised domestic LPG for commercial use could not be ruled out (CAG, 2019). This provides an additional reason to distinguish between connections, refills and actual household cooking consumption when assessing LPG access.

Reliable data is not available on refills availed per year by typical households in different parts of the country (see BOX 1). However, anecdotal data from the field indicates that multi-fuel-stacks is the more common scenario in both rural and urban India. This is further elaborated on in Section 2.

[93] Council on Energy, Environment and Water (CEEW). (2021). *State of Clean Cooking Energy Access in India: Insights from the India Residential Energy Survey (IRES) 2020.* CEEW – State of Clean Cooking Energy Access in India
[94] Ministry of Petroleum and Natural Gas (MoPNG), Government of India. (2026). Data and statements on PMUY connections, refill consumption and LPG subsidy provisions
[95] Council on Energy, Environment and Water (CEEW). (2023). *CEEW research on LPG distributors and last-mile delivery, based on the 2022–23 distributor survey*
[96] MECS. (2025). *A Wide-ranging Review of India's Journey Towards Electric Cooking.* Modern Energy Cooking Services

Box: 3

Reported refill figures under PMUY may be affected by diversion of subsidised domestic cylinders into commercial use. A CAG audit found 2.61 lakh households purchased two refills on the same day nearly three lakh times, and over 1,300 consumers bought 12 cylinders each in a single day between 2016–2018. CAG considered such high consumption prima facie improbable for household use and noted that diversion of domestic cylinders for commercial use could not be ruled out.[97] The structural incentive arises because subsidised domestic LPG is priced far below commercial LPG, encouraging small eateries and vendors to source gas informally (Manur & Suresh, 2026)[98]. Reporting during the 2026 crisis confirmed that migrant workers, tea stalls, and small eateries without documentation rely disproportionately on such informal cylinders (Down To Earth, 2026)[99]. Unlike anecdotal claims of black-marketing, this leakage shows up directly in the numbers: the CAG checked real purchase records from the gas companies and found specific, countable cases of implausible buying, like IOCL and HPCL issued 2–20 refills in a day to a single-bottle beneficiary in 3.44 lakh instances. Because the CAG evidence dates to 2016–18, it establishes that diversion was a documented risk but does not provide a basis for estimating current diversion levels. [100]

Box: 4 : The core metric gap

LPG connections rose from 62% to effectively 100% of households over eight years (2016-2024) but actual LPG usage rose by only ~44% over the same period (MECS, A wide-ranging review of India's journey towards electric cooking,).

2.1.2 LPG as a transitional fuel

A recurring theme in the independent literature, including IEEFA, IISD and MECS, is that LPG should be understood as a transitional rather than a final clean cooking technology for India. The argument rests on three points.

First, **fiscal exposure**. The gap between the cost of supplying domestic LPG and the price households pay (the under-recovery) was about ₹41,338 crore in FY2024-25[101] and is estimated at about ₹60,000 crore in FY2025-26.[102]

[97]Singh, A. (2019). CAG lifts the lid on cylinder scam under Ujjwala scheme. Deccan Herald. https://www.deccanherald.com/amp/story/business%2Fcag-lifts-the-lid-on-cylinder-scam-under-ujjwala-scheme-784776.html

[98]Manur, A., & Suresh, A. (2026, March). Policy Responses to India's LPG Supply Crisis, Takshashila Institution — https://takshashila.org.in/content/publications/20260318-Policy-Responses-to-India-LPG-Supply-Crisis.html

[99]https://www.downtoearth.org.in/energy/in-protecting-politically-sensitive-household-consumers-from-lpg-shock-economically-vulnerable-groups-being-exposed-to-war-driven-price-surge-experts

[100]Comptroller and Auditor General of India. (2019). *Performance audit of Pradhan Mantri Ujjwala Yojana, Ministry of Petroleum and Natural Gas* (Report No. 14 of 2019). https://cag.gov.in/uploads/download_audit_report/2019/Executive_Summary_of_Report_No_14_of_2019_Performance_Audit_of_Pradhan_Mantri_Ujjwala_Yojana_Ministry_of_Petroleum_and_Natural_Gas_0.pdf

[101]Indian households continue to pay among the lowest cooking gas prices in the world, 7 June 2026 https://www.pib.gov.in/PressReleaseDetail.aspx?PRID=2269944&reg=3&lang=1

[102]Cabinet release, August 2025 (₹30,000 crore, 2024-25 losses): https://www.pmindia.gov.in/?p=16658357 .

Second, **energy security.** India imports roughly 60 per cent of its LPG, and about 92 per cent of those imports come from the Middle East via the Strait of Hormuz (PPAC; Dataful, 2026).[103]

Third, **technology economics.** MECS modelled households that cook only on LPG shifting to 80 per cent electric cooking and 20 per cent LPG. If 25 to 40 per cent of such households made this shift by 2030, the LPG subsidy bill would fall by ₹2,200 to ₹3,500 crore a year, against current subsidy spending of about ₹11,000 crore.[104]

Most such analyses treat electric cooking as the only alternative. We suggest that decentralised renewable options such as biomass, biogas, solar, and emerging new technologies mentioned in Section 1, may offer comparable or stronger economic benefit, energy security, environmental and health benefits, compared to use of grid electricity for household cooking.

This is not an argument for abandoning LPG, or challenging the road map centered on e-cooking. LPG will remain the backbone fuel for the majority of Indian households for the foreseeable future given its entrenched distribution infrastructure and consumer familiarity. We are challenging the rationale of treating electricity as the only future option, when coal-based (and therefore GHG emission inducing) electricity generation is unlikely to go away for decades. A variety of analyses and data from the field indicate that there is a strong case for actively building parallel, DRE based, zero or low GHG emission cooking capacity (biogas, e-cooking, solar) rather than treating these technologies as irrelevant for the future.

2.2 The Multi-Fuel Stacking

As per the IRES 2020, while 85 per cent of Indian households use clean cooking fuels, only 47 per cent use them exclusively meaning nearly half of LPG-owning households continue to "stack" LPG with solid fuels. In rural India, around two-thirds of clean-fuel-using households engage in stacking, and roughly one-fourth of rural clean-fuel users still use traditional solid biomass fuels as their primary cooking fuel despite owning an LPG connection.[105]

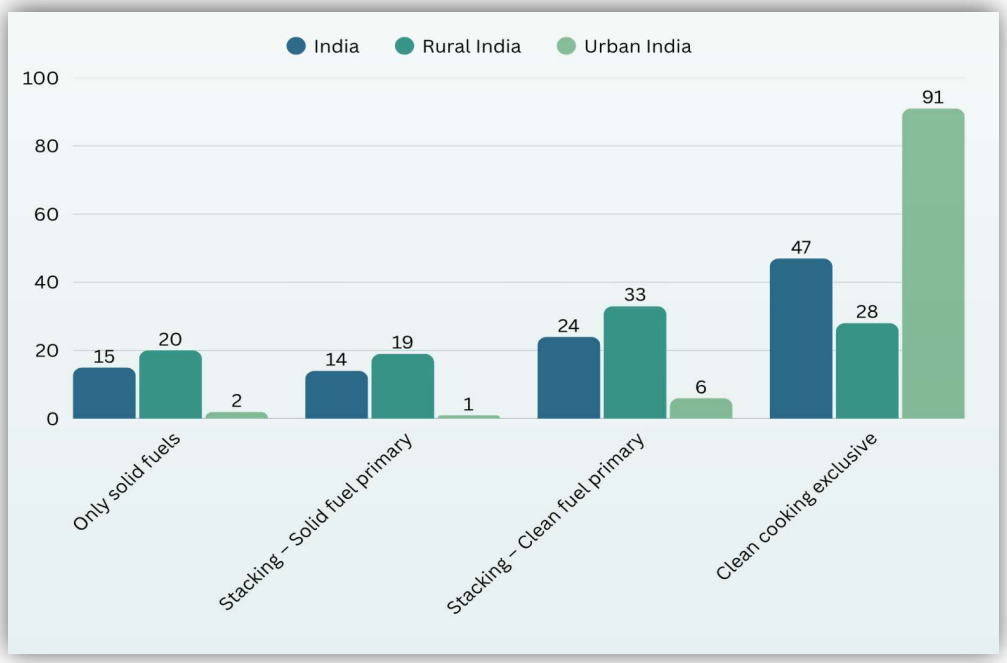


Figure 1 : Region-Wise Household cooking-fuel status

Source: CEEW, IRES 2020.

The dominant driver, cited by 87 per cent of stacking households nationally in the

[103]CEEW (Mani et al., 2021), IRES 2020, p.20; Legal Service India, "India's LPG Crisis 2026: Causes, Impacts, and Legal Remedies" (15 March 2026). [for 90% Hormuz figure] https://www.legalserviceindia.com/Legal-Articles/indias-lpg-crisis-2026-causes-impacts-and-legal-remedies/
[104]MECS (Rousseau et al., 2026), A wide-ranging review of India's journey towards electric cooking.
Kephart, J. L., Fandiño-Del-Rio, M., Williams, K. N., et al. (2021). Nitrogen dioxide exposures from LPG stoves in a cleaner-cooking intervention trial. Environment International, 146, 106196. https://doi.org/10.1016/j.envint.2020.106196

[105]CEEW (Mani et al., 2021), IRES 2020.

study, is simply that LPG is expensive relative to household budgets, followed by a preference for chulha-cooked food for specific dishes (76 per cent), free availability of biomass (62 per cent), and unreliable LPG availability (47 per cent). Reading across this survey finding alongside the rest of the literature cited in this paper, seven distinct drivers of stacking emerge, each with a different policy implication.[106]

- **Affordability:** At today's prices, exclusive LPG use costs about 3.3 to 3.8 per cent of annual rural household spending, and up to 9.3 per cent on the IRES 2020 estimate (Section 2.2). To our knowledge, the IRES has not been repeated at national level since 2020, so the latest national estimate predates the recent price changes. PMUY households took an average of 4.71 refills in FY 2025-26, covering only 59 to 67 per cent of what exclusive use requires, so a substantial part of their cooking continues on biomass and other fuels
- **Supply-chain gaps:** Late and uncertain refills, push households back to firewood and dung cake (Section 2.2)
- **Free biomass:** About 14 per cent of rural households in India rely on free of cost biomass exclusively, while another 50 per cent collect biomass to supplement clean fuels. Zero marginal cost makes biomass rational for slow, high-heat tasks where LPG would burn expensive gas for comparatively little benefit.[107]
- **Agro-industrial task mismatch:** High-heat, long-duration loads such as cattle-feed boiling, jaggery making and paddy parboiling fall outside what LPG can economically serve, so biomass use continues even in households that cook daily on LPG, if those households are engaged in such food processing operations (Section 2.4).
- **Cultural preference and cooking identity:** Both a Springer study and MECS document a persistent preference for chulha-cooked flavour among PMUY beneficiaries, particularly for millet rotis, tempering, and char-based dishes.[108] For biogas specifically, the informal association of biogas with "gobar gas", linked to the drudgery of daily dung feeding and to lower social status, is a further cultural barrier that awareness campaigns have only partly addressed.[109]
- **Consumer myths about e-cooking alternatives:** MECS identifies widespread beliefs that electric cooking causes high electricity bills, does not suit Indian dishes, affects food taste, or is unsafe for children, beliefs that persist even where the data clearly shows e-cooking to be cheaper and technically capable.[110]
- **Awareness Gaps and Unrealistic Expectations in DRE Cooking:** For DRE based clean cooking alternatives, the biggest problem is lack of awareness, and misconceptions about the utility of technologies like solar cooking, pellet fuelled stoves, and biogas plants.

It is important to read fuel stacking as rational household risk management rather than policy failure per se. A household stacking LPG with firewood is typically hedging against LPG price volatility, delivery delay, and running out mid-month, a sensible response given the affordability and reliability constraints documented above.

[106]CEEW (Mani et al., 2021), IRES 2020 .
[107]CEEW (Mani et al., 2021), IRES 2020 . https://www.ceew.in/publications/state-of-clean-cooking-energy-access-in-india-ires-2020-report
[108]Springer (2025), Discover Sustainability . https://link.springer.com/article/10.1007/s43621-025-02241-2
[109]World Bioenergy Association, Market Report / India Country Report (2023) . https://www.worldbiogasassociation.org/wp-content/uploads/2023/12/FINAL_COUNTRY_REPORT.with-authors.pdf
[110]MECS (Rousseau et al., 2026), A wide-ranging review of India's journey towards electric cooking . https://mecs.org.uk/wp-content/uploads/2026/03/A-wide-ranging-review-of-Indias-journey-towards-electric-cooking-by-the-Modern-Energy-Cooking-Services-Programme.pdf

But this rational individual behaviour produces a systemic trap for public health goals: even substantial clean-fuel penetration does not translate into a proportional reduction in household air pollution exposure, because stacking households continue to inhale biomass smoke on the days they use it. MECS's broader research affirms this pattern extends to electric cooking too. Indian households rarely switch fuels in a binary manner, and "clean stacking" (LPG or PNG plus electric, rather than full substitution) is a more realistic medium-term outcome than complete fuel replacement for most households, even affluent ones with reliable grid access.[111] What is not highlighted in most of the e-cooking studies, but is observed in the field is that in most of these cases, the newly introduced e-cooking replaces some of the cooking functions of LPG, while the traditional biomass use continues as it is.

The policy implication, argued explicitly by IEEFA and implicit in CEEW's state-by-state stacking analysis, is that India's clean cooking strategy needs to design for stacking rather than treat it as a transitional anomaly to be eliminated. A more logical approach would be to make other cleaner-than-traditional cooking energy options (e.g., smokeless cookstove, or biomass pellets, or biogas, or a solar/electric hybrid, or one of the new emerging DRE technologies, etc.) available as the stacking partner to LPG (and/or electricity), rather than expecting households to abandon multi-fuel cooking altogether.[112] This is the ideal space for DRE based clean cooking technologies to occupy.

2.2.1 Harmful vs. functional stacking: a distinction worth drawing

Not all stacking is the same problem, and treating it as a single category is itself a policy error. Harmful stacking is substitutional: LPG capacity exists in the household, but biomass with traditional cookstove is used instead for tasks LPG could technically perform, driven by affordability or habit. This is the pattern behind most of the elevated exposure to harmful pollutants and it is what programme design should be working to close. Functional stacking is complementary: biomass or another fuel is used for tasks LPG genuinely cannot serve efficiently or affordably- the high-heat, long-duration agro-industrial loads described earlier, space heating in cold climates, or simultaneous multi-burner festival cooking. Functional stacking is not a failure to be eliminated; it reflects an irreducible diversity of household thermal energy needs that a single fuel was never designed to serve, or the supply related challenges are too difficult or expensive to overcome.

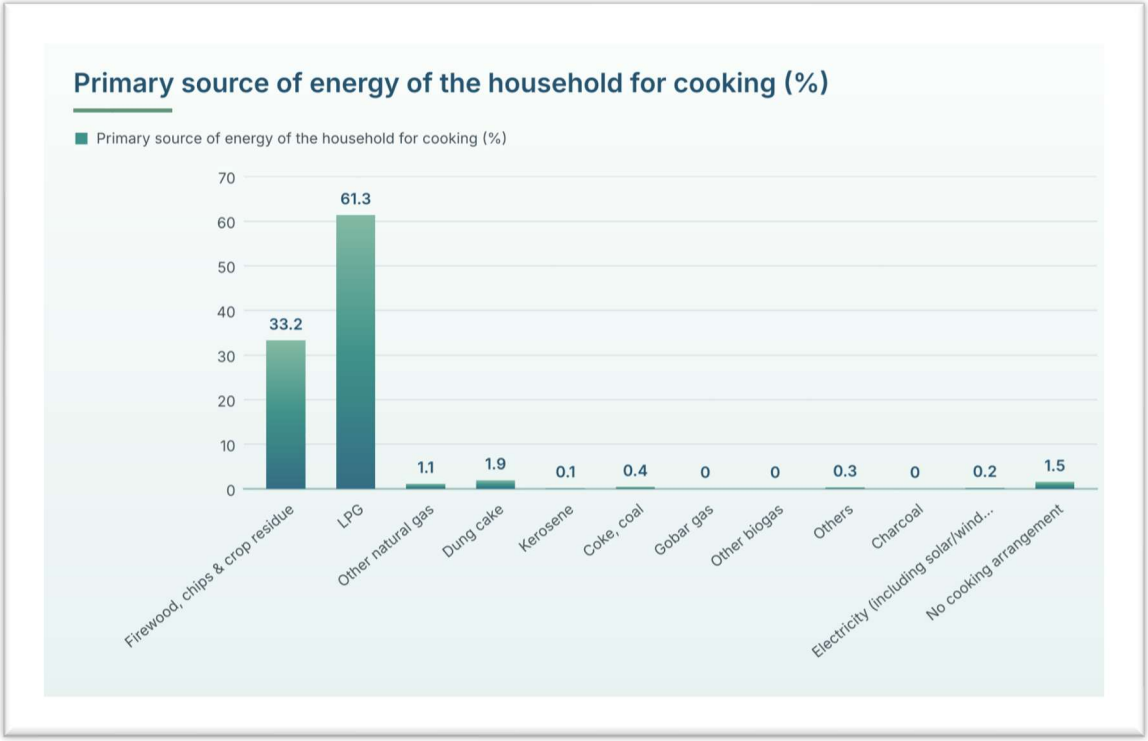
The practical policy task is to narrow stacking to its functional core: ensuring a clean cooking system is used exclusively for the routine daily cooking it is well suited to, while genuine secondary use is met by other clean alternatives - improved biomass stoves with chimneys, biogas, solar cookers, or dedicated agro-industrial solutions, etc., rather than open fires. MECS makes the same point for electric cooking, and the argument applies equally to DRE based clean cooking technologies. Fuel stacking that progressively substitutes cleaner fuels for dirtier ones is itself a form of progress, and this paper suggests it should be measured and credited as such rather than treated only as a shortfall from full substitution.[113]

[111]MECS (Rousseau et al., 2026), A wide-ranging review of India's journey towards electric cooking.
[112]IEEFA (Jain, 2024), India's clean cooking challenge: Can we look beyond subsidising LPG? . https://ieefa.org/resources/indias-clean-cooking-challenge-can-we-look-beyond-subsidising-lpg
[113]MECS (Rousseau et al., 2026), A wide-ranging review of India's journey towards electric cooking . https://mecs.org.uk/wp-content/uploads/2026/03/A-wide-ranging-review-of-Indias-journey-towards-electric-cooking-by-the-Modern-Energy-Cooking-Services-Programme.pdf

Box 5: Measuring what matters

Stacking becomes a policy trap specifically when connection distribution is counted as success while sustained clean fuel use for routine cooking is neither measured nor rewarded. This paper suggests the primary success metric should shift from connections distributed to exclusive or near-exclusive clean fuel use for meeting thermal energy needs including cooking, verified where possible through stove-use monitoring data, while separately tracking and supporting functional secondary fuel use through progressively cleaner alternatives. The fiscal stakes of getting this right are large: India's annual government health cost attributable to cooking-related indoor air pollution is estimated at roughly ₹30,000-40,000 crore, some 2.5-3.3 times the entire FY2025-26 PMUY subsidy outlay of ₹12,000 crore..

Figure 2. Primary source of energy of the household for cooking.



Source: HCES 2022–23.

2.3 The Overlooked Thermal Energy Landscape and the untapped DRE resource

While household clean cooking access dominates the policy conversation, it must also be noted that there are thermal energy needs beyond cooking, at domestic level. Solid biomass fuels have traditionally been used for these applications too - such as a three stone fire used for heating water for bath, or a traditional charcoal stove for space heating, or traditional stoves with solid biomass fuels used for home-based micro-industries, etc. Transitioning to cleaner fuel-stove combinations is a requirement for these thermal energy needs too. This is also an important reason why a household LPG connection often fails to fully replace the use of a traditional cookstove in a rural household.

Additionally, substantial, poorly quantified demand for cooking and food processing heat sits outside the household altogether. One of these segments involves cooking for a large number of people - either in institutional (e.g. school midday meals, kitchens of residential not-profit facilities like old age homes, etc.) setting or commercial (e.g., restaurants, industrial canteens, etc.) setting. As described earlier, some DRE solutions are already available for such kitchens (e.g. solar concentrator-based steam cooking, biogas plants based on food waste, large pellet stoves, etc.) although adoption is low primarily due to lack of marketing and finance for upfront installation costs. Considering the high cost of commercial LPG or PNG, or grid connected high power induction stove, DRE powered institutional/commercial kitchens can be an economically attractive proposition in the long run. However, a combination of several DRE technologies needs to be integrated, and intensive and long-term hand holding of the kitchen staff is required to ensure smooth operation and timely food preparation. Another neglected segment is that of process heat required in rice mills, jaggery units, dairies, tea processing, bakeries, cattle-feed/fodder preparation, etc. While strictly speaking these are not 'cooking' energy requirements, the processes and therefore energy devices used are similar to cooking energy devices.

All these demands are largely invisible in national clean cooking statistics, which are household-survey based (thereby failing to capture the thermal energy needs outside household kitchens. In addition, the survey questions are specifically focused on 'cooking' rather than overall thermal energy needs.

For thermal energy for food processing, rice parboiling is a well-documented example: a rice-husk-powered gasifier system for parboiling mills has been shown to achieve 49-57 per cent overall system efficiency with payback periods as short as two years, using a byproduct (rice husk) that mills already generate and often discard or burn openly.[114] Biomass gasifiers more broadly have demonstrated 25-30 per cent cooking-time reduction and 28 per cent fuel savings against traditional systems in institutional-cooking field trials,[115] with a TERI-operated 10 kWe gasifier at its own campus preparing meals for nearly 300 people daily at an installation cost of roughly ₹1.2 lakh and a fuel cost of about ₹5/kg.[116]

Cattle-feed and dairy-belt cooking energy is a related but distinct invisible-demand segment. India's roughly 40 million cattle-rearing households with three or more animals generate a dung feedstock stream that, at standard conversion rates, could displace up to about 100 kg of LPG per household annually, or roughly seven cylinders.[117] If even a quarter of these households (10 million) shifted to biogas, up to about 1 million tonnes of LPG, or around 70 million cylinders, would be displaced each year. At today's prices, this is worth about ₹6,600 crore a year at the ₹942 retail price in Delhi, and about ₹11,300 crore at the import linked cost of supply, which the government put at over ₹1,600[118] per cylinder in June 2026. (The PMUY price of ₹642 is not used here, as it applies only to beneficiaries and only to the first four refills a year.)

2.3.1 A scheme-design gap, not just a data gap

The invisibility of this demand is not only a measurement problem; it is built into how India's clean cooking schemes are designed. PMUY (under the Ministry of Petroleum and Natural Gas) and the Biogas Programme (under MNRE's National Bioenergy Programme, which was running till March 2026) were both designed almost exclusively around one-use case: a household member cooking meals on a two-burner domestic stove. Neither scheme's eligibility criteria, technology specifications, nor outcome metrics account for a substantial

[114]Beno Wincy, W. & Edwin, M., "Techno-economic assessment on the implementation of biomass gasifier in conventional parboiling rice mills", International Journal of Energy Research (2019) . https://onlinelibrary.wiley.com/doi/epdf/10.1002/er.4991
[115]Pradhan, P. et al., "Field evaluation of biomass gasifier for bioenergy application: Case studies on institutional cooking in India", Sustainable Energy Technologies and Assessments (Oct 2023) . https://www.sciencedirect.com/science/article/abs/pii/S2213138823004022
[116]TERI, "TERI Demonstrates Biomass Gasifier for Clean, Affordable Community Cooking" . https://www.global-agriculture.com/india-region/teri-demonstrates-biomass-gasifier-for-clean-affordable-community-cooking-invites-media-to-experience-technology-first-hand/
[117]Kar, A., & Gill, B. (2026, May 6). *Biogas could be LPG hedge in India's dairy belt*. *Deccan Herald*. https://www.deccanherald.com/opinion/biogas-could-be-lpg-hedge-in-indias-dairy-belt-3992775
[118]https://www.pib.gov.in/PressReleasePage.aspx?PRID=2269944&lang=2&reg=3

category of energy-intensive, biomass-powered thermal work that happens alongside or outside the domestic kitchen. The Sustainable Cleaner Cooking Coalition identifies this as a structural design gap: open fires serve many household functions that no single clean stove-fuel combination can replace, and no current government scheme is designed to serve them.[119] It must be emphasised that this is no inherent limitation of these thermal technologies, but it indicates towards the reality that the technology development effort has focused on developing the 'best' option for cooking daily meals. But in the process, the potential for multifunctionality has been sacrificed. For India's roughly 40 million cattle-rearing households, feed boiling and similar tasks are small but daily thermal loads that a two-burner domestic stove is not designed for. Small agro-industrial units such as jaggery plants, parboiling mills and dairies need sustained heat of 20 to 500 kW, a scale at which LPG becomes uneconomical. Despite this, biogas remains unsubsidised for this specific application. At the same time, hardly any R&D on DRE alternatives has been undertaken, and as the solutions do not exist, the approach is not built into any national programme's architecture.

The Indian Journal of Medical Research explicitly identifies small rural industries such as jaggery plants using unprocessed biomass for energy as a recognised anthropogenic air pollution source, yet these sources remain unregulated, unmeasured in national indoor-air-pollution surveys, and unaddressed by any clean energy scheme.[120]

Box 6: Common Thermal-Energy Uses

Livestock feed and water heating: Dairy-owning households often use biomass chulhas to boil chaff, bran and other feed, as well as heat livestock water. Higher biomass dependence and fuel stacking among livestock-owning households indicate that energy demand extends beyond meal preparation. CEEW (Mani et al., 2021).
Jaggery production: India produces approximately 9–10 million tonnes of jaggery annually, with small rural units relying heavily on bagasse, sugarcane trash and firewood for process heat. These dispersed furnaces represent a significant but poorly characterised source of biomass combustion. (Beno Wincy, W. & Edwin, M. 2020)
Paddy parboiling: Traditional rice parboiling is highly biomass-intensive, with studies estimating around 1,659 MJ of biomass energy per tonne of paddy. Rice-husk gasification has shown technical potential, but wider adoption has faced operational and financial constraints.
Space and water heating: In northern and Himalayan India, biomass hearths may serve cooking, livestock water heating and winter space-heating needs. These multiple uses can increase household air-pollution exposure, particularly in poorly ventilated spaces. WHO (2025).
Agro-industrial residues and biogas: Sugar mills generate substantial residues such as pressmud, which can yield approximately 80–105 m^3 of biogas per tonne under favourable conditions. This creates opportunities for biogas and compressed biogas production. World Bioenergy Association (2023)

2.3.2 The untapped DRE potential

India generates a surplus of around 179 million tonnes of agricultural biomass a year that goes unused domestically, a large share of which is burned in the field, pushing pollutant concentrations in nearby settlements to hazardous range. For example, PM2.5 levels in Delhi rise to roughly 98 micrograms per cubic

[119]Clean Cooking Alliance (2022), cited by reviewer as an external addition . https://www.cleanercooking.org/_files/ugd/770ad3_f1b3c38b806748158cd00a067a716674.pdf
[120]Indian Journal of Medical Research, via PMC (2024) . https://pmc.ncbi.nlm.nih.gov/articles/PMC11463883/

metre during the burning season, about twenty times the WHO's 2021 annual guideline of 5 micrograms per cubic metre.[121] It must be noted that converting agricultural waste into pellets or briquettes for industrial use is already a fairly well-established business sector. If a large quantity of agricultural waste is still being burnt in open air, there is obviously surplus biomass and therefore scope for finding additional uses for the same. In other words, there is a huge potential DRE resource being wasted.

Aggregating and converting waste biomass into briquettes or pellets or ethanol or biogas through a large number of small processing units, promoting these as cooking fuels with appropriately designed cookstoves made available at low cost, and developing a localised distribution system for each of these is the best option to dispose of the organic waste on one hand, and to help attain a reliable and secure clean cooking system for local communities on the other hand. The beneficiaries of these zero pollutions and low-emission, locally sourced cooking approaches can be both rural and urban users in agriculture-dominant geographies. Collectively such an approach will reduce the pressure on LPG and PNG supply chains, thereby reducing India's import bill too.

Table 1. India's untapped biogas feedstock: a summary.

Feedstock	Annual Potential	Current Use
Cattle & buffalo manure	10 BCM/yr	Partially used (5.1M plants)
Poultry waste	~1 BCM/yr	Near-zero
Pressmud / spent wash (sugar)	5.68–9.09 BCM/yr	Near-zero
Municipal Solid Waste (50% organic)	31 MMT organic/yr	Minimal
Surplus crop residue	179 MMT dry biomass/yr	Mostly burned
Sewage (urban, untreated)	40,527 MLD untreated	Near-zero

Source: World Bioenergy Association (2023), Market Report: India.

2.4 Indoor air pollution: the health and gender burden and the monitoring gap

Household air pollution (HAP) is, by WHO's global estimate, responsible for roughly 2.9 million deaths a year, including over 309,000 deaths of children under five, and 95 million disability-adjusted life years (DALYs) lost in 2021 alone.[122] For India specifically, the Lancet Countdown 2025 attributes 113 deaths per 100,000 people to HAP in 2022, with rural mortality (125 per 100,000) substantially exceeding urban mortality (99 per 100,000), a gap that tracks closely with the rural-urban gap in clean fuel use.[123]

More recent field measurement (One Health Trust) recorded real-time particulate concentrations of 500-2,000 µg/m³ during cooking in biomass-using Indian households, one to two orders of magnitude above WHO guideline levels.[124]

[121]World Bioenergy Association, Market Report / India Country Report (2023) . https://www.worldbiogasassociation.org/wp-content/uploads/2023/12/FINAL_COUNTRY_REPORT.with-authors.pdf
[122]WHO, "Household air pollution" fact sheet (16 December 2025) . https://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health
[123]Earth5R, State of Air Quality in India: Crisis, Policy & Community-Led Action, citing Lancet Countdown 2025 . https://earth5r.org/india-air-pollution-2025-crisis-community-action/
[124]One Health Trust, "Notes from the Field — Measuring the Effects of Indoor Air Pollution on Women and Children's Health in India",https://onehealthtrust.org/indoor-air-pollution-womens-health-the-value-of-vaccines-in-amr-control/?utm ; Earth5R (400-cigarette figure).

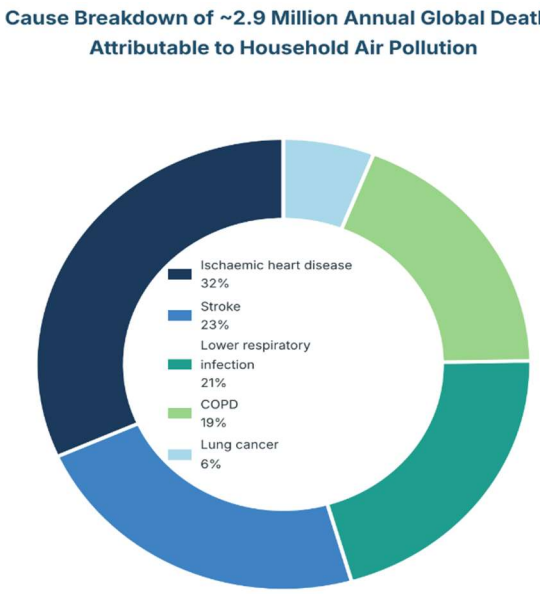


Figure 3— Cause breakdown of global HAP-attributable deaths. Source: WHO, "Household air pollution" fact sheet (2025).

2.4.1 Women and children: the unequal burden, and the co-benefits of transition

WHO identifies women and children as bearing a disproportionate share of the health burden from household air pollution (HAP), as they typically spend more time cooking, collecting fuel and near household smoke. Globally, HAP-attributable deaths are estimated to comprise 32 per cent from ischaemic heart disease, 23 per cent from stroke, 21 per cent from lower respiratory infections, 19 per cent from COPD and 6 per cent from lung cancer; HAP accounts for around 11 per cent of all adult lung cancer deaths.[125]

The time burden of biomass cooking is a related and systematically undercounted gender-equity dimension. The Clean Cooking Alliance, drawing on a study by Practical Action, found that women in surveyed Indian households using traditional cookstoves spent approximately 374 hours a year collecting firewood, equivalent to more than two weeks of continuous time. The study also found that women using traditional stoves spent around four hours a day cooking and could save about 70 minutes per day with a clean cookstove.[126]

Evidence from rural Indore illustrates both the scale of this unpaid work and the limits of assuming that time savings automatically translate into employment. A time-use survey of 2,942 primary cooks found that women spent more than 40 hours a week on cooking and cleaning.

The benefits of transition therefore extend beyond reduced smoke exposure. A 2024 study of PMUY beneficiaries reported improvements in women's physical and mental health and empowerment, including self-efficacy and social participation.[127] The policy objective should consequently be broader than distributing connections: it should reduce women's exposure and unpaid domestic burden while making clean cooking affordable and reliable enough for sustained use.

2.4.2 The monitoring gap

India's existing systems for tracking HAP exposure and disease burden have three structural weaknesses that limit their usefulness for policy targeting. First, national ambient air quality standards (NAAQS) are calibrated for outdoor pollution and set at 40 µg/m³ annual mean PM2.5 - eight times the WHO's revised 2021 guideline

https://onehealthtrust.org/news-media/blog/notes-from-the-field-measuring-the-effects-of-indoor-air-pollution-on-women-and-childrens-health-in-india/

[125]WHO, "Household air pollution" fact sheet (2025) . https://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health

[126]Clean Cooking Alliance (2021) . https://cleancooking.org/news/05-05-2015-women-spend-374-hours-each-year-collecting-firewood-in-india-study-finds/

[127]https://www.tandfonline.com/doi/full/10.1080/23311886.2024.2428823

of 5 µg/m³, and there is no equivalent binding indoor/household air quality standard at all, meaning HAP exposure sits largely outside formal regulatory monitoring.[128]

Second, national disease burden estimates rely on Global Burden of Disease exposure-response functions derived largely from lower-pollution countries, and few Indian cohort studies link long-term PM2.5 exposure to mortality using causal methods.[129]

Third, and most consequential for programme design, there is no routine, representative national surveillance mechanism that links PMUY/LPG usage data to health outcomes at the household level, meaning refill-rate data (an administrative proxy for exposure reduction) and actual health-outcome data are tracked in entirely separate systems that are rarely, if ever, jointly analysed.

This is a genuine evidence gap: PMUY's own government-cited justification is framed around health and empowerment outcomes, yet the programme's monitoring and evaluation framework (as per CEEW's assessment) remains centred on connection and, more recently, refill counts, not health-outcome tracking.

Box 7: A Missing Step: Life-Cycle Assessment

India does not have a regular system for conducting **life-cycle assessments (LCA)** before scaling up a cooking fuel or technology. An LCA looks at the environmental impact of a fuel or technology across its entire life cycle—from production and extraction to final use—rather than only measuring emissions at the point of use. Most comparisons of the life-cycle impact of cooking fuels in India come from a single study conducted in 2016 for the US EPA and Global Alliance for Clean Cookstoves, rather than from a regular national assessment system. This is important because, as the study shows, a fuel that appears clean at the point of use may have significant environmental impacts elsewhere in its life cycle. Monitoring only household emissions and health outcomes could therefore miss important trade-offs, such as emissions from electricity generation or high water use.

Box 8: Burden of Household Air Pollution

The latest GBD 2021 estimates attribute approximately 1.05 million deaths in India in 2021 to household air pollution (HAP), linking it to COPD, cardiovascular disease, stroke, respiratory infections, neonatal disorders, diabetes and lung cancer. Earlier GBD 2019 estimates placed HAP-related deaths at around 0.61 million, while the broader economic burden of air pollution was estimated at US$36.8 billion (1.36% of GDP). Cooking-related HAP also represents a significant healthcare burden, with one estimate placing attributable government health expenditure at ₹30,000–40,000 crore annually, excluding household and productivity costs. Cooking energy additionally generated an estimated 84.3 $MtCO_2e$ in 2022, reinforcing its importance as a climate priority. Evidence further suggests disproportionate health vulnerability: a 2024 study found an 8.6% increase in all-cause mortality for every 10 µg/m³ rise in annual PM2.5 exposure, while biomass-related HAP has been associated with substantial burdens of chronic bronchitis, cataract and tuberculosis among Indian women. Together, these findings establish clean cooking as a health, economic and climate priority, rather than solely an energy-access issue.

[128]NCBI/Lancet Planetary Health (Jaganathan et al.), "Estimating the effect of annual PM2.5 exposure on mortality in India: a difference-in-differences approach" .
[129]NCBI/Lancet Planetary Health (Jaganathan et al.), "Estimating the effect of annual PM2.5 exposure on mortality in India: a difference-in-differences approach", "Evidence before this study" section .

2.4.3 Beyond PM2.5: a fuller pollutant profile

The HAPIN Tamil Nadu pilot remains the most directly relevant Indian household reference point: biomass kitchens recorded a median PM2.5 concentration of 134 micrograms per cubic metre (interquartile range 71-258) against 27 micrograms per cubic metre for LPG kitchens, with personal exposure of 75 micrograms per cubic metre for biomass users against 36 for LPG users- both figures well above the WHO's 24-hour PM2.5 guideline of 15 micrograms per cubic metre and India's own NAAQS of 60. Biomass-using kitchens in this study routinely recorded 5 to 17 times the WHO limit.[130]

2.5 The business model problem- across all stakeholders

Clean cooking in India suffers from a business-model gap that recurs, in different forms, across every stakeholder category. This is not a single failure but a set of related, mutually reinforcing weaknesses.

2.5.1 For government

The dominant government business model for clean cooking has been a recurring consumption subsidy (per-cylinder LPG subsidy plus periodic OMC under-recovery compensation) rather than a capital subsidy for durable, non-recurring clean cooking assets. This is fiscally awkward: LPG subsidy commitments must be renewed and are exposed every year to global price movements, as the March 2026 crisis illustrated in real time, whereas a one-time capital subsidy for a biogas plant or induction stove, once disbursed, requires no further annual outlay. IISD's direct comparison is instructive: the National Biogas Programme's entire five-year budget (₹1,715 crore, FY2021/22-FY2025/26) is smaller than a single year's LPG subsidy commitment even in a moderate year, despite biogas plants being a durable asset with a multi-decade lifespan against LPG's permanent recurring cost.[131]

2.5.2 For deployers and enterprises

Clean cooking appliances and fuel systems are rarely treated as income-generating or bankable assets by India's formal financial sector, which limits deployer and household access to credit from banks, microfinance institutions, and pay-as-you-go providers.[132] Last-mile distribution economics for non-LPG technologies remain thin: biogas plant installation and maintenance require trained masons and technicians, of whom MECS documents only around eight dedicated training centres existed nationally as of 2024, concentrated in a handful of states- a supply-chain bottleneck, not a demand bottleneck.[133]

2.5.3 For consumers and households

Households face the mirror-image problem: clean cooking technologies that require upfront capital (biogas plants, induction stoves, solar cookers) compete against LPG's comparatively low entry cost (subsidised connection, pay-per-cylinder), even where the alternative technology is cheaper over its lifetime. This is a classic consumer-finance market failure — the technology with the better total-cost-of-ownership loses to the technology with the lower upfront cost, in the absence of accessible consumer credit. PMUY itself illustrates

[130]HAPIN Tamil Nadu pilot data . https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7690197/
[131]IISD (Mani et al., 2026), India's Clean Cooking Shift: Scaling non-fossil fuel solutions .
[132]MECS (Rousseau et al., 2026), A wide-ranging review of India's journey towards electric cooking.
[133]IISD (Mani et al., 2026), India's Clean Cooking Shift: Scaling non-fossil fuel solutions.

the same dynamic at a smaller scale: roughly 30 per cent of PMUY beneficiaries financed their connection cost through an OMC loan, and subsidy credits are diverted to loan repayment until it is settled — meaning some of the poorest beneficiaries do not see the promised per-refill subsidy discount until months into their connection.[134]

> **Box 9: The common thread**
>
> Across government, deployers, and households, the business-model problem takes the same underlying shape: durable, capital-intensive clean cooking assets are financially disadvantaged relative to LPG's recurring, low-upfront-cost model, even where the durable asset is cheaper over its lifetime. Closing this gap through blended finance, asset-backed lending, and capital (rather than consumption) subsidies is a recurring theme in upcoming sections.

2.6 The 2026 LPG crisis: a stress test for an LPG-centred model

On 28 February 2026, the United States and Israel launched coordinated military strikes on Iran. Iran retaliated by effectively shutting the Strait of Hormuz to commercial shipping in early March 2026, a disruption Union Petroleum Minister Hardeep Singh Puri described in Parliament as unprecedented in modern energy history. It lasted several months: restrictions on commercial LPG were lifted only on 25 June 2026, after a US–Iran agreement that included reopening the waterway. Prior to the crisis, India imported approximately 60% of its LPG requirements and with historically around 90 per cent of that volume transiting Hormuz.[135]

Within the first two weeks of the closure[136], weekly LPG inflows to India fell by an estimated 30%. Brent crude crossed USD 100 a barrel on 8 March 2026 for the first time in four years, with the IEA describing the episode as the largest single supply disruption in oil market history .[137]

2.6.1 Impact on India's LPG supply, prices and consumption

Petroleum Planning and Analysis Cell (PPAC) data shows India's LPG consumption fell to 2.379 million tonnes in March 2026, against 2.729 million tonnes in March 2025, a decline of roughly 12.8-13 per cent year-on-year, equivalent to about 350,000 tonnes of cooking gas that did not reach the country.[138] The decline was not evenly distributed: domestic (household) consumption fell a comparatively modest 8.1 per cent to 2.219 million tonnes, while non-domestic (commercial and industrial) consumption fell nearly 48 per cent, reflecting the government's deliberate policy of prioritising the roughly 330 million active LPG connections that depend on LPG for daily cooking over commercial users.[139]

On 7 March 2026, the three public-sector oil marketing companies raised the price of a 14.2-kg domestic cylinder by ₹60, taking it to ₹913 in Delhi for non-subsidised consumers, with PMUY beneficiaries paying approximately ₹613 after the ₹300 government subsidy- against an estimated market-parity price of roughly ₹987[140], meaning the government was absorbing a larger share of the underlying cost increase than the headline

[134]CEEW (Mani et al., 2021), IRES 2020.
[135]VCNow, "India's LPG Crisis 2026" (19 March 2026); Takshashila Institution, Policy Responses to India's LPG Supply Crisis, v.1.0 (March 2026). https://takshashila.org.in/content/publications/20260318-Policy-Responses-to-India-LPG-Supply-Crisis.html
[136]VCNow, "India's LPG Crisis 2026" (19 March 2026). https://learn.vcnow.in/india-lpg-crisis-2026/
[137]Iyer, K. (2026, April 19). *West Asia crisis chokes India's kitchen: LPG consumption plunges 13% in March 2026*. Hindustan Herald. https://hindustanherald.in/india-lpg-crisis-hormuz-war-march-2026/
[138]Iyer, K. (2026, April 19). *West Asia crisis chokes India's kitchen: LPG consumption plunges 13% in March 2026*. Hindustan Herald. https://hindustanherald.in/india-lpg-crisis-hormuz-war-march-2026/
[139]Manur, A., & Suresh, A. (2026, March). *Policy responses to India's LPG supply crisis* (Takshashila Report 2026-07, Version 1.0). The Takshashila Institution. https://takshashila.org.in/content/publications/20260318-Policy-Responses-to-India-LPG-Supply-Crisis.html
[140]VCNow, "India's LPG Crisis 2026" (19 March 2026). https://learn.vcnow.in/india-lpg-crisis-2026/

price hike suggests. reportedly reached ₹6,000.[141] A further ₹29 increase on 7 June took the Delhi price to ₹942.[142]

India's strategic LPG storage, unlike its roughly 60-day crude oil reserve, covers only around five to ten days of demand, depending on the estimate, a gap that several analysts, including the Takshashila Institution, flagged as a clear infrastructure investment priority exposed by the crisis.[143]

Deccan Herald reported roughly 25 Bengaluru eateries closed at the height of the shortage; Indian Railways reportedly advised caterers to explore alternative fuels.[144] Restaurants, hostels, bakeries, and institutional kitchens across Indian regions were most affected with curtailed menus or suspended energy-intensive dishes.

2.6.2 Government response

The government's position, articulated by Minister Puri in Parliament, framed the crisis as an unprecedented, externally caused geopolitical shock that the government responded to swiftly and effectively, citing the production increase, import diversification, and household-priority allocation as evidence of preparedness.[145].
The government invoked emergency measures to curb hoarding, prioritise essential sectors and maximise domestic LPG production, which rose to 13.1 million tonnes in FY2025-26.[146] Refineries were directed to maximise LPG output by diverting feedstock away from petrochemical production, domestic LPG production rose to 1.4 million tonnes in March 2026 from 1.1 million tonnes a year earlier.. The Ministry of Petroleum and Natural Gas issued tiered supply directives prioritising households, PNG, CNG transport, and fertiliser production, leaving non-priority industries at 70-80 per cent of normal supply.

In March 2026, 48,000 kilolitres of kerosene was allocated to States/UTs, and a 29 March Gazette notification permitted PDS Superior Kerosene Oil to be distributed in previously kerosene-free States/UTs for cooking and lighting through designated PSU oil-company service stations, with up to two such outlets per district permitted to stock up to 5,000 litres.(Government of India. (2026),[147] The return to kerosene, a fossil fuel the country has been moving away from for cooking, shows how few non-LPG options were ready at scale.

Box 10: Historical precedent: The 1970s oil crisis

The March 2026 Hormuz closure is not India's first import-driven cooking-fuel shock. The 1970s global oil crises (1973 and 1979) sharply raised the cost of kerosene, then India's dominant transition fuel, and are credited, per IISD's biogas history (IISD, 2026), with first putting biogas on the national policy agenda as an alternative domestic energy source. The parallel is instructive: fifty years on, biogas remains under 1 per cent of primary rural cooking fuel despite two separate oil-shock-driven policy pushes to scale it, illustrating how difficult diversification away from an entrenched imported fuel has proven even when the security case has been made twice.

[141]Manur, A., & Suresh, A. (2026, March). *Policy responses to India's LPG supply crisis* (Takshashila Report 2026-07, Version 1.0). The Takshashila Institution. https://takshashila.org.in/content/publications/20260318-Policy-Responses-to-India-LPG-Supply-Crisis.html-to-India-LPG-Supply-Crisis.html
[142]Discovery Alert, "India LPG Supply Crisis: Manufacturing and Economic Disruption Explained" (7 April 2026). https://discoveryalert.com.au/india-lpg-supply-crisis-import-dependency-2026/
[143]VCNow, "India's LPG Crisis 2026" (19 March 2026). https://learn.vcnow.in/india-lpg-crisis-2026/
[144]BM, A. (2026, March 15). *LPG crisis: Hoteliers say 25 eateries shut in Bengaluru; more may close if supply isn't restored in 2 days*. *Deccan Herald*. https://www.deccanherald.com/india/karnataka/bengaluru/lpg-crisis-hoteliers-say-25-eateries-shut-in-bengaluru-more-may-close-if-supply-isnt-restored-in-2-days-3933052
[145]Manur, A., & Suresh, A. (2026, March). *Policy responses to India's LPG supply crisis* (Takshashila Report 2026-07, Version 1.0). The Takshashila Institution. https://takshashila.org.in/content/publications/20260318-Policy-Responses-to-India-LPG-Supply-Crisis.html
[146]Iyer, K. (2026, April 19). *West Asia crisis chokes India's kitchen: LPG consumption plunges 13% in March 2026*. Hindustan Herald. https://hindustanherald.in/india-lpg-crisis-hormuz-war-march-2026/
[147] Government of India. (2026). "Retail Fuel Availability and Pricing Measures / Kerosene Availability and Distribution Measures." Press Information Bureau, Ministry of Petroleum and Natural Gas, 2026.

2.7 Reading the DRE Market: Insights from Providers

A survey was undertaken to collect primary data from DRE based clean cooking players to understand the evolving market and financing landscape, particularly in the context of the LPG crisis. We gathered data from 12 clean cooking enterprises and practitioners between May and September 2026. The respondents represented a diverse range of clean cooking technologies, including biogas, biomass-based solutions, improved cookstoves, hydrogen, and solar cooking devices, providing insights into the emerging technology landscape and the experiences of different types of clean cooking players.

The questionnaire covered organizational and technology profiles, customer segments and geographies, changes in demand and consumer behaviour, supply-chain and affordability constraints, and missed sales opportunities. It also examined the impact of the LPG crisis on clean cooking adoption and business operations, along with policy and sector priorities.

The sector is witnessing a significant increase in awareness and demand for alternatives to conventional cooking fuels, particularly following the LPG supply disruption since March 2026. Rather than indicating a straightforward shift from one dominant cooking fuel to another, the evidence points towards a gradual movement towards greater diversification of cooking-energy sources and increased emphasis on reliability, affordability and energy security.

2.7.1 The crisis was a demand and an awareness shock

The most prominent trend emerging from the responses is the sharp increase in interest in alternative cooking technologies during the LPG disruption. Across several respondents, enquiries increased dramatically compared with the pre-crisis period. The increase was particularly pronounced for technologies that could provide an immediately available alternative to LPG.

Several respondents reported very substantial increases in enquiries:

- One provider reported enquiries related to improved cookstoves and solar cookers increasing from 10–20 per month to approximately 200, equivalent to roughly a 10–20-fold increase.
- Another reported an increase from 20–25 enquiries to approximately 800–1,200, representing an estimated 32–60-fold increase for solar cookers.
- A further respondent reported enquiries for forced draft improved biomass cookstoves increasing from 100 to more than 2,000, or at least a 20-fold increase.

The dataset suggests that improved biomass cooking remains one of the most commercially active segments of the alternative cooking market. Natural-draft improved cookstoves are reported across multiple technology providers, while pellet-based systems are also increasingly visible. The scale of this increase is significant because it suggests that the crisis altered the way consumers perceived cooking energy. Alternatives that had previously been viewed primarily through the lens of sustainability, fuel savings or environmental benefits increasingly came to be considered from the perspective of energy security and continuity of cooking operations. This was particularly evident among commercial users, for whom interruption of cooking operations has direct economic consequences.

However, the data also demonstrate that increased interest did not automatically translate into adoption. One respondent received around 200 enquiries but reported conversion rates of approximately 50% for cookers and only 10–15% for improved cookstoves. Another reported more than 2,000 enquiries against approximately 120

conversions. This indicates a substantial gap between market interest and actual uptake.The crisis therefore appears to have functioned primarily as a catalyst for awareness and experimentation, rather than producing an immediate large-scale transition away from conventional fuels.

2.7.2 Demand is diversifying towards commercial and institutional users

The responses indicate that clean cooking demand is no longer concentrated exclusively among rural households. Urban commercial kitchens, restaurants, cafés and other high-volume cooking establishments have emerged as an important source of demand, particularly during periods of fuel insecurity.One respondent reported that approximately 50% of its demand came from urban commercial users and another 25% from rural commercial users, while around 15% came from urban households. Another reported that approximately 90% of demand came from urban households and 10% from institutions/schools. A separate response indicated that 60% of its demand came from rural households, 20% from rural commercial users, 10% from urban households and 10% from urban commercial users. Although these figures cannot be aggregated into a national market share because each respondent serves different markets, they collectively demonstrate the breadth of the emerging customer base.

The crisis also revealed a particularly strong commercial imperative. Consequently, the value proposition for alternative technologies is increasingly shifting from simply “cleaner cooking” to reliable, continuous and economically viable cooking.

Clean cooking is increasingly becoming relevant not only as a household welfare intervention but also as an energy-management issue for businesses and institutions.

2.7.3 Supply, not demand, is the bottleneck

The sharp rise in demand during the crisis exposed a second major characteristic of the sector: the supply side is not yet sufficiently prepared to respond to sudden increases in demand. Multiple respondents reported manufacturing constraints, raw-material problems, fuel/feedstock shortages and distribution challenges. One respondent reported that manufacturers could not keep up with increased demand because of limited production capacity. Another reported that fuel was unavailable and suppliers were not accustomed to producing in sufficiently large quantities. A further respondent reported manufacturing and raw-material constraints and noted that supply problems became more significant as the rainy season approached.One respondent reported that orders could not be fulfilled because of limited stock and manufacturing lead times, while another reported technical mismatches because customers wanted different configurations from those available.

Importantly, the problem is therefore not simply a lack of consumer demand. In several cases, demand existed but the market could not supply the required product, fuel or specification at the required time.

This suggests that the next stage of market development will require greater attention to manufacturing capacity, local supply chains, fuel availability, distribution networks and inventory management. A demand shock can generate significant market interest, but without corresponding supply-side capacity, much of this interest may not translate into sustained adoption.

2.7.4 Affordability is relative, not absolute

Price remains relevant, but the question is increasingly whether the total cost and reliability of an alternative are favourable compared with the incumbent fuel.

Reported product prices vary substantially, from approximately ₹3,200–₹3,500 for some improved cooking systems to ₹50,000 for more customised biomass systems, while a solar cooking system was reported at around ₹7,000 and a larger integrated solar-electric system at approximately ₹3 lakh. Several respondents did not identify product price as their principal barrier; concerns centred on fuel availability technical suitability and consumer familiarity.

At the same time, there are clear examples of price pressure. One respondent reported a 10–15% increase in biomass product costs and approximately 10% growth in fuel costs during the crisis. Another reported increases in product, fuel and installation costs. . A technology with a higher purchase price may nevertheless become attractive if it reduces recurring fuel expenditure or provides greater energy security.

2.7.5 The sector moving from pilot to commercialisation, but adoption remains uneven

The responses indicate that clean cooking technologies have moved beyond purely experimental applications, with several respondents reporting deployments ranging from hundreds to several thousand units. Reported deployment figures include approximately 1,500 natural-draft and 3,000 pellet systems from one respondent, around 157 improved cookstoves from another, and approximately 194 sales conversions from another.

However, the data also reveal uneven utilisation. One respondent reported that only around 20% of customers were regularly using the technology after the LPG crisis, with some users reverting to conventional LPG once supplies became available again. This highlights the difference between purchase, adoption and sustained use.

The sector therefore appears to be moving from the question of *"Can the technology work?"* towards the more difficult questions of *"Will users continue to use it?", "Can the fuel supply be maintained?", and "Can the technology compete with conventional cooking over the long term?"*

Sustained adoption will ultimately depend on whether clean cooking technologies can deliver a combination of reliability, convenience, affordability and cooking performance, rather than environmental benefits alone.

2.8 Key takeaways

- LPG delivered access, not exclusive use: PMUY households averaged 4.71 refills in FY 2025-26 against 7 to 8 needed, and the subsidised entitlement has now fallen to four refills a year.
- Stacking is a rational response to cost and reliability gaps. DRE options should be designed as the clean partner to LPG and electricity, not as a replacement for them.
- A large thermal demand, in institutions, agro-industry and rural homes, sits outside household surveys and outside every national scheme. This is where DRE already competes.
- The 2026 crisis turned DRE from a sustainability choice into an energy security one, but weak supply capacity, after-sales service and finance limited how much of the new interest providers could convert.
- Durable clean cooking assets lose to LPG on upfront cost. Capital subsidies, blended finance and asset-backed lending are the missing pieces, taken up in the chapters that follow.
- Success should be measured by sustained and exclusive clean fuel use, with credit for cleaner stacking, rather than by connections distributed.

3. Financing Architecture for Clean Cooking Technologies in India

India's transition away from solid biomass and toward improved biomass, biogas, LPG, and electric cooking has never been constrained primarily by technology. Efficient stoves, biodigesters, and induction appliances have existed for well over a decade. Almost every technology has received fairly long term grant support form the government and other funders, initially. And yet, what continues to determine the pace and durability of adoption, is a financing architecture capable of moving capital to the level of an individual household's kitchen.

That required architecture is not a single instrument but a layered system in which four distinct pools of end-user finance, enterprise finance, corporate social responsibility (CSR) funding, and carbon market revenue-interact, substitute for, and reinforce one another. This chapter maps that system as it currently operates in India, drawing on company-level case studies.

End-user finance addresses the affordability gap facing the household or micro-enterprise that must pay for a stove, cylinder, or biodigester. Enterprise finance addresses the working-capital and growth-capital needs of the manufacturers and last-mile distributors who build and sell these products. CSR resources typically de-risk early market entry, fund awareness and behaviour-change work, and subsidise unit economics that would otherwise be unviable. Carbon markets, meanwhile, convert the emissions and health co-benefits of clean cooking into a tradeable revenue stream that can subsidise both the enterprise's balance sheet and the end consumer's price. In practice, as the case studies below show, a single transaction such as the Asian Development Bank's (ADB) loan to Greenway Grameen Infra often draws on more than one of these pools simultaneously (ADB, 2023).[148]

It must be noted that in each of these types of finance options, the DRE based clean cooking technologies have to compete with increasingly dominant LPG and grid electricity based technologies.

3.1. End-User Finance

3.1.1 Government-Anchored Consumer Credit

3.1.1.1 The Ujjwala EMI Model

The largest single end-user finance mechanism in Indian clean cooking is embedded within the Pradhan Mantri Ujjwala Yojana (PMUY). While the Rs. 1,600 connection subsidy is a grant, the cost of the first stove and the initial refill is structured as an interest-free loan extended by the public sector oil marketing companies (OMCs) including Indian Oil, Bharat Petroleum, and Hindustan Petroleum and recovered in small instalments deducted from the subsidy due on each subsequent cylinder refill (India Brand Equity Foundation, n.d.).[149]

This EMI-style recovery mechanism has allowed more than ten crore connections to be issued since 2016, with the loan for the stove and cylinder typically repaid over two to three years of ordinary refill purchases.[150] The design has periodically been adjusted in the beneficiaries' favour: in 2018, OMCs deferred loan recovery for

[148]Asian Development Bank. (2023, November 22). ADB, Greenway sign deal to channel carbon finance for enhancing improved cookstove usage in rural India. https://www.adb.org/news/adb-greenway-sign-deal-channel-carbon-finance-enhancing-improved-cookstove-usage-rural-india
[149]India Brand Equity Foundation. (n.d.). Pradhan Mantri Ujjwala Yojana (PMUY scheme). Retrieved July 2026, from https://www.ibef.org/government-schemes/pradhan-mantri-ujjwala-yojana
[150]ClearTax. (2025, April 21). Pradhan Mantri Ujjwala Yojana (PMUY). https://cleartax.in/s/pradhan-mantri-ujjwala-yojana-pmuy

six refill cycles to ease the burden on beneficiaries who were consuming cylinders more slowly than assumed at the scheme's design (Zee Business, 2018).[151] This illustrates a structural feature of consumer-facing clean cooking finance in India: because it is bundled into a public fuel-subsidy administration system rather than run through a conventional lender, the credit terms can be adjusted administratively rather than through contractual renegotiation (Ministry of Petroleum and Natural Gas, n.d.).[152]

3.1.1.2 Government subsidy models for improved cookstoves and biogas

Historically, government support for improved biomass cookstoves was largely provided as a direct subsidy on the initial purchase or installation cost. Under the National Programme on Improved Chulhas (NPIC), initiated as a demonstration programme in December 1983, the subsidy structure evolved over time. Initially, the entire hardware cost of fixed chulhas was borne by the Central Government, while portable chulhas received subsidies of 75% for Scheduled Caste/Scheduled Tribe and hilly-area beneficiaries and 50% for general-category users. From 1987–88 onwards, beneficiary contributions were progressively introduced, including contributions towards supervision and material costs. By 1992–93, the subsidy was subject to an upper ceiling of ₹50 for fixed chulhas and ₹50 for portable chulhas for general users and ₹75 for portable chulhas for SC/ST and hilly-area beneficiaries (MNES, 1993).[153] Parliamentary records from the 1990s show that a fixed chulha could receive assistance of up to ₹50, subject to a minimum beneficiary contribution of 50% of the cost, while portable chulhas received a subsidy of around one-third of the cost for general-category users, with higher support for certain disadvantaged groups. Parliamentary records from 1995 similarly indicate that fixed chulhas received assistance of up to ₹50, subject to a minimum beneficiary contribution of 50% of the cost, while portable chulhas received 33% of the cost for general-category users, subject to a maximum of ₹50, and up to 50% for SC/ST beneficiaries, subject to a maximum of ₹75. Thus, the NPIC should not be characterised as having provided uniformly free cookstoves; rather, the government absorbed a significant share of the initial capital cost, while beneficiaries contributed a smaller share, with the precise subsidy varying by technology, beneficiary category and period. The programme also incorporated support for installation, repair and maintenance follow-up, user education, publicity, technical back-up and payments to self-employed workers involved in installation and programme implementation (Government of India, 1995).[154] It must however be put on record that in several states, the state nodal agencies and the state governments provided additional financial support to further reduce the cost for the end users.

The later Unnat Chulha Abhiyan (UCA) followed a broadly similar approach of reducing the upfront cost of improved biomass cookstoves through government financial support. Launched in 2014, UCA provided subsidies of approximately ₹300–800 per improved cookstove, depending on the technology. The programme envisaged the deployment of 2.75 million improved cookstoves by March 2017 and had a budget allocation of ₹294 crore. However, the programme achieved only about 1.3% of its deployment target by March 2017. Importantly, the unsubsidised cost of an improved cookstove was estimated at approximately ₹1,200 for natural-draft models and ₹4,500 for forced-draft models, demonstrating the role of the subsidy in reducing the upfront price faced by households (NITI Aayog, 2019)[155]. The subsidy was therefore primarily an upfront capital-

[151]Zee Business. (2018, March 24). Free LPG scheme: Big relief to borrowers, loan repayment deferred. https://www.zeebiz.com/india/news-free-lpg-scheme-big-relief-to-borrowers-loan-repayment-deferred-40342

[152]Ministry of Petroleum and Natural Gas, Government of India. (n.d.). Pradhan Mantri Ujjwala Yojana. Retrieved July 2026, from https://www.pmuy.gov.in/

[153] Ministry of Non-Conventional Energy Sources (MNES). (1993). *Indian Improved Cookstoves: A Compendium.* Government of India/FAO, Field Document No. 41

[154] Government of India. (1995). *Twenty-Fourth Report of the Standing Committee on Energy: National Programme on Improved Chulhas.* Lok Sabha, Parliament of India.

[155] NITI Aayog. (2019). *A Roadmap for Access to Clean Cooking Energy in India.* Government of India

support mechanism rather than a consumer-financing mechanism in which the government recovered its contribution through subsequent household payments.

The biogas programme is somewhat different in its design but retains the basic principle of government-supported capital assistance. Government support for household biogas dates back to the early 1980s, while under the current Biogas Programme under the National Bioenergy Programme, the Ministry of New and Renewable Energy (MNRE) provides Central Financial Assistance (CFA) in fixed amounts according to plant capacity and beneficiary category. For small plants of 1–25 m³/day under the 2021–26 programme, CFA for general categories ranges from ₹9,800 for a 1 m³/day plant to ₹52,800 for a 20–25 m³/day plant. Higher assistance, ranging from ₹17,000 to ₹70,400, is available for beneficiaries in hilly/North-Eastern regions, island territories and SC/ST categories (MNRE, 2022)[156]. As of 31 March 2026, the biogas programme has come to an end, and although more than 6 months have passed at the time of the release of this white paper, no new program has replaced it to date.

3.1.2 Microfinance Institutions and NBFCs

Away from the LPG-specific EMI mechanism, the deepest channel for end-user finance is India's microfinance sector, which reaches rural and peri-urban women through group-lending and individual small-ticket loan products. Two patterns are visible in the evidence base.

First, established cookstove manufacturers embed microcredit directly into their distribution model. Greenway Grameen Infra, India's largest cookstove manufacturer distributes its Smart Stove and Jumbo Stove ranges through partnerships with microfinance institutions, cooperatives, and banks rather than through retail cash sale alone; the company specifically credits its relationship with Grameen Koota (now part of CreditAccess Grameen) and other MFI partners, and more recently with Bank of India and HDFC Bank across ten-plus states, for extending affordable monthly-installment purchase options to rural women (Greenway Appliances, n.d.).[157] Acumen, an early equity investor in Greenway, reported that microfinance-enabled installment purchases were central to the company's ability to reach low-income rural households at scale (Acumen, n.d.).[158]

Another variant of end-user microfinance is visible in the biogas segment, where Sistema.bio bundles consumer credit with its equipment sale: the company states that although its smallest biodigester unit costs approximately Rs. 36,000, a combination of subsidy layering, carbon financing, and CSR-funded cost reduction brings the effective upfront contribution required from a smallholder farmer down to roughly Rs. 6,000–15,000 (Fertilizer Daily, 2024, as cited in Sistema.bio financing disclosures). This illustrates how end-user affordability in practice depends on the enterprise's ability to draw down CSR and carbon revenue elsewhere in the same transaction.

3.1.3 Commercial Banks, Regional Rural Banks, and NABARD Refinance

For household biogas plants, the dominant end-user finance channel is not direct MFI lending but a subsidy-cum-bank-loan structure administered under the National Biogas and Manure Management Programme (NBMMP) and its successor, the New National Biogas and Organic Manure Programme (NNBOMP). Under this design, a household beneficiary receives a capital subsidy from the Ministry of New and Renewable Energy (MNRE) and finances the balance of the unit cost through a bank loan; State Unit Cost Committees, coordinated

[156] Ministry of New and Renewable Energy (MNRE). (2022). *Biogas Programme under the Umbrella Scheme of National Bioenergy Programme for FY 2021–22 to 2025–26 (Phase-I): Implementation Guidelines.* Government of India.
[157] Greenway Appliances. (n.d.). Empowering rural women through better cooking: Greenway Grameen's partnership with financial institutions. Retrieved July 2026
[158] Acumen. (n.d.). Wood cookstoves to reduce costs in India: Greenway Grameen [Case study]. Retrieved July 2026, from https://acumen.org/case-studies/https-acumen-org-case-studies-greenway-grameen/

with NABARD, periodically revise the benchmark unit cost so that loan sanctioning remains realistic (International Energy Agency, n.d.; KIP Financial Consultancy, 2024).[159,160]

The lending institutions authorised to disburse these loans are explicitly Regional Rural Banks and nationalised commercial banks, refinanced by NABARD (Ministry of New and Renewable Energy, SPV Division, n.d.).[161] This NABARD-anchored RRB channel is the closest India has to a dedicated "clean cooking loan" issued by mainstream banking rather than microfinance or an oil-marketing company subsidy ledger but it remains almost entirely confined to family-type biogas plants rather than improved cookstoves or any other cooking energy technologies, several of which are financed instead through the MFI and consumer-durable-loan channels described above.

3.2 Enterprise Finance

3.2.1 Development Finance Institution Debt

The single largest disclosed enterprise financing transaction in the Indian clean cooking sector is the $6.5 million senior secured loan signed in November 2023 between the Asian Development Bank and Greenway Grameen Infra, intended to fund production and distribution of one million improved cookstoves across Madhya Pradesh and Odisha (ADB, 2023).[162] The transaction is a clear illustration of blended finance in the enterprise-finance sense: alongside the senior loan, ADB layered in a $3.25 million first-loss liquidity reserve from its Climate Innovation and Development Fund (CIDF), capitalised in part by Bloomberg Philanthropies and Goldman Sachs, which absorbs early losses so that the senior lender's risk is reduced (ADB, 2023).[163] Notably, the loan itself is explicitly designed to be serviced partly through carbon credit revenue, since Greenway's subsidiary, SDG 13 Ventures, plans to monetise the emissions reductions generated by the distributed stoves, making this a case in which enterprise debt and carbon market revenue are structurally linked within a single facility rather than being separate financing pools.

3.2.2 Impact Equity and Venture Capital

Equity investment in Indian and India-focused clean cooking enterprises has come predominantly from impact-oriented and development-finance-affiliated investors rather than mainstream venture capital. Greenway Grameen's equity capitalisation history includes the New York-based Acumen Fund, the Asha Impact fund, and the Centre for Innovation, Incubation and Entrepreneurship (Outlook Planet, 2023, citing ADB transaction reporting). Acumen's own case-study material states that its investment supported Greenway through a period of business-model iteration, after which the company grew sales and profit every year from 2019 onward, eventually reaching almost three million cookstoves sold (Acumen, n.d.).[164]

Servals Automation, a Chennai-based manufacturer of top-lit updraft (TLUD) gasifier biomass stoves targeted at small eateries and low-income urban and rural households, was capitalised by two prominent Indian impact-

[159]International Energy Agency. (n.d.). National Biogas and Manure Management Programme – Policies. Retrieved July 2026, from https://www.iea.org/policies/4308-national-biogas-and-manure-management-programme
[160]KIP Financial Consultancy. (2024, February 20). Subsidy for bio gas business. https://kipfinancial.com/subsidy-for-bio-gas-business/
[161]Ministry of New and Renewable Energy, SPV Division, Government of India. (n.d.). Scheme for financing solar photovoltaic lighting and small capacity systems through NABARD. https://agritech.tnau.ac.in/govt_schemes_services/pdf/LIghting-Scheme-through-NABARD.pdf
[162]Asian Development Bank. (2023, November 22). *ADB, Greenway sign deal to channel carbon finance for enhancing improved cookstove usage in rural India*. https://www.adb.org/news/adb-greenway-sign-deal-channel-carbon-finance-enhancing-improved-cookstove-usage-rural-india
[163]Ibid
[164]Acumen. (n.d.). *Greenway Grameen: Clean cooking catches fire in India*. Acumen. Retrieved October 21, 2026, from https://acumen.org/case-studies/https-acumen-org-case-studies-greenway-grameen

investment vehicles: Aavishkaar, one of India's oldest social investment funds and the Grassroots Business Fund, an IFC-supported vehicle for base-of-pyramid enterprises (Servals Automation, n.d.).[165]

Sistema.bio, whose biodigesters are deployed at scale in India for combined biogas cooking fuel and bio-fertiliser production, illustrates the most internationally diversified capital stack in the sector: its 2024 financing round of $15 million combined continuing equity from Chroma Impact Investment, KawiSafi Ventures, AXA IM Alts, Blink CV, and EcoEnterprises Fund with debt-facility extensions from FMO (the Dutch development bank) and Triodos Bank, structured and led by ElectriFI/EDFI Management Company (Sistema.bio, 2024).[166] In late 2025, the company also drew in Next Bharat Ventures, a strategic investor with an explicit India angle, the impact fund created by Suzuki Motor Corporation specifically to expand manufacturing capacity and India distribution (Marca Money, 2025, citing Sistema.bio funding disclosures).

3.2.3 Blended and Concessional Junior Debt

A distinct financing layer sits between pure grant/CSR funding and commercial equity or senior debt: catalytic junior debt provided by philanthropic foundations alongside impact lenders, designed to absorb risk that commercial lenders will not. In Sistema.bio's 2024 raise, the UK-registered Shell Foundation and BIX Capital jointly provided this junior debt tranche, itself co-funded with UK government aid, sitting below the senior facilities from FMO and Triodos in the capital structure (Sistema.bio, 2024).[167] Shell Foundation's broader India and Africa portfolio explicitly names Clean Cooking as one of its core investment verticals, alongside asset financing, cold storage, and diesel-genset replacement (Shell Foundation, n.d.).[168] and its own account of its history records that it has been a founding partner of the Clean Cooking Alliance since 2010 (Shell Foundation, n.d.).[169]

3.2.4 Grants, Accelerators, and Market-Building Facilities

Alongside debt and equity, enterprise-level grant capital has played a foundational role in building manufacturing and distribution capacity in this sector. The Clean Cooking Alliance's own factsheet on India records that Greenway Appliances (Greenway Grameen) established its full manufacturing facility with the support of a Spark Grant awarded through the Alliance's grant programme, before the company went on to raise the commercial debt and equity described above (Clean Cooking Alliance, n.d.).[170] More recently, Shell Foundation and Accion jointly launched the Climate and Finance Innovations (ClimaFii) Alliance, under which Upaya Social Ventures is tasked with supporting early-stage climate enterprises in India, including clean cooking solutions aimed at micro-entrepreneurs such as restaurant and food-cart operators to become investment-ready, with Accion separately working with financial service providers to design consumer-finance products for the same customer segment (Accion, 2025).[171]

[165]Servals Automation Pvt. Ltd. (n.d.). An overview of our TLUD gasifier biomass stove [Presentation]. https://www.slideshare.net/slideshow/servals-tlud-biomass-stove-deck/8860777

[166]Sistema.bio. (2024, October 15). Sistema.bio secures $15M in additional financing to accelerate global expansion [Press release]. https://sistema.bio/blog/sistema-bio-secures-15m-in-additional-financing-to-accelerate-global-expansion/

[167]Sistema.bio. (2024, October 14). *Sistema.bio secures $15M in additional financing to accelerate global expansion*. Sistema.bio. https://sistema.bio/blog/sistema-bio-secures-15m-in-additional-financing-to-accelerate-global-expansion

[168]Shell Foundation. (n.d.). Our portfolio. Retrieved July 2026, from https://shellfoundation.org/our-portfolio/

[169]Shell Foundation. (n.d.). Impact timeline. Retrieved July 2026, from https://shellfoundation.org/impact-timeline/

[170]Clean Cooking Alliance. (n.d.). India factsheet. https://cleancooking.org/binary-data/RESOURCE/file/000/000/518-1.pdf

[171]Accion. (2025, January 21). Shell Foundation and Accion announce new program to finance and scale emission-reducing technologies in emerging markets. https://www.accion.org/news/shell-foundation-and-accion-announce-new-program/

3.3 CSR Projects

In the clean cooking sector, CSR capital has functioned less as a source of consumer subsidy at scale (that role is played by PMUY and MFI credit) and more as patient, risk-tolerant capital for market research and pilot demonstrations.

3.3.1 Corporate Foundations and Trusts

The very first attempt in India was the funding support provided by Shell Foundation to Appropriate Rural Technology Institute (ARTI) in Maharashtra and Development Alternatives (DA) in Madhya Pradesh, from 2003 to 2010. This came soon after the closure of the National Programme on Improved Cookstoves (NPIC) in 2002, and supported the first generation cookstove manufacturing focused on commercial sale to end users. This effort achieved moderate success, and led the foundation of subsequent efforts at commercialisation of biomass-based clean cooking technologies in India.

Tata Trusts and the Hindustan Unilever Foundation have both directed CSR resources toward rural energy-access pilots and impact evaluation in the clean cooking space, alongside impact investors such as Acumen and Omidyar Network India, which is a CSR-adjacent patient capital rather than pure commercial investment (NITI Aayog Frontier Tech, 2025).[172] Numerous small CSR grants have supported deployment of biogas plants and solar cookers across rural India over the years.

3.4 Carbon Markets

Carbon markets convert the avoided emissions associated with a shift away from traditional cooking to a low carbon clean cooking technology, into a saleable credit, typically a Verified Emission Reduction (VER) or Verified Carbon Unit (VCU) issued by a voluntary registry such as Gold Standard or Verra, or historically the UN Clean Development Mechanism. For Indian clean cooking enterprises, carbon revenue functions simultaneously as an enterprise-finance instrument (it can be pre-financed against future credit sales, as in the ADB-Greenway structure) and as a mechanism for subsidising the end-user price, since a portion of expected carbon revenue is frequently used to reduce the upfront cost charged to the household or farmer.

3.4.1 Mechanics and Methodologies

Three cookstove-specific carbon methodologies dominate current issuance: Verra's Energy Efficiency and Fuel-Switch Measures in Cookstoves methodology (VM0050), Gold Standard's Technologies and Practices to Displace Decentralized Thermal Energy Consumption (TPDDTEC) methodology, and Gold Standard's newer Metered and Measured Energy Cooking Devices methodology; all three have recently received the Core Carbon Principles label from the Integrity Council for the Voluntary Carbon Market (ICVCM), which is intended to signal that they meet a baseline standard of environmental integrity (RMI, 2025).[173] A separate cross-registry review notes that Verra is generally chosen by developers seeking scale and access to the largest pool of international buyers, while Gold Standard is more often selected for community-facing cookstove, clean water, and social-impact projects specifically because of the sustainable-development co-benefit premium often an additional $2–3 per tonne that Gold Standard-certified credits can command (Carbon Market Network, 2026).[174]

[172]NITI Aayog Frontier Tech. (2025, June 19). Smart stoves: A sustainable solution for clean cooking in rural India. https://frontiertech.niti.gov.in/story/smart-stoves-a-sustainable-solution-for-clean-cooking-in-rural-india/

[173]RMI. (2025, November 25). Technical explainer: Clean and improved cookstove carbon credits. https://rmi.org/resources/technical-explainer-clean-and-improved-cookstove-carbon-credits/

[174]Carbon Market Network. (2026). Carbon credit registries in India. https://carbonmarketnetwork.com/blog/carbon-credit-registries-india/

3.4.2 Companies and Specific Project Examples

Greenway Grameen's ADB-financed cookstove distribution programme is explicitly structured around carbon monetisation: the project is projected to avoid 22.9 million tonnes of carbon dioxide over its life, and the credits generated are to be sold to international buyers through Greenway's dedicated subsidiary, SDG 13 Ventures Private Limited (ADB, 2023).[175]

EKI Energy Services Ltd.- one of the largest Indian-headquartered carbon credit developers and traders in the voluntary market announced in 2024 the registration of what it described as the first improved biomass cookstove project in India, and in Asia more broadly, to be verified under Verra's Sustainable Development Verified Impact Standard (SD VISta), a standard focused specifically on documenting sustainable-development co-benefits rather than emissions reduction alone (Carbon Herald, 2024).[176]

Sistema.bio has taken a further step toward structuring carbon revenue as up-front project finance rather than a post-hoc credit sale: its FarmCarbon vehicle, first launched in India before planned expansion to other Asian and African markets, pre-finances biogas project development against future emissions-reduction delivery, which is then sold forward to carbon credit buyers under multi-year purchase agreements — in effect turning expected future carbon revenue into present-day working capital for biodigester rollout (A&O Shearman, 2025).[177]

In examining Earthfit's carbon credit initiatives, it becomes evident that their projects are designed to integrate technological innovation with social and environmental sustainability. The carbon credits are generated through two principal mechanisms: the dissemination of improved cookstoves, which replace inefficient biomass stoves and thereby reduce emissions, deforestation, and indoor air pollution; and the deployment of biochar solutions, which sequester carbon in soils while simultaneously enhancing fertility and agricultural productivity. The Maharashtra-based grouped project, registered under Verra's Verified Carbon Standard (VCS) and validated by Carbon Check India, was officially registered on 22 February 2024 and spans the period from 3 August 2023 to 2 August 2030. With an estimated annual reduction of nearly 4 million tonnes of CO_2, the project employs methodology VMR0006 (Energy Demand) to ensure rigorous measurement and verification. (Earthfit, 2024)[178]

At the household level, a Gold Standard-registered improved cookstove project in India monitored by Climate Impact Partners records that approximately 40 percent of participating households used microcredit loans to purchase their efficient cookstove, with the balance of the affordability gap covered through subsidies funded in part from carbon revenue (Climate Impact Partners, n.d.).[179]

3.4.3 Evolving Standards and Verification Requirements

In March 2025 the ICVCM approved updated Verra and Gold Standard cookstove methodologies under its Core Carbon Principles label, while simultaneously ruling that legacy credits issued under older methodology versions, representing roughly a third of cumulative cookstove credit issuance, required further review before

[175]Asian Development Bank. (2023, November 22). *ADB, Greenway sign deal to channel carbon finance for enhancing improved cookstove usage in rural India*. https://www.adb.org/news/adb-greenway-sign-deal-channel-carbon-finance-enhancing-improved-cookstove-usage-rural-india
[176]Carbon Herald. (2024, June 20). EKI's first improved cookstove project received Verra verification. https://carbonherald.com/eki-first-improved-cookstove-project-received-verra-verification/
[177]A&O Shearman. (2025). Sistema.bio climate finance vehicle: FarmCarbon. https://www.aoshearman.com/en/news/ao-shearman-advises-sistemabio-inc-on-marketfirst-finance-vehicle-aimed-at-expanding-climate-finance
[178] Earthfit. (2024, February 22). *Carbon projects*. Earthfit. https://www.earthfit.in/carbon-projects
[179]Climate Impact Partners. (n.d.). Improved cookstoves, India. Retrieved July 2026, from https://www.climateimpact.com/global-projects/improved-cookstoves-india/

qualifying (Climate Change News, 2025; Carbon Credits, 2025).[180][181] For Indian project developers and their financiers, the practical implication is that new cookstove and biogas projects registered from 2025 onward are expected to migrate to metered or digitally monitored measurement approaches, which raises the fixed cost of project verification but is intended to restore buyer confidence in the credit type (RMI, 2025).[182]

3.4.4 India's Domestic Compliance Market

A parallel development is the emergence of India's own domestic compliance carbon market, the Carbon Credit Trading Scheme (CCTS), which is expected to create a large pool of domestic demand, reported to cover more than 700 million tonnes of CO2e of obligated emissions once its Offset Mechanism becomes fully operational, alongside the voluntary-market registries (Verra, Gold Standard) that Indian cookstove and biogas developers currently rely upon (Carbon Market Network, 2026).[183] Sector analysts note that project developers who register early under the domestic Offset Mechanism may benefit from a first-mover advantage as compliance buyers begin to source credits domestically rather than relying solely on international voluntary-market offtake, a dynamic that is likely to reshape how Indian clean cooking carbon projects are financed and sold over the remainder of the decade.

3.5. Financing Landscape of CLEAN's Member Organizations: Survey Findings

Financing remains one of the most significant determinants of the ability of clean cooking organizations to scale their operations, expand market reach, and sustain long-term impact. An analysis of survey responses from several organizations including non-governmental organizations, technology providers, manufacturers, and private enterprises, reveals that while financing models are becoming increasingly diverse, access to affordable and appropriate capital continues to be a major challenge across the clean cooking ecosystem in general[184], but even more so for DRE based clean cooking ecosystem

3.5.1 Current Sources of Financing

The organizations rely on a combination of grants, internally generated revenue, commercial investments, concessional finance, and emerging carbon finance mechanisms. Grant funding continues to play a critical role, particularly for non-profit organizations and those implementing community-based interventions in rural and under-served areas. Grants are commonly used to support pilot projects, awareness campaigns, market development activities, and technology demonstrations, where commercial returns are either uncertain or insufficient to attract private investment.

Commercial enterprises complement grant funding with revenues generated from product sales and private investments. Some organizations have also begun leveraging carbon finance as an additional revenue stream, reflecting the increasing importance of carbon markets in supporting clean cooking initiatives. However, carbon finance remains concentrated among relatively larger organizations with the technical capacity to develop and

[180]Climate Home News. (2025, March 7). Most cookstove carbon credits ruled out of quality scheme. https://www.climatechangenews.com/2025/03/07/most-cookstove-carbon-credits-ruled-out-of-quality-scheme-in-push-for-high-integrity/

[181]Carbon Credits. (2025, March 10). Verra's cookstove credits get ICVCM green light – Boosting carbon market trust. https://carboncredits.com/verras-cookstove-credits-get-icvcm-green-light-boosting-carbon-market-trust/

[182]RMI. (2025). *Technical explainer: Clean and improved cookstove carbon credits*. https://rmi.org/resources/technical-explainer-clean-and-improved-cookstove-carbon-credits

[183]Carbon Market Network. (2026, April 21). *India's Carbon Credit Trading Scheme (CCTS) explained*. https://carbonmarketnetwork.com/blog/indias-carbon-credit-trading-scheme-ccts-explained

[184] A detailed section on financing captured existing sources of grants and subsidies, types and quantum of finance required, financing challenges, preferences for future financial instruments, blended finance opportunities, and potential business and financing models for scaling clean cooking solutions.

manage carbon projects. Overall, the financing landscape remains characterized by a reliance on multiple funding sources rather than a single stable financing mechanism.

Several examples of cross-subsidising market segments and revenue diversification exist. One such example of a hybrid enterprise model is Samuchit Enviro Tech. Its cooking portfolio includes biomass- and charcoal-based devices, including its steam cooker, which is sold commercially, while the organisation also provides cooking-energy need assessments, technology-selection services, rural technology consultancy, carbon accounting and training to NGOs, CSR programmes and other institutional clients. Commercial sales to customers with greater purchasing capacity coexist with lower-cost, project-based engagements in rural markets, while non-cooking environmental services broaden the overall revenue base. Its founder has also described the evolution of the enterprise from a rural clean-energy initiative into a wider sustainability business, including climate education and carbon-accounting consultancy, precisely because a business dependent only on cookstove sales would be difficult to sustain.

OrjaBox LLP represents a similar but smaller-scale model. Rather than functioning solely as a cookstove manufacturer, OrjaBox combines commercial sales and demonstrations of solar and bioenergy cooking technologies with education, experiential activities, food services, solar-dried products, training and technical support to organisations. Its own materials describe food stations for hostels, restaurants and hospitals, solar-dried products, solar-based meal experiences and training for SHGs, while also noting that it provides technical and implementation support to companies and NGOs for clean-cooking projects. Its solar centre also charges visitors for demonstrations, illustrating another small but potentially important revenue stream around customer education and experience rather than hardware alone. Thus, OrjaBox demonstrates how a company can sell DRE based cooking technologies to urban consumers at market prices while using training, demonstrations, food experiences, product sales and technical consultancy to create additional revenue streams. This diversification is particularly relevant because it reduces the pressure on the sale of cooking-device itself to bear the entire cost of market development, consumer education and technology demonstration.

Chakraakaar Lifestyle Solutions Private Limited, which operates the Vaayu Biogas business, provides perhaps the clearest example of a higher-paying urban customer model. Vaayu sells compact household biogas systems directly to customers, with its current small module listed at approximately ₹45,000 plus transportation and installation and its larger household module at approximately ₹1.6 lakh, while customised systems are offered to canteens, hotels and restaurants (Vaayu Biogas, 2026). [185] The model therefore does not depend on a poor rural household being able to purchase a heavily subsidised appliance: the principal value proposition is instead the conversion of household or institutional food waste into cooking gas and fertiliser, allowing customers with paying capacity to pay for an integrated waste-management and energy service. Evidence of market uptake is significant: reporting in 2026 indicated more than 450 installations, while the Vaayu system has been deployed in housing societies, including a township where 98 flats were connected to biogas generated from decentralised food-waste treatment (Hindustan Times, 2026).[186]

3.5.2 Types of Financing Required

The responses indicate that organizations require different financing instruments depending on their stage of growth and operational needs. Grant funding continues to be viewed as essential for innovation, and expanding access to underserved populations, at the same time, organizations consistently highlighted the need for concessional or low-interest loans that can reduce borrowing costs and support business expansion.

[185] Vaayu Biogas. (2026). *Home / Solutions.* Chakraakaar Lifestyle Solutions Pvt. Ltd.
[186] Hindustan Times. (2026, March). *Household biogas system developed by Pune IIT engineer offers alternative amid LPG shortage.*

Working capital financing emerged as one of the most pressing needs across manufacturers and technology providers. Organizations require accessible credit to finance inventory, production, distribution, and day-to-day operations, particularly as they seek to expand into new markets. Several respondents also identified equity investment from impact investors as an important source of growth capital, especially for enterprises seeking to scale production capacity and strengthen market presence. Blended finance models that combine grants, concessional debt, equity investment, and carbon revenues were widely viewed as the most appropriate approach for supporting the sector.

3.5.3 Broader trends within the clean cooking sector

1. The sector remains heavily dependent on non-commercial capital. Even commercially oriented enterprises continue to rely on grant funding for market creation, awareness generation, product development, and early-stage expansion. This suggests that many DRE based clean cooking markets, particularly those serving low-income and rural households, have yet to reach the level of commercial maturity required to attract mainstream private finance.

2. Financing gaps exist throughout the DRE based clean cooking value chain rather than only among manufacturers. Manufacturers require investment for production facilities and equipment; distributors need working capital to expand distribution networks; service providers require financing for installation and after-sales support; and end-users often require affordable consumer finance to overcome high upfront technology costs. This highlights the importance of designing financing interventions that address the needs of the entire ecosystem rather than focusing solely on technology developers.

3. Working capital constraints appear to be more immediate than long-term infrastructure financing needs. Many organizations are able to secure project-based funding but face persistent challenges in financing inventories, receivables, and business operations. Improving access to revolving credit facilities and short-term financing could therefore have a substantial impact on organizational sustainability and growth.

4. Another recurring theme is the limited accessibility of conventional commercial lending. High collateral requirements, elevated interest rates, and limited understanding of DRE based clean cooking business models among financial institutions make commercial credit difficult to obtain. Consequently, organizations continue to prefer concessional loans and blended finance arrangements.

5. Although carbon finance is emerging as a valuable financing mechanism, its adoption remains uneven. Larger organizations are better positioned to participate in carbon markets due to the technical expertise and scale required for project development and verification. Smaller enterprises often lack the resources necessary to access these opportunities, indicating a potential role for technical assistance, aggregation mechanisms, and intermediary institutions to broaden participation. The possible opportunities from the recently launched domestic carbon market may substantially change this landscape in the next few years.

6. The responses also demonstrate that blended finance is increasingly recognized as the most appropriate financing model for the sector. By combining grants for market development, concessional loans for business expansion, equity investment for scaling, carbon revenues for long-term sustainability, and consumer financing for household affordability, blended finance can address multiple financing barriers simultaneously while reducing investment risk.

7. The most fundamental constraint identified across responses is consumer affordability. Regardless of technological readiness, adoption remains constrained by the high upfront cost of clean cooking

solutions for many households. Consequently, financing mechanisms such as microfinance, installment payment schemes, pay-as-you-go models, interest subsidies, and targeted consumer credit are likely to play an equally important role as enterprise financing in accelerating adoption.

8. Finally, the responses suggest that financing needs vary according to organizational maturity. Early-stage organizations primarily require grants and pilot funding; growth-stage enterprises need working capital and concessional debt to expand operations; while more mature companies increasingly seek larger equity investments, commercial capital, and carbon finance to support large-scale growth.

3.5.4 Future Financing Requirements

Looking ahead, financing requirements are expected to increase substantially as organizations transition from pilot-scale implementation to wider commercial deployment. Respondents anticipate requiring additional capital to expand manufacturing capacity, strengthen distribution and service networks, improve after-sales support, and increase market penetration. Among organizations that quantified their financing needs, requirements generally ranged from approximately ₹50 lakh to ₹2 crore for moderate expansion, while larger enterprises projected financing needs of ₹2–5 crore or more to support scaling activities.

Importantly, organizations emphasized that future financing should be more flexible than conventional commercial lending. Longer repayment periods, lower interest rates, patient capital, and risk-sharing mechanisms were frequently identified as necessary to align financing structures with the relatively long investment horizons and affordability challenges associated with clean cooking technologies. Respondents increasingly recognized blended finance, concessional debt, impact investment, and carbon finance as promising mechanisms for bridging the gap between grant dependence and fully commercial financing.

3.6. Conclusion: A Layered and Interdependent Architecture

The evidence suggests that Indian DRE based clean cooking finance should not be understood as four parallel, independent markets but as a single layered architecture in which each pillar compensates for a specific limitation of the others. End-user finance, whether the PMUY EMI mechanism, MFI microcredit, or NABARD-refinanced RRB lending, solves the affordability problem at the point of sale, but is rarely sufficient on its own to make an enterprise's unit economics work, because small-ticket rural lending carries high transaction costs relative to loan size. Enterprise finance solves the manufacturer's working-capital and growth-capital problem, but DFI and impact-investor capital is generally contingent on the enterprise demonstrating a credible distribution and repayment channel - which is to say, contingent on end-user finance already existing. CSR capital fills the gap that neither commercial debt nor equity investors will fund on their own: market research, behaviour-change communication, and multi-year pilot testing in geographies too uncertain for a return-seeking investor.

The survey highlights that the sector’s financing landscape is fragmented, with persistent reliance on non-commercial capital and limited access to conventional credit. Blended finance emerges as the most viable pathway, combining grants, concessional loans, carbon revenues, and consumer finance to address ecosystem-wide gaps. Consumer affordability continues to be the most fundamental constraint for products aimed at rural consumers, underscoring the importance of microfinance, PAYG model, and targeted subsidies. Ultimately, financing needs evolve with organizational maturity, requiring tailored instruments from pilot grants to equity and carbon finance for achieving scale.

4. CLEAN's Efforts in Promoting DRE based Clean Cooking Technologies

CLEAN has been committed to supporting DRE based clean cooking from its inception. CLEAN secretariat actively participated in various consultations and efforts to sustain policy support for DRE based cooking technologies. After the end of NPIC, there was a gap of stove testing and certifying laboratories in India. CLEAN funded establishment of a testing laboratory at NEERI, Nagpur, and established a system for testing and certification for its members. CLEAN also undertook efforts to develop a user-centric approach to testing, certification, and promotion of DRE based clean cooking technologies.

4.1 A User-Centred Approach to DRE based Clean Cooking Technology Promotion

The promotion of DRE based clean cooking technologies requires more than making alternative stoves or fuels available to households. Technology adoption and sustained use depend on whether a cooking solution is affordable, safe, durable, compatible with locally available fuels, capable of meeting household cooking (and other thermal energy) requirements and convenient for users. CLEAN worked towards creating a system for assessing, comparing and communicating the performance of cooking technologies, so that end user/donors/scheme implementers can make informed choices around technologies and specific products best suited to the needs of the target community.

The principal initiative by CLEAN is the development of a labelling scheme for solid biomass cookstoves, with an explicit focus on compliance with ISO standards. ISO alignment was considered important because it could facilitate acceptance by the Bureau of Indian Standards (BIS) or another agency responsible for reviewing and anchoring the labelling system. At the same time, the framework deliberately retained criteria identified by users and cooks as important for technology adoption and sustained use.

The underlying objective was therefore twofold. First, the label was intended to provide practitioners with a structured way of identifying advantages as well as limitations in different cooking technologies. Second, it was intended to communicate performance characteristics to users so that they could make more informed and appropriate technology choices, based on their cooking preferences.

This approach is particularly relevant because conventional technology testing often emphasises parameters such as efficiency and emissions, while household adoption is also shaped by factors such as cooking speed, heat control, cooking practices, fuel availability and the suitability of the stove to existing cooking vessels. CLEAN's proposed framework attempted to bring these dimensions together within a single technology-assessment and communication mechanism.

4.2. Development of a Multi-Dimensional Performance Labelling System

The core of CLEAN's intervention was the development of a star-based performance label for solid biomass cookstoves. The proposed label was designed to present information on both technical performance and user-relevant characteristics. The principal performance categories were thermal efficiency, CO emissions, PM2.5

emissions, safety, durability, heat-output controllability and cooking versatility. In addition, the label was intended to provide information on fuel types, cooking vessels, auxiliary energy requirements, other thermal services and legally required product information.

The first five parameters—thermal efficiency, CO emissions, PM2.5 emissions, safety and durability—were linked to standardised testing approaches. For thermal efficiency, for example, the framework linked the star rating to IWA performance tiers under the relevant ISO testing protocol. A stove achieving thermal efficiency of 45% or above was assigned the highest five-star efficiency category, while lower levels were assigned progressively lower ratings.

The emissions component was similarly structured around measurable performance. CO was included because of its direct relevance to health of the householder family, with the rating based on CO concentration per unit of useful energy delivered to the cooking pot. PM2.5 was treated as another critical health-related parameter and assessed using the relevant ISO test protocol. The framework also included safety, assessed through a weighted set of parameters related to accident and injury risks, and durability, intended to capture both expected stove lifetime and perceptions of product quality.

An important feature was that absolute performance values were not intended to disappear behind the star ratings. The scheme recommended reporting actual thermal-efficiency, CO and PM2.5 measurements alongside the ratings. This was considered particularly useful for donors, funders and investors because it would enable them to assess the potential health, environmental and climate benefits of technologies and distinguish between products that might otherwise receive similar star ratings.

4.3. Incorporating User Needs, Cooking Practices and Field Conditions

Two specific user-centric parameters were incorporated into the star-rating system: heat-output controllability and cooking versatility. The framework was developed around factors identified as important by Indian household cooks. For testing these parameters, manufacturers were expected to provide cooking vessels that were already widely available and closely matched to those used by the target community. Highly customised vessels could be rejected unless the stove and vessels were intended to be sold as a package.

Heat-output controllability

Heat control was included because cooking frequently requires movement between high and low heat. The proposed test measures the time lag between the action taken by the cook or operator to reduce heat and the resulting change in temperature at the cooking pot. The protocol involved heating two litres of water to 80°C, reducing the stove's heat output and recording the temperature at five-second intervals. The test was to be repeated at least three times and the average response time calculated.

The rating ranges from **H*** for stoves with no effective controllability to **H***** where the desired temperature reduction occurs in less than ten seconds, or where heat controllability is not required for the particular technology.

Cooking versatility

CLEAN also recognised that cooking requirements vary by cuisine and geography. The framework therefore considered three common cooking processes—boiling, roasting and frying. Boiling was treated as a basic

cooking activity across India, while roasting and frying were recognised as particularly important for specific foods and regional cooking practices, such as roti and poori preparation.

The proposed testing system measures whether a stove can heat water adequately for boiling, achieve appropriate and sufficiently uniform temperatures for roasting and heat oil to the required temperature for frying. The resulting rating ranges from one star where the stove fails the relevant performance requirements to five stars where it performs adequately across all the three processes.

The user-centred approach extended beyond these two ratings. The label was designed to specify appropriate pot types, pot sizes and food quantities, allowing households to determine whether the stove is suitable for their family size and cooking requirements.

Fuel compatibility was another important consideration. The label proposed listing up to four biomass fuel types, ranked according to their emissions performance. The framework recognises that stove performance under field conditions depends partly on the fuel used and that households need to know whether the fuels recommended for a stove are actually accessible to them.

The label was also expected to disclose requirements for auxiliary energy, such as electricity or battery charging required for forced-draft stoves. Information on additional services or by-products—such as charcoal production or space heating—was included because these could affect the economic value and willingness to pay for a technology.

4.4. Strengthening Consumer Information, Technology Quality and Stakeholder Decision-Making

CLEAN's proposed labelling initiative also addressed a major barrier to technology adoption: limited and uneven information about product quality and performance. The proposed label was not restricted to technical ratings. It also included legally mandated and practical information that could help consumers understand the product they were purchasing.

The legally mandated component included the maximum retail price, manufacturer's name and address, customer-care contact information, product weight and dimensions, batch or lot identification, manufacturing date and warranty conditions. The proposal recommended making these requirements applicable to both factory-produced and artisanal cookstoves.

CLEAN also recommended that labelled stoves be accompanied by a user manual. The manual was expected to contain pictorial and preferably multilingual instructions, recommendations for improving performance, cautions and troubleshooting information, and details of spare parts, servicing and maintenance. It was also expected to explain the basis on which the stove's star rating had been calculated.

This is important because the effectiveness of a cooking technology does not end at purchase. Correct operation, maintenance, fuel choice and appropriate cooking practices can influence actual performance. The proposed information system therefore sought to improve not only consumer choice before purchase, but also technology utilisation after purchase.

The framework also created an important role for manufacturers. Information that could not be quantitatively tested—particularly location-specific or situation-dependent characteristics—was to be provided descriptively by manufacturers. Although full validation by the labelling authority was recognised as difficult at the initial stage, requiring manufacturers to provide the information in writing was expected to create greater accountability, including through the possibility of customer complaints and competitive scrutiny.

At the sector level, the label could therefore improve the flow of information between manufacturers, consumers, testing institutions, funders, investors and other practitioners. For investors and donors, the underlying performance data could provide a basis for distinguishing technologies according to their efficiency, emissions and potential health and environmental benefits.

The initiative thus positioned technology promotion as partly an information and market-development exercise. Instead of assuming that consumers would adopt a technology simply because it was labelled "clean", it sought to make the specific advantages and limitations of different products visible.

4.5 Operationalisation, Stakeholder Engagement and Broader Significance

CLEAN's work extended beyond designing the label to developing a proposed process for putting the system into operation. The implementation plan envisaged a collaboration between **CLEAN and NEERI**, with NEERI undertaking additional testing beyond the standard emissions and efficiency testing and incorporating the additional requirements into future testing. CLEAN would receive the resulting test reports and combine the test data with information supplied by manufacturers or suppliers to generate the final label.

CLEAN also planned a structured engagement process with manufacturers and other stakeholders. Members who had submitted stoves for testing, or intended to do so, were to be invited to a webinar explaining the new label, its design and the information required from manufacturers. Subsequently, CLEAN would organise meetings with individual manufacturers or suppliers to explain their labels and obtain feedback from ground-level teams and existing users. This feedback would then be followed up by CLEAN and discussed through a broader brainstorming process involving CLEAN, NEERI, entrepreneurs and the labelling project team.

The proposed approach also recognised a methodological challenge: because the framework produced separate ratings for multiple criteria, a stove could potentially have seven different star ratings. The document notes that collapsing these into one overall rating could make the label easier to read, but would also risk losing important information and would raise methodological questions about how fundamentally different performance dimensions should be aggregated. The proposed solution was therefore to develop a visual design that could communicate multiple dimensions clearly while allowing buyers and users to prioritise the characteristics most relevant to them.

Finally, CLEAN envisaged extending the approach beyond solid biomass cookstoves. The proposed next step was to assess whether the labelling framework could be extended to **other DRE cooking-energy technologies**, potentially creating a common assessment framework for a wider range of cooking devices. The principles of incorporating user satisfaction into appliance ratings were also proposed for possible application to other distributed renewable-energy appliances.

Taken together, these efforts demonstrate that CLEAN's role in clean cooking technology promotion was primarily focused on **building an enabling ecosystem for better technology selection, development and adoption**. The organisation's intervention addressed several interconnected barriers: lack of comparable

performance information, limited consumer awareness, inadequate consideration of cooking practices, uncertainty regarding technology quality, and the absence of a common mechanism for communicating performance to different market actors. The proposed labelling framework brought technical standards, health and environmental performance, user preferences, fuel compatibility, safety, durability and consumer information into one system.

By making technology characteristics more transparent and incorporating the requirements of actual users into assessment, the initiative sought to improve the likelihood that clean cooking technologies would not only be adopted but also remain useful and acceptable in everyday household cooking.

5. Policy Recommendations: Towards a Decentralised and Diversified Clean Cooking Energy System in India

India's clean cooking transition has achieved substantial progress in expanding access to modern fuels, particularly through the rapid expansion of LPG under the Pradhan Mantri Ujjwala Yojana (PMUY). However, recent disruptions to LPG supply and the associated volatility in fuel availability and prices demonstrate the limitations of a cooking-energy strategy that relies heavily on a single fuel. The experience of 2026, when geopolitical developments in West Asia affected energy-security concerns and required the government to introduce measures to protect LPG availability, further underscores the vulnerability associated with dependence on an internationally exposed fuel supply chain (PIB, 2026). While the government encouraged consumers during the disruption to consider PNG, induction and electric cooktops wherever feasible, while simultaneously prioritising domestic LPG supplies several CLEAN member DRE based cooking technology solution providers reported an increase in inquiries and direct sale to end users.

Table 2: Seven priority recommendations

#	Recommendation	Lead and support	Builds on	Timeline
1	Set up a National Cooking Energy Resilience Mission with one accountable lead and a joint steering group	MoPNG and MNRE jointly; MoP and BEE, MoHUA, MoWCD, Education and Health departments, state nodal agencies	PMUY delivery machinery; National Bioenergy Programme	Year 1
2	Make public institutional kitchens (schools, anganwadis, hospitals, hostels, community kitchens) the anchor buyers of DRE cooking, and bring private commercial kitchens (hotels, caterers, cafes, canteens) into the same support	State departments through state nodal agencies, with MNRE technical support	Existing government meal and nutrition programmes; public procurement	Phase 1: Years 1 to 3
3	Create one technology neutral support window for clean cooking: capital subsidy, results based incentives and concessional finance	MNRE and MoPNG, with Ministry of Finance	PMUY financing logic, redirected so support is not tied to one fuel	Years 1 to 5
4	Introduce common testing, certification and performance standards for all DRE cooking devices and fuels	BEE and BIS with MNRE	BEE work on electric cooking (BEE, 2024); the tier rating framework proposed in the Clean Cooking Working Group, CLEAN's work on labeling for improved cookstoves.	Years 1 to 2

#	Recommendation	Lead and support	Builds on	Timeline
5	Fund RD&D for hybrid, multi energy cooking systems	MNRE with research institutions and start-ups	The Surya Nutan model, OrjaBox model of combination of technologies to replace typical stacks consisting of LPG and Traditional stoves.	Years 1 to 5
6	Update housing and urban planning rules so new buildings are "energy flexible", including through PMAY-G and PMAY-U	MoHUA and BEE, with states	Building codes and housing standards (BEE, 2024; IEA, 2021); PMAY-G and PMAY-U	Years 2 to 4
7	Reinstate or replace the central biogas subsidy without a gap, and extend support to toilet linked and community biogas	MNRE	National Bioenergy Programme; existing additional support for toilet linked biogas	Immediate: first 6 months

Measure of success: every household and institution has at least one affordable, reliable, low emission cooking option, and no household falls back to firewood during any fuel supply disruption.

5.1. Moving from a single-fuel model towards cooking-energy diversification

The central policy lesson is that energy access should not be equated with access to a single cooking fuel. LPG has played a transformative role in replacing firewood and other traditional fuels, and its health and convenience benefits are well established. However, the affordability and reliability of LPG remain important constraints. The recent supply disruptions have added another dimension to this vulnerability: even when a household possesses an LPG connection, the availability of cylinders at the required time and place cannot always be taken for granted during periods of market or geopolitical stress as well as local environmental crises.

This vulnerability extends beyond poor rural households. LPG supply disruptions have affected urban households, restaurants, hotels, institutional kitchens, schools, hospitals and community kitchens, all of which require reliable and continuous access to cooking energy. For commercial and institutional consumers, interruptions can directly translate into higher operating costs, reduced service capacity and increased expenditure on alternative fuels. For households, particularly those with limited disposable income, increases in the effective cost of cooking can divert expenditure away from food, education, health and other essential consumption. Thus, cooking-energy security should increasingly be understood as a component of household and livelihood economic security, rather than simply an issue of fuel access.

An important concern is that when modern fuels become unaffordable or unavailable, consumers may not necessarily move horizontally towards another clean technology. Instead, they may move backwards down the energy ladder, returning to traditional firewood chulhas because these fuels remain locally accessible. Such reversals undermine the health and environmental gains achieved through clean-cooking programmes. India's experience therefore suggests that the objective of policy should not be to replace biomass with LPG and subsequently LPG with another single energy source. Rather, it should be to establish a portfolio of reliable

cooking-energy options, allowing consumers to switch between appropriate technologies according to availability, affordability, location and end-use requirements.

Box 11: LPG supply disruption during COVID-19

The COVID-19 lockdown of 2020 provides another important precedent for understanding the vulnerability of India's LPG-dependent cooking system during a sudden disruption. Following the announcement of the nationwide lockdown in March 2020, households responded with panic booking and stockpiling of LPG cylinders, causing a sharp but temporary increase in demand; LPG distributors reported demand increases of around 25–30%, while some consumers initially experienced delays in receiving refills. The disruption was compounded by restrictions on movement and the migration of 20–30% of some distributor workforces from urban areas, creating potential last-mile delivery constraints. (IndianOil, 2020) [187]

Box 12: Early lessons from the 2026 LPG disruption (Clean Cooking Working Group call, April 2026)

Members of the Clean Cooking Working Group shared the following experience of the disruption. These are qualitative observations from the sector and are a survey of the complete market.

- **Demand rose across renewable cooking technologies.** Enquiries rose for pellet, biogas, solar and induction cooking. One biogas service provider reported a five-fold rise in daily enquiries (from about 20 to about 100), and some manufacturers received unexpected orders through online marketplaces.
- **The market that opened was urban and commercial.** Hotels, caterers, cafes and canteens, mostly with no earlier awareness of biomass pellets, approached the sector. Much effort went into basic education before sales could be made. Rural users were largely unaffected because they had never fully given up traditional stoves.
- **Supply chains were not ready.** Pellet supply was thin and inconsistent from city to city, and suppliers had to be vetted one by one. Solar cooker manufacturers were few, and many cookers were damaged in transit. Some input costs rose by about 20 percent because plastic granule imports from West Asia were disrupted.
- **Many urban kitchens fell back on charcoal**, one of the most polluting options, because it was the easiest alternative to find.
- **Public support lagged.** The government response named PNG and electricity but not renewable cooking. Members reported that the central biogas subsidy (₹14,000 per farmer) lapsed on 31 March 2026 without a successor scheme, and conversions stalled.

The lesson is that demand was present but readiness was not. The risk now is that customers return to fossil fuels once LPG supply normalises, which makes the actions in 5.4 time sensitive.

[187] IndianOil. (2020).LPG distributors shift focus to rural consumers as urban demand plateaus . Indian Oil Corporation Limited, March/April 2020

5.2. Electrification should complement, rather than replace, other cooking-energy sources

The increasing policy interest in electric cooking represents an important opportunity, but it should not reproduce the same structural dependence that emerged around LPG. The Bureau of Energy Efficiency has identified electric cooking, including induction cooking, as an important pathway for efficient and cleaner cooking, while the Government has also promoted induction cooktops and other electric cooking appliances (BEE, 2024). However, universal electrification does not automatically imply universal suitability of electric cooking. Cooking requires not merely a grid connection but electricity that is reliable, affordable, sufficiently powered and available when food needs to be prepared.

This distinction is particularly important in remote and underserved areas where electricity supply may remain intermittent. An induction cooktop cannot provide a reliable cooking service during a prolonged power outage unless it is backed by storage or another source of energy. Moreover, a rapid and large-scale shift of cooking demand from direct fuels to electricity would transfer part of the energy burden from the cooking sector to the power system. The environmental consequences of electric cooking consequently depend on the evolving electricity mix. India has made significant progress in renewable energy based electricity, but thermal generation continues to constitute an important part of the power system. Thus, electrification can contribute to decarbonisation, but its long-term sustainability depends on simultaneously increasing renewable generation, strengthening distribution infrastructure and managing peak electricity demand (IEA, 2021)[188]

5.3. Promoting a portfolio of decentralised renewable cooking technologies

The next phase of India's clean-cooking policy should therefore move towards a multi-technology, decentralised renewable energy (DRE) approach. Instead of asking which single fuel should replace LPG, policy should ask which combination of technologies can provide reliable and clean cooking services for a particular location and user group. This approach is particularly relevant for households, but its application should extend to community kitchens, anganwadi centres, schools, hospitals, restaurants, hotels and other commercial and institutional kitchens.

A diversified cooking portfolio could include pellet- and briquette-based biomass stoves, improved biomass cookstoves, biogas systems, solar cookers and solar-electric cooking systems, green DME and hydrogen based stoves, alongside LPG, PNG and induction cooking. Such a portfolio can increase resilience because the failure or temporary unavailability of one energy source does not necessarily result in the complete loss of cooking capacity.

The renewable component of this portfolio is especially significant because it can simultaneously address several policy objectives. Biomass briquettes, pellets, biogas and green DME can convert agricultural residues, animal waste and other organic material into useful energy, thereby linking clean cooking with waste management, rural livelihoods and energy security. The Ministry of New and Renewable Energy's National Bioenergy Programme explicitly recognises this interconnection, highlighting benefits such as greenhouse-gas reduction, improved sanitation and rural employment (MNRE, 2022).Unlike fossil fuels, sustainably managed biomass and organic waste can form part of a circular energy system, in which residues and wastes are repeatedly converted into productive resources. Biogas provides an especially strong example: the digestion

[188] International Energy Agency (IEA). (2021). *Air Quality and Climate Policy Integration in India*. Paris: IEA

process produces both cooking fuel and nutrient-rich bio-slurry that can be returned to agricultural systems as organic manure (MNRE, 2022).[189]

Solar thermal cooking, hydrogen based stoves, etc., can be complementary to LPG/PNG/Electricity use in urban/semi-urban households, wherever sunny open terraces are available. A bigger impact of such technologiesis for large kitchens where steam generation with the help of solar concentrators (instead of grid electricity use) can drastically reduce the cost of cooking energy.

Such systems can also reduce dependence on imported fossil fuels and strengthen local energy security.

5.4. A strong policy-side behavioural and market push is needed from the Government

Technology availability alone will not produce a large-scale clean-cooking transition. The efforts during PMUY validate the importance of strong government intervention in creating markets and changing consumer behaviour. PMUY was launched in 2016 with a target of providing eight crore LPG connections to deprived households by March 2020; the target was achieved ahead of schedule, and the programme subsequently expanded to more than 10 crore connections (MoPNG, 2023)[190]. This demonstrates the ability of public policy to alter entrenched cooking practices within a relatively short period when financial support, institutional delivery mechanisms, political prioritisation and behavioural messaging operate together.

A similar policy push is now required for non-fossil and decentralised renewable energy cooking technologies. Government intervention should move beyond isolated pilots and demonstrations towards sustained market creation. This could include capital subsidies or targeted financing for clean cooking devices, results-based incentives for manufacturers and distributors, concessional finance for households and enterprises, local technician training, after-sales service networks, consumer awareness campaigns and procurement programmes for public institutions.

Action A: Make public institutional kitchens the anchor market

Schools, anganwadi centres, hospitals, hostels and community kitchens are where the government is already the buyer and the decision maker. It can create demand for technology switching as well as behavioural change directly. These kitchens were hit hard by the LPG disruption, with higher operating costs, reduced service capacity and spending on costlier alternative fuels. They are also the places where interventions like solar concentrators can cut cooking energy costs the most, and where biogas and pellet systems can run at a steady scale. We therefore recommend that:

- MNRE and MoPNG jointly set a national target for DRE and hybrid cooking in public institutional kitchens, with year wise state targets [with an initiative with CLEAN, target can be set after a baseline count of institutional kitchens].
- States begin with schools and anganwadi centres in the first phase, then extend to hospitals, hostels and community kitchens.
- Procurement is done in bulk through state nodal agencies, with approved device lists, so that manufacturers get a predictable order book.

[189] Ministry of New and Renewable Energy (MNRE). (2022). *National Bioenergy Programme*. Government of India
[190] Ministry of Petroleum and Natural Gas (MoPNG). *Pradhan Mantri Ujjwala Yojana: About the Scheme*. Government of India.

- A viability gap funding window covers the difference between the cost of DRE systems and conventional options in the early years, with support reducing as volumes grow.
- Every institutional kitchen keeps at least two energy sources, so that one failure does not stop meals.
- Include private commercial kitchens (hotels, caterers, cafes and canteens), the segment that opened up during the 2026 disruption (Clean Cooking Working Group call, April 2026), in the same support window, awareness efforts and supplier lists, so that early switchers do not return to fossil fuels.

Action B: Build one technology neutral support window for households and enterprises

Support today is heavily tied to one fuel. A single window, run through one lead agency, should offer three instruments:

- *Capital support* for clean cooking devices, targeted at low income and remote households.
- *Results based incentives* for manufacturers and distributors, paid on verified and continued use, not on units shipped. This addresses the refill affordability problem seen under PMUY.
- *Concessional finance* for households, women's groups and local enterprises, so that upfront cost does not block adoption.

The scale of this opportunity can be assessed against the Union government's existing support for LPG. In FY 2025–26, the Union Cabinet approved ₹12,000 crore for the targeted PMUY subsidy of ₹300 per 14.2 kg cylinder for up to nine refills a year. In August 2025, the government also announced ₹30,000 crore in compensation to public sector oil marketing companies for domestic LPG under-recoveries, although ₹12,500 crore was approved in supplementary demands for grants for FY 2025–26. PIB, August 2025; PRS, 2026.

For FY 2026–27, the Budget provides ₹9,200 crore for LPG connections to poor households and ₹1,500 crore for LPG subsidy transfers under PAHAL. A proposed annual allocation of ₹1,200 crore for decentralised renewable energy (DRE) cooking devices, equivalent to 10% of the FY 2025–26 targeted PMUY subsidy, would offer a useful benchmark for a dedicated clean cooking programme. This provides a concrete financial benchmark for designing a dedicated DRE cooking programme, drawing on the scale of public investment already committed to LPG.

Verification and finance. Two further elements are needed to make the window work.

- *Measurement, reporting and verification.* Incentives paid on continued use require a simple and credible way to verify it. Digital tools such as sensors and geo tagging can be used, with clear rules on how fuel stacking is treated.
- *Carbon and blended finance.* Options to explore include carbon revenue backed loans, advance purchase agreements and blended finance, which were raised in sector discussions (Clean Cooking Working Group call, April 2026). Another option to explore is whether the scale of PMUY support could back a national carbon programme with credits claimed by the government. Any carbon finance arrangement should include consent, grievance redress and disclosure rules, so that revenue and benefits reach women and communities.

Action C: Build the service chain, not only the device

PMUY worked because the distribution network already existed. DRE cooking has no such network, so the push must create it. Funding should cover local technician training, after sales service and spare parts

availability, pellet and feedstock supply chains, and local enterprises that can manufacture, install and maintain systems. These are also sources of rural and semi urban jobs, linking this section to the employment argument in 5.8.

Sector discussions (Clean Cooking Working Group call, April 2026) point to four priorities:

- Move from dependence on donors and bulk buyers towards direct to consumer sales, supported by technology neutral intermediaries that handle last mile sales and after sales service.
- Standardise stoves, pellets, fuels and business practices, as a precondition for government confidence and market scale. The tier rating framework already developed by sector experts can be revisited and extended to cover all clean cooking technologies.
- Maintain vetted, city level lists of pellet and feedstock suppliers, and set packaging and transport standards for products such as solar cookers.
- Test a single platform, physical or online, that brings together cooking solutions, skilling, after sales service and awareness.

Behavioural interventions should also recognise that households do not adopt technologies simply because they are technically cleaner. Convenience, cooking speed, taste, reliability, maintenance, fuel availability, upfront cost and social familiarity influence technology choice. Consequently, communication campaigns should present DRE technologies as practical cooking solutions rather than merely environmental products.

Action D: Communicate DRE as a practical cooking solution

Building on the point above, campaigns should:

- show real kitchens, using demonstration kitchens and urban pilots;
- use school meals and anganwadis as visible examples, so that families see these technologies working before they buy;
- be directed at urban households and commercial kitchens too, not only rural areas.

Language also matters. Working group discussions (Clean Cooking Working Group call, April 2026) suggested that "clean cooking" may no longer be the most resonant frame, and that renewable, domestic and decentralised energy, or self reliance, may work better with government and urban consumers.

This is particularly important because India's clean-cooking transition cannot be considered complete merely because a household has received a connection. The distinction between access, adoption, sustained use and exclusive use is critical. The evidence on PMUY itself illustrates this challenge: although LPG connections expanded dramatically, affordability of refills continued to influence sustained usage (Sahu et al., 2024)[191].

Action E: Hold on to the 2026 demand with immediate measures

Several steps cannot wait for a full mission to be set up. We recommend that, in the first six months:

- MNRE reinstates or replaces the central biogas subsidy without a gap, and extends support to toilet linked and community or village biogas plants, which members considered more cost effective and easier to use than individual household units (Clean Cooking Working Group call, April 2026). An additional ₹1,500 for toilet linked biogas is already offered by MNRE.

[191] Sahu, V., Tripathi, S. N., Sutaria, R., Dumka, N., Kotwal, A., Ghosh, K., & Singh, R. K. (2024). Assessment of a clean cooking fuel distribution scheme in rural households of India – Pradhan Mantri Ujjwala Yojana (PMUY). *Energy for Sustainable Development, 81*, 101492.

- Educational material on alternative cooking technologies is prepared and shared through sector networks, aimed at urban commercial kitchens and rural users.
- The approval of bio-slurry as a biofertiliser is completed, so that biogas systems can earn from both fuel and fertiliser.

Safeguards

To make sure this push does not repeat past problems, we recommend that:

- All devices and fuels supported must meet common emissions and safety standards, with independent testing (see priority recommendation 4 in the box above).
- Subsidy design must protect low income households, so that a price rise or supply failure does not send them back to firewood.
- Plan for fallback fuels. In 2026 many urban commercial kitchens turned to charcoal, and low income households fell back on firewood with traditional stoves. Support design and awareness should steer both towards cleaner alternatives.
- Progress is tracked by sustained and exclusive use, not by connections or devices distributed.

Suggested indicators

- Number of public institutional kitchens running at least one DRE system.
- Share of supported households still using the clean option after 12 months.
- Number of local technicians trained and service points active.
- Cooking energy cost per meal in institutional kitchens, before and after.

5.5 Strengthening R&D for user-centric and hybrid clean cooking technologies

A diversified clean-cooking ecosystem will require a much stronger focus on research, development and demonstration (RD&D) of user-centric, multifunctional and hybrid thermal-energy technologies. Rather than developing individual devices around a single fuel, R&D should increasingly focus on technologies that can accommodate the realities of different users, locations and energy-availability conditions. This includes devices designed for different scales—from household and small-enterprise applications to community, institutional and commercial kitchens—and technologies capable of combining multiple energy sources within a single cooking system. Examples could include a single burner capable of operating on LPG, PNG and biogas; solar cookers integrated with thermal or battery storage for operation beyond sunshine hours; or electric cooking systems that can automatically switch between grid electricity, solar power and battery storage. Such hybridisation would directly address one of the principal weaknesses of single-fuel systems: the inability to provide reliable cooking when one energy source becomes unavailable or unaffordable. Importantly, this is not an entirely new direction for Indian innovation. The development of Surya Nutan demonstrates how targeted R&D and institutional support can produce an indigenous cooking technology that integrates solar energy with an auxiliary energy source and is designed for round-the-clock use; the Government has also highlighted its hybrid functionality as a means of improving reliability. The policy lesson from such initiatives should be to replicate the innovation model across a much wider range of decentralised renewable-energy applications, rather than concentrating support on a limited number of technologies.

A broader and more systematic incentive framework could therefore create an ecosystem in which universities, start-ups, manufacturers, public-sector R&D institutions and end-users collaborate to develop the next

generation of flexible DRE-based thermal-energy devices. Such support would help bridge the persistent gap between laboratory innovation and mass-market adoption and, more importantly, would make clean cooking more resilient by shifting the focus from *fuel-specific appliances* towards energy-flexible cooking systems

5.6. Adopt a needs-based, location-specific and multi-device strategy

Finally, clean-cooking policy should move away from the assumption that one technology can meet the cooking requirements of all Indian consumers. Cooking energy needs differ according to climate, household size, cooking practices, available space, electricity reliability, local biomass availability, livestock ownership, income, type of kitchen and whether the user is a household or a commercial/institutional consumer.

A location-specific DRE strategy could therefore combine technologies according to local resource conditions. Areas with reliable electricity and adequate grid capacity could prioritise induction and other efficient electric cooking technologies, supported by renewable electricity and storage where appropriate. Regions with substantial agricultural residues could develop pellet or briquette-based cooking systems. Livestock-intensive rural areas could support household or community biogas systems. Areas with high solar availability could deploy solar cookers or solar-assisted systems. LPG and PNG should remain available as complementary fuels.

This “multiple devices, multiple fuels and local resource” model would also improve resilience in the event of future disruptions. Local entrepreneurs could manufacture, distribute, maintain and service DRE-based systems, while community-level energy enterprises could aggregate demand and organise fuel or feedstock supply.

The policy objective should consequently shift from achieving fuel substitution to achieving cooking-energy resilience. India's next generation of clean-cooking policy should ensure that every household and institution has access to at least one affordable, low-emission and reliable cooking option, while encouraging a combination of technologies where local conditions permit.

5.7. Institutional design, built environment integration and awareness creation

A successful transition to a diversified clean-cooking system also requires institutional redesign and changes in the built environment. Housing and urban planning frameworks must begin to incorporate provisions for multiple or multi-fuel cooking-energy systems, including space, ventilation, electrical load capacity, fuel storage and safety infrastructure for technologies such as induction cooktops, biogas units, biomass pellet systems and hybrid cooking setups. Current building designs in both rural and urban India are largely optimised for either traditional biomass or LPG, and are not adequately prepared for integrated DRE-based cooking systems. Updating housing standards and urban planning guidelines is therefore essential to ensure that new homes and public buildings are “energy-flexible” and capable of accommodating multiple clean cooking technologies (BEE, 2024; IEA, 2021)[192].

Housing schemes offer a ready entry point. Clean cooking systems, such as biogas units or the space and wiring needed for induction cooking, could be included as an integral package in PMAY-G and PMAY-U, so that new homes are designed for more than one cooking energy source from the start.

[192] Bureau of Energy Efficiency (BEE). (2024). *India Energy Scenario: For the Year 2023–24*. Ministry of Power, Government of India.
International Energy Agency (IEA). (2021). *Air Quality and Climate Policy Integration in India*. Paris: IEA.

In addition, large-scale awareness and behavioural change campaigns are required to normalise the use of diverse clean cooking technologies across both rural and urban populations. Clean cooking should not be framed as a rural development issue alone; urban households, commercial kitchens and institutional users must also be actively included in the transition narrative. Demonstration kitchens, urban pilot projects, school-based awareness programmes and community-level engagement can help build familiarity and trust in DRE technologies. A balanced adoption across rural and urban areas is essential to ensure that all segments of society participate in and benefit from the clean cooking transition.

5.8. Employment generation and green livelihoods potential

The transition towards a decentralised clean cooking ecosystem also presents a significant opportunity for employment generation and green livelihood creation. A diversified DRE-based cooking system would require a wide range of skilled and semi-skilled workers across the value chain. These include jobs in the design and manufacturing of clean cooking devices. It would also generate substantial employment in installation, distribution, after-sales service, repair and maintenance networks, particularly in rural and semi-urban areas where decentralised systems are more likely to be deployed.

In addition, the sector would create demand for research and development professionals, engineers, energy planners and innovation specialists working on improving efficiency, affordability and usability of clean cooking technologies. The development of local biomass supply chains, biogas systems and pellet production units would further generate rural employment linked to agricultural residue collection, waste management, logistics and energy entrepreneurship. As highlighted in the National Bioenergy Programme, bioenergy systems in particular have strong linkages with rural employment and local value creation (MNRE, 2022)[193]. Overall, a decentralised clean cooking transition can evolve into a labour-intensive green economy sector, contributing not only to energy security and emissions reduction but also to inclusive economic development.

Gender, health and livelihood benefits: The transition should also be judged by what it delivers for women, who carry most of the burden of cooking. The benefits include less exposure to smoke, time saved on fuel collection and cooking, and opportunities as local entrepreneurs, technicians and members of women's groups. Subsidy and carbon finance design should therefore include consent, grievance redress and clear disclosure, so that benefits and any revenue reach women and communities.

The broader policy rationale is therefore not to reject LPG or electric cooking, but to avoid reproducing the vulnerability associated with dependence on any single energy source. India's experience with LPG demonstrates that government policy can transform cooking practices at national scale; the next policy challenge is to apply that same capacity to create a diversified ecosystem of renewable and low-carbon cooking technologies. Such an approach would simultaneously strengthen energy security, reduce exposure to imported fossil-fuel price shocks, improve resilience to supply disruptions, reduce household air pollution and emissions, create rural economic opportunities and convert agricultural and organic waste into productive energy resources. A resilient clean-cooking transition should thus be understood not as a linear movement from biomass → LPG → electricity, but as a transition towards a diversified, decentralised and locally appropriate cooking-energy system

[193] Ministry of New and Renewable Energy (MNRE). (2022). *National Bioenergy Programme*. Government of India.

Annexure

Table 1. Share of households using LPG as primary cooking fuel by state, selected years (in percentage).

State	Census (2011)	NFHS-4 (2015–16)	NSSO (2018)	IRES (2020)
Andhra Pradesh + Telangana	*36*	*65*	*86*	*92*
Assam	*19*	*25*	*59*	*75*
Bihar	*8*	*18*	*49*	*49*
Delhi	*90*	*98*	*94*	*100*
Gujarat	*38*	*53*	*67*	*76*
Haryana	*44*	*52*	*69*	*86*
Himachal Pradesh	*39*	*34*	*52*	*80*
Jharkhand	*12*	*19*	*33*	*47*
Karnataka	*33*	*55*	*81*	*86*
Kerala	*36*	*57*	*59*	*65*
Madhya Pradesh	*18*	*30*	*48*	*54*
Maharashtra	*43*	*60*	*76*	*91*
Odisha	*10*	*19*	*33*	*47*
Punjab	*55*	*66*	*85*	*87*
Rajasthan	*23*	*32*	*48*	*69*
Tamil Nadu	*48*	*73*	*87*	*86*

State	Census (2011)	NFHS-4 (2015–16)	NSSO (2018)	IRES (2020)
Uttar Pradesh	*19*	*33*	*50*	*71*
Uttarakhand	*44*	*51*	*70*	*78*
West Bengal	*18*	*28*	*43*	*50*

Source: CEEW (Mani et al., 2021), IRES 2020

Table 2. Current cooking energy technology status in India (2024–26).

Fuel / Technology	Current Reach (2024–26)	Primary Adoption Barrier	Renewability Status
LPG (incl. PMUY)	32.94 cr connections; 10.56 cr PMUY	Refill cost (4.71 (FY 2025-26) PCC vs 7-8 needed); 60–65% imported; price volatility	None
Traditional Biomass	35% primary fuel (HCES 2023–24); 840M use partially	Baseline.	Context-dependent : renewable for agri-residue/dung/fallen wood; not renewable if from trees felled specifically for fuel.
Biogas	~5.1M household/community plants; large urban WTE projects already producing **7,71,008 m^3/day biogas + 2,64,467 kg/day bioCNG + 401 MW power**; 0.3% HHs as primary fuel *(WBA p.3)*	High upfront capital cost; feedstock access; no agro-industrial use support	Yes ,fully renewable; large potential
Improved Solid biomass (improved cookstoves, pellets, briquettes)	No national count.	Pellet and briquette supply is patchy. Forced draft stoves cost about ₹4,500 against ₹1,200 for natural draft. Weak after-sales service and sustained use	Yes, if made from agricultural residue (179 MMT of surplus biomass a year). Context dependent if sourced from felled trees
Electric / Induction	~11M units sold till 2025; ~10% urban HHs	In-kitchen wiring upgrades; upfront cost; cookware compatibility; consumer misconceptions about cooking energy cost	Partially ,tied to state grid mix (coal-dominated nationally); decarbonises and becomes more and more renewable as grid cleans up
Solar Thermal	Institutional pilots mostly; Shirdi (50,000 meals/day)	Daytime-only; no supply chain for rural HH use; limited awareness	Yes, fully renewable, underutilised

Fuel / Technology	Current Reach (2024–26)	Primary Adoption Barrier	Renewability Status
Ethanol / Methanol	Niche pilots only; no policy-scale deployment	Fuel supply chain immaturity; no dedicated distribution network	Potentially , feedstock-dependent

Source: HCES 2023–24 (MoSPI); IISD (Mani et al., 2026); WBA (2023) Market Report: India; MECS (Rousseau et al., 2026); IEEFA (2024); MNRE.