



# India's Clean Cooking Shift

Scaling non-fossil fuel solutions

IISD REPORT



Sunil Mani  
Gunjan Kohli  
Shruti Sharma  
Gaurav Limaye  
Abdurahman Alsulaiman

© 2026 International Institute for Sustainable Development  
Published by the International Institute for Sustainable Development  
This publication is licensed under a [Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License](#).

## International Institute for Sustainable Development

The International Institute for Sustainable Development (IISD) is an award-winning, independent think tank working to accelerate solutions for a stable climate, sustainable resource management, and fair economies. Our work inspires better decisions and sparks meaningful action to help people and the planet thrive. We shine a light on what can be achieved when governments, businesses, non-profits, and communities come together. IISD's staff of more than 200 people come from across the globe and from many disciplines. With offices in Winnipeg, Geneva, Ottawa, and Toronto, our work affects lives in more than 100 countries.

IISD is a registered charitable organization in Canada and has 501(c)(3) status in the United States. IISD receives core operating support from the Province of Manitoba and project funding from governments inside and outside Canada, United Nations agencies, foundations, the private sector, and individuals.

### India's Clean Cooking Shift: Scaling non-fossil fuel solutions

February 2026

Written by Sunil Mani, Gunjan Kohli, Shruti Sharma, Gaurav Limaye, and Abdurahman Alsulaiman

Photo: hadynyah/iStock

### Head Office

111 Lombard Avenue, Suite 325  
Winnipeg, Manitoba  
Canada R3B 0T4

**Tel:** +1 (204) 958-7700

**Website:** [iisd.org](https://iisd.org)

**X:** [@IISD\\_news](#)

## Acknowledgements

We would like to thank the International Development Research Centre (IDRC) Canada and the Government of Denmark for their generous support for this publication. We express our appreciation to Bhim Adhikari (IDRC) for his guidance and assistance. This working paper is part of a series by the International Institute for Sustainable Development (IISD) and partners under the Unlocking Inclusive Policy Making for Clean Energy Transition project.

The authors would like to express their gratitude to the individuals and institutions who contributed to this project at different stages. This includes colleagues involved in data collection (including Saumya Jain, Policy Analyst, IISD), project design, analysis, and outreach and experts from various organizations who provided their peer review inputs for the report.

The authors would also like to thank various organizations for facilitating the data collection process with end-consumers across their respective states: Punjab Agricultural University (Punjab), People's Education and Development Organization (Rajasthan), the Pan Himalayan Grassroots Development Foundation (Uttarakhand), Asar Social Impact Advisors and Cornerstone Knowledge Builders (Delhi), and Hasiru Dala (Bengaluru, Karnataka).

Finally, the authors especially thank the following peer reviewers for their expert insights:

- Sita Ram Meena, Ministry of New and Renewable Energy
- Mukesh Bisane, Ministry of New and Renewable Energy
- Purva Jain, Institute for Energy Economics and Financial Analysis
- Debajit Palit, Chintan Research Foundation
- Suman Sharma, Sistema.bio
- Sarbjit Singh Soodh, Punjab Agricultural University

The views expressed in this working paper do not necessarily reflect those of funders or reviewers.



## Executive Summary

Over 2 billion people, primarily in South Asia and sub-Saharan Africa, depend on traditional fuels such as firewood, dung cakes, and crop residues for cooking. These fuels cause severe indoor and outdoor air pollution, leading to major health issues, particularly among women and children. As per recent national sample survey data, 37% of Indian households still rely primarily on solid polluting fuels to meet their cooking energy needs (7% in urban areas and 51% in rural areas). Clean cooking, meaning cooking that uses alternatives to traditional solid fuels, is thus a development priority.

Yet, for many emerging economies like India, clean cooking has become nearly synonymous with liquefied petroleum gas (LPG) subsidies. Initiatives such as Pradhan Mantri Ujjwala Yojana (PMUY) and the Direct Benefit Transfer for LPG (DBTL) have increased access to clean cooking fuels such as LPG. India's annual LPG consumption doubled between 2011/12 and 2024/25, rising from ~15 MMT to ~31 MMT. More than 93% of the increase in LPG consumption during this period was met through an increase in imports.

While LPG has expanded access to cleaner cooking for millions of households, it remains a fossil fuel with fiscal and energy security drawbacks. Continuing to scale LPG as the default solution risks locking India into a carbon- and import-intensive pathway that is not aligned with its net-zero ambitions. Reliance on imported fossil fuels also raises a number of other concerns owing to volatile international LPG prices. Increased access to LPG for households also represents a significant subsidy outlay every year for the government.

To align with its net-zero commitments, India could unlock a menu of scalable, non-fossil fuel clean alternatives that have the potential to reduce recurring costs for households and the public exchequer.

## Report Objectives

This report supports a shift to non-fossil clean cooking fuels in India by proposing a twin-track strategy: scale biogas for rural areas and electric cooking (e-cooking) for urban and peri-urban households. An analysis of the potential of these pathways, grounded in fieldwork across three Indian states, demonstrates that decentralized non-fossil alternatives can be viable, desirable, and cost-effective for households if supported with the right institutional and financial mechanisms.

The analysis draws on fieldwork in the states of Punjab, Rajasthan, and Uttarakhand (biogas), and in the cities of Bengaluru and Delhi (e-cooking), including household surveys and focus group discussions with current and former users of LPG, biogas, and e-cooking technologies.

The study also employed two Excel-based analytical models to examine the cost dynamics of different clean cooking fuels. The first model compares biogas and LPG for rural households by assessing the upfront and recurring costs of biogas against the recurring costs of LPG, assuming that LPG is already widely available with most Indian households. The second model focuses on urban contexts, comparing the recurring costs of LPG, piped natural gas (PNG), and e-cooking.



Although no PNG users were captured in our fieldwork, its growing urban penetration makes this comparison important from both consumer and policy perspectives.

In addition to this cost analysis, the report focuses on identifying enabling factors for adoption, barriers to sustained usage, and emerging opportunities for policy action.

## Key Findings: Biogas

Biogas is produced from organic waste: agricultural residues, animal manure, food waste, and municipal waste. It provides renewable household energy and generates bio-slurry, a valuable organic fertilizer that can improve soil health and reduce dependence on chemical fertilizers.

Despite favorable conditions in India, such as a strong agricultural base, a large livestock population, and government subsidies, biogas adoption remains minimal: only 0.3% of households (0.4% in rural areas) use it as their primary cooking fuel. Issues relate to poor operations and maintenance (O&M), inconsistent feedstock supply, high installation costs for low-income households, and a number of social and behavioral barriers, including low awareness and cultural resistance to adopting new methods.

The following main findings on biogas emerged from the fieldwork:

1. **User satisfaction with biogas for cooking is high.** Respondents reported minimal maintenance challenges and found biogas to be as efficient as LPG, with cooking time nearly identical.
2. **Robust decentralized O&M support enables the sustained usage of biogas plants.** Both prefabricated and civil-construction-based biogas models work well in the presence of regular on-the-ground O&M support.
3. **Prefabricated biogas models have advantages.** Civil construction models require 12 to 15 days for completion, and their durability depends heavily on masonry skills. Prefabricated models, manufactured off-site, need only one to two days for installation. Furthermore, prefabricated models are more compact and require less space and less maintenance.
4. **Prefabricated biogas plants may be better suited in regions with alpine climatic conditions.** There were some reports that prefabricated plants were less prone to decreased efficiency during winter and to leakage issues caused by heavy rains.
5. **There has been a sustained reduction (70%) in firewood usage.** Many households reported that, when they transitioned to biogas, they reduced firewood usage in a sustained manner, primarily because there is a lack of recurring expenditure associated with biogas (unlike LPG).
6. **Biogas plants present high upfront costs for some households.** Although the government provides a 40% subsidy on the upfront cost of a biogas plant, the remaining cost of ~INR 24,000 (USD 273) is still unaffordable for most rural households. During our fieldwork, a few households highlighted that they had wanted to switch to biogas much earlier, because of its lack of recurring costs (as seen with LPG), but they could not afford it without additional funding support.



## Policy Recommendations

**Increase financial support to biogas plants** through a range of measures, such as providing subsidies targeted to low-income rural households to make biogas more affordable; revisiting subsidy disbursement mechanisms to avoid subjecting beneficiaries to financial strain; leveraging corporate social responsibility funds and carbon credits; and providing support to community financing models linked with self-help groups to mobilize affordable capital.

**Expand and diversify biogas technology options**, including by promoting the manufacturing of larger prefabricated plants (3 to 6 m<sup>3</sup>) suited for households with higher cooking needs. Incentivize the creation of decentralized local manufacturing units in regions with a higher share of rural population and agricultural and livestock activity to address production and servicing challenges. Building training centres (even for prefabricated biogas plants) can also help boost local capacity to educate users on proper O&M practices.

**Conduct targeted awareness campaigns** highlighting the long-term cost-effectiveness and environmental benefits of biogas, through the state nodal agencies, which are responsible for biogas promotion in the Indian states. These campaigns could also involve hands-on training programs to educate users on proper O&M practices, which is essential to ensuring the longevity of biogas plants.

**Support year-round performance improvements:** Encourage low-cost, context-specific technical solutions, such as insulation or simple thermal management practices, to maintain consistent gas production across different seasons.

## Key Findings: E-Cooking

E-cooking involves cooking with devices such as double-plated induction stoves or infrared-based induction devices. The adoption of e-cooking devices is markedly higher in urban areas than rural regions. The International Energy Agency (2023) projects that e-cooking will meet approximately three-quarters of overall cooking energy needs by 2050 in emerging markets and developing economies. E-cooking is expected to be initially concentrated in urban areas, as many households in metro cities (meaning cities with populations above 1 million and advanced infrastructure), such as Delhi and Bengaluru, have adopted e-cooking devices. It is expected to gradually spread to rural households as infrastructure improves.

In order to promote e-cooking, the government launched the Go Electric campaign in 2021 to raise mass awareness around electricity-based cooking. Additionally, Energy Efficiency Services Limited launched the National Efficient Cooking Programme in November 2023 to support the deployment of induction cookstoves to encourage large-scale adoption.

The following main findings on e-cooking emerged from the fieldwork:

1. **High upfront costs:** Devices have high upfront costs and are prohibitively expensive for many low-income households, which discourages widespread adoption, even in urban areas.
2. **Power supply challenges:** Urban areas have seen significant improvements in the quality (voltage stability) and reliability (fewer power cuts) of the electricity supply,



making e-cooking more feasible. In rural areas, an unreliable and poor-quality electricity supply remains a major barrier.

3. **Less versatility of devices:** Some households reported that e-cooking devices were less versatile than traditional LPG stoves, particularly for cooking certain food items. Therefore, they often use e-cooking devices only for backup.
4. **O&M challenges:** Households also reported inadequate repair and maintenance services for post-warranty devices.
5. **Limited access to subsidized electricity for low-income urban households:** One of the primary challenges facing low-income urban households is their exclusion from electricity subsidies owing to a lack of formal electricity connections.
6. **Awareness and infrastructure issues:** Uptake is limited by lack of awareness, safety concerns, and inadequate in-home wiring.

We performed a cost comparison between cooking on LPG, PNG, and electricity, and we found that e-cooking is already cheaper for most Indian households in terms of operational expenditure. At current prices—INR 853 per LPG refill (14.2 kg), INR 50/SCM PNG, and INR 6/kWh electricity—a non-PMUY household spends about INR 6,800 to INR 6,900 a year on LPG or PNG for exclusive cooking, versus INR 5,800 to INR 5,900 a year with e-cooking, making e-cooking already cheaper on operating costs. E-cooking remains cost-competitive up to INR 7/kWh; if LPG is priced at its market level (INR 1,110 per refill, hypothetically), it stays cheaper even at INR 9.1/kWh—well above the average cost of supply for most distribution companies (discoms).

---

**E-cooking is already cheaper for most Indian households in terms of operational expenditure.**

---

We also ran a modelling process to identify the long-term financial benefits of e-cooking adoption in urban India, particularly in terms of subsidy savings. We find that aggressively scaling e-cooking in urban areas could halve LPG demand, cutting imports immediately. Under a high-growth scenario, the impact until 2030 remains moderate, but continuously scaling e-cooking could deliver savings -up to INR 2.4 trillion by 2050, which would ease the government's fiscal burden. These savings could be diminished if electricity subsidies are not rationalized as e-cooking is scaled up.

## Policy Recommendations

1. **Address affordability constraints through research and development (R&D) and targeted financial incentives.** R&D support currently needs to be targeted to develop affordable, energy-efficient electric cookstoves—including double-plated induction and flame-replicating models—that align with Indian cooking needs.
2. **Target subsidized electricity for low-income informal urban households** by revisiting current metering practices. This would remove a major affordability barrier and help integrate e-cooking into routine use for low-income households.



3. **Improve O&M infrastructure** via the establishment of decentralized after-sale service centres to provide post-warranty repairs, reduce the risk of early device disposal, and build trust in cooking technologies.
4. **Improve familiarity with e-cooking in communities to enable its transition from backup to primary cooking option.** Community-led demonstrations can raise awareness on how to use electric cookstoves in alignment with Indian cooking habits, highlight their benefits, and dispel misconceptions about e-cooking performance and safety.
5. **Position e-cooking as a climate, subsidy, and energy security solution.** Urban e-cooking adoption could reduce LPG demand by up to 50% by 2050, translating to substantial import savings and fiscal relief for the government from LPG subsidies. Integrating e-cooking into India's net-zero, clean energy, and gender strategies can unlock greater policy visibility and funding support for non-fossil fuel clean cooking.
6. **Redirect potential LPG subsidy savings from e-cooking adoption to support e-cooking consumption among poorer households** within urban India. Discoms are in a position to identify poorer households based on their electricity consumption profiles.

## Next Steps

India has expanded access to clean cooking through LPG and PNG, but these fossil fuel-based pathways are not aligned with the net-zero commitments. India currently does not have an actionable non-fossil-fuel clean cooking roadmap. However, non-fossil fuel cooking is not only feasible, it is essential for a net-zero, fiscally sound, and health-positive future. In this context, there is a need to diversify towards e-cooking and decentralized biogas systems, which are better aligned with India's energy security, climate, and development goals.

The proposed transition strategy is as follows:

- **Urban areas:** Promote e-cooking, leveraging improved power reliability; and address affordability concerns among low-income households through targeted financial incentives.
- **Rural areas:** Deploy decentralized biogas systems using local organic waste and make biogas more affordable for low-income rural households by channelling a small share of LPG subsidies that currently bypass these households toward increasing support for biogas.

Such a transition can reduce fossil fuel imports, lower subsidy burdens, and improve sustainability.

While this report provides directional evidence on the viability of non-fossil fuel solutions, the sample size is too small to draw broad generalizations. Policy-makers and researchers should treat these insights as hypotheses for larger-scale testing and to help in the design of robust state-level clean cooking roadmaps that diversify away from LPG.



# Table of Contents

<b>1.0 Introduction</b> .....	<b>1</b>
<b>2.0 Methodology</b> .....	<b>3</b>
2.1 Biogas Methodology .....	3
2.2 Electric Cooking Methodology .....	4
<b>3.0 Context</b> .....	<b>6</b>
3.1 The Current Cooking Fuel Mix in India.....	6
3.2 Challenges in the Use of LPG and PNG .....	8
3.3 Biogas as an Alternative.....	11
3.4 Electric Cooking as an Alternative.....	14
3.5 Policy Gaps in the Promotion of Clean Cooking Alternatives .....	15
<b>4.0 Biogas Findings</b> .....	<b>16</b>
4.1 Key Findings of the Fieldwork.....	16
4.2 Factors Encouraging Biogas Adoption.....	17
4.3 Challenges Associated With Biogas.....	19
4.4 Policy Recommendations .....	20
<b>5.0 Electric Cooking Findings</b> .....	<b>24</b>
5.1 Key Findings of the Fieldwork.....	24
5.2 Cost Comparison of E-Cooking, LPG, and PNG for Indian Households.....	25
5.3 Estimated LPG Subsidy Savings From a Transition to E-Cooking .....	26
5.4 Policy Recommendations .....	32
<b>6.0 Conclusion</b> .....	<b>33</b>
<b>References</b> .....	<b>35</b>
<b>Appendix A. Biogas vs. Liquefied Petroleum Gas Lifetime Cost Comparison Model</b> .....	<b>43</b>
<b>Appendix B. Liquefied Petroleum Gas Price Buildup Model</b> .....	<b>46</b>



## List of Figures

Figure 1. Clean cooking mix of Indian households, 2020.....	6
Figure 2. Clean cooking reliance among Indian households.....	8
Figure 3. LPG production and consumption in India.....	9
Figure 4. Domestic production and imports of natural gas in India.....	10
Figure 5. Schematic diagram of a household biogas system.....	12
Figure 6. Payback period for biogas plants vs. LPG at the different refill prices.....	18
Figure 7. Typical expenditure levels for LPG, PNG, and e-cooking in Indian households.....	25
Figure 8. E-cooking adoption scenarios from 2025 to 2050.....	28
Figure 9. Number of households in urban and rural India from 2025 to 2050.....	28
Figure 10. Annual LPG consumption (in number of refills) from 2025 to 2050.....	29
Figure 11. Projected annual LPG imports in different scenarios.....	29
Figure 12. Projected foreign exchange spent on importing LPG into India.....	30
Figure 13. Annual spending by the government on under-recovery on LPG.....	30
Figure 14. Cumulative savings in LPG subsidies from 2025 to 2050.....	31
Figure A1. Payback period comparison between LPG and biogas plant without any subsidy on the upfront cost of biogas plant).....	45

## List of Tables

Table 1. Biogas plants under study.....	16
Table A1. Price and subsidy assumptions for LPG and biogas.....	44
Table B1. Assumptions for LPG price buildup model for India (on April 8, 2025).....	46
Table B2. Using propane and butane prices to derive LPG prices for April 2025.....	47

## List of Boxes

Box 1. A brief history of biogas programs in India.....	13
---	----



## Abbreviations and Acronyms

<b>CGD</b>	city gas distribution
<b>CSR</b>	corporate social responsibility
<b>DBTL</b>	Direct Benefit Transfer for LPG
<b>e-cooking</b>	electric cooking
<b>FY</b>	fiscal year
<b>GOBARdhan</b>	Galvanizing Organic Bio-Agro Resources Dhan
<b>GST</b>	goods and services tax
<b>IEA</b>	International Energy Agency
<b>INR</b>	Indian rupee
<b>LPG</b>	liquefied petroleum gas
<b>MNRE</b>	Ministry of New and Renewable Energy
<b>MOHFW</b>	Ministry of Health and Family Welfare
<b>MoPNG</b>	Ministry of Petroleum and Natural Gas
<b>NBP</b>	National Bio Energy Programme
<b>NECP</b>	National Efficient Cooking Programme
<b>NFHS</b>	National Family Health Survey
<b>NGO</b>	non-governmental organization
<b>O&amp;M</b>	operations and maintenance
<b>OMC</b>	oil marketing companies
<b>PMUY</b>	Pradhan Mantri Ujjwala Yojana
<b>PNG</b>	piped natural gas
<b>PPAC</b>	Petroleum Planning and Analysis Cell
<b>R&amp;D</b>	research and development
<b>USD</b>	United States dollar



## 1.0 Introduction

Globally, over 2 billion people rely on polluting fuels such as firewood, dung cakes, and crop residues to meet their cooking energy needs. Most of these people reside in developing and underdeveloped regions, including South Asia and sub-Saharan Africa (Ritchie, 2021; World Health Organization, n.d.). These traditional fuels are affordable and easily available but have severe health and environmental consequences. The burning of solid fuels releases harmful pollutants such as particulate matter (PM<sub>2.5</sub>), carbon monoxide, and volatile organic compounds, causing indoor air pollution that disproportionately affects women and children, who spend the most time cooking. Transitioning to clean cooking alternatives, meaning those that do not use traditional fuels, is thus essential not only to protect individual and community health but also to reduce environmental degradation and advance progress on the UN's Sustainable Development Goals.

In recent years, India has made significant progress in expanding clean cooking energy access through initiatives such as Pradhan Mantri Ujjwala Yojana (PMUY) and the development of extensive city gas pipeline networks. These efforts have provided millions of households with clean, convenient, reliable, and efficient cooking fuels in the form of liquefied petroleum gas (LPG) and piped natural gas (PNG). However, relying on these imported fuels to meet India's clean cooking energy needs poses multiple challenges. These include heightened energy security risks, continued affordability issues for a majority of households, logistical barriers to doorstep delivery, and significant fiscal strain resulting from the provision of government subsidies (Jain, 2024).

LPG subsidies are the main strategy to promote clean cooking in India, as in many other developing and emerging countries around the world. The international LPG market is highly volatile, resulting in large fiscal subsidies when international prices are high, while retail prices are fixed at below-market prices to ensure affordability. However, even subsidized prices can be unaffordable for many consumers, particularly those in rural and regional areas, who also have ready access to biomass for cooking—which seems free but carries high costs in terms of collection time, health impacts, and environmental degradation.

While recent initiatives to blend compressed biogas and green hydrogen into PNG pipelines suggest a pathway to cleaner fuels, their large-scale integration faces technical, economic, and policy hurdles (Ministry of New and Renewable Energy [MNRE], 2023; Koonampilli, 2024; Petroleum and Natural Gas Regulatory Board, 2025a). For instance, India's compressed biogas sector has been struggling with supply–demand mismatches, permitting delays, and financing constraints, which limit the reliable volume of compressed biogas available for injection into pipelines (EAC International Consulting, 2023; United States Environmental Protection Agency, 2025).

Further, adapting the PNG pipelines for hydrogen blending could add another 10% to 15% to the overall capital cost of a new installation's investment, with compressor upgrades alone adding 6% to 11% (ICF Consulting, 2025; Ribeiro et al., 2025). These costs could escalate rapidly once hydrogen's share in the gas mix exceeds roughly 10% by volume, underscoring



the substantial financial and operational pressures on the current PNG infrastructure (National Energy Technology Laboratory, 2024).

Given these limitations, expanding PNG as a dominant clean cooking pathway risks locking India into high-cost, fossil fuel-dependent infrastructure. Both LPG and PNG, being fossil fuels, carry environmental and fiscal consequences that run counter to India's net-zero ambitions and increase its import dependence.

A more sustainable approach would be to diversify clean cooking strategies, meaning accelerating the adoption of electric cooking (e-cooking) and decentralized biogas systems powered by local renewable energy. Such solutions can reduce dependence on imports, enhance energy security, and contribute to a more sustainable and resilient energy future for India.

However, India does not have a government-endorsed, time-bound national roadmap that explicitly targets and prioritizes non-fossil fuel clean cooking alternatives that are better aligned with the country's economic and climate priorities. This represents a policy gap, especially as global trends and technologies are shifting towards electrification and renewable energy.

This study attempts to fill this gap by developing strategies for India to transition away from fossil fuel-based clean cooking solutions to alternative solutions such as e-cooking and biogas. E-cooking offers a viable alternative for urban households, especially given the significant improvements in India's power supply reliability in recent years.

For rural areas, biogas presents a decentralized and renewable alternative that leverages locally available organic waste, reducing dependence on imported LPG while addressing waste management challenges.

Transitioning to non-fossil fuel cooking can help reduce the economic burden associated with fossil fuel subsidies while improving energy security through reduced fuel imports. This report provides actionable strategies for policy-makers, including targeted incentives, capacity-building programs, and infrastructure investments, to drive the adoption of these clean cooking technologies across diverse socioeconomic contexts.



## 2.0 Methodology

This section details the methodologies used to assess the situation with regard to biogas and e-cooking.

While this study provides valuable insights, the sample size is limited and does not allow for broad generalizations across regions or populations. The findings should thus be interpreted as indicative rather than conclusive. We recommend that future research treat these insights as hypotheses and test them through larger, more representative studies to inform evidence-based policy design and implementation.

### 2.1 Biogas Methodology

The primary objective of this part of the study was to look at successfully operating biogas plants in three states and isolate factors for their success that are replicable in other states.

We identified three distinct and successful models of biogas promotion, implemented in the states of Punjab, Rajasthan, and Uttarakhand. In Punjab, the biogas plants are promoted and operated by Punjab Agricultural University in collaboration with the state nodal agency. In Rajasthan, the biogas plants are operated and promoted in Dungarpur district by the People's Education and Development Organization, a non-governmental organization (NGO) working in rural development since 1980. In Uttarakhand, the plants were installed and are operated and promoted by another NGO, commonly known as Grassroots, which is part of the Pan Himalayan Grassroots Development Foundation, founded in 1992.

Biogas models in these states were studied for differences in plant types (prefabricated or civil construction),<sup>1</sup> eligibility criteria,<sup>2</sup> financing options to support the upfront costs of plants, and operations and maintenance (O&M) for the smooth functioning of the plants.

#### 2.1.1 Data Collection and Stakeholder Engagement

The study employed a non-probability, purposive sampling strategy; it selected villages where the implementing organization had established operations and demonstrated a successful program model. This approach drew on networks of convenience, leveraging existing relationships and infrastructure to gain access to participants.

Fieldwork, including site visits, was conducted from April to June 2024 in each state: Punjab (Moga district), Rajasthan (Dungarpur district), and Uttarakhand (Almora and Nainital districts).

---

<sup>1</sup> Civil-construction-based biogas plants are built on-site (of end-use), using conventional materials such as brick and concrete. Prefabricated biogas plants are pre-assembled off-site in modular components and then transported to the end-use site. These plants allow for quicker installation.

<sup>2</sup> In Rajasthan, owning at least four cattle is a prerequisite for receiving a biogas plant; no such condition exists in Uttarakhand.



Interviews were conducted with ~75 rural households (25 in each state) using a semi-structured questionnaire, prioritizing women as interview subjects wherever possible, as they are often the primary users of cooking fuel. We captured their experiences, from installation to daily usage, to gain insights into the benefits and challenges of using biogas.

Interviews were also conducted with one implementing organization in each of these three states to better understand their strategies and operational frameworks: Punjab Agricultural University in Punjab, People's Education and Development Organization in Rajasthan, and the Pan Himalayan Grassroots Development Foundation in Uttarakhand. All interviews were held with the ground-level staff responsible for managing the system in their respective region. Interviews focused on the nature and frequency of complaints received as well as approaches to addressing them.

### 2.1.2 Excel-Based Model

A life-cycle cost analysis, using an Excel-based model, was designed to assess the economic viability of a household-scale biogas plant. We developed a payback period model that compared the lifetime cost of biogas use with the cost of using LPG cylinders across different user categories. This multifaceted approach allowed us to comprehensively analyze the effectiveness of these models and derive actionable insights for promoting biogas adoption. For more details on the model please refer to Appendix A.

## 2.2 Electric Cooking Methodology

The primary objective of our field study on e-cooking was to understand household perceptions and usage patterns to inform policy recommendations aimed at increasing its adoption.

### 2.2.1 Data Collection and Stakeholder Engagement

We conducted interviews with a total of 100 households in rural and urban settings, of which 25 were urban households in Bengaluru and Delhi and the remaining 75 were from the biogas sample across three states.

#### Urban Households

- **General urban households:** Based on network-based convenience sampling, we engaged with 10 households residing in rented apartments and housing societies in the metro city of Bengaluru, in Karnataka state. Their monthly income was in the range of INR 30,000 to INR 50,000. These households are the within the top 20% but below the top 10% (Azim Premji University, 2025). These were primarily LPG-using households, but all of them had some experience with e-cooking; half actively used it regularly.
- **Urban low-income households:** Sampling was purposive, based on partnerships with local NGOs. In Delhi, we worked with Asar Social Impact Advisors and Cornerstone Knowledge Builders, which support the ragpicker community in Madanpur Khadar, a peri-urban slum region in southeast Delhi, and in Bengaluru



with Hasiru Dala, a social impact organization working with the waste-picker community. We interviewed 15 households (eight in Delhi and seven in Bangalore).

### Rural Households (Biogas Users)

For the e-cooking part of the study, we interviewed the same 75 biogas-using rural households interviewed for the biogas part of the study, 25 each in Punjab, Rajasthan, and Uttarakhand. We interviewed biogas-using households, as no households were active users of e-cooking. Their monthly income ranged between INR 8,334 and INR 12,500, placing them in the bottom 40% of the population (Azim Premji University, 2025).

Both urban and rural households were interviewed using a semi-structured questionnaire customized to their experience of using e-cooking.

- **Urban households:** Since some households were using e-cooking, questions explored experiences with e-cooking, frequency of use, and potential challenges or enablers.
- **Rural households:** Since none of these households were actively using e-cooking, questions focused primarily on perceptions about e-cooking, the barriers to its adoption, and potential factors that could drive these households' transition to e-cooking in the future.

### 2.2.2 Excel-Based Model

We built another Excel-based model to estimate the potential savings in future LPG subsidies if Indian households were to start shifting to e-cooking. We use this model also to understand the potential impact of a small increase in e-cooking adoption over time, only in urban India, on LPG subsidy expenditures, LPG demand, and foreign exchange in the long run. This model does not account for the electricity subsidies currently offered to households in India that would counteract the LPG subsidy savings.

To estimate the actual retail cost of a 14.2-kg domestic LPG cylinder in India, the report uses an LPG price build-up model that incorporates a range of cost components across the LPG supply chain. These include the international benchmark price (the base price set by the Saudi Aramco oil company for LPG plus ocean freight, import-related charges, bottling and distribution costs, commissions, taxes, and estimated margins). Where applicable, historical values from official and publicly available sources are adjusted or held constant based on data availability. Daily exchange rates are applied to convert international prices to INR. Specifically, the model helps quantify the potential gap between retail prices and the true cost of supplying LPG in order to offer insight into whether the central government's reported subsidies are sufficient to fill the gap.

In doing this, the model also sheds light on the hidden fiscal pressures on public-sector oil marketing companies (OMCs). It estimates potential deficits or margins for OMCs over time, based on difference between retail prices and cumulative cost inputs. For a full breakdown of all variables and data assumptions used in the model, please refer to Appendix B.

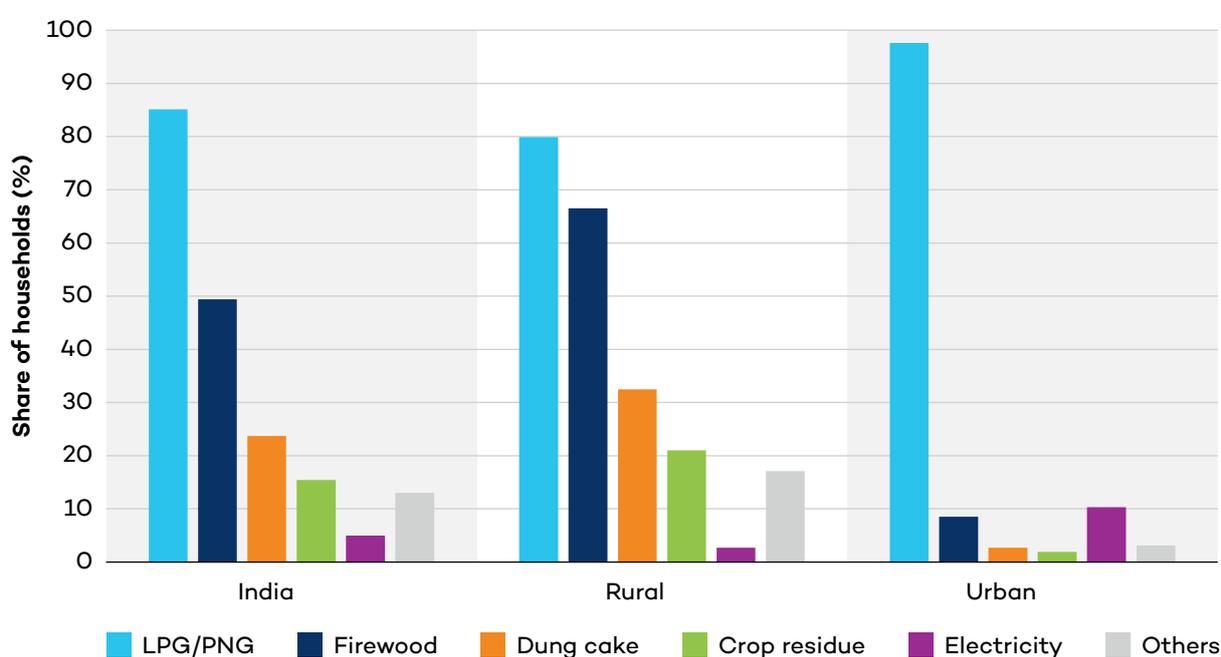


## 3.0 Context

### 3.1 The Current Cooking Fuel Mix in India

India's clean cooking mix includes LPG, PNG, biogas, improved cookstoves, and electricity-based cooking solutions such as induction, electric pressure cookers, and electric coil stoves. However, LPG has become India's mainstay clean cooking fuel (Mani et al., 2020). As per the India Residential Energy Survey 2020, six out of every seven Indian households owned an LPG connection in that year (Figure 1).

**Figure 1.** Clean cooking mix of Indian households, 2020



Note: Percentages in this figure do not add up to 100, as many households used a mix of clean cooking methods. Out of 85.1% Indian households owning LPG/PNG connections in the figure, only 0.4% had a PNG connection in 2020.

Source: Mani et al., 2020.

India supports LPG consumption and access through the Direct Benefit Transfer for LPG (DBTL) and PMUY. These schemes aim to help low-income households shift from traditional solid fuels, to reduce the indoor air pollution that disproportionately affects women and young children.

The DBTL consumption subsidy scheme was launched in 2014 to curb illegal consumption and prevent the misuse of subsidized LPG. Under the scheme, consumers pay the market price for LPG upfront and the government later transfers the subsidy amount directly to their bank accounts. Subsidized LPG is available in 14.2 kg and 5 kg cylinders, distributed through three national OMCs. To access these benefits, households must register with the OMC serving their area and provide a valid form of personal identification.



PMUY, another subsidy scheme, launched in 2016, provides a connection subsidy of INR 1,600 per connection to low-income households (Ministry of Information and Broadcasting, n.d.). This subsidy covers the initial costs of acquiring an LPG connection, including the first cylinder, an LPG stove, and necessary equipment (Sharma et al., 2019; Patnaik et al., 2020). The scheme aims to reduce financial barriers that prevent low-income households from adopting LPG, thereby promoting a transition away from biomass-based cooking toward cleaner, modern fuels. In August 2025, the scheme also extended into a consumption subsidy scheme giving INR 300 per cylinder to beneficiaries (Press Information Bureau, 2025).

Since its launch, PMUY has connected more than 100 million households to LPG and made LPG the mainstay clean cooking fuel for India: 99% of households have access to LPG, though they may all not be consuming it (Mani et al., 2020; Ministry of Petroleum and Natural Gas [MoPNG], 2024a). LPG connections in India doubled from 166 million in 2016 (the year of the launch of PMUY) to ~331 million as of July 2025 (MoPNG, 2025a). India's LPG subsidies also fluctuated considerably within this period, from ~INR 23,000 crore in fiscal year (FY) 2016/17 to a high of ~INR 58,000 crore in FY 2022/23, reflecting both volatile international LPG prices and evolving subsidy delivery mechanisms (Raizada et al., 2024).<sup>3</sup>

Apart from LPG, India has also been rapidly advancing the adoption of PNG through its city gas distribution (CGD) network, which now covers 307 geographical areas in all districts of the country (MoPNG, 2025b; Petroleum and Natural Gas Regulatory Board, 2025b). This expansion marks a significant increase in infrastructure and access, as PNG is now supplied not just in large metropolitan centres but also in numerous tier-2 and tier-3 cities (Nair, 2025).<sup>4</sup> The number of domestic PNG connections has increased by 67% in the past 3 years, from 9.3 million in March 2022 to more than 15.5 million as of July 31, 2025 (Lal, 2022; Petroleum Planning and Analysis Cell [PPAC], 2025a; Sehbag & Kuhrana, 2025). Such rapid expansion means that almost all Indian households now have access to a clean cooking solution in the form of either LPG or PNG, which is a significant improvement compared with 62% in April 2016 (MoPNG, 2024b).

While domestic PNG consumers currently do not receive targeted consumption subsidies as LPG users do, the rapid expansion of PNG networks has been facilitated by significant policy support and government capital grants (such as viability gap funding) that subsidize pipeline infrastructure (Cabinet Committee on Economic Affairs, 2020; Indradhanush Gas Grid Limited, 2023; Kaushik, 2025). This support lowers the delivery cost for CGD companies, making it possible to serve more households, including in less commercially attractive areas. In addition, the regulated ceiling on domestic gas prices effectively acts as an implicit subsidy for consumers, helping CGD firms maintain stable and competitive end-user prices (PPAC,

---

<sup>3</sup> These subsidy estimates include both direct subsidies (subsidizing LPG consumption for PMUY consumers through the DBTL and promoting LPG adoption through PMUY connection subsidies) and indirect subsidies (keeping LPG market prices below actual cost and compensating OMCs for the under-recovery and goods and services tax concessions and custom duty exemptions on LPG).

<sup>4</sup> In India, cities are classified in a population-based tier system. For instance, a metropolitan (or a metro) city is a city with a typical population above 1 million and an advanced infrastructure. Similarly, tier-2 cities are typically those with populations of 50,000 to 99,999, and tier-3 cities are home to 20,000 to 49,999 people. However, it is also important to highlight that these ranges are indicative and may not always be applied strictly across contexts.



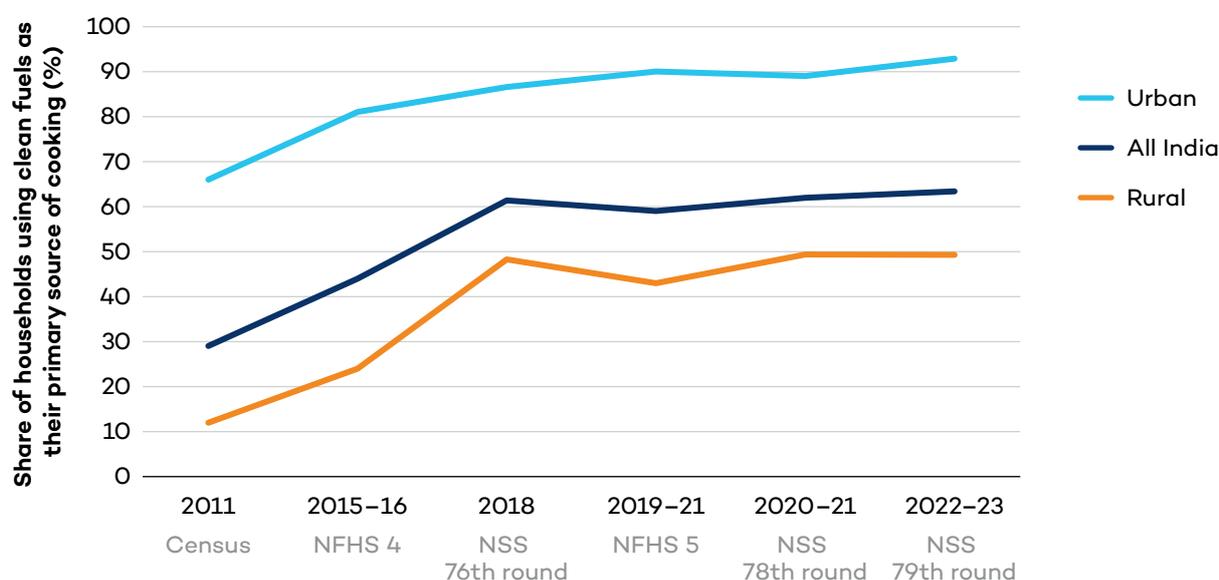
2025a; *Times of India*, 2025). The domestic gas allocation policy further reinforces this support by giving priority access to the CGD sector (PNG and compressed natural gas), ensuring that it receives a preferential share of the cheapest domestic natural gas supply (International Energy Agency [IEA], 2025; Press Trust of India, 2025). Together, these layered forms of support reduce overall delivery costs for CGD firms.

## 3.2 Challenges in the Use of LPG and PNG

### 3.2.1 Affordability

Although the dual approach of promoting LPG and PNG has led to significant benefits in the past few years, there are still considerable gaps in ensuring the exclusive use of clean cooking fuels. As per the 79th round of the National Sample Survey (2022–2023) (National Sample Survey Office, 2024), 37% of Indian households still rely primarily on solid polluting fuels to meet their cooking energy needs (Figure 2). This is highlighted in the fact that, while the number of domestic LPG connections in India doubled between 2015/16 and 2023/24, annual domestic LPG consumption grew by only 48%, from 17.2 MMT to 25.5 MMT (PPAC, 2024a).

**Figure 2.** Clean cooking reliance among Indian households



Note: NFHS = National Family Health Survey.

Source: Authors' compilation based on National Statistical Office, 2019; National Sample Survey Office, 2023, 2024; Ministry of Health and Family Welfare (MOHFW), 2022; the 2011 Census of India (Office of the Registrar General & Census Commissioner, India, 2011); and the National Family Health Survey (NFHS-4) (MOHFW, 2017).

Similarly, domestic annual PNG consumption grew by only 11% in the 2-year period between March 2022 and March 2024 (from 959 MMSCM to 1,068 MMSCM), when the PNG connection count went up by 40% (PPAC, 2024b). This disconnect—between the rapid

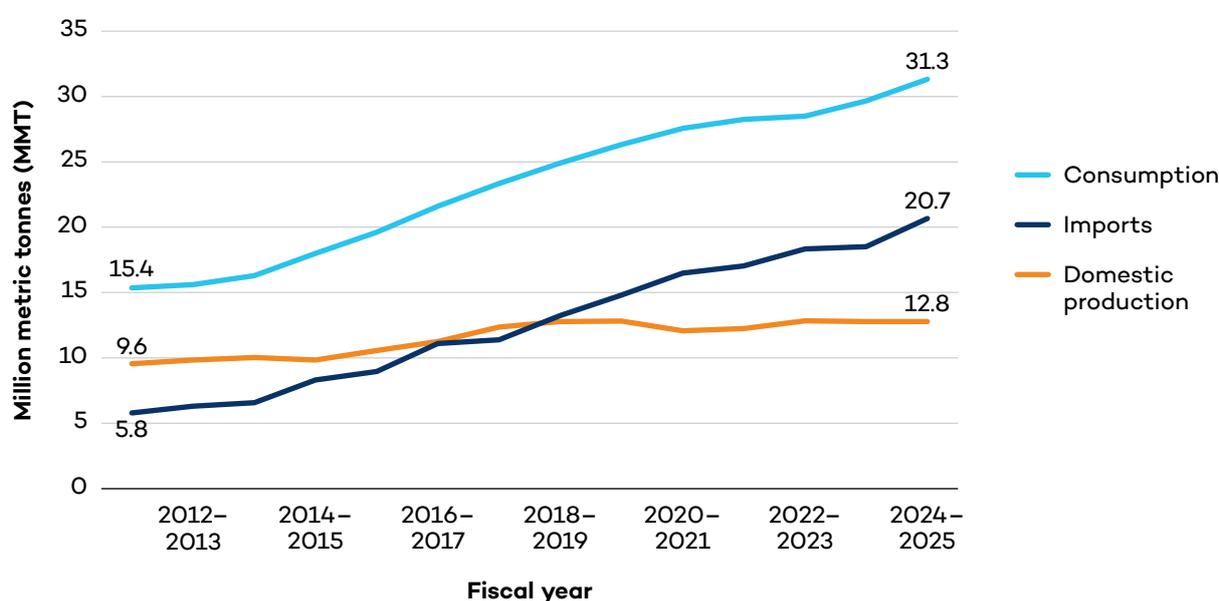


increase in LPG and PNG connections and slow growth in the consumption of these fuels—underscores the persistent affordability barriers many households face, particularly in low-income and rural areas.

### 3.2.2 Risks of Staying Locked into PNG and LPG

India's annual LPG consumption doubled between 2011/12 and 2024/25, rising from ~15 MMT to ~31 MMT (Powell et al., 2023). However, more than 93% of the increase in LPG consumption during this period was met through an increase in imports, which rose from ~6 MMT in 2011–12 to ~21 MMT in 2024–25 (Figure 3).

**Figure 3.** LPG production and consumption in India



Source: Authors' compilation based on PPAC, 2025a.

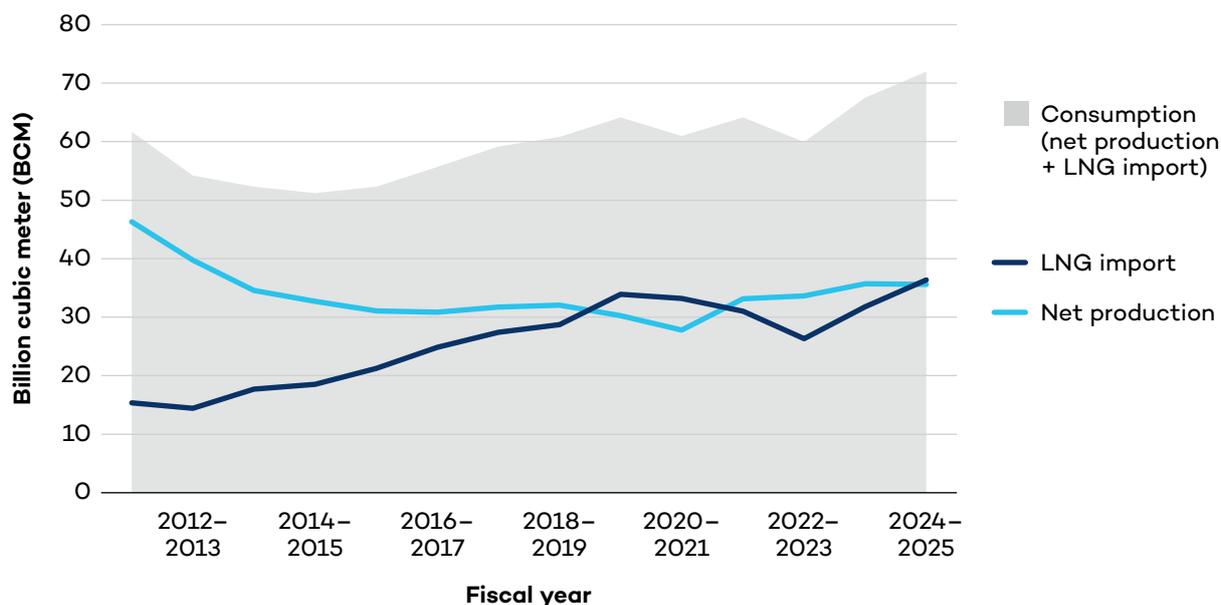
Note: Total LPG consumption does not match imports plus domestic production, because it accounts for exports, changes in inventories and non-energy use as petrochemical feedstock.

In contrast, natural gas consumption and its reliance on imports have grown at a more modest rate in recent years (Figure 4). Nevertheless, India will likely require a substantial increase in natural gas imports to meet the projected target of expanding domestic PNG connections to 120 million households by 2030—an eightfold increase (Petroleum and Natural Gas Regulatory Board, 2025c).

Such a significant increase in India's reliance on imported fuels to meet growing demand increases the country's exposure to multiple economic, energy, and environmental risks. Beyond this, the environmental implications of expanding clean cooking energy access using LPG and PNG—both fossil fuels—are at odds with India's net-zero commitments. To sustain progress in clean cooking while reducing exposure to these vulnerabilities, India will need to diversify its energy mix by promoting alternatives such as e-cooking and biogas.



**Figure 4.** Domestic production and imports of natural gas in India



Source: Authors' compilation based on PPAC, 2016, 2021, 2025c.

The following key risks are associated with the continued expansion of LPG and PNG for clean cooking:

### 1. Increasing energy security risk

The stagnation of domestic production of LPG and natural gas over the past several years (shown in Figures 3 and 4) suggests that India will continue to rely heavily on imports to meet the growing demand. This increasing dependence on imports poses substantial energy security risks, as it exposes the country to volatile exchange rates and potential disruptions in global supply chains.

### 2. Increasing unaffordability for households, leading to reduced sustained use

The rise in global oil and gas prices after the COVID-19 pandemic led to a significant increase in domestic LPG and PNG prices. This heightened the vulnerability of low-income households and will continue to adversely impact the sustained use of clean cooking solutions.

### 3. Limited doorstep availability of LPG and uneven access

Around half of LPG-using households in rural India still do not have home delivery of LPG (Mani et al., 2020). This increases the direct and indirect costs of procuring refills for households that are already struggling with high LPG refill prices in India. Replacing empty cylinders also represents a cost and time burden for households. Although PNG provides convenience and eliminates delivery challenges, it will remain concentrated in urban and peri-urban networks, leaving most rural regions still dependent on solid biomass or poorly available LPG refills (Koshy, 2019).



#### 4. A significant subsidy outlay every year for the government

The Government of India continues to bear a significant fiscal burden—estimated at ~INR 40,000 crore annually—to sustain the affordability of LPG. This includes the DBTL, as well as periodic compensation to OMCs for under-recoveries incurred when the market price of LPG refills for domestic consumers is kept artificially lower than the real global market price (international parity). For example, the Union Cabinet approved a one-time grant of INR 22,000 crore in October 2022 to offset LPG losses between June 2020 and June 2022, followed by an additional INR 30,000 crore in compensation in August 2025 amid persistently high international LPG prices.

However, with crude oil prices softening and a domestic increase of INR 50 per refill in April 2025, OMCs are expected to reduce their LPG under-recoveries in FY 2025/26 (NewsGram, 2025). Yet, given the inherent volatility of international LPG markets, future subsidy requirements will remain highly uncertain. This underscores the need for diversified, non-fossil fuel clean cooking alternatives to reduce long-term fiscal exposure.

In addition, the government bears **indirect fiscal costs**, including revenue foregone from lower goods and services tax on LPG at 5%, compared to 18% for most other fossil fuels, such as coal.

#### 5. Risk of stranded assets in PNG infrastructure owing to climate action

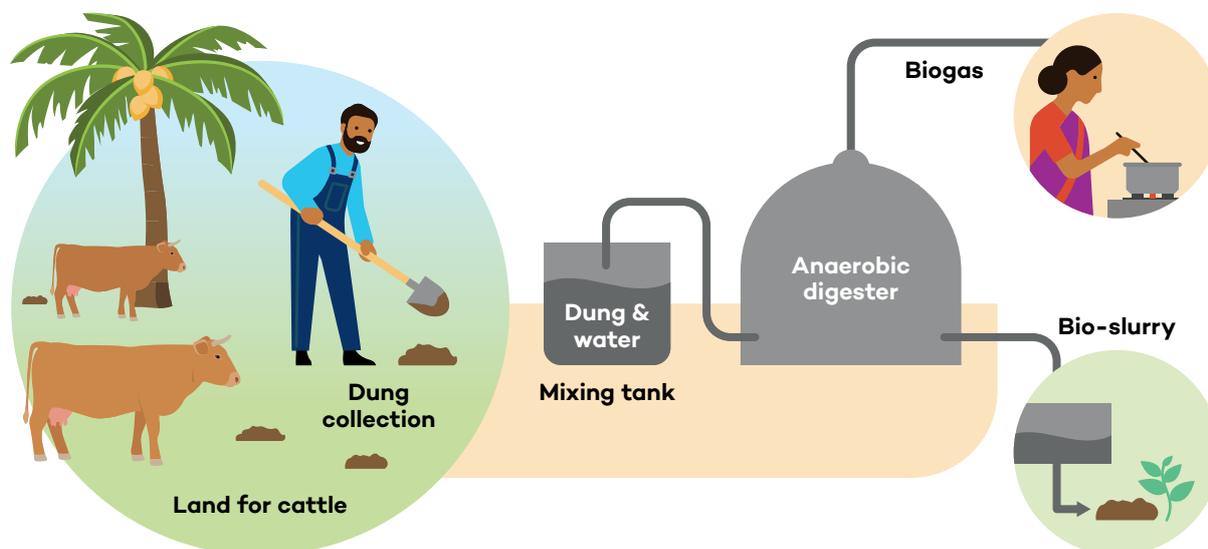
The high infrastructure costs associated with PNG expansion pose a significant challenge. If there is a universal shift towards electrification and renewable energy—which is increasingly likely in the global effort to achieve net-zero emissions—this could lead to stranded assets and render the significant investments in PNG infrastructure potentially unviable and unsustainable in the long run (Hamidi & New, 2021; IEA, 2021). Some forward-looking jurisdictions, such as New York City and the state of California (the United States), Montreal (Canada), and parts of the European Union (e.g., Denmark and the Netherlands), are already banning natural gas infrastructure in new residential developments in favour of electricity (see Logan, 2023; IEA, 2024; Hu, 2025; Energy in Buildings and Industry, n.d.; Louw, n.d.). This risk highlights the need for careful energy planning that balances short-term energy security with long-term climate goals.

### 3.3 Biogas as an Alternative

Biogas, produced from organic waste such as agricultural residues, animal manure, food waste, and even municipal solid waste, is an important non-fossil fuel clean cooking alternative, especially for rural India. Beyond providing a renewable source of household energy, biogas production also yields bio-slurry, a nutrient-rich byproduct that can be used as organic fertilizer, thereby reducing dependence on chemical fertilizers and improving soil health.



**Figure 5.** Schematic diagram of a household biogas system



Note: In a typical household-level biogas system, organic feedstock (mainly cattle dung and crop residues) is mixed with water and fed into an anaerobic digester, where it decomposes in the absence of oxygen to produce biogas (a mixture of methane and carbon dioxide). This gas can be directly used for cooking, heating, or electricity generation, while the residual slurry that exits the digester serves as an organic fertilizer (bio-slurry), reducing dependence on chemical fertilizers. On average, one adult cow produces about 12 to 15 kg of dung per day. Maintaining a 2-m<sup>3</sup> biogas plant typically requires three to four cattle and about 25 to 30 m<sup>2</sup> of additional space for the digester and slurry pit, making it feasible only for rural households with livestock.

Source: Authors.

Figure 5 presents a schematic diagram of a typical household-level biogas system. For rural India, where agriculture is still the dominant sector, leveraging biogas for clean cooking offers multiple co-benefits: it enhances rural energy access, improves waste management, and supports sustainable farming practices through the circular use of organic resources. Box 1 summarizes the historical evolution of India's biogas programs, which have laid the foundation for these opportunities.



### Box 1. A brief history of biogas programs in India

During the 1970s, India began experiencing significant challenges with energy supply, particularly in rural areas, where the main fuels used for cooking were firewood, agricultural residues, and animal dung. The health and environmental impacts of these traditional fuels was becoming increasingly clear, and biogas was seen as a promising alternative.

The first major government initiative on biogas came with the National Project on Biogas Development, launched in 1981 by the Ministry of Non-Conventional Energy Sources (now part of the MNRE). The project focused on the promotion of household biogas plants, primarily in rural areas where there was easy access to organic waste such as animal dung (Planning Commission, 2002).

By the 1990s, the Government of India had begun to recognize biogas not just as an energy source but also as a key component of sustainable rural development and sanitation, primarily because of its ability to also provide organic fertilizer (bio-slurry), which contributes to agricultural productivity and improved soil health. Therefore, in 2003–2004, the government renamed the National Project on Biogas Development to the National Biogas and Manure Management Programme, which focused on expanding biogas coverage for both domestic and community use. The program started providing financial assistance and technical support to help rural communities set up biogas units.

The Government of India continued to undertake such initiatives (including setting up biogas development and training centres) to promote the uptake of biogas plants in rural India. The Galvanizing Organic Bio-Agro Resources Dhan (GOBARdhan) scheme, launched in 2018, and the National Bio Energy Programme (NBP), launched in 2022, which allocates ~INR 184 crore for setting up of biogas plants, are prime examples (MNRE, 2025).<sup>5</sup>

Despite decades of government efforts, however, including significant subsidies, as well as a robust agricultural economy, a large livestock population, and favourable environmental conditions, biogas adoption as a clean cooking solution has not been able to scale up in India. According to the National Family Health Survey (NFHS-5), (MOHFW, 2022), biogas serves as the primary cooking fuel for only 0.3% of Indian households (0.4% in rural areas) (MOHFW, 2022).

---

<sup>5</sup> MNRE launched the NBP on November 2, 2022. This initiative, spanning FY 2021/22 to FY 2025/26, focuses on promoting bioenergy solutions in two phases. The NBP groups support into different components, including a biogas component and a biomass component. Originally, under Phase I, a total budget of INR 858 crore was allocated, of which INR 100 crore was earmarked specifically for the Biogas Component. Based on a recent communication by MNRE, we have learned that, in May 2025, an additional ~INR 33.75 crore was reallocated from the biomass component of the NBP to the biogas component, to increase the support for small and medium biogas plants. Later, in September 2025, MNRE approved an additional supplementary budget for the NBP, raising the total allocation for Phase I to INR 998 crore and increasing the Biogas component allocation to approximately INR 183.75 crore (from INR 133.75 crore). These funds under the biogas component specifically support the establishment of small and medium biogas plants, ranging from 1 m<sup>3</sup> to 2,500 m<sup>3</sup> of biogas generation per day, which cater to cooking needs, power generation (3 kW to 250 kW), and thermal or cooling applications.



This limited success of household biogas plants can be attributed to a combination of technical, operational, and institutional factors. On the technical side, inadequate maintenance, improper operation, and inconsistent feedstock supply often reduce system efficiency and shorten plant lifespans. Economically, high upfront installation costs (market price ~INR 40,000 for a 2-m<sup>3</sup> plant), even after accounting for government support covering up to 40% of capital costs under the Central Financial Assistance scheme, remain prohibitive for many low-income households (Mittal et al., 2018). This challenge is compounded by the variability in biogas output, which affects the perceived cost-effectiveness of the technology.

At the same time, social and behavioral factors have also limited the large-scale adoption of biogas in India. For instance, many communities exhibit low awareness of biogas benefits, lack of trust in the technology, and cultural resistance rooted in traditional cooking practices (Boyd Williams et al., 2023).

Further, limited policy continuity and competition from subsidized fossil fuels such as LPG form a complex set of interlinked barriers that have constrained the scalability and sustained use of household biogas systems, despite their significant social and environmental potential (International Renewable Energy Agency, 2017).

### 3.4 Electric Cooking as an Alternative

The IEA Access for All scenarios projects that e-cooking will meet approximately three-quarters of overall cooking energy needs by 2050 in emerging market and developing economies (IEA, 2023).

Electricity-based cooking can involve a range of electric technologies and appliances, such as electric rice cookers and electric pressure cookers. In this report, e-cooking refers to cooking with devices such as induction stoves (including both single- or double-plated) or infrared-based induction devices more specifically because they are the centrepiece of a large government scheme, the National Efficient Cooking Programme (NECP). To promote and raise mass awareness about e-cooking, the national government launched the Go Electric campaign in 2021 (Cruze, 2021). This was followed by the launch of the NECP in November 2023 by Energy Efficiency Services Limited, a public sector undertaking joint venture company under the Ministry of Power (Ministry of Power, 2023).

The NECP is a demand aggregation initiative designed to promote energy-efficient e-cooking solutions, such as induction cookstoves, by leveraging bulk procurement to reduce costs. The program aims to make e-cooking more affordable and accessible, while also contributing to India's energy efficiency and clean cooking goals. NECP has a target of deploying 2 million induction cookstoves to households and public institutions, such as Anganwadis (government-funded children's day care centres) (Press Information Bureau, 2023). There is no official timeline for achieving this target, and the government has not conducted any official surveys either to track the progress on e-cooking adoption. In fact, even NFHS 5 tracks clean cooking fuels without isolating induction cookstoves (NFHS 5, 2021). States are using NECP to establish their own targets and deployments (Times News Network, 2025).



E-cooking is expected to be initially concentrated in urban areas and to gradually spread to rural households as infrastructure improves and costs decline. The adoption of e-cooking devices is markedly higher in urban areas than in rural regions. Independent research suggests that ~10% of urban and ~3% of rural households reported using an e-cooking device in 2020/21, not necessarily as the primary fuel. Common devices included induction cooktops and rice cookers (Agrawal et. al, 2021).

Shifting the cooking load onto the electrical power system will require distribution companies (discoms) to plan for changing power demands by pairing adoption with time-of-day or critical peak pricing signals, checking feeder capacity and in-house wiring, enforcing Bureau of Indian Standards safety standards, and using smart-meter data to manage evening peaks. Electricity regulatory agencies will also have to design electricity tariffs in a manner that higher-income households do not disproportionately benefit from electricity subsidies and instead ensure that any electricity subsidies for cooking are targeted to low-income households, among other things through volumetric targeting.

### 3.5 Policy Gaps in the Promotion of Clean Cooking Alternatives

In recognition of the need to promote clean cooking alternatives, the Government of India has already taken a number of steps, as sections 3.3 and 3.4 have shown. Cooking fuels such as LPG and natural gas are anticipated to persist, but with increasing integration of bio-derived alternatives such as biogas, bioLPG, and bioethanol. These fuels will be particularly relevant in regions where cultural preferences and logistical barriers make an exclusive shift to electricity challenging.

However, the country currently lacks comprehensive national or state-level plans with clear targets to promote non-fossil fuel clean cooking alternatives. Although many studies have explored the adoption of clean cooking technologies, there remains a significant gap in understanding of household perspectives, particularly regarding non-fossil fuel alternatives such as biogas and e-cooking. Existing research often emphasizes quantitative metrics such as adoption rates, but it lacks in-depth qualitative insights into user experiences, cultural preferences, and the daily challenges facing households that are transitioning to these technologies. For instance, a systematic review on the adoption of improved fuels and cookstoves highlights the factors that influence adoption but does not delve deeply into the nuanced household perspectives that drive these choices (Shankar et al., 2020).

This paucity of qualitative data hampers the development of effective policies tailored to the real-world experiences of end-users. Without a comprehensive understanding of household needs, behaviours, and sociocultural contexts, policy interventions may fail to address the barriers to the adoption of clean cooking solutions. Such insights are crucial for designing policies that not only promote the adoption of non-fossil fuel clean cooking alternatives but also ensure their sustained use and acceptance within diverse communities.



## 4.0 Biogas Findings

This study examined three distinct biogas plant models, located in Punjab, Rajasthan, and Uttarakhand (Table 1), and identified key factors in their successful operations.

**Table 1.** Biogas plants under study

State	Biogas plant model
Punjab	Civil-construction-based model
Rajasthan	Prefabricated biogas plants
Uttarakhand	Prefabricated biogas plants, with three households having used civil construction-based plants in the past

Note: All the models put a special emphasis on O&M and aftersales service.

Source: Authors.

### 4.1 Key Findings of the Fieldwork

1. **User satisfaction with biogas for cooking is high.** Across all three states, most users expressed satisfaction with biogas, regardless of whether the plant was civil-construction-based or prefabricated. Users reported minimal maintenance challenges and found biogas to be as efficient as LPG, with cooking time nearly identical.
2. **Robust decentralized O&M support enables the sustained usage of biogas plants.** Both prefabricated and civil-construction-based biogas models work well in the presence of regular on-the-ground O&M support. This not only addresses post-installation challenges but also provides households with constant guidance on effectively operating plants during any issues they encounter. When appropriately utilized and maintained, plants demonstrate satisfactory longevity, which challenges prevalent perceptions regarding their durability and efficacy within sustainable energy frameworks.
3. **Prefabricated biogas models have advantages.** Civil construction models require 12 to 15 days for completion, and their durability depends heavily on masonry skills. Prefabricated models, manufactured off site, need only one to two days for installation. Furthermore, prefabricated models are more compact and require less space and less maintenance.
4. **Prefabricated biogas plants may be better suited in regions with alpine climatic conditions.** In Uttarakhand, three households that had had the experience of using both civil-construction-based and prefabricated biogas plants reported that the prefabricated plants were less prone to decreased efficiency during winter and leakage issues caused by heavy rains, meaning that they offer a relatively more durable and reliable solution.



5. **There has been a sustained reduction in firewood usage.** Upon analysis of the fuel transition patterns among households utilizing a combination of firewood, LPG, and biogas, 24 out of 29 (82%) reported that, before adopting biogas, they had transitioned from firewood to LPG. However, during this transition, they had not reduced firewood usage in a sustained manner, owing to the high and recurring cost of LPG. When they transitioned to biogas, they reduced firewood usage in a much more sustained manner, primarily because there is a lack of recurring expenditure associated with biogas (see point 1 in Section 4.1). Households reported that, after shifting to biogas, their firewood consumption reduced by 70%.

## 4.2 Factors Encouraging Biogas Adoption

### Cash–Time Trade-Off (Pre-Biogas)

Before biogas adoption, most households in our sample stacked clean fuels (LPG) with unclean cooking fuels (particularly, firewood). This meant bearing both the recurring cash outlay for LPG refills<sup>6</sup> and the time cost of collecting firewood (often, paying cash to purchase it) alongside higher calorie needs from physically demanding work. Continued firewood use also imposed substantial time and health burdens: households spend ~6 hours per week collecting fuelwood on average (a load borne disproportionately by women) (Desai et al., 2010), and solid-fuel use drove large household air-pollution risks. Awareness about these realities explained the transition pathway we observed, where biogas displaced both firewood and LPG. This shift cut smoke and time burdens and eased the pressure of recurring cash outflow.

### Comparing Payback Period of Biogas vs. LPG

Building on the cash–time trade-off above, many households began asking a practical question: “Over time, will biogas actually save us more than LPG?” To better answer this question, we also ran a life-cycle cost analysis (Excel-based) comparing biogas plants with LPG use. The model estimates the payback period—the time (in months or years) for biogas to recover its upfront cost through avoided LPG expenditure. Figure 6 shows results across user categories and annual use of LPG cylinders: if the LPG consumption is higher, payback shortens sharply when a household switches to biogas. A household-scale biogas plant with an assumed 15-year lifespan appears financially viable at current LPG prices (particularly, for non-PMUY users consuming at least three LPG refills in a year).

However, in our study sites, households did not develop this understanding on their own. Awareness efforts by People’s Education and Development Organization (Rajasthan) and Grassroots (Uttarakhand) translated the numbers into everyday terms (monthly cash savings and expected payback in months), and what this means for seasonal fuel requirements.

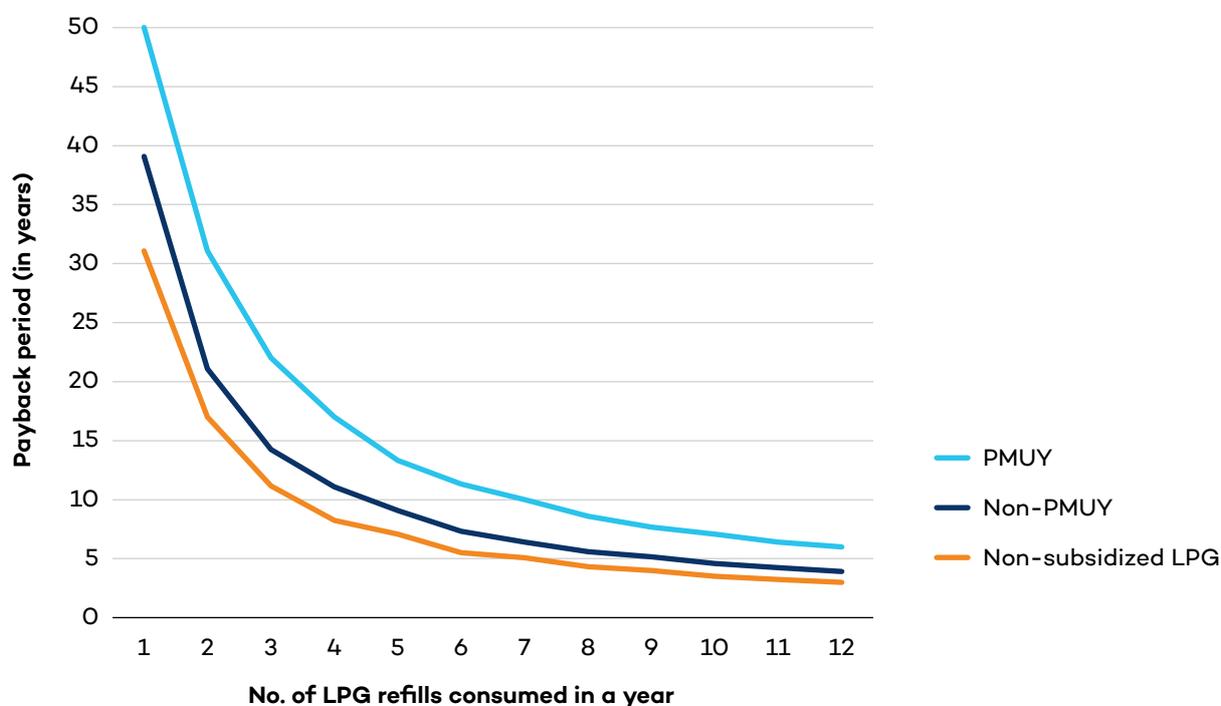
---

<sup>6</sup> In our survey, the annual income of rural households ranged from INR 100,000 to INR 150,000. Consuming an average of 10 LPG refills in a year would cost them at least 6% to 8% of their annual income (a 14.2-kg LPG refill costs ~INR 850 to INR 900). In the 2-year period between May 2020 and May 2022, no LPG-using household received DBTL subsidy benefits, and many households shifted to biogas during this time period.



This grounded communication helped households recognize the cumulative savings and understand how the investments could pay back within a reasonable time frame.

**Figure 6.** Payback period for biogas plants vs. LPG at the different refill prices



Note: Three lines in Figure 6 show the payback period for biogas plant for three categories of LPG-using consumers (PMUY, non-PMUY, and consumers purchasing non-subsidized LPG from the open market). If the current annual LPG consumption (in terms of no. of 14.2 kg LPG refills consumed in a year) for a consumer category is higher, their payback period for biogas will become lesser, as they will save more money per year (which they were spending on LPG), after shifting to biogas for cooking.

Source: Authors' calculations.

### Social Influence Followed by Financial Support

In Punjab and Uttarakhand, households reported that witnessing successfully operational biogas plants, receiving positive feedback from neighbours, and learning about the cost-effectiveness of biogas (particularly in comparison to LPG) had motivated them to consider installing plants. Similarly, in Rajasthan, awareness campaigns led by grassroots organizations and self-help groups were instrumental in generating interest among rural households. However, it is also important to highlight that in all these cases, upfront financial support also played an essential role in converting the desire to adopt biogas into actual implementation. This underscores the need to combine awareness initiatives with accessible financing mechanisms to drive widespread biogas adoption.



## 4.3 Challenges Associated With Biogas

Some biogas users also reported encountering several issues, and these issues may impact the scalability of biogas in rural India:

1. **High upfront cost of biogas plants:** Although the government provides a 40% subsidy on the upfront cost of a biogas plant, the remaining cost is still unaffordable for most rural households.<sup>7</sup> During our fieldwork, a few households that had made the switch to biogas highlighted that they had wanted to switch much earlier, because of its lack of recurring costs (as compared with LPG), but they could not afford it without additional funding support, such as from corporate social responsibility (CSR) funds.
2. **Reduced productivity of biogas during winter:** Biogas plants require a minimum temperature of 20°C for optimal production. When the ambient temperature drops below this threshold, biogas productivity can decrease by a range of 25% to 60%, depending on the extent of the temperature drop. This often forces households to turn to alternative cooking methods (including solid fuels) during the winter months. Interviews with biogas experts in Punjab suggested that this challenge could be alleviated through some simple yet effective measures. These include using hot instead of cold water to mix with cow dung, insulating biogas plants with materials such as paddy straw, and adjusting the feedstock mixture by adding 25% slurry to a blend of 50% cow dung and 25% water (as opposed to the standard cow dung and water mixture used in warmer months). However, these best practices are not well known among households.
3. **Biogas plant size and bigger families:** Our fieldwork revealed that a household with no more than four members using a 2-m<sup>3</sup> prefabricated plant or a 4-m<sup>3</sup> civil construction plant could meet their cooking energy needs using biogas even in winter. However, bigger households may require larger plants. For instance, 5 out of 22 households (all with more than four members<sup>8</sup>) using prefabricated biogas plants of 2 m<sup>3</sup> reported difficulties meeting their cooking needs even during summer and in the monsoon.
4. **Land availability challenges:** A civil-construction-based biogas plant of 2 m<sup>3</sup> requires an area of 50 m<sup>2</sup> to 60 m<sup>2</sup> to accommodate the digester, inlet and outlet tanks, mixing pit, and safety buffer zones. A prefabricated biogas plant needs only around 20 m<sup>2</sup>. Further, the land must be even, and the pipeline connecting the biogas plant to the kitchen stove should not exceed 200 m, as greater distances can reduce the efficiency of the gas supply. Therefore, the land must be of a sufficient size, flat, and close enough to the house to ensure the pipeline length remains within 200 m.
5. **Limited manufacturing of prefabricated biogas plants within India:** Currently, domestic manufacturing capacity for prefabricated biogas plants is restricted to a very

---

<sup>7</sup> We assume the cost of a 2-m<sup>3</sup> biogas plant (sufficient for a family of four) as INR 39,500. We assume a similar price for prefabricated and civil-construction-based biogas plants. Even after a 40% subsidy from the government, the upfront cost of a biogas plant will be INR 23,700.

<sup>8</sup> The median family size of rural households from our survey data was five. However, around 20% of households had more than seven members.



few Indian states, including Gujarat and Maharashtra. Transporting plants incurs significant additional costs, which raises the overall upfront costs further for end-consumers.

6. **Limited numbers of biogas training centres established by MNRE:** As of 2024, there were only eight training centres across India, which primarily train only masons and technicians for civil-construction-based (not prefabricated) biogas models. This concentration has led to a proliferation of such plants.

## 4.4 Policy Recommendations

To effectively address the challenges hindering the widespread adoption and sustained use of biogas plants, a comprehensive and multipronged policy approach is essential. The following recommendations outline strategies to overcome existing barriers and promote biogas as a viable clean cooking solution for rural India.

### 1. Provide financial support to reduce the upfront cost of biogas adoption.

#### Increase subsidies for biogas plants

To make biogas more affordable for a broader segment of the rural population, the government should consider increasing subsidies, particularly targeted at low-income households. Currently, the NBP has allocated a total budget of INR 1,715 crore over 5 years (FY 2021/22 to FY 2025/26) to promote various bioenergy solutions (Hazarika, 2023).

Within the NBP, Phase I has an overall budget of INR 858 crore, with only INR 184 crore earmarked for small and medium biogas plants catering to cooking needs. This allocation is disproportionately lower compared to India's LPG subsidies, which stood at INR 30,000 crore in FY 2022/23—the year the NBP was launched (PPAC, 2025b). Even if we conservatively assume only 50% of the overall LPG subsidy goes to rural consumers, it is still INR 15,000 crore per year, orders of magnitude higher than biogas subsidies. At a modest capital subsidy of INR 15,000 per household, INR 15,000 crore per year (if allocated to the biogas program) could transition some ten million rural households to biogas annually—a one-time investment per household, unlike LPG subsidies that must be disbursed every year.

One way to enhance biogas affordability is to start by reallocating a small portion of current LPG subsidies to biogas. This would not only make biogas plants more viable for rural households but also yield long-term benefits for the government by reducing recurring expenditures on LPG subsidies as households transition to biogas. It would also align with India's broader goals of reducing import dependence on fossil fuels.

#### Revisit subsidy disbursement mechanisms

The current practice of providing subsidies only after installation sometimes places undue financial strain on beneficiaries. Disbursing subsidies at earlier stages, such as during planning or installation, would reduce the effective upfront costs and encourage adoption.



## Explore the utilization of CSR funds

Engaging the Ministry of Corporate Affairs to explore the potential use of CSR funds for subsidizing biogas plants and collaborating with corporate entities could be an effective strategy to reduce the upfront cost of biogas adoption. Successful models, such as those implemented by Grassroots in Uttarakhand (covered in our fieldwork), demonstrate the potential of such partnerships: this partnership was able to lower the cost of biogas adoption by up to 50%.

## Integrate carbon credits (household biogas under Article 6)

In July 2025, the Ministry of Environment, Forest and Climate Change's revised Article 6.4 positive list excluded clean-cooking activities, which closed the door for exporting credits from small biogas and cookstove projects (Ministry of Environment, Forest and Climate Change, 2025; Singh, 2025). The "positive list" determines which types of projects are automatically eligible to generate internationally traded carbon credits under Article 6.4 of the Paris Agreement.<sup>9</sup> Linking biogas projects to carbon credit mechanisms (under Article 6.2/6.4) can enable long-term carbon revenues to the manufacturers, which could further reduce the upfront costs significantly. For instance, Sistema.bio's India program finances biogas units via Gold Standard credits (with an AAe rating) (*Times of India*, 2024; Sistema.bio, 2025).<sup>10</sup> The Ministry should be requested to reinstate small household biogas plants on the Article 6 whitelist, reversing the July 2025 exclusion of clean-cooking devices, to unlock carbon-credit revenues and cut farmers' net upfront cost.

## Support community-based financing models

Self-help groups can also play a pivotal role in addressing upfront financing challenges in rural areas. For example, in Rajasthan, People's Education and Development Organization collaborates with local self-help groups, which finance the initial cost of biogas plants and offer flexible repayment terms (of up to 18 months at a 1% monthly interest rate). Similarly, in Uttarakhand, Grassroots has implemented interest-free installment models. These financial flexibilities have played a significant role in making biogas plants more financially accessible to households in the respective localities.

---

<sup>9</sup> Article 6 of the Paris Agreement allows countries to cooperate on emissions reductions by transferring them (among each other) through carbon markets. Article 6.4 establishes a UN-supervised crediting mechanism for mitigation projects. A "positive list" is a predefined set of eligible project types that automatically qualify to generate credits. Projects not on the positive list must undergo additional approvals or may be disallowed from crediting altogether.

<sup>10</sup> The AAe rating signifies a very high likelihood that future carbon credits will deliver real, measurable, and durable climate impact. It is a rare outcome in the voluntary carbon market: only 4% of projects that have issued credits and been evaluated by BeZero have received an AA rating, and there has never been an AA rating awarded in the waste or household sector before. This achievement places the project among a select few globally. The "e" denotes the ex-ante nature of the evaluation, conducted at the early stage of the project's development.



## 2. Address winter productivity challenges.

### Promote best practices

Encouraging users to adopt best practices such as mixing warm water with dung, keeping feedstock fresh and well-mixed, and insulating the dome with locally available materials (e.g., paddy straw or husk) can help microbes stay active in colder months and optimize biogas production without requiring significant additional investment. Further, in areas with persistent winter temperature dips, small, time-bound exploratory pilots could be conducted to test simple nutritional boosters (e.g., jaggery or gur added to warm water which is mixed with dung) to stabilize microbes and improve gas yields. If performance still lags, ready-made micronutrient premixes (such as an iron, cobalt, and nickel blend) can also be dosed as per the supplier's guidance.

## 3. Expand prefabricated biogas plant options.

### Promote the manufacturing of larger prefabricated plants with targeted incentives

To address the limitations of the one-size-fits-all 2-m<sup>3</sup> model, funding and technical support should be extended to build a manufacturing base for prefabricated biogas plant models ranging from 3 m<sup>3</sup> to 6 m<sup>3</sup>. The government could also consider offering a small production-linked incentive per 3- to 6-m<sup>3</sup> unit made in India (and it could be time-bound, say for an initial 3 years). Offering one-time grant for factory tools and moulds could be an effective way to incentivize manufacturers to produce larger prefabricated biogas plants, which would better serve households with larger family sizes and higher cooking energy demands.

### Incentivize the setup of decentralized manufacturing units

Incentivizing the creation of decentralized local manufacturing units in regions with a higher share of rural population and agricultural and livestock activity would address production and servicing challenges. These units would also be more likely to train (and later employ) local workers in both the production and maintenance of prefabricated biogas plants, which would promote local economic development while ensuring the timely availability and maintenance of biogas plants.

## 4. Build awareness and capacity.

### Conduct awareness campaigns

The government should conduct targeted awareness campaigns highlighting the long-term cost-effectiveness and environmental benefits of biogas, through the state nodal agencies, which are responsible for biogas promotion in the Indian states. These campaigns could also involve hands-on training programs, which may require village-level pilots related to biogas, to educate users on proper operation and maintenance practices, which is essential to ensuring the longevity of biogas plants.



### **Run community-led awareness drives (beyond state nodal agencies)**

The government should partner with self-help groups (part of national rural livelihood missions), farmer producer organizations, dairy co-ops and milk collection centres, Panchayats and Gram Sabhas, Krishi Vigyan Kendras, and Common Service Centres to host biogas demo days. The government could also leverage ASHA/Anganwadi workers and Krishi/Pashu Sakhis as trusted “biogas champions” for household visits, maintenance reminders, and slurry use guidance.

### **Embed biogas in existing rural touchpoints**

The government should co-message with Mahatma Gandhi National Rural Employment Guarantee Scheme, the Swachh Bharat Mission-Grameen (a major sanitation project), and GOBARdhan meetings to link toilet and waste management to biogas.

### **Conduct hands-on training and village pilots**

Besides state nodal agencies-led efforts, the government should commission travelling demo kits and school and Primary Health Centre canteen biogas showcases. Offer O&M micro-courses (2 to 4 hours) via Krishi Vigyan Kendras, culminating in a village O&M roster and two trained local technicians per Gram Panchayat.

### **Expand and diversify training centres**

Increasing the number of biogas training centres, particularly for prefabricated models, would build local capacity for installation and O&M. The accreditation of private installers, local NGOs, and dairy or farmer producer organization skill labs (if present) could be leveraged to deliver standardized modules, particularly around installation, troubleshooting, slurry management, and health and safety.



## 5.0 Electric Cooking Findings

This chapter discusses the findings from fieldwork conducted across urban and rural India and discusses the challenges and opportunities associated with promoting e-cooking.

### 5.1 Key Findings of the Fieldwork

The adoption of e-cooking devices is markedly higher in urban areas. In Delhi and Bengaluru, many households have adopted such devices, albeit primarily as supplementary or backup options rather than as primary cooking solutions. In contrast, rural areas exhibited virtually no adoption of e-cooking devices for various reasons, as discussed in this section.

1. **High upfront costs:** Devices that are most suitable as primary cooking equipment, especially double-plated induction stoves or infrared-based induction devices, have high upfront costs and are prohibitively expensive for many households. The cost discourages widespread adoption, even in urban areas. The rural households surveyed often had relatively larger family sizes (7 to 10 members, compared to 4 to 5 in urban homes) and would find it difficult to meet their cooking needs with smaller, single-plated induction stoves that come at a lower upfront cost.
2. **Power supply challenges:** Urban areas have seen significant improvements in the quality (voltage stability) and reliability (fewer power cuts) of the electricity supply, making e-cooking more feasible. In rural areas, an unreliable and poor-quality electricity supply remains a major barrier.
3. **Less versatility of devices:** Some households reported that e-cooking devices were less versatile than traditional LPG stoves, particularly for cooking certain food items (e.g., *chapati*, *baingan ka bharta*) that require flame-based techniques. Therefore, households often use e-cooking devices only for backup or for certain kinds of cooking.
4. **O&M challenges:** Households that used e-cooking devices also reported inadequate repair and maintenance services for post-warranty devices. In Bengaluru, two out of three households reported that they had discarded malfunctioning induction devices owing to a lack of repair options, leading to wastage.
5. **Limited access to subsidized electricity for low-income urban households:** One of the primary challenges facing low-income urban households is their exclusion from electricity subsidies owing to a lack of formal electricity connections.
  - **Common electricity meters:** Fieldwork revealed that typically 30 to 50 households in Bengaluru and 5 to 10 households in Delhi are grouped and rely on a shared single electricity meter. This arrangement prevents individual households from receiving government-subsidized electricity tariffs.
  - **Unaffordable electricity bills:** Without direct access to subsidized electricity, these households pay higher per-unit charges, which discourages the use of electricity-based alternatives.

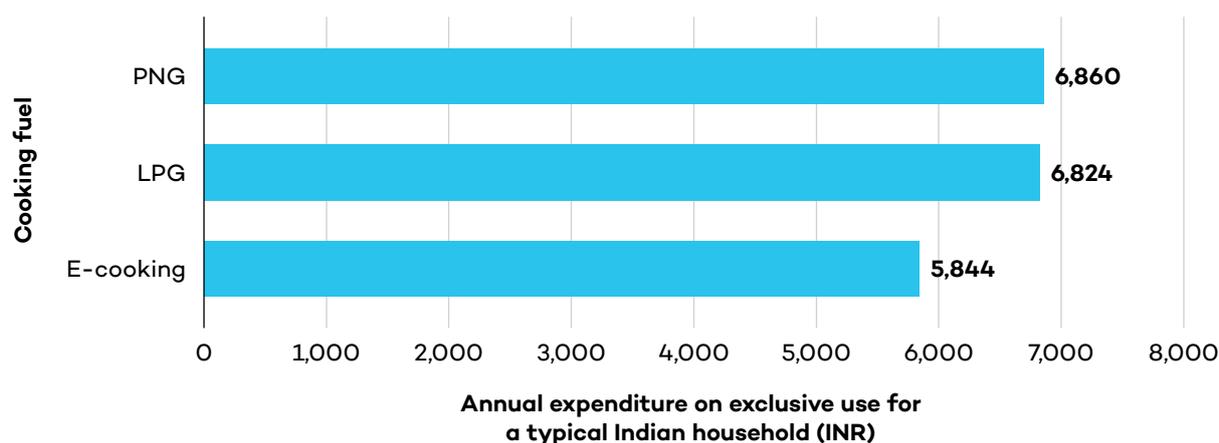


- **Dependence on contractors or landowners:** In several cases, the landowner or contractor holds the electricity connection, which further restricts access to government subsidies and affordable tariffs. Some community members reported that landowners refused to provide electricity in their name, fearing long-term settlement claims.
- **Skepticism towards e-cooking:** While some local NGOs have tried to introduce electric cookstoves, many households are reluctant to adopt them owing to concerns about rising electricity costs and lack of properly wired electricity connections.

## 5.2 Cost Comparison of E-Cooking, LPG, and PNG for Indian Households

We conducted a cost comparison between LPG, PNG, and e-cooking and found that e-cooking is already cheaper for most Indian households in terms of operational expenditure. At the prevailing LPG and PNG prices of INR 853 per 14.2 kg refill and INR 50 per SCM, respectively, a typical non-PMUY household spends around INR 6,800–INR 6,900 annually on LPG or PNG for exclusive cooking use, compared with only INR 5,800–INR 5,900 per year for e-cooking (assuming an average residential electricity tariff of INR 6/kWh) (Figure 7).<sup>11</sup> In fact, e-cooking remains cost-competitive until the effective electricity price exceeds about INR 7/kWh. The price advantage for e-cooking would widen further if LPG were sold at its actual market price of INR 1,110 per refill (hypothetical scenario), in which case e-cooking would remain cheaper even at electricity tariffs of up to INR 9.1/kWh—a level significantly higher than the average cost of supply for most state discoms in India.

**Figure 7.** Typical expenditure levels for LPG, PNG, and e-cooking in Indian households



Source: Authors' calculations.

<sup>11</sup> We use assumptions from Agrawal et al. (2021) for this analysis. As per this study, a typical Indian household (with four to five family members) relying exclusively on LPG would consume eight LPG refills (of 14.2 kg each) in a year. For PNG, this figure is 137.2 SCM per year, and for e-cooking, it is 974 kWh per year. For more details on their methodology, refer to the original report.



For PMUY households (most of which are in rural India), e-cooking will be a more affordable and sustainable option if electricity tariffs are kept below INR 4.5 per kWh. However, since the reliability of the rural electricity supply remains a key constraint in India, it is better to continue to promote LPG consumption to these households (or even biogas, wherever feasible). Over time, as grid stability improves, India's electricity grid becomes greener, and appliance costs decline, e-cooking can emerge as the lowest-cost and most resilient clean cooking pathway for the whole of India. It promises to deliver savings to consumers while aligning with India's broader decarbonization and energy security goals.

## 5.3 Estimated LPG Subsidy Savings From a Transition to E-Cooking

This section estimates potential savings in future LPG subsidies if Indian households start shifting to e-cooking. We developed an Excel-based LPG model to understand the potential long-run impact of a small increase in adoption over time, only in urban India, on LPG subsidy expenditures, LPG demand, and foreign exchange. The model does not account for the electricity subsidies currently offered to households in India that counteract the LPG subsidy savings.

It is important to emphasize that future savings in LPG subsidies depend on various factors, including global LPG prices, which will determine overall expenditure on LPG subsidies in India. This high variability prevents the model from predicting future savings. Rather, the model serves as an analytical tool to help policy-makers and stakeholders understand the potential benefits of e-cooking adoption under certain assumptions. The model is flexible, which allows for adjustments in assumptions as India's energy and policy landscape evolves. This flexibility makes it possible to revise estimates of LPG subsidy savings.

### 5.3.1 Assumptions of the Model

The modelling exercise incorporates conservative and flexible assumptions to account for various possible growth scenarios. Key assumptions include:

1. **Urban-only focus:** E-cooking adoption is considered only for urban households, though the model can be extended to rural areas in future analyses.
2. **Three growth scenarios for e-cooking penetration in 2050:**
  - High growth: 60% of urban households adopt e-cooking as a primary cooking source.
  - Medium growth: 40% of urban households adopt e-cooking as a primary cooking source.
  - Low growth: 20% of urban households adopt e-cooking as a primary cooking source.



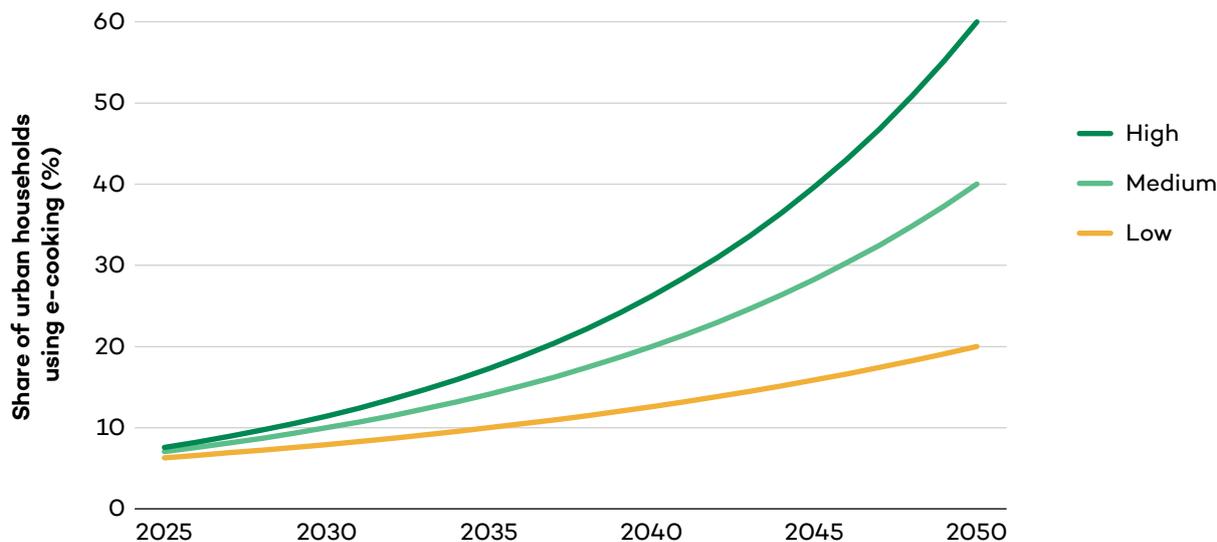
3. **Annual trajectories for e-cooking adoption from 2025 to 2050:** As per Agrawal et al. (2021), 5% of Indian households adopted e-cooking in 2020. In order to arrive at the annual trajectories of e-cooking adoption in each of the above scenarios, we applied simple compound annual growth rate from 2020 to 2050 (see Figure 8).
4. **Urbanization trends:** By 2050, 68% of India's population is expected to reside in urban areas (United Nations Department of Economic and Social Affairs, 2018). Based on these projections, we arrived at the urban and rural population of Indian households (Figure 9), which helps in estimating the number of households that may adopt e-cooking and their annual LPG consumption from 2025 to 2050.
5. **LPG consumption patterns:** A typical urban household that does not use e-cooking is assumed to consume eight LPG refills (14.2 kg each) per year. As urban households transition to e-cooking, their annual LPG consumption gradually declines. Since e-cooking has some technological limitations, Indian households will be able to replace LPG only gradually (continued stacking):
  - 2025–2030: six refills per year (two LPG refills replaced by e-cooking)
  - 2030–2040: four refills per year (four LPG refills replaced by e-cooking)
  - 2040–2050: two refills per year (six LPG refills replaced by e-cooking)
6. **Price estimates:** All price-related estimates, including LPG import costs, domestic LPG prices, and subsidies, are based on 2025 values and do not account for inflation or future market variations. Based on our estimations from the LPG price buildup model (more details in Appendix B), LPG refills are subsidized by INR 257 for every household in the country. While the 14.2-kg refills are being sold at INR 853 per refill, the actual cost-reflective price, based on import price, is INR 1,110. Different analyses often report slightly varying estimates of LPG underpricing depending on the methodology, reference period, and components considered in the price buildup. For instance, CareEdge (2025) estimates that domestic LPG is underpriced by around INR 220 per 14.2 kg refill, while our LPG price buildup model indicates an underpricing of about INR 257 per refill for the same period.<sup>12</sup>

---

<sup>12</sup> These differences in under-recovery estimates owe primarily to differences in reference month and international benchmarking for the price of LPG. Small shifts in international LPG prices or exchange rates can easily cause a variation of INR 20 to INR 40 per refill. Further, our model also incorporates distributors' commission, bottling, inland freight, and marketing costs, in addition to the import parity price and taxes, to reflect the full consumer-facing cost. CareEdge uses a net-back pricing approach that excludes certain downstream costs, leading to a slightly lower under-recovery figure.

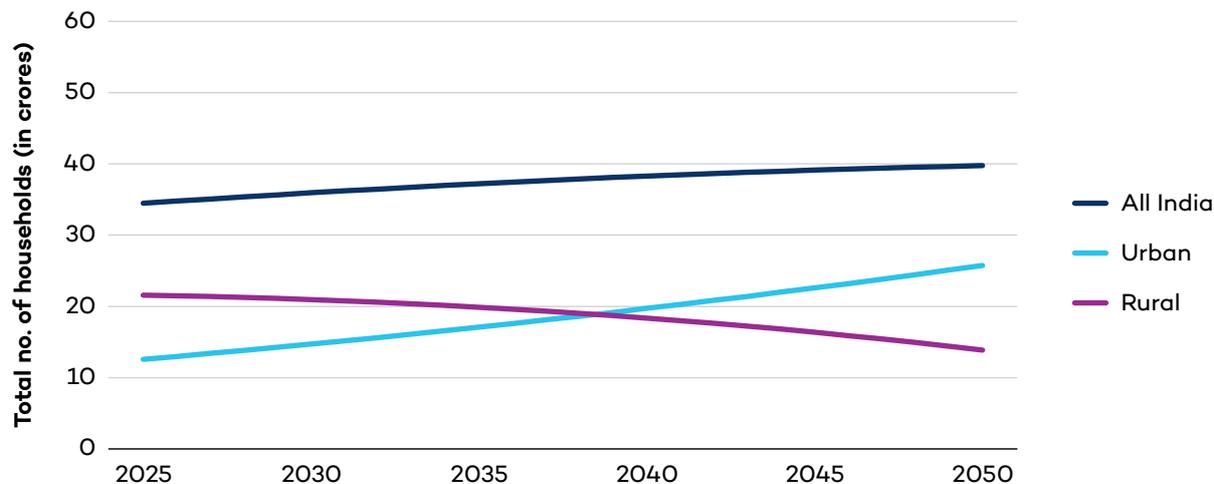


**Figure 8.** E-cooking adoption scenarios from 2025 to 2050



Source: Authors' assumptions.

**Figure 9.** Number of households in urban and rural India from 2025 to 2050



Source: Authors' calculations, based on United Nations Department of Economic and Social Affairs (2018).

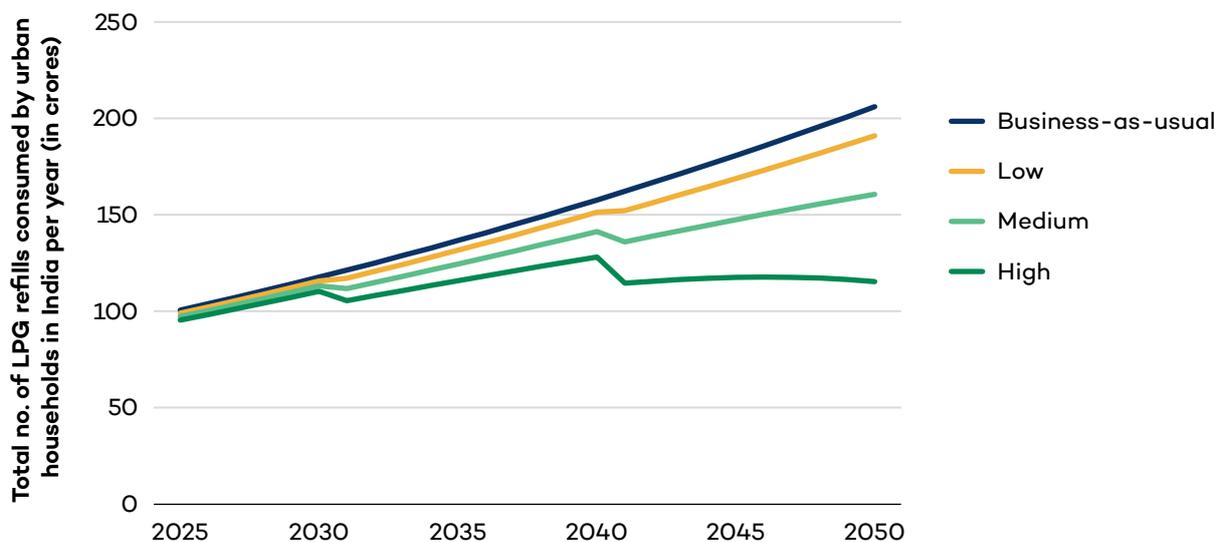
### 5.3.2 Findings

#### LPG Demand Reduction and Energy Security Benefits

In an aggressive e-cooking promotion scenario, urban household LPG demand could be reduced by up to 50% by 2050 (Figure 10). This would cut LPG imports by more than half, improve India's energy security, and reduce foreign exchange expenditure (Figures 11 and 12).



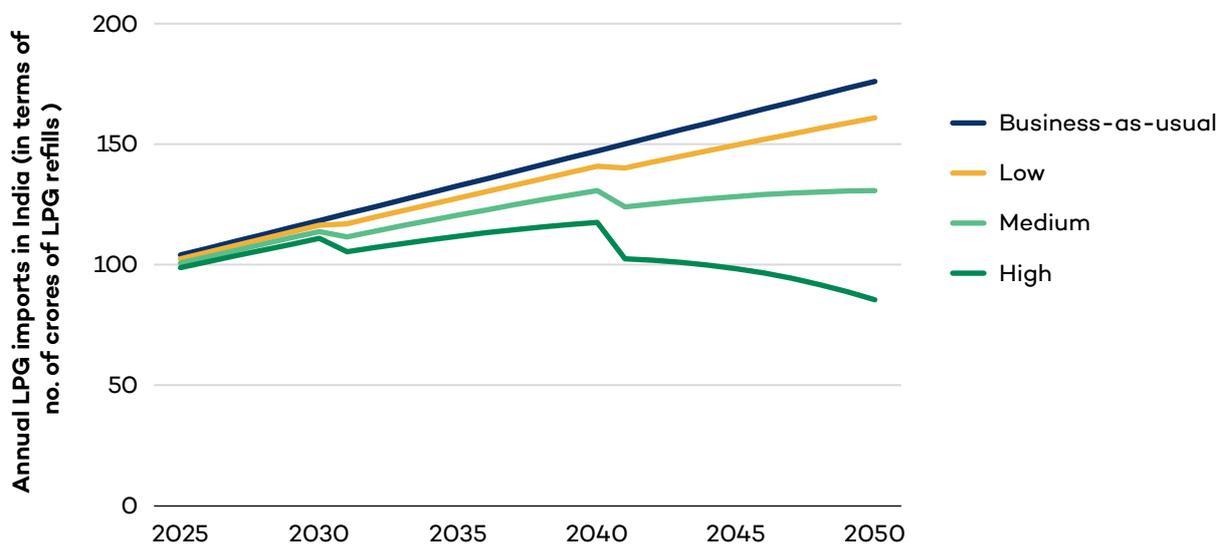
**Figure 10.** Annual LPG consumption (in number of refills) from 2025 to 2050



Note: The value of annual domestic LPG consumption in 2024/25 was obtained from the PPAC (2025a). Since this was available in MMT, it was divided by 14.2 (quantity of LPG in every LPG refill) to arrive at the number of LPG cylinders consumed by Indian households in 2024/25.

Source: Authors' calculations.

**Figure 11.** Projected annual LPG imports in different scenarios

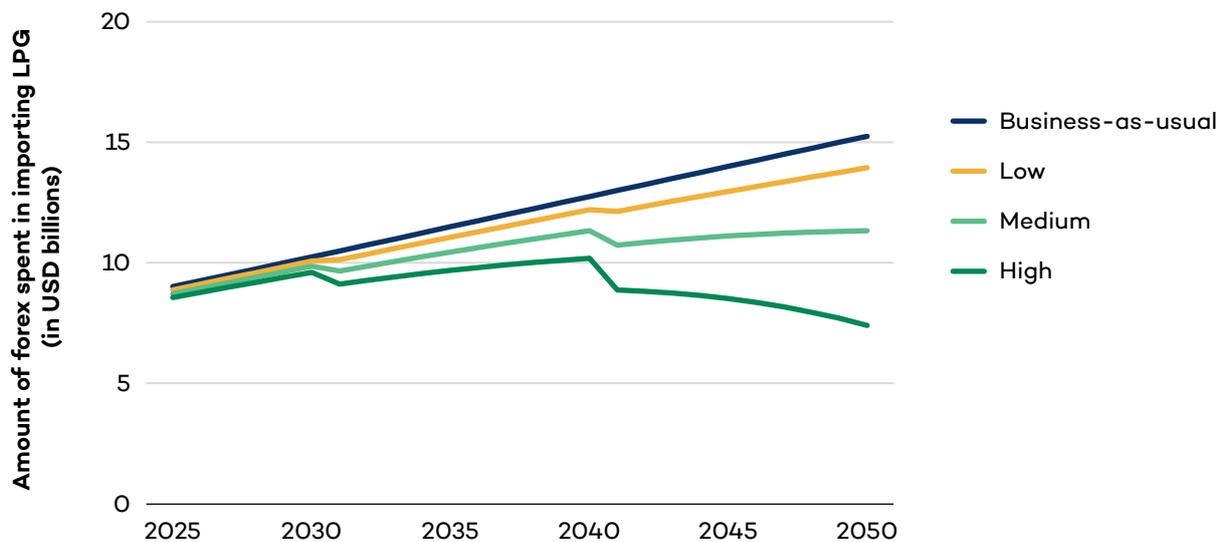


Note: The value of LPG imports and foreign exchange spent in importing LPG (for domestic use) in 2024/25 was obtained from PPAC, 2025a.

Source: Authors' calculations.



**Figure 12.** Projected foreign exchange spent on importing LPG into India



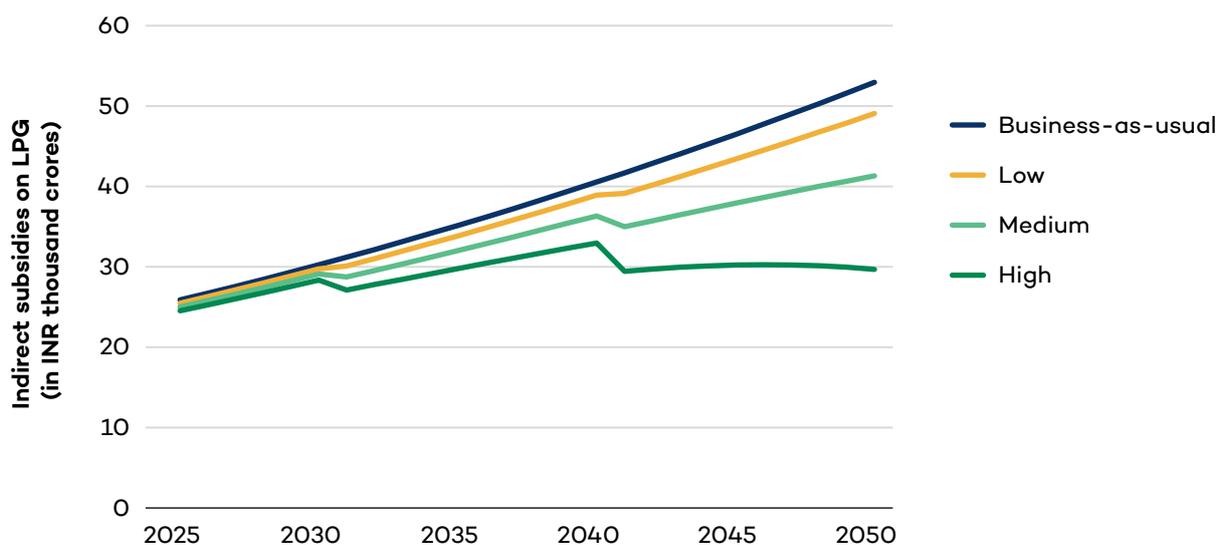
Note: The value of LPG imports and foreign exchange spent in importing LPG (for domestic use) in 2024/25 was obtained from PPAC.

Source: Authors' calculations.

### Significant Reduction in LPG Subsidy Burden

By 2030, the impact of e-cooking adoption on LPG subsidies is projected to be limited, owing to the gradual nature of the adoption process. However, by 2050, significant savings of up to INR 2.4 trillion can be achieved under a high-growth scenario, which would reduce the government's financial burden (Figures 13 and 14).

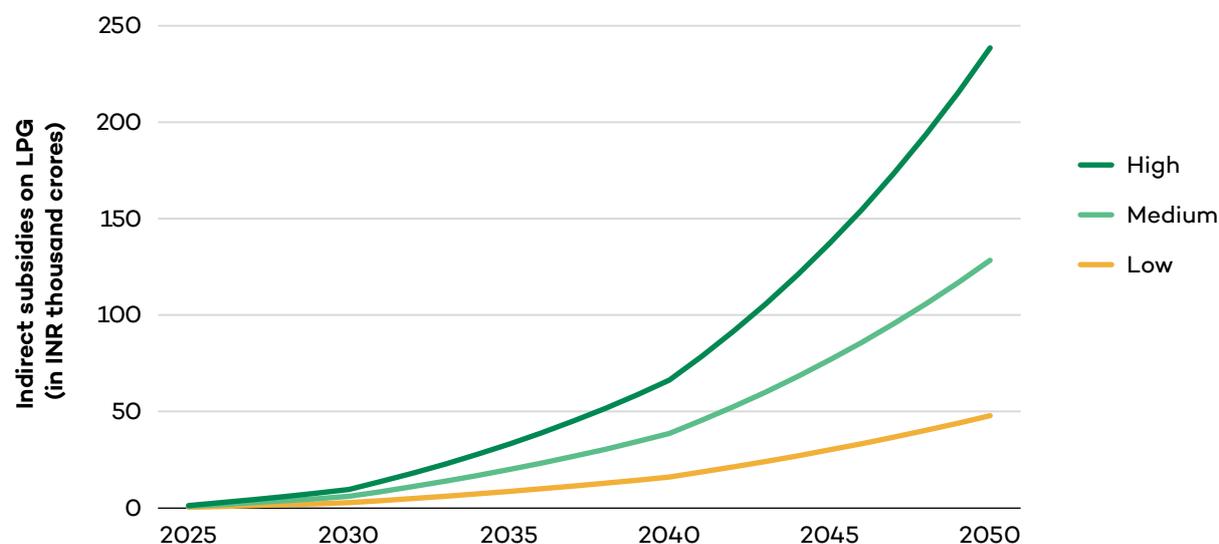
**Figure 13.** Annual spending by the government on under-recovery on LPG



Source: Authors' calculations.



**Figure 14.** Cumulative savings in LPG subsidies from 2025 to 2050



Source: Authors' calculations.

### 5.3.3 Discussion

The Excel-based modelling demonstrates the long-term financial benefits of e-cooking adoption in urban India, particularly in terms of subsidy savings. While the impact by 2030 remains moderate, by 2050 significant savings and reduced import dependence could be realized under a sustained e-cooking promotion strategy. These could be diminished if electricity subsidies are not rationalized.

The potential LPG subsidy savings from e-cooking adoption can also be redirected gradually to support e-cooking among poorer households within urban India. Electricity discoms have historical electricity consumption data for every consumer, which is correlated with households' economic profile (Kostakis, 2020; Ali et al., 2021). Therefore, discoms are in a good position to identify poorer households based on their electricity consumption profiles. This targeted approach could enable better subsidy allocation by providing these households with e-cooking solutions, which was not easily possible with LPG. In fact, targeting LPG subsidies to the poor has always been a persistent challenge in India (Sharma et al., 2021).

The growing penetration of smart meters in India (Asian News International, 2025b) could also make it easier to distinguish the e-cooking load from other types of electricity consumption, and thereby to subsidize this load for poorer households in a targeted manner (Zhang et al., 2017; Agrawal et al., 2020). This data-driven approach could enable the precise identification of households and targeting of cooking energy subsidies and could improve efficiency compared to inefficient LPG subsidies.

This modelling effort is a starting point to assess the potential of e-cooking in India. It provides policy-makers with a framework to explore non-fossil fuel cooking solutions and adjust strategies as new data and realities emerge. Periodic updates will be essential in order to reflect changing circumstances, which would allow for revised subsidy and foreign exchange



savings estimates with changes in LPG prices (both in India and globally). Future refinements could examine different adoption rates in urban and rural areas to capture varied patterns of e-cooking uptake.

## 5.4 Policy Recommendations

### Address the affordability barrier.

#### Research and development (R&D)

- Invest in R&D to design cheaper and more efficient electric cookstoves that are also compatible with the utensils currently used on LPG stoves.
- Expand initiatives such as Energy Efficiency Services Limited's NECP to also include double-plated induction devices. This will not just encourage the production of energy-efficient double-plated induction stoves but also will help drive cost reductions (essential to making them affordable) through their bulk procurement.

#### Subsidies and incentives

Gradually reducing LPG subsidies for urban households and redirecting them to provide targeted electricity subsidies to cover the operational costs of e-cooking will also incentivize the sustained use of e-cooking.

### Facilitate the transition of e-cooking from backup to primary option.

In addition to promoting the production of affordable double-plated induction stoves, further R&D could explore design innovations that enhance the user experience and cooking versatility of electric cookstoves, particularly for food that traditionally relies on flame-based techniques, such as roasting or puffing. However, any such innovations would need to balance the replication of flame effects with the preservation of high thermal efficiency, since introducing visible flames or indirect heat transfer could reduce energy efficiency and increase heat losses. Collaborative research with stove technologists and behavioral experts could help identify optimal design solutions that combine efficiency, safety, and cultural compatibility.

### Improve O&M services.

- Establishing decentralized aftersales service centres for e-cooking devices, with different manufacturers collaborating to share costs and resources, would also incentivize their adoption in all parts of the country.
- Training local technicians to provide repair and maintenance services (even past warranty expiration) would reduce the likelihood of devices being discarded after a malfunction.



## 6.0 Conclusion

India's transition to non-fossil fuel clean cooking solutions is both a challenge and an opportunity. Our results indicate that significant savings are possible for both governments—up to INR 2.4 trillion subsidy savings by 2050 from e-cooking alone—and households. The findings and recommendations in this report underscore the need to shift away from fossil fuel-based cooking solutions such as LPG and PNG, which, despite their widespread adoption, pose significant challenges related to energy security, affordability, and environmental sustainability. Government subsidies for these fuels and related infrastructure are also holding back the clean energy transition, doing nothing to promote the inevitable demand for the electrification of household energy. Biogas and e-cooking emerge as viable alternatives, each with unique advantages and challenges that require tailored policy interventions.

Biogas presents a decentralized and sustainable solution for rural India, leveraging locally available organic waste to provide clean cooking energy while addressing waste management challenges. Successful models in states such as Punjab, Rajasthan, and Uttarakhand demonstrate that, with improved financial support and robust O&M support, biogas can significantly reduce firewood usage and provide a cost-effective alternative to LPG.

E-cooking, particularly in urban areas, offers a promising pathway to reduce reliance on imported fuels and lower greenhouse gas emissions over the long term, especially as India's power grid integrates more renewable energy into the system. Importantly, recent distribution reforms—such as universal household electrification and ongoing reliability, metering, and loss reduction efforts under the Revamped Distribution Sector Scheme—create enabling conditions for e-cooking. Further, smart metering can support the implementation of time-of-day prices and targeted assistance for poorer households, while improved billing and collections would strengthen discom finances to invest in local infrastructure upgrades. Taken together, these reforms increase the practical feasibility of e-cooking in urban and peri-urban areas while biogas scales in rural settings, with policies tailored to the distinct barriers and enablers of each.

However, the higher upfront costs (especially for double-plated induction stoves), power supply reliability issues, maintenance challenges (after the warranty expiration), and adaptability barriers must be addressed through targeted subsidies, improved aftersales services, and R&D. For households, on-bill subsidization enabled by smart meters would be helpful, as would ensuring extended warranties and aftersales services to keep devices in service.

Similarly, upfront costs also arise for discoms, which will need to reinforce networks for coincident evening loads. Government could manage these via a phased, peak-focused roll-out, and feeders with spare capacity could be prioritized first for e-cooking expansion. Further, a part of potential LPG subsidy savings could be utilised to co-fund these approaches.



Urban adoption can serve as a testing ground to refine e-cooking, driving economies of scale and making it more accessible for rural households in the future as grid services improve.

The government's role in facilitating the transition to non-fossil fuel clean cooking solutions will be pivotal. By rebalancing a portion of recurring LPG subsidy outlay toward one-time biogas capital expenditures and grid upgrades for e-cooking, leveraging CSR funds for public-facing pilots, and supporting awareness-raising and training initiatives, India can make clean cooking solutions more affordable and accessible.

In conclusion, a twin and phased approach to promoting non-fossil fuel clean cooking solutions, starting with urban e-cooking and rural biogas adoption, can pave the way for a sustainable, equitable, and resilient energy future for India. This transition will not only reduce the fiscal burden of LPG subsidies but also align with India's climate goals, improve public health, and enhance energy security. With the right policies, incentives, and stakeholder collaboration, India can lead the way in achieving universal access to non-fossil fuel cooking and set a global example for sustainable development.



## References

- 3Mco. (n.d.). Saudi Aramco LPG prices per metric tonne (MT). <https://3mgas.vn/news/saudi-aramco-lpg-prices-per-metric-tonne-mt-n153.html>
- Agrawal, S., Mani, S., Ganesan, K., & Jain, A. (2020). *What smart meters can tell us: Insights on electricity supply and use in Mathura and Bareilly households* (Council on Energy, Environment and Water Report). [https://img.etb2bimg.com/files/retail\\_files/reports/data\\_file-what-1582787296.pdf](https://img.etb2bimg.com/files/retail_files/reports/data_file-what-1582787296.pdf)
- Agrawal, S., Mani, S., Ganesan, K., & Jain, A. (2021). *Are Indian homes ready for electric cooking? Insights from the India Residential Energy Survey (IRES) 2020* (Council on Energy, Environment and Water Policy Brief). <https://www.ceew.in/publications/are-indian-homes-ready-for-electric-cooking-transition>
- Ali, S., Razman, M., Awang, M., Asyraf, M., Ishak, M., Ilyas, R., & Lawrence, R. (2021). Critical determinants of household electricity consumption in a rapidly growing city. *Sustainability*, 13(8), 4441. <https://doi.org/10.3390/su13084441>
- Asian News International. (2025a). Piped gas network covers nearly 100% of India's geographical area. *Tribune India*. <https://www.tribuneindia.com/news/business/piped-gas-network-covers-nearly-100-of-indias-geographical-area/>
- Asian News International. (2025b). Smart metering programme can help discoms generate Rs 4 lakh crore additional revenue: Care Edge. *Economic Times*. <https://economictimes.indiatimes.com/industry/energy/power/smart-metering-programme-can-help-discoms-generate-rs-4-lakh-crore-additional-revenue-care-edge/articleshow/119741566.cms?from=mdr>
- Azim Premji University. (2025). *The distribution of household income, 2019–2024*. <https://ruralindiaonline.org/en/library/resource/the-distribution-of-household-income-2019-2024/>
- Boyd Williams, N., Chandra Baruah, D., Dickie, J., & Raha, D. (2023). Overcoming socio-cultural resistance towards biogas technology. *Ideas for India*. <https://www.ideasforindia.in/topics/human-development/overcoming-socio-cultural-resistance-towards-biogas-technology.html>
- Cabinet Committee on Economic Affairs. (2020). Cabinet approves capital grant as viability gap funding to Indradhanush Gas Grid Limited for setting up the North East Natural Gas Pipeline Grid [Press release]. Government of India. <https://www.pib.gov.in/Pressreleaseshare.aspx?PRID=1598709>
- CareEdge. (2025). *LPG under-recoveries of OMCs expected to reduce by ~45% Y-o-Y in FY26*. Ratings. [https://www.careratings.com/uploads/newsfiles/1747127941\\_LPG%20Industry%20-%20CareEdge%20Report.pdf](https://www.careratings.com/uploads/newsfiles/1747127941_LPG%20Industry%20-%20CareEdge%20Report.pdf)
- Cruze, D. (2021). Go Electric campaign launched in India: Key aspects of new govt initiative. *Mint*. <https://www.livemint.com/auto-news/go-electric-campaign-launched-in-india-key-aspects-of-new-govt-initiative-11613740641340.html>



- Desai, S. B., Dubey, A., Joshi, B. L., Sen, M., Shariff, A., & Vanneman, R. D. (2010). Household assets and amenities. In *Human development in India: Challenges for a society in transition* (pp. 60–71). Oxford University Press. <https://doi.org/10.13140/2.1.3474.0162>
- EAC International Consulting. (2023). *Enablers and challenges – Indian compressed biogas (CBG) industry: Identifying and removing obstacles to a potential growth story*. [https://task37.ieabioenergy.com/wp-content/uploads/sites/32/2023/05/Knowledge-Paper\\_Indian-CBG-Industry\\_IFGE\\_EAC\\_April-2023\\_18042023-1.pdf](https://task37.ieabioenergy.com/wp-content/uploads/sites/32/2023/05/Knowledge-Paper_Indian-CBG-Industry_IFGE_EAC_April-2023_18042023-1.pdf)
- Energy in Buildings and Industry. (n.d.). *The Netherlands to ban fossil fuel installations from 2026*. <https://eibi.co.uk/news/the-netherlands-to-ban-fossil-fuel-heating-from-2026/>
- Hamidi, A., & New, P. (2021). *COP26, getting to net-zero: How clean electricity can be crowdsourced by digitalizing the grid*. World Economic Forum. <https://www.weforum.org/stories/2021/10/clean-electrification-crowdsource-net-zero-cop26-digitalization/>
- Hazarika, G. (2023). MNRE targets over 15,000 plants in phase II of biogas program for FY24. *Mercom*. <https://www.mercomindia.com/mnre-targets-over-15000-phase-ii-of-biogas-program-for-fy24>
- Hu, A. (2025). US cities seeking to ban natural gas in new buildings just got a big win in court. *Wired*. <https://www.wired.com/story/us-cities-seeking-to-ban-natural-gas-in-new-buildings-just-got-a-big-win-in-court/>
- ICF Consulting. (2025). *Pathways for transmission of hydrogen in natural gas pipelines and city gas distribution network*. Final report. [https://pngrb.gov.in/pdf/CaseStudies/20250619\\_CSR\\_Report.pdf](https://pngrb.gov.in/pdf/CaseStudies/20250619_CSR_Report.pdf)
- Indian Oil. (n.d.) Previous Price of Nonsubsidised 14.2 Kg IndaneGas. <https://iocl.com/indane-14Kg-nonsubsid-previous-price>
- Indo-Asian News Service. (2025). LPG connections in India have jumped to over 33 crore in last 11 years: Hardeep Puri. *EnergyWorld from Economic Times*. <https://energy.economictimes.indiatimes.com/news/oil-and-gas/lpg-connections-in-india-increase-to-over-33-crore-in-the-last-11-years-hardeep-puri/124246760>
- Indradhanush Gas Grid Limited. (2023). Sub: Indradhanush Gas Grid Limited (IGGL) comments/views on the expression of interest (EOI) from Duliajan Numaligarh Pipeline Limited (DNPL) to lay, build, operate, or expand natural gas pipeline from Duliajan to Chandrapur near Guwahati via Jorhat, Golaghat, Karbi Anglong, and Nagaon. PNGRB Public Notice PNGRB/Auth/2-NGPL (02)/2023. [https://pngrb.gov.in/pdf/public-notice/IGGL\\_30082023.pdf](https://pngrb.gov.in/pdf/public-notice/IGGL_30082023.pdf)
- International Energy Agency. (2021). *Net zero by 2050. A roadmap for the global energy sector*. <https://www.iea.org/reports/net-zero-by-2050>
- International Energy Agency. (2023). *A vision for clean cooking access for all*. World Energy Outlook special report. <https://iea.blob.core.windows.net/assets/f63eebbc-a3df-4542-b2fb-364dd66a2199/AVisionforCleanCookingAccessforAll.pdf>



- International Energy Agency. (2024). *Implementation of bioenergy in Denmark – 2024 update*. Country report. [https://www.ieabioenergy.com/wp-content/uploads/2024/12/CountryReport2024\\_Denmark\\_final.pdf](https://www.ieabioenergy.com/wp-content/uploads/2024/12/CountryReport2024_Denmark_final.pdf)
- International Energy Agency. (2025). *India gas market report: Outlook to 2030*. <https://iea.blob.core.windows.net/assets/ef262e8d-239f-4cfc-8f8c-4d75ac887a0f/IndiaGasMarketReport.pdf>
- International Renewable Energy Agency. (2017). *Biogas for domestic cooking*. Technology brief. [https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2017/Dec/IRENA\\_Biogas\\_for\\_domestic\\_cooking\\_2017.pdf](https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2017/Dec/IRENA_Biogas_for_domestic_cooking_2017.pdf)
- Jain, P. (2024). *India's clean cooking challenge: Can we look beyond subsidising LPG?* Institute for Energy Economics and Financial Analysis. <https://ieefa.org/resources/indias-clean-cooking-challenge-can-we-look-beyond-subsidising-lpg>
- Kaushik, K. R. (2025). Challenges and opportunities in India's city gas distribution (CGD) sector: A critical analysis. *International Journal of Scientific Research and Engineering Development*, 8(5). <https://ijsred.com/volume8/issue5/IJSRED-V8I5P124.pdf>
- Koonampilli, K. (2024). *Policy and market briefing 2024: India*. World Biogas Association. <https://www.worldbiogasassociation.org/wp-content/uploads/2024/10/WBA-India-Policy-and-Market-Briefing-2024.pdf>
- Koshy, S. M. (2019). Overcoming India's clean cooking challenge. *Down to Earth*. <https://www.downtoearth.org.in/energy/overcoming-india-s-clean-cooking-challenge-68562>
- Kostakis, I. (2020). Socio-demographic determinants of household electricity consumption: Evidence from Greece using quantile regression analysis. *Current Research in Environmental Sustainability*, 1, 23–30. <https://www.sciencedirect.com/science/article/pii/S2666049020300025>
- Lal, D. (2022). City gas distribution: Imperative to gas growth in India. *Gas Statistics Review*. <https://ngsindia.org/wp-content/uploads/2023/11/Feature-July-2022.pdf>
- Logan, C. (2023). Montreal joins growing wave of cities banning natural gas. *National Observer*. <https://www.nationalobserver.com/2023/10/27/news/montreal-joins-growing-wave-cities-banning-natural-gas>
- Louw, S. (n.d.). Fossil fuel bans and electrified construction. *Sustainable Development Code*. <https://sustainablecitycode.org/brief/fossil-fuel-bans-and-electrified-construction/>
- Mani, S., Agrawal, S., Jain, A., & Ganesan, K. (2020). *State of clean cooking energy access in India: Insights from the India Residential Energy Survey (IRES) 2020*. Council on Energy, Environment and Water. <https://www.ceew.in/sites/default/files/ires-report-on-state-of-clean-cooking-energy-access-in-india.pdf>
- Ministry of Environment, Forest and Climate Change (2025). List of activities finalized in India under Article 6.4 mechanism of Paris Agreement - reg [Office memorandum]. Government of India. <https://moef.gov.in/storage/tender/1755586183.pdf>



- Ministry of Health and Family Welfare. (2017). *National Family Health Survey (NFHS-4), 2015–16*. Government of India. <https://dhsprogram.com/publications/publication-fr339-dhs-final-reports.cfm>
- Ministry of Health and Family Welfare. (2022). *National Family Health Survey (NFHS-5) 2019–21: India Report*. Government of India. <https://dhsprogram.com/pubs/pdf/FR375/FR375.pdf>
- Ministry of Information and Broadcasting. (n.d.). *Universal access to clean fuel: Freedom from smoke*. Government of India. <https://static.pib.gov.in/WriteReadData/specificdocs/documents/2023/apr/doc2023424185701.pdf>
- Ministry of New and Renewable Energy. (2023). Status of adoption of green hydrogen in the country [Press release]. Government of India. <https://www.pib.gov.in/Pressreleaseshare.aspx?PRID=1989809>
- Ministry of New and Renewable Energy. (2025). Administrative approval for supplementary budget of Rs.140 Crore for implementation of umbrella scheme of National Bioenergy Programme for duration of FY 2021-22 to 2025-26 (Phase-I)- Reg. Government of India. <https://cdnbbsr.s3waas.gov.in/s3716e1b8c6cd17b771da77391355749f3/uploads/2025/09/202509171760844558.pdf>
- Ministry of Petroleum and Natural Gas. (2024a). LPG connections under PMUY [Press release]. Government of India. <https://www.pib.gov.in/PressReleaseIframePage.aspx?PRID=2043041>
- Ministry of Petroleum and Natural Gas. (2024b). Distribution of LPG connections to eligible beneficiaries [Press release]. Government of India. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2082375>
- Ministry of Petroleum and Natural Gas. (2025a). Irregularities in LPG distribution and subsidy transfer. Rajya Sabha, Starred Question 151. Government of India. [https://sansad.in/getFile/annex/268/AS151\\_W5phf9.pdf?source=pqars](https://sansad.in/getFile/annex/268/AS151_W5phf9.pdf?source=pqars)
- Ministry of Petroleum and Natural Gas. (2025b). Steps by government for door-to-door gas supply through pipeline [Press release]. Government of India. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2099188>
- Ministry of Power. (2023). Promotion of electricity-based cooking [Press release]. Government of India. <https://www.pib.gov.in/PressReleaseDetailm.aspx?PRID=1988253>
- Ministry of Statistics and Programme Implementation. (2016). Consumer price index numbers on base 2012=100 for rural, urban and combined for the month of March 2016 [Press release]. Central Statistics Office, Government of India. <https://cpi.mospi.gov.in/PDFFile/Press/PR%20March%202016.PDF>
- Ministry of Statistics and Programme Implementation. (2025). Consumer price index numbers on base 2012=100 for rural, urban and combined for the month of June 2025 [Press release]. Central Statistics Office, Government of India. <https://cpi.mospi.gov.in/PDFFile/Press/PR%20June%202025.pdf>



- Mittal, S., Ahlgren, E., & Shukla, P. R. (2018). Barriers to biogas dissemination in India: A review. *Energy Policy*, 112, 361–370. <https://www.sciencedirect.com/science/article/pii/S0301421517306869>
- Mumbai Port Authority. (2025). Exchange rate history: 2025. [https://mumbaiport.gov.in/show\\_content.php?lang=1&level=2&ls\\_id=1342&lid=1067](https://mumbaiport.gov.in/show_content.php?lang=1&level=2&ls_id=1342&lid=1067)
- Nair, A. (2025). Not a pipe dream anymore. *New Indian Express*. <https://www.newindianexpress.com/cities/thiruvananthapuram/2025/Aug/21/not-a-pipe-dream-anymore>
- National Energy Technology Laboratory. (2024, June 28). *FECM/NETL natural gas with hydrogen pipeline cost model (2024): Model results and comparative analysis*. [https://www.netl.doe.gov/projects/files/FECMNETLNaturalGaswithHydrogenPipelineCostModel2024ModelResultsandComparativeAnalysis\\_062824.pdf](https://www.netl.doe.gov/projects/files/FECMNETLNaturalGaswithHydrogenPipelineCostModel2024ModelResultsandComparativeAnalysis_062824.pdf)
- National Sample Survey Office. (2023). *Multiple indicator survey in India. NSS 78th round 2020–2021*. Ministry of Statistics and Programme Implementation, Government of India. [https://www.mospi.gov.in/sites/default/files/publication\\_reports/MultipleIndicatorSurveyinIndiaf.pdf](https://www.mospi.gov.in/sites/default/files/publication_reports/MultipleIndicatorSurveyinIndiaf.pdf)
- National Sample Survey Office. (2024). *Comprehensive annual modular survey. NSS 79th round 2022–2023*. Ministry of Statistics and Programme Implementation, Government of India. [https://www.mospi.gov.in/sites/default/files/publication\\_reports/CAMS%20Report%20October%20N.pdf](https://www.mospi.gov.in/sites/default/files/publication_reports/CAMS%20Report%20October%20N.pdf)
- National Statistical Office. (2019). *Drinking water, sanitation, hygiene, and housing condition in India. NSS 76th round 2018*. Ministry of Statistics and Programme Implementation, Government of India. [https://www.mospi.gov.in/sites/default/files/NSS7612dws/Report\\_584\\_final.pdf](https://www.mospi.gov.in/sites/default/files/NSS7612dws/Report_584_final.pdf)
- NewsGram. (2025). Indian oil companies to clock strong earnings in FY26 on lower prices, reduced LPG losses. *NewsGram*. <https://www.newsgram.com/economy/2025/08/27/indian-oil-companies-strong-earnings-in-fy26>
- Office of the Registrar General & Census Commissioner, India. (2011). *Census of India 2011*. Ministry of Home Affairs, Government of India. <https://censusindia.gov.in/>
- Patnaik, S., Jha, S., Pradhan, K., & Jain, A. (2020). *Energy safety nets: India country study* (Council on Energy, Environment and Water publication). Sustainable Energy for All. [https://www.seforall.org/system/files/2020-02/ESN-India\\_SEforALL.pdf](https://www.seforall.org/system/files/2020-02/ESN-India_SEforALL.pdf)
- Planning Commission. (2002). *Evaluation study on national project on biogas development*. Government of India. <https://dmeo.gov.in/sites/default/files/2019-10/Evaluation%20study%20on%20National%20Project%20on%20Biogas%20Development.pdf>
- Petroleum and Natural Gas Regulatory Board. (2025a). *Compressed biogas integration in India's gas economy: Progress and prospects*. Government of India. [https://pngrb.gov.in/pdf/CBG/20250826\\_CBG.pdf](https://pngrb.gov.in/pdf/CBG/20250826_CBG.pdf)
- Petroleum and Natural Gas Regulatory Board. (2025b). *PNGRB MIS report*. Government of India. <https://pngrb.gov.in/data-bank/20250531-CGD-MIS-Report.pdf>



- Petroleum and Natural Gas Regulatory Board. (2025c). *Progress of PNG D, CNG and pipeline (inch-km) in the country—July 2025*. Government of India. <https://pngrb.gov.in/data-bank/20250731-CGD-MIS.pdf>
- Petroleum Planning and Analysis Cell. (n.d.-a). Price build-up of PDS kerosene at Mumbai. [https://www.bharatpetroleum.in/pdf/etropricesheet/pp\\_9\\_pricebuildupsensitiveproducts\\_1\\_2\\_3.pdf](https://www.bharatpetroleum.in/pdf/etropricesheet/pp_9_pricebuildupsensitiveproducts_1_2_3.pdf)
- Petroleum Planning and Analysis Cell. (n.d.-b). Distributor commission on domestic LPG. <https://ppac.gov.in/dealers-distributors-commission-on-petrol-diesel-pds-kerosene-domestic-lpg/dealers-commission-on-petrol-and-diesel>
- Petroleum Planning and Analysis Cell. (2016). *Ready reckoner: Oil industry information at a glance*. Ministry of Petroleum & Natural Gas, Government of India. [https://ppac.gov.in/download.php?file=rep\\_studies/1673523430\\_201607140526572624198ReadyReckonerJune2016\\_\(1\)\\_compressed.pdf](https://ppac.gov.in/download.php?file=rep_studies/1673523430_201607140526572624198ReadyReckonerJune2016_(1)_compressed.pdf)
- Petroleum Planning and Analysis Cell. (2021). *India's oil & gas ready reckoner: Oil industry information at a glance*. Ministry of Petroleum & Natural Gas, Government of India. [https://ppac.gov.in/download.php?file=rep\\_studies/1670473880\\_202109010920476205160PPACRRJuly2021webversion.pdf](https://ppac.gov.in/download.php?file=rep_studies/1670473880_202109010920476205160PPACRRJuly2021webversion.pdf)
- Petroleum Planning and Analysis Cell. (2024a). *LPG profile report 2023–2024*. Ministry of Petroleum and Natural Gas, Government of India. [https://ppac.gov.in/download.php?file=rep\\_studies/1716870573\\_LPG\\_Profile\\_Report\\_FY\\_2023-24-Web.pdf](https://ppac.gov.in/download.php?file=rep_studies/1716870573_LPG_Profile_Report_FY_2023-24-Web.pdf)
- Petroleum Planning and Analysis Cell. (2024b). *Monthly report on natural gas production, availability and consumption, March 2024*. Ministry of Petroleum and Natural Gas, Government of India. [https://cgdindia.net/wp-content/uploads/2024/06/1714107405\\_Monthly-Gas-Report-Mar-2024-WebV.pdf](https://cgdindia.net/wp-content/uploads/2024/06/1714107405_Monthly-Gas-Report-Mar-2024-WebV.pdf)
- Petroleum Planning and Analysis Cell. (2025a). *Snapshot of India's oil and gas data, monthly ready reckoner, August-25*. Ministry of Petroleum and Natural Gas, Government of India. [https://ppac.gov.in/download.php?file=rep\\_studies/1758005745\\_Snapshot\\_of\\_Indias\\_Oil%20Gas\\_data-August\\_2025\\_A5\\_Final\\_01.pdf](https://ppac.gov.in/download.php?file=rep_studies/1758005745_Snapshot_of_Indias_Oil%20Gas_data-August_2025_A5_Final_01.pdf)
- Petroleum Planning and Analysis Cell. (2025b). *Subsidies/under recoveries to oil marketing companies (OMCs) on sale of sensitive petroleum products (Rs. crore)*. Ministry of Petroleum and Natural Gas, Government of India. <https://ppac.gov.in/subsidy/subsidies-under-recoveries-to-oil-marketing-companies-omcs-on-sale-of-sensitive-petroleum-products-rs-crore>
- Petroleum Planning and Analysis Cell. (2025c). *India's oil & gas ready reckoner: Oil & gas industry information at a glance. FY 2024-25*. Ministry of Petroleum & Natural Gas, Government of India. [https://ppac.gov.in/download.php?file=rep\\_studies/1747978983\\_Final\\_Ready\\_Reckoner\\_FY\\_2024-25\\_Ver01.pdf](https://ppac.gov.in/download.php?file=rep_studies/1747978983_Final_Ready_Reckoner_FY_2024-25_Ver01.pdf)
- Poten & Partners. (2015). Poten LPG opinion: Quantifying the India delay factor. <https://www.hellenicshippingnews.com/wp-content/uploads/2015/08/IndiaWebsiteArticle.pdf>



- Powell, L., Sati, A., & Tomar, V. K. (2023). *Liquefied petroleum gas: Supply challenges in India*. Observer Research Foundation. [https://www.orfonline.org/expert-speak/liquefied-petroleum-gas-supply-challenges-in-india?utm\\_source=chatgpt.com](https://www.orfonline.org/expert-speak/liquefied-petroleum-gas-supply-challenges-in-india?utm_source=chatgpt.com)
- Press Information Bureau. (2023). *National Efficient Cooking Programme launched, to promote affordable and energy-efficient induction cookers* [Press release]. Government of India. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=1974191>
- Press Trust of India. (2025). Govt tweaks city gas policy, moves to advance quarterly allocations. *Business Standard*. [https://www.business-standard.com/industry/news/govt-tweaks-city-gas-policy-moves-to-advance-quarterly-allocations-125041800772\\_1.html](https://www.business-standard.com/industry/news/govt-tweaks-city-gas-policy-moves-to-advance-quarterly-allocations-125041800772_1.html)
- Raizada, S., Sharma, D., Laan, T., & Jain, S. (2024). *Mapping India's energy policy 2023. A decade in action*. International Institute for Sustainable Development. <https://www.iisd.org/publications/report/mapping-india-energy-policy-2023>
- Ribeiro, C., Delmonte, B., Sliepen, J., & Maas, S. (2025). Techno-economic analysis on implementing hydrogen in a combined heat and power plant in Luxembourg to reduce carbon emissions. *Sustainability*, 17(8), 3369. <https://doi.org/10.3390/su17083369>
- Ritchie, H. (2021). *How many people do not have access to clean fuels for cooking?* Our World in Data. <https://ourworldindata.org/no-clean-cooking-fuels>
- Sehbag, P., & Khurana, T. (2025). PNG: Beyond business as usual. *New Indian Express*. <https://www.newindianexpress.com/business/2025/Jul/06/png-beyond-business-as-usual-2>
- Shankar, A., Quinn, A., Dickinson, K., Williams, K., Williams, K., Masera, O., Charron, D., Jack, D., Hyman, J., Pillarisetti, A., Bailis, R., Kumar, P., Ruiz-Mercado, & Rosenthal, J. (2020). Everybody stacks: Lessons from household energy case studies to inform design principles for clean energy transitions. *Energy Policy*, 141, 111468. <https://doi.org/10.1016/j.enpol.2020.111468>
- Sharma, S., Moerenhout, T., Aklin, M., & Bajaj, K. (2021). *How to target LPG subsidies in India: Step 2. Evaluating policy options in Jharkhand* (Global Subsidies Initiative report). International Institute for Sustainable Development. <https://www.iisd.org/system/files/2021-04/target-lpg-subsidies-india-jharkhand.pdf>
- Sharma, S., Singh, C., Beaton, C., Sharma, A., Merrill, L., Laan, T., Zinecker, A., & Kitson, L. (2019). *Gender and fossil fuel subsidy reform in India: Findings and recommendations* (Global Subsidies Initiative report). International Institute for Sustainable Development. <https://www.iisd.org/system/files/publications/gender-fossil-fuel-subsidy-reform-india.pdf>
- Singh, A. (2025). India excludes cookstoves from Article 6 eligibility list. *Carbon Pulse Premium*. <https://carbon-pulse.com/438706/>
- Sistema.bio. (2025). Sistema.bio super pollutant destruction and clean energy carbon program sets a new quality standard receiving one of BeZero's highest ratings [Press release]. <https://sistema.bio/blog/sistema-bio-bezero-rating-carbon-program/>
- Times of India*. (2024). Global firm to set up 2,250 domestic biogas plants in UP. *Times of India*. <https://timesofindia.indiatimes.com/city/lucknow/sistemabio-launches-2250-biogas-plants-in-uttar-pradesh-to-boost-rural-energy-and-farming/articleshow/114359954.cms>



- Times of India*. (2025). PNGRB price order: Regulator tells CGD firms to charge one PNG rate; warns against misuse of subsidised gas. *Times of India*. <https://timesofindia.indiatimes.com/business/india-business/pngrb-price-order-regulator-tells-cgd-firms-to-charge-one-png-rate-warns-against-misuse-of-subsidised-gas/articleshow/122796262.cms>
- Times News Network. (2025). Andhra Pradesh government to distribute induction stoves to 11,400 Anganwadi centres from today. *Times of India*. <https://timesofindia.indiatimes.com/city/vijayawada/andhra-pradesh-government-to-distribute-induction-stoves-to-11400-anganwadi-centres-from-today/articleshow/121629265.cms>
- United Nations Department of Economic and Social Affairs. (2018). *68% of the world population projected to live in urban areas by 2050, says UN*. <https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html>
- United States Environmental Protection Agency. (2025, January). *Methane mitigation: Lessons learned from India's compressed biogas (renewable natural gas) projects*. Prepared for the Global Methane Initiative. [https://www.globalmethane.org/documents/CBG\\_Report\\_%20January%202025.pdf](https://www.globalmethane.org/documents/CBG_Report_%20January%202025.pdf)
- World Health Organization. (n.d.). *Household air pollution data*. <https://www.who.int/data/gho/data/themes/air-pollution/household-air-pollution>
- Zhang, G., Wang, G., Farhangi, H., & Palizban, A. (2017). Data mining of smart meters for load category based disaggregation of residential power consumption. *Sustainable Energy, Grids and Networks*, 10, 92–103. <https://www.sciencedirect.com/science/article/abs/pii/S2352467716301278>



## Appendix A. Biogas vs. Liquefied Petroleum Gas Lifetime Cost Comparison Model

To assess the economic viability of a household-scale biogas plant, we developed a payback period model that compares the lifetime cost of biogas use with the cost of using liquefied petroleum gas (LPG) cylinders across different user categories. The model includes key assumptions on input prices, system costs, fuel usage, and opportunity costs.

### LPG Cylinder Price Categories

The model incorporates three categories of LPG refill prices:

1. **Current refill price for Pradhan Mantri Ujjwala Yojana (PMUY) users:** Since PMUY beneficiaries receive an extra direct subsidy of INR 300 per refill (into their bank account right after purchasing the LPG refill), their LPG refills (14.2 kg) are effectively priced at INR 553 per refill.
2. **Current refill price for non-PMUY users:** Currently, general (non-PMUY) domestic consumers receive LPG refills (14.2 kg) at a price of INR 853 per refill. Even though these consumers do not receive any direct subsidies, they continue to receive refills at a price much below their actual market price.
3. **Completely non-subsidized market price:** We derived this from the LPG price buildup model in Appendix B. Currently, no domestic consumer in India pays this price, but it is around INR 1,110.

Each of the above categories reflects different levels of government subsidy and market exposure, which significantly influence the comparative economics of LPG versus biogas.

### Biogas Plant Specification and Assumptions

The analysis is based on a 2 m<sup>3</sup> Deenbandhu-model biogas plant,<sup>13</sup> which has an estimated capital cost of INR 39,500 (without subsidy). The plant's operational lifespan is assumed to be 15 years. The model applies standard financial parameters, including a discount rate and projected inflation in LPG prices, to determine the lifetime cost of LPG usage for different levels of LPG consumption under each of the three price categories.

---

<sup>13</sup> A Deenbandhu-model biogas plant is a popular, low-cost, fixed-dome type of digester widely used in India, developed in 1984 by Action for Food Production. The structure consists of a spherical or hemispherical brick masonry digester, built mostly underground, with a fixed (non-moving) dome gas holder. This design minimizes construction materials and costs compared to older models (such as the floating-drum Khadi and Village Industries Commission model), while maintaining efficiency. The feedstock, typically cattle dung and water, is fed through an inlet into the digester, where it anaerobically decomposes to produce biogas under the dome and bio-slurry as a byproduct. The Deenbandhu model is the standard for rural household-scale biogas in India and constitutes about 90% of all Indian biogas plants.



## Cow Dung Requirement and Opportunity Cost

A 2-m<sup>3</sup> biogas plant requires 50 kg of cow dung per day, totaling 18,250 kg annually. The model estimates and includes the opportunity cost of dung (based on the value of alternative uses foregone), and we fix its cost as 6 paisa (INR 0.06) per kg, translating into a spending of INR 1,095 per year on dung alone over the plant's 15-year lifespan. This is calculated using annualized opportunity cost figures adjusted for the discount rate and inflation, both assumed at 5% per annum.

## Subsidy Consideration

The model assesses the payback period both with and without a 40% capital subsidy on biogas plants, as available under the Ministry of New and Renewable Energy GOBARdhan scheme. This enables an understanding of how financial support influences the adoption feasibility of biogas systems.

All of the above parameters are found in Table A1.

**Table A1.** Price and subsidy assumptions for LPG and biogas

	Price (INR)
<b>LPG consumer type</b> (price of 14.2 kg LPG refill)	
PMUY	553
Non-PMUY	853
Non-subsidized price	1,110
<b>Biogas</b>	
Cost of biogas plant	39,500
Lifetime cost of input	16,425 (1,095 per year multiplied by a lifetime of 15 years)
Subsidy amount	15,800 (40% of the actual cost of a biogas plant)
Effective cost to consumer	40,125 (39,500 + 16,425 - 15,800)

Source: Authors.

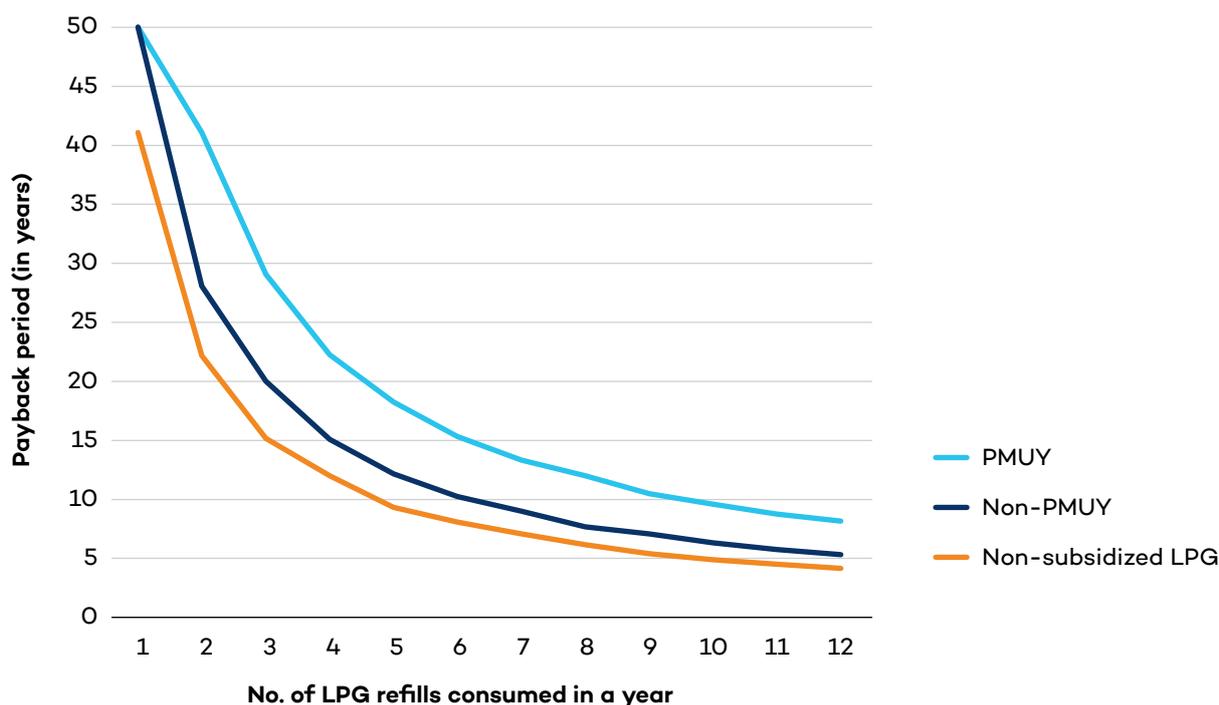
## Payback Period Estimation

The model calculates and compares the time, in months and years, required for the biogas plant to recover its investment cost through savings on LPG expenses. While the payback period for biogas plants (with 40% subsidy) is presented in Figure 6 of the report, we present the payback period results without any subsidy on biogas plants in this section.



Figure A1 presents payback period results across varying annual LPG cylinder usage levels and user categories (PMUY, non-PMUY, and consumers purchasing non-subsidized LPG from the open market). Just like Figure 6, if the current annual LPG consumption (in terms of the number of 14.2-kg LPG refills consumed in a year) for a consumer category is higher, their payback period for biogas will become lesser, as they will save more money per year (which they were spending on LPG), after shifting to biogas for cooking.

**Figure A1.** Payback period comparison between LPG and biogas plant without any subsidy on the upfront cost of biogas plant)



Source: Authors.

Note: Three lines in Figure A1 show the payback period for biogas plant for three categories of LPG-using consumers (PMUY, non-PMUY, and consumers purchasing non-subsidized LPG from the open market).

## Model Flexibility

Users can adjust key inputs, such as biogas plant cost, subsidy percentage, and LPG cylinder prices across user categories.

This makes the tool adaptable to different geographies, policy contexts, and market conditions, which enhances its utility for policy analysis and implementation planning.



## Appendix B. Liquefied Petroleum Gas Price Buildup Model

Table B1 lists all the variables used to create the liquefied petroleum gas (LPG) price buildup model for India. We also explain all these variables in detail below the table.

**Table B1.** Assumptions for LPG price buildup model for India (on April 8, 2025)

	Variable	INR per 14.2-kg LPG refill
1	International price of LPG (Saudi Aramco contract price)	740.43
2	Ocean freight from the Arab Gulf to Jamnagar	97.11
3	Import charges (insurance, ocean loss, Letter of Credit charges, port dues)	5.94
4	Storage and distribution cost	15.34
5	Bottling charges	59.58
6	Inland freight	51.13
7	Cost of working capital	2.80
8	Delivery charges (from bottling plan to distributor)	15.4
9	Goods and services tax (GST) (5% on the sum of 1 to 8)	49.39
10	Distributors' commission	73.08
<b>Total expected market price per 14.2 kg LPG refill</b>		<b>1,110.2</b>

Source: Authors' compilation.

### 1. International price of LPG (Saudi Aramco contract price)

To estimate the international price of LPG (Saudi Aramco contract prices), we first obtain the price of propane and butane (in USD per MT). On April 8, 2025, the price of LPG for domestic consumers in India was revised to INR 853 per 14.2-kg refill (New Delhi price). During this time (April 2025), the Saudi Aramco prices of propane and butane were USD 615 and USD 605 per MT, respectively (3Mco, n.d.).

We assumed that LPG consists of propane and butane in a 1:1 ratio by weight, and based on this assumption, we computed the average international price per MT of LPG. We then converted these prices from USD to INR, at the prevailing exchange rate on April 8, 2025.

**Table B2.** Using propane and butane prices to derive LPG prices for April 2025

		Price (USD)	Price (INR) <sup>14</sup>
Price per MT on April 8, 2025	Propane	615	
	Butane	605	
	LPG (50% propane, 50% butane)	610	
Price per 14.2 kg LPG refill		8.662	740.43

Source: Authors' compilation based on 3Mco, n.d.

## 2. Ocean freight from the Arab Gulf to Jamnagar (INR/14.2-kg refill)

While there was no reliable recent estimate available on ocean freight from the Arab Gulf to India, some anecdotal evidence indicates that it generally remains around USD 80 per MT. In fact, it reached a high of USD 120 per MT in June 2015 (Poten & Partners, 2015). With an average of USD 80 per MT, the cost of ocean freight comes out to INR 6.84 per kg, which then translates to INR 97.11 for a 14.2-kg refill.

## 3. Import charges (insurance, ocean loss, Letter of Credit charges, port dues) (INR/14.2-kg refill)

There is no reliable estimate available for LPG import charges in India. Therefore, we relied on Bharat Petroleum's price buildup of domestic subsidized LPG (14.2-kg refill) in Delhi from March 1, 2016, onwards (Petroleum Planning and Analysis Cell [PPAC], n.d.-a). Bharat Petroleum reported an import charge of INR 3.86 per refill from March 1, 2016. Applying an inflation rate of 54% between March 2016 and April 2025 results in an import charge of INR 5.94 per refill in April 2025 (Ministry of Statistics and Programme Implementation, 2016; 2025).

## 4. Storage and distribution cost and return on investment (INR/14.2-kg refill)

The same price buildup document from Bharat Petroleum reports a storage and distribution cost of INR 9.96 per refill (PPAC, n.d.-a). Applying a 54% rate of inflation, this comes out to INR 15.34 in April 2025.

## 5. Bottling charges (INR/14.2-kg refill)

Bottling charges are determined by adding the bottling charges and other charges per refill (PPAC, n.d.-a). While bottling charges were reported to be INR 20.58 in March 2016, other charges for cylinder cost were INR 18.11 per refill. Adding these two gives a total value of INR 39.69 per refill in March 2016, and applying an inflation rate of 54% leads to INR 58.58 per refill in April 2025.

<sup>14</sup> The USD to INR exchange rate on April 8, 2025, was USD 1 = INR 85.48 (Mumbai Port Authority, 2025).



## **6. Inland freight (INR/14.2-kg refill)**

The price buildup document from Bharat Petroleum reports inland freight as INR 33.2 in March 2016. Applying an inflation rate of 54% makes it INR 51.13 per refill in April 2025.

## **7. Cost of working capital (INR/14.2-kg refill)**

The cost of working capital was reported as INR 1.82 in March 2016, and applying an inflation rate of 54% makes it INR 2.80 per refill in April 2025.

## **8. Delivery charges (from bottling plant to distributor)**

The cost of delivering cylinders from bottling plants to distributors' locations was reported as INR 10 per refill in March 2016, and applying an inflation rate of 54% makes it INR 15.4 per refill in April 2025.

## **9. GST (INR/14.2-kg refill)**

Since GST is added before adding the distributor's commission, in order to find out the exact amount of GST, we need to add all the values from point 1 to point 8 (estimated in Table B1) and then apply a 5% GST (point 9). Adding values from 1 to 9 gives us a total value of INR 987.73 per refill, and an effective GST amount of INR 49.39 per LPG refill. Adding the GST value takes the total value of refill to INR 1037.12.

## **10. Distributors' commission for home delivery of LPG refills (INR/14.2-kg refill)**

Finally, we add an LPG distributors' commission of INR 73.08, as reported by the PPAC (n.d.-b).

By adding 1 to 10, we arrive at the actual market price of a 14.2-kg LPG refill, which stands at INR 1,110.2 per refill.

## **11. Retail price of a 14.2-kg LPG refill (INR)**

To compare the market value that we obtained in steps 1 to 10 with the actual retail prices, we obtained data for Delhi from the Indian Oil Corporation Limited (Indian Oil, n.d.). We found that prices for domestic LPG refills were changed to INR 853 per refill on April 8, 2025, which indicates that oil marketing companies are incurring an effective under-recovery of INR 253 for each refill sold to domestic consumers in India.

©2026 International Institute for Sustainable Development  
Published by the International Institute for Sustainable Development

**Head Office**

111 Lombard Avenue, Suite 325  
Winnipeg, Manitoba  
Canada R3B 0T4



[iisd.org](https://www.iisd.org)