Just transitions to clean energy: Bottom-up creation of pathways for low-income urban settlements in Odisha

[Study period: June 2022 – October 2024]

JANAAGRAHA

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Premise of the Study

What does a 'Just Energy Transition' mean?

"Ensuring India's energy transition is just, equitable, and people centric."
(Just Transitions, The Energy and Resources Institute (TERI), India)

"A 'Just Transition for All' initiative puts people and communities at the centre of the transition. ***The initiative works with stakeholders to create the plans, policies, and reforms needed to mitigate environmental impacts; support impacted people and build a new clean energy future****."*
(World Bank)

"To avert catastrophe, we must now radically switch to a sustainable, net-zero future. This transition needs to happen fast, but it also has to happen in a fair and inclusive way.
If done right, the transition offers immense opportunities: ***a systems change in which all communities, workers, and countries are lifted up."***
(United Nations Development Program)

"The just transition ***seeks to centre the interests of those that are most affected by the low-carbon transition****, including workers, vulnerable communities, suppliers of goods and services, specifically small and medium-sized enterprises (SMEs), and* ***consumers****. This approach strongly advocates the inclusion of these stakeholders in shaping the net zero transition so that* ***no one is left behind****."*
(London School of Economics and Political Science, Grantham Research Institute on Climate Change and the Environment)

Focus of this study

Urban poor in Just Transitions

- In cities, the urban poor are the most vulnerable to climate change due to:
  - Spatial reasons and
  - Limited mitigation and coping ability given lack of finance, knowledge, and access to markets and technology.

- Urban poor are also impacted by climate change and energy transition in different ways. For instance,
  - From a supply perspective, those whose livelihood is directly impacted as the world moves away from coal mining for electricity, or
  - From a **demand perspective**, those who are consumers of energy and need to/aspire to move to cleaner fuels for quality-of-life reasons - health, availability, affordability, self-reliance, etc. and/or sensitivity towards environment.

- However, in climate change adaptation and mitigation efforts (programs and interventions),

The urban poor are often left out presuming their primary concerns are limited to water, sanitation, housing security, employment, income stability, and living costs.

Even if they are included,
- Urban poor are considered as 'beneficiaries' instead of including them in decision making, and
- Flow of funds, transfer of knowledge and technology, etc. is top down.[1]

- **This Study aims to CAPTURE AND ECHO THE VOICES OF THE URBAN POOR (their circumstances, preferences, and aspirations) IN THE ECO-SYSTEM, to include them (literally and figuratively) in the journey of SYSTEMIC JUST TRANSITIONS towards cleaner energy at the household level (specifically cooking and electric appliances).**

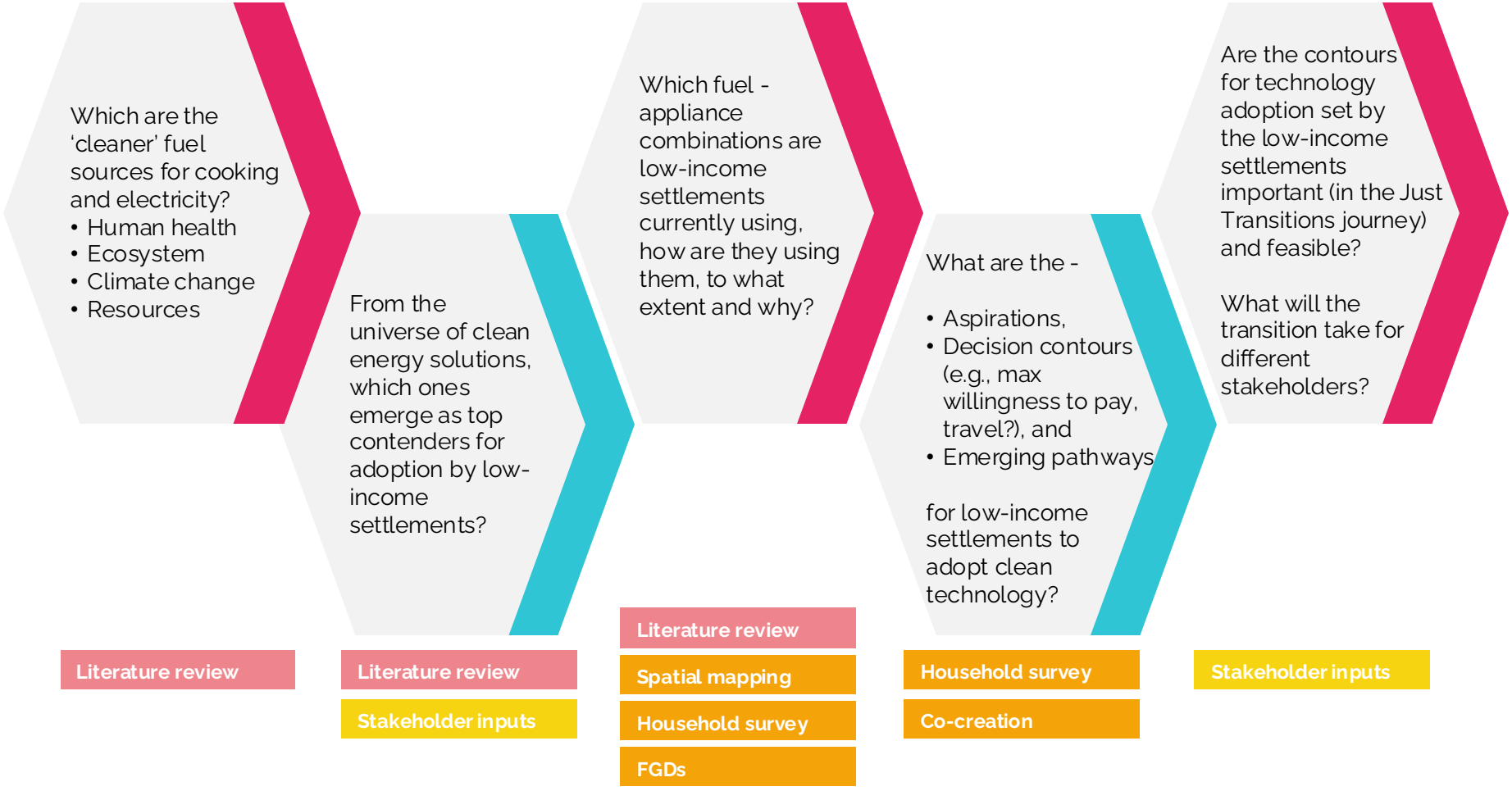
1: Matthews, N., Vora, S. and Patel, S. (2023, October 19). Climate action: How to put communities first. Idr.

Study framework and broad methodology

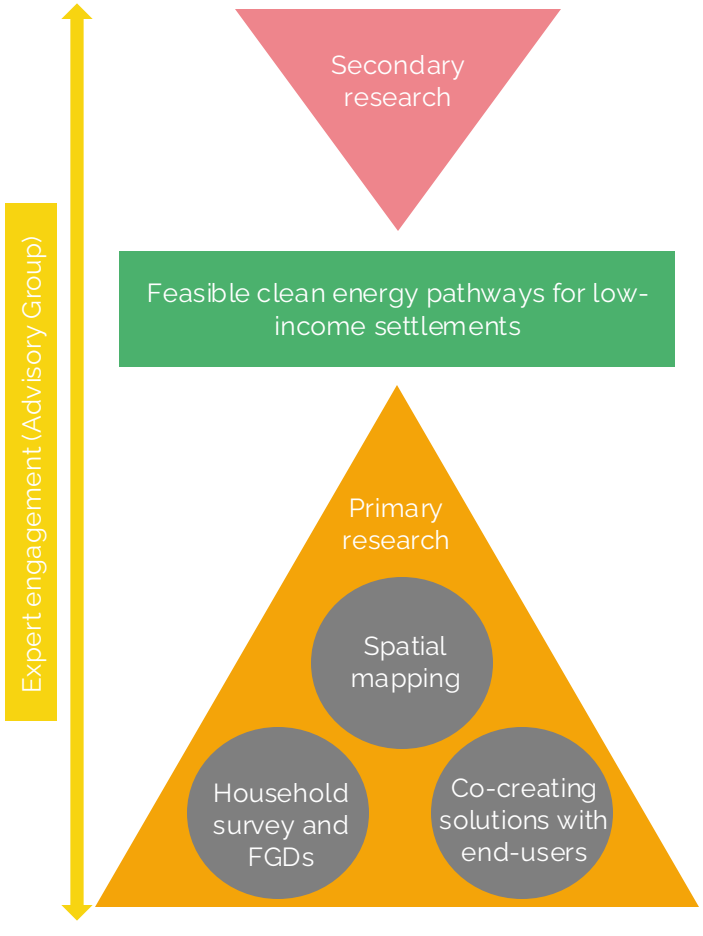
The big research question

What are just, equitable and feasible pathways for energy transitions for household uses (cooking and electric appliances) for urban poor in Odisha?

Study framework



Approach and methodology



1. Understand different aspects of cities in Odisha (e.g., demographic and climate profiles, cultural characteristics, urban governance structure, energy choice/consumption patterns).
2. Study relevant government schemes.
3. Identify which sources of energy are clean based on a life cost analysis framework, and research contextual clean energy solutions.
4. Select final cities, settlements and study focus areas using insights from secondary research and reconnaissance visits.
5. Undertake primary survey (5368 households)
   - Pre-survey citizen and local stakeholders' interaction,
   - Spatial mapping to build an informed understanding of sampled settlements,
   - Survey instrument design,
   - Sampling,
   - Survey.
6. Analyze survey data and undertake participatory design of clean energy solutions through FGDs/interviews with citizens and stakeholders.
7. Draft clean energy solutions, recommendations and opportunity areas for different stakeholders.

Secondary research provided critical inputs for primary research

What are the clean sources of energy?

What is clean?

Understanding or definitions of 'clean energy' are different across international frameworks and agencies. Examples -

Intergovernmental Panel on Climate Change (IPCC) - Special Report on Renewable Energy Sources and Climate Change Mitigation:	• Provides definitions of 'renewable energy', 'energy access', 'low-carbon technology'.
International Energy Agency (IEA) - World Energy Outlook Report, 2022	• Clean cooking systems are those that release **less harmful pollutants**, are **more efficient and environmentally sustainable than traditional cooking** options that make use of solid biomass (such as a three-stone fire), coal or kerosene. This refers to improved cook stoves, biogas/biodigester systems, electric stoves, LPG, natural gas or ethanol stoves.
World Health Organisation (WHO) - Clean Household Energy Solutions Toolkit	• Clean cooking fuels and technologies are those that attain the fine **particulate matter (PM2.5) and carbon monoxide (CO)** levels recommended in the 'WHO Guidelines for indoor air quality: household fuel combustion (2014)'.
City of San Jose	• "Clean" energy is energy that **emits little to no greenhouse gas emissions** and includes renewable and carbon-free sources.

Is clean energy really 'clean'?

- By most common definitions, clean energy is energy generated from sources that do not emit greenhouse gases (GHG).
- In truth, clean energy is a broad term with a fluctuating definition and a complicated lifecycle.
- What are some of the trade-offs? What parameters should we considered to designate a fuel/energy source as "clean"?

This Study adopts a life cycle analysis approach to assess 'extent of clean' as it looks at impact of each source from cradle to grave.

See Appendix A - section E for a detailed literature review..

Clean energy framework

Undertook an exhaustive analysis of fuels used for for cooking and electricity generation:

Considered 12 and 7 most used energy sources in India for cooking and electricity, respectively.

- **Cooking:** Firewood, Crop residue, dung cake, hard coal, kerosene, charcoal, biomass pellets, ethanol from sugarcane, biogas from dung, LPG, natural gas, electricity.
- **Electricity:** Hard coal, natural gas, nuclear power, hydropower, concentrated solar power, solar photovoltaic and wind power.

Used a Life – Cycle Analysis (LCA) approach.

- Assesses the impact of different energy sources modelled over the whole life cycle of each source, from cradle to grave.
- Ensures that all flows of materials and energy, waste and emissions, are accounted for from extraction to end-of-life treatment.

Considered 10 and 9 impact categories for cooking and electricity respectively across 4 key buckets.

- Human health
- Ecosystem
- Climate change
- Resources

Undertook quantitative (QT) and qualitative (QL) assessment from secondary research.

- Life cycle assessment of cookstove fuels in India and China, US EPA, 2016.
- Life cycle assessment of cookstove fuels in India, China, Kenya and Ghana, US EPA, 2017.

Note: After screening over a dozen studies, we conducted a detailed evaluation of 6 studies. We only considered those LCA studies which provided a comparative assessment of multiple energy sources at parity and in the Indian context.

Clean energy framework: Cooking

	Impact category 1								Impact category 2									
Fuel choices for cooking	**Impact on human health**								**Impact on ecosystem**									
	Particulate matter formation		**Photochemical oxidant formation**		**Black carbon and short- lived climate pollutants**		Avg. QT score	Avg. QL score	**Freshwater eutrophication**		**Terrestrial Acidification**		**Ozone Depletion**		**Water Depletion**		Avg. QT score	Avg. QL score
	QT	QL	QT	QL	QT	QL			QT	QL	QT	QL	QT	QL	QT	QL		
Fuel A (e.g., LPG)																		
Fuel B (e.g., firewood)																		
Fuel C (e.g., Kerosene)																		

Note: Extent of clean is estimated using a relative approach*. For each parameter, we calculated the median value across all fuels, and then scored each fuel for each parameter based on its difference from that median value.*

See Appendix B for detailed calculations.

Clean energy framework: Cooking

Impact category 3 **Impact category 4** **Across all 4 impact categories**

Fuel choices for cooking	Impact on climate change				Impact on resources						Average QT score	Average QL score	Average of QT and QL score	Ranking
	Climate change		Avg. QT score	Avg. QL score	Fossil depletion		Cumulative Energy Demand		Avg. QT score	Avg. QL score				
	QT	QL			QT	QL	QT	QL						
Fuel A (e.g., LPG)														
Fuel B (e.g., firewood)														
Fuel C (e.g., Kerosene)														

Note: Extent of clean is estimated using a relative approach*. For each parameter, we calculated the median value across all fuels, and then scored each fuel for each parameter based on its difference from that median value.*

See Appendix B for detailed calculations.

Clean energy framework: Electricity

	Impact category 1								Impact category 2							
Fuel choices for cooking	**Impact on human health**								**Impact on ecosystem**							
	Ionising radiation		**Human toxicity - non-carcinogenic**		**Human toxicity - carcinogenic**		Avg. QT score	Avg. QL score	**Freshwater eutrophication**		**Land use**		**Water Depletion**		Avg. QT score	Avg. QL score
	QT	QL	QT	QL	QT	QL			QT	QL	QT	QL	QT	QL		
Fuel A (e.g., Hard coal)																
Fuel B (e.g., solar PV)																
Fuel C (e.g., wind)																

Note: Extent of clean is estimated using a relative approach*. For each parameter, we calculated the median value across all fuels, and then scored each fuel for each parameter based on its difference from that median value.*

See Appendix B for detailed calculations.

Clean energy framework: Electricity

Impact category 3 **Impact category 4** **Across all 4 impact categories**

Fuel choices for cooking	Impact on climate change				Impact on resources						Average QT score	Average QL score	Average of QT and QL score	Ranking
	Climate change		Avg. QT score	Avg. QL score	Mineral resource scarcity		Cumulative Energy Demand		Avg. QT score	Avg. QL score				
	QT	QL			QT	QL	QT	QL						
Fuel A (e.g., Hard coal)														
Fuel B (e.g., solar PV)														
Fuel C (e.g., wind)														

Note: Extent of clean is estimated using a relative approach*. For each parameter, we calculated the median value across all fuels, and then scored each fuel for each parameter based on its difference from that median value.*

See Appendix B for detailed calculations.

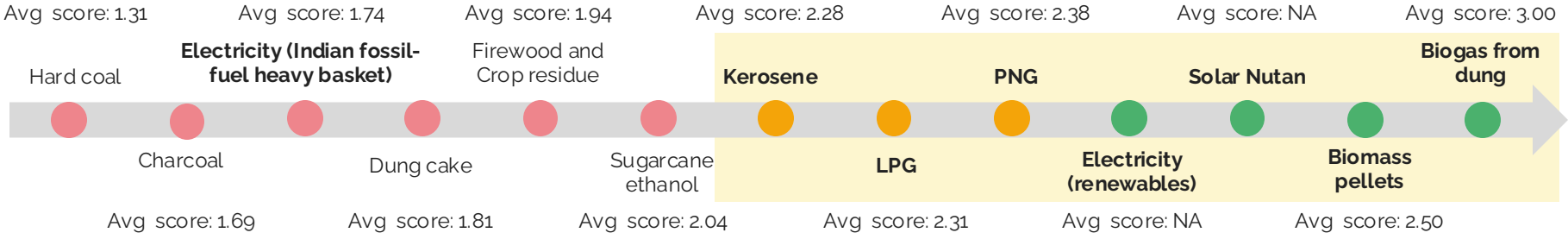
Max score: 3 (most clean relative to other fuels). Score is an average of quantitative and qualitative assessment.

Note: This diagram is not to scale and is only indicative.

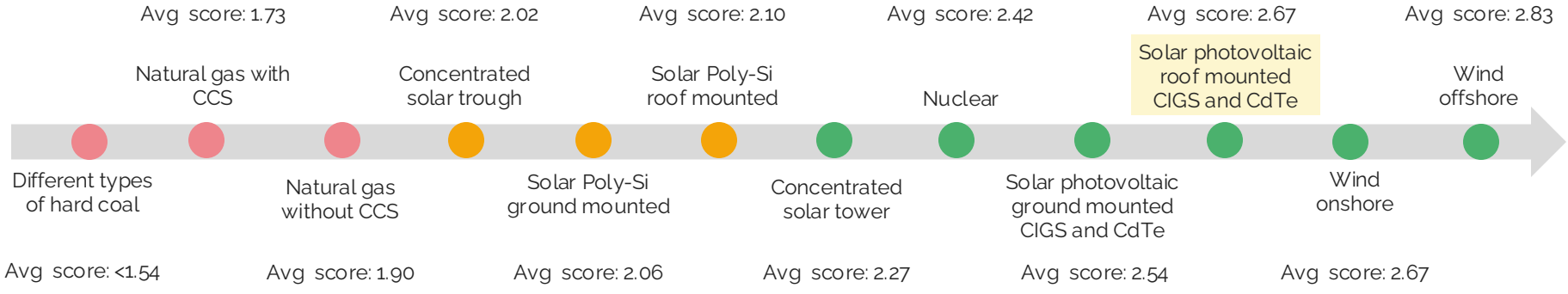
Fuels focused on for further analysis in the study.

Extent of clean of different fuels

Cooking:



Electricity:



Notes:

- *There is no data available to assess extent of clean of cooking directly from solar and renewable grid electricity. This is an identified gap.*
- *There is no data available to assess extent of clean of hydropower as its impact varies significantly based on size of the plant. This is an identified gap.*

City and settlement selection

Initial shortlisting of cities

- Assessed cities through a city selection framework: Shortlisted 25 cities from 114 Odisha cities, and then 6 front runner cities (Table 1) and finally 3 selected cities.

- Parameters used for selection: mix of listed and delisted slums (JAGA mission), mix of coastal/tribal, diversity in energy choices & patterns, logistics' feasibility, etc.

- Parameters assessed using knowledge from Janaagraha's local teams in Odisha and Project Advisory Group (PAG), reconnaissance visits to the cities, and desk research.

Table 1: Six front runner cities

S. No.	Front-runner cities	District	Key features important for selection
1	Bhubaneswar	Khorda	Typical large urban centre
2	Paradeep	Jagatsinghpur	Coastal, coal dependence, diversity in energy choices
3	Keonjhar (Kendujhar)	Keonjhar (Kendujhar)	Tribal, mining area
4	Baripada	Mayurbhanj	Tribal, cultural diversity, mining area
5	Sundargarh	Sundargarh	Tribal, mining area
6	Koraput	Koraput	Tribal, more primitive tribes, high poverty

Selection of final cities: Bhubaneswar (Cuttack) + Koraput

Contrast from Bhubaneswar

Economic status: Bhubaneswar is the most economically better-off city while Koraput is the weakest

	Bhubaneswar	Koraput
District wise GDP	INR 8,50,861	INR 3,73,668
Percentage of BPL households (district)	59.17%	83.81%
Presence of slums	435	58
Usual monthly consumption expenditure (district)	INR 14,521.73	INR 9,047.36
Ownership of household assets (city level)	High	Low

Level of urbanization

- District level:
  - Share of urban population: Khorda – >35%, Koraput – 10%-20%
- City level:
  - Bhubaneswar is Odisha's largest urban centre with a large population, infrastructure and development, and commercial activity
  - Koraput is a small city, distinct rural, agrarian, forestry character

Climate risk:

- Wind and cyclones: Bhubaneswar - very high risk, Koraput - high or slight risk
- Earthquakes: Bhubaneswar - moderate to less damage zone, Koraput - very low damage zone
- Floods – same risk

Energy and appliance choices: Low-income settlements show significant similarities in energy and fuel choices across the cities

Key criteria for selecting the second city for this study

Presence of large tribal population

- Bhubaneswar has a very low tribal population as compared to Koraput

	Bhubaneswar	Koraput
% of households belonging to STs	1% - 5%	20% - 50%
Types of tribes	NA	Paroja, Khond, Gadaba, Kotia
Nature of tribes	Live in ghettos. Move to cities for livelihood - informal work	Primitive

Support from urban local bodies & data availability

- Bhubaneswar
  - Good support and rapport with community and government due to strong local presence of Janaagraha.
  - Data for low-income settlements (JAGA mission) getting updated and should be available for all 436 settlements
- Koraput
  - Good ULB support and data availability
  - ULB would be interested in biogas-based solutions using faecal sludge

Logistics feasibility

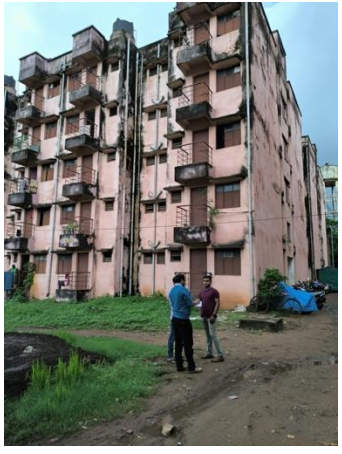
- Bhubaneswar and Koraput are both easy to reach via air transport

Bhubaneswar	Koraput
Bhubaneswar airport	200 km (from Vizag airport) 25 km (from Jeypore airport) Connected to Bhubaneswar via a night train

Reconnaissance visit to Odisha: Bhubaneswar

Food being cooked on a wood-fired mud chulla in 'Tapoban basti' in B'war

Wood being stocked in 'Chala Sahi' slum in B'war



Interaction at 'Patharabandha' (RAY) Project site in B'war

Untangled electricity cables posing safety hazard in 'Jharana Sahi-A' slum in B'war

Interaction at 'Jharana Sahi-A' slum in Bhubaneswar

Different size of LPG cylinders stored in 'Tapoban basti' in Bhubaneswar

Settlement selection

Key criteria adopted:

✓ Delisted and yet to be delisted slums (as per JAGA mission) + affordable housing

✓ Cooking fuel usage power supply situation

✓ Choice of appliances

✓ Housing condition

✓ General socio-economic status – e.g., income, occupation, etc.

✓ Geographic location of settlement

✓ Size of settlement

✓ Support from local leaders

Note: We haven't listed the names of the settlements for anonymity and ethics reasons. We interviewed a significant proportion of residents in each settlement.

COOKING

Choice behavior

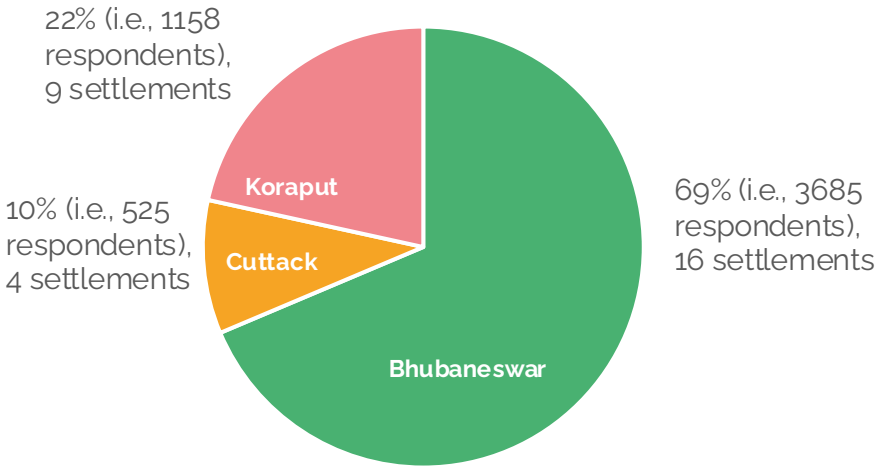
[COOKING]

Findings from the primary survey

Household location

- 5368 households surveyed across 3 cities and 29 settlements.[1] (Figure 1).

Figure 1: Geographic spread of respondent households

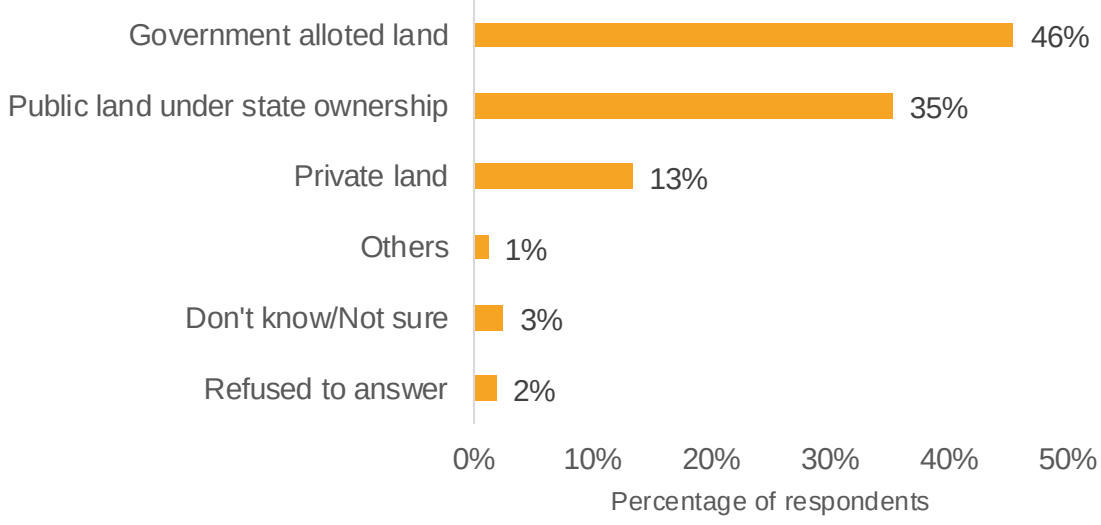


1: >80% coverage in each of 21 settlements, 70%-80% coverage in 5 settlements, approximately 60% coverage in 2 settlements, and 47% coverage in 1 settlement. Our goal was to cover 85% of households in the mapped settlements. However, some households could not be surveyed due to locked homes, instances of refusal, termination of interview before completion, due to political intervention some of the people refused to take part in survey, etc. Refer Appendix C for detailed Sampling Methodology.

Land ownership and stay

- 46% of the households surveyed live on government allotted land while 35% live on public land under state ownership (Figure 2).
- Of those who live on government allotted land or private land, 89% own the home they live in while 10% rent it.[1]
- 90% of the households surveyed have been living in that settlement for more than 5 years.
- 93% of the households surveyed reported that family members do not migrate seasonally for work.

Figure 2: Land ownership



1: Others said refused to answer.

Household economic status

- Over 3/4th of the households surveyed are part of notified slums, with some also part of lower middle-class housing and informal settlements.
- 60% of the households interviewed spend < INR 10,412 per month on household expenses (Table 2).
- The chief wage earner of the households is mostly a daily labourer (Table 3) with limited education (Table 4)[3]

Table 2: Total monthly household expenditure

Percentiles	Value (INR)
20%	5,697
40%	7,975
60%	10,412
80%	14,082
99%	27,348
100%	42,250

Table 3: Occupation of chief wage earner[1]

Occupation	% of respondents who said 'Yes'
Farmer	1%
Farm labourer	1%
Daily labourer	60%
Shopkeeper	7%
Street vendor	1%
Service/Job	13%
Businessmen	2%
Unemployed	1%
Student	1%
Homemaker	4%
Other[2]	10%

Table 4: Education of chief wage earner

Level of education	% of respondents
Illiterate	23%
Literate but no formal schooling/School upto 4 years	8%
School - 5 to 9 years	36%
SSC/HSC/Diploma	24%
Graduate/Postgraduate	7%
Other	1%
Refused to answer	1%

1: This was a multiple tick question in the survey. 2: Examples - Auto driver, painter, electrician, carpenter, cook, plumber, pensioner. 3: Respondents surveyed had a similar profile. Additionally, they were 41% male, 59% female and <1% reported other.

Physical structure of the homes

- Approximately 50% of the households surveyed comprise of 3-4 members (Figure 3).
- Homes mostly comprise of 1-2 rooms (Table 5), with 56% respondents reporting a single room home.
- 69% report that their house does not have a separate kitchen (Table 6).
- 52% households report having no window in their house.

Figure 3: Household size

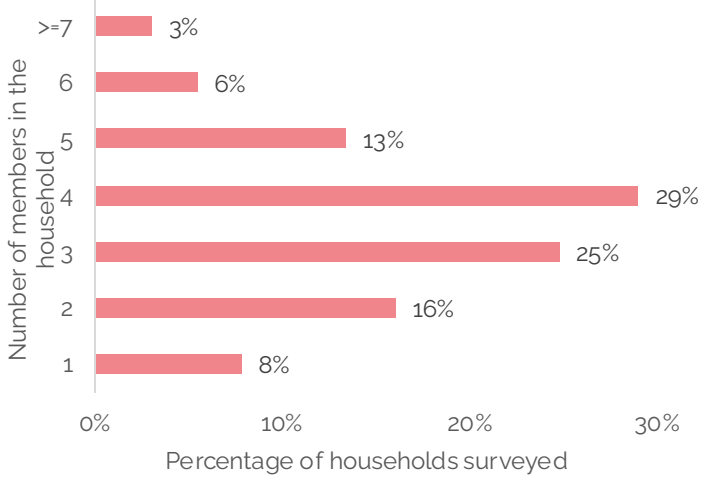


Table 5: Number of rooms in the house

Number of rooms in the house	% of households surveyed
1	56%
2	24%
3	17%
>3	3%

Table 6: Percentage of households with a separate kitchen

Options	% of households surveyed
Separate kitchen	28%
No separate kitchen	69%
Refused to answer	3%

Cooking fuel use

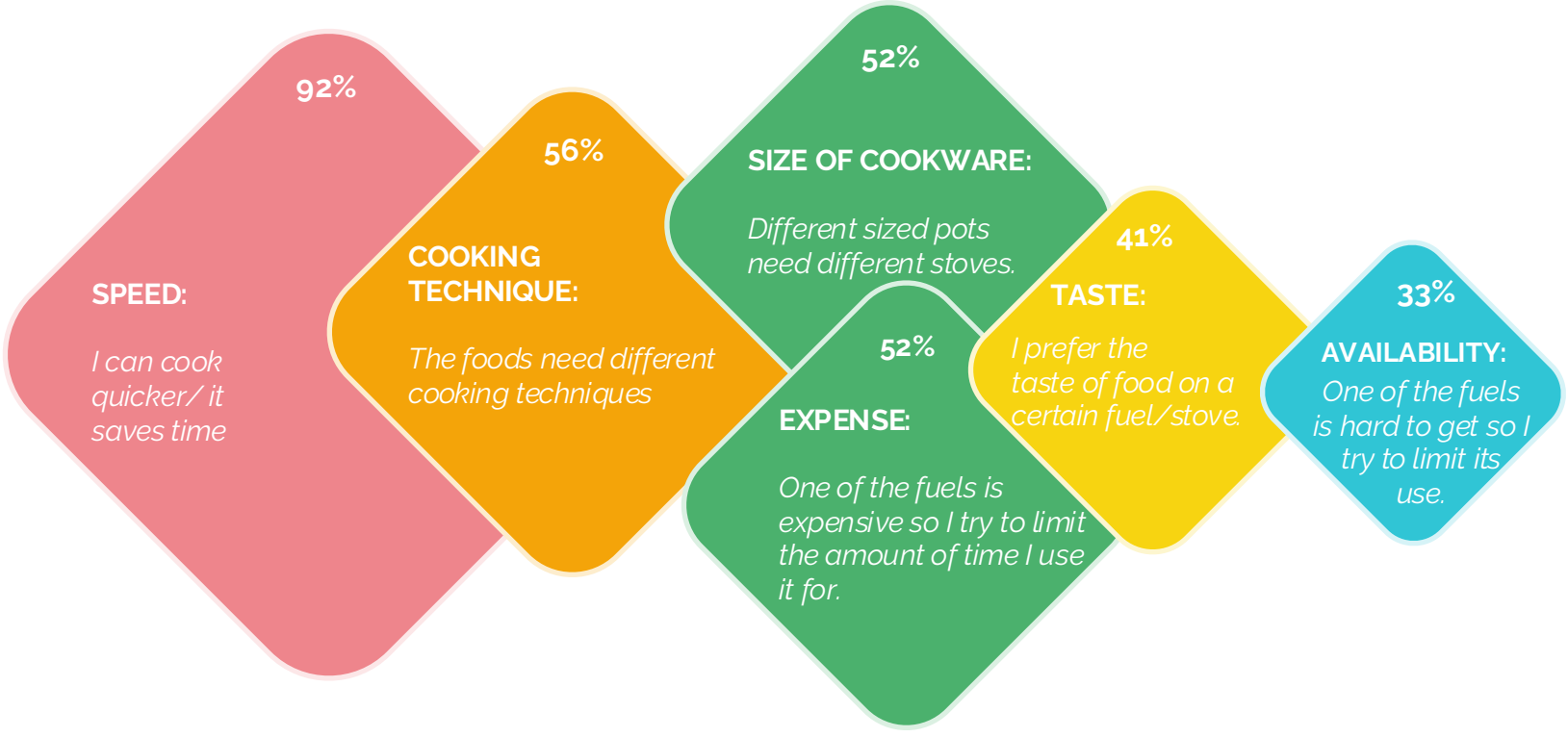
- LPG is the primary cooking fuel used by the vast majority (whether alone or in combination with another fuel), followed by firewood. There are only small incidences of cooking using electricity, coal, and kerosene.

Table 7: Fuel mix used by households surveyed for cooking

Extent of fuel usage for cooking	Number of respondents	Percentage of respondents
100% coal	7	0.1%
100% electric	2	0.0%
100% firewood	709	13.2%
100% kerosene	6	0.1%
100% LPG	3625	67.5%
>=50% LPG & <50% firewood	436	8.1%
<100% electric + LPG + firewood	43	0.8%
<100% kerosene + LPG + firewood	13	0.2%
>50% firewood & <50% LPG	227	4.2%
50-50 LPG and firewood	248	4.6%
Others	52	1.0%
TOTAL	5368	

Fuel use

- 19% of the households surveyed use more than one fuel for cooking. Of these, 43% of them use more than one fuel simultaneously for cooking, mostly LPG and firewood, for a variety of reasons shown below:



Note: This diagram is not exactly to scale and is only indicative. The % imply percentage of respondents who selected the specific reason in the multiple-choice question..

Expenditure on cooking

- 85% of respondents who provided an estimate[1] report spending <= INR 1000 per month on cooking fuel (Table 8).
- Cooking expenditure as a percentage of household expenditure ranges between 3% - 16% and increases with household expenditure (Table 8).

Table 8: Cooking expenditure

Household cooking fuel expenditure per month (INR)	Number of respondents basis cooking fuel expenditure percentiles	Average cooking fuel expenditure per month (INR)	Average household expenditure per month (INR)	Cooking fuel expenditure as a percentage of household expenditure
0	347	0	7017	0%
1-420	864	263	8057	3%
421-600	876	512	9692	5%
601-900	876	726	10650	7%
901-1000	974	957	12801	7%
1001-2000	679	1269	13154	10%
2001-4540	41	2676	16887	16%

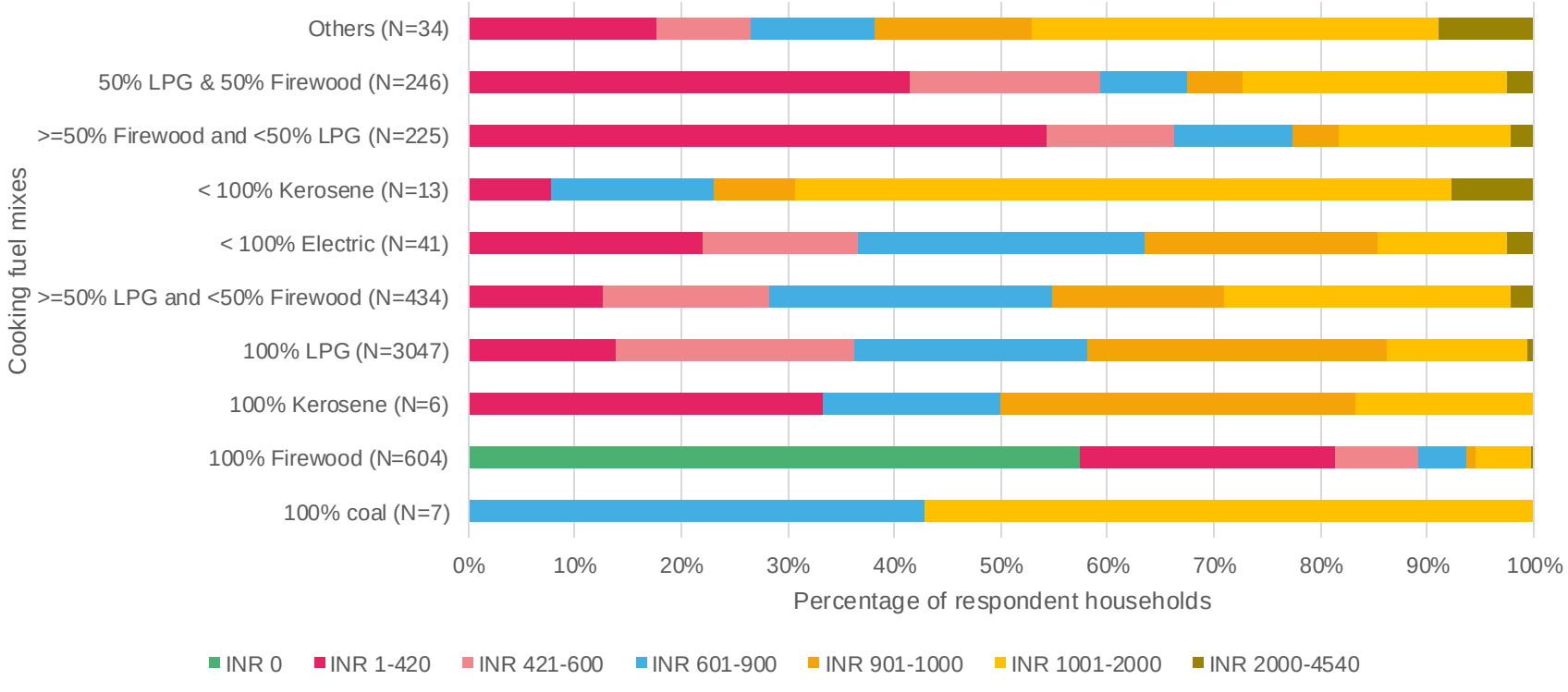
1: While routed to all, the question on household expenditure on cooking was answered by 4657/5368 respondents. Of the 711 don't know/refused to answer responses,

- *105 and 578 responses belong to 100% firewood and 100% LPG categories where respondents were not able to provide the information required for this calculation.*
- *Electric users could not estimate electricity expense from cooking. Therefore, responses of 100% electric users are in missing. By the same logic cooking fuel expense of "<100% electric + LPG + firewood' users is an underestimate. At the maximum they use electricity for 70% of their cooking, although 65% of electric users use it for <30% of their cooking.*

Expenditure on cooking

- Firewood users incur less cooking fuel expenditure than LPG users (Figure 4).

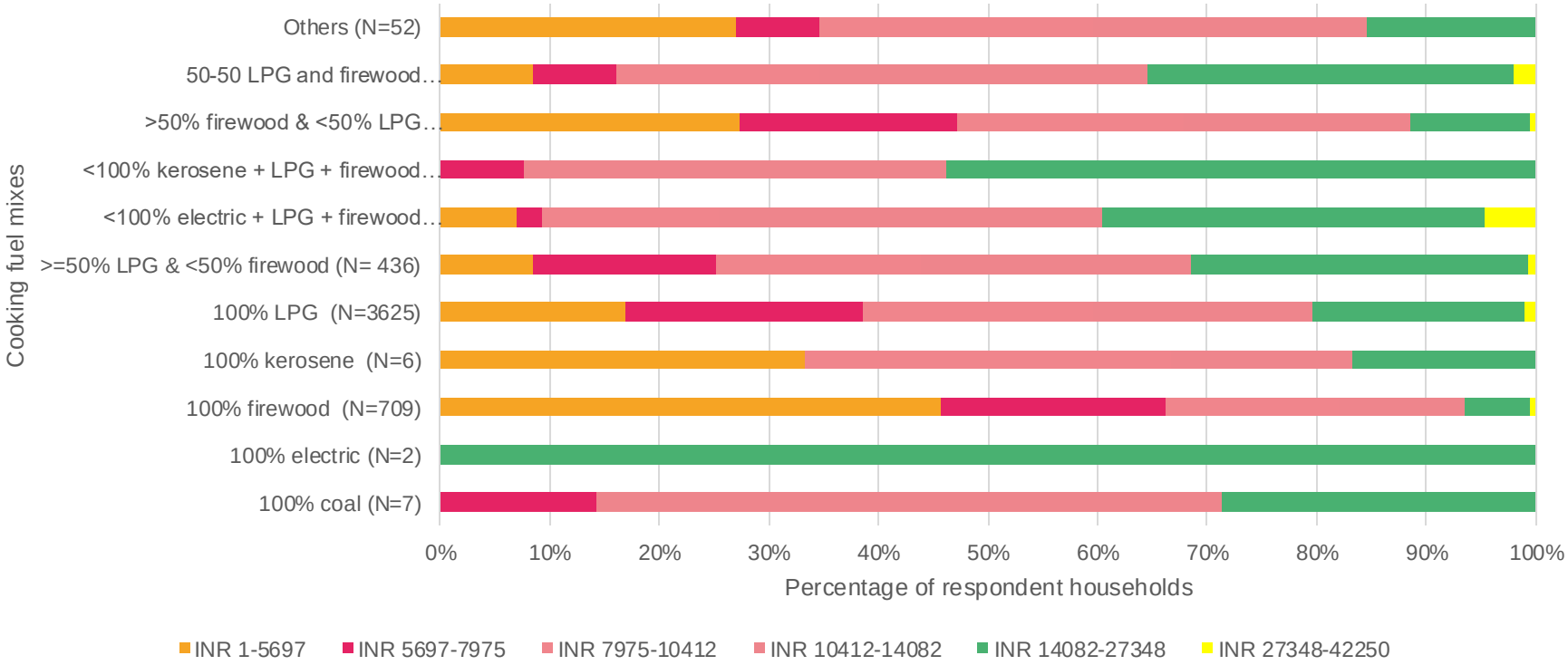
Figure 4: Cooking expenditure by fuel use groups (INR per month)



Fuel - use vis-à-vis household expenditure

- Firewood users belong to lower household income categories compared to LPG and electric users (Figure 5).

Figure 5: Household expenditure by fuel use (INR per month)

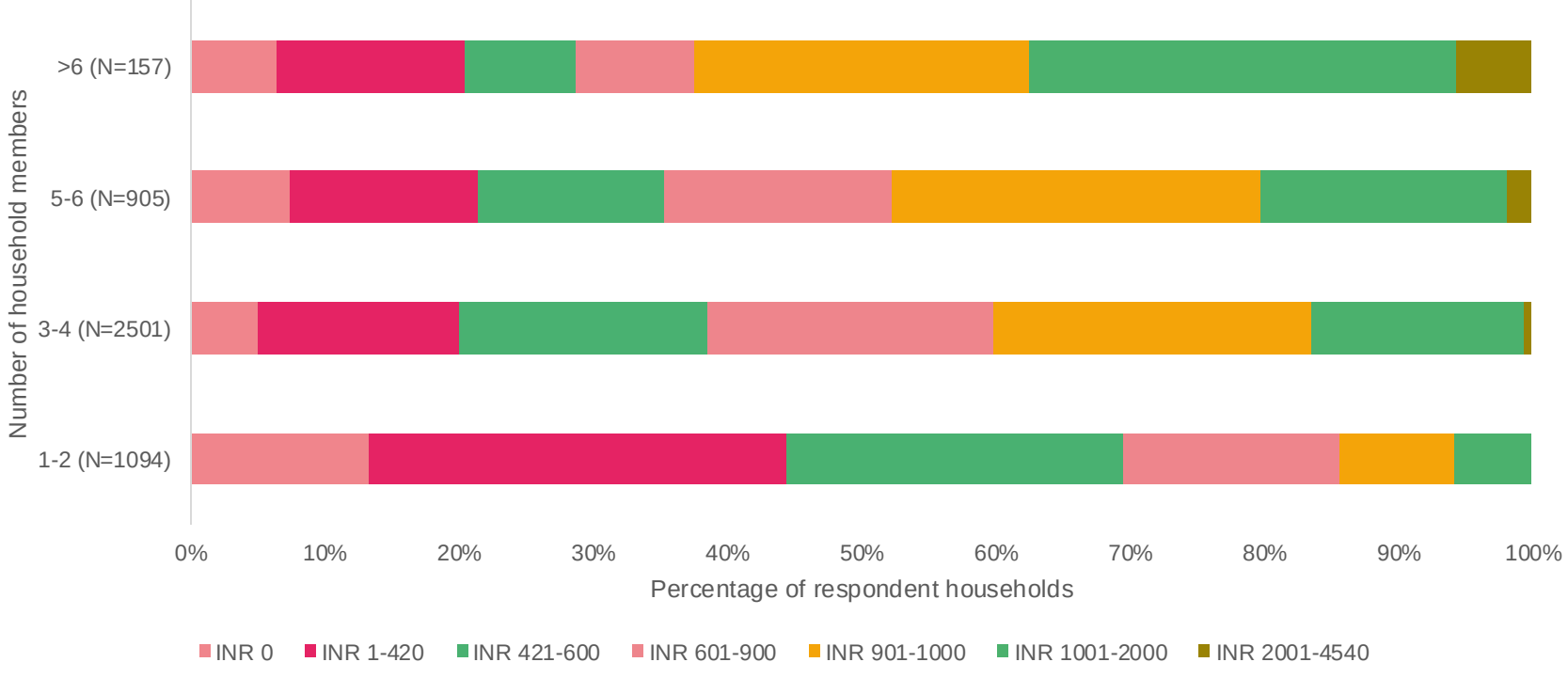


Note that the total expenditure is a summation of expenditure reported by households under different categories such as transport, food, cooking fuel, health, education, etc. Households may not have reported expenditure under certain categories (where their expense may be 0 or they may not know their expense), and so the total expenditure numbers may be underestimates in some cases. This chart is only to provide an overall indicative picture.

Expenditure on cooking

- As would be expected, households with more members spend more on cooking fuel every month (Figure 6) though the increase is not linear.

Figure 6: Cooking expenditure by household size (INR per month)



User experience: LPG

- Over 80% of LPG users have been using the fuel for >5years.

- LPG is used to cook all types of food (e.g., rice, lentils, tea/coffee, vegetables, meat), but relatively less for boiling water for drinking

- Key drivers for switching to LPG:
  - LPG is easy & quick to cook using (69%), LPG is healthy/better for my family (55%), LPG is reliable & easily available (55%), LPG is better for the environment (53%). Other reasons cited by around 30% of the LPG users are food taste is better, increase in family income, and relocation to the city.

- Cylinder delivery:
  - 56% LPG users have cylinder delivered to their doorstep, 49% go to the go to market[1]
  - Out of those who don't have doorstep delivery, 40% travel less than 1km, 20% travel 1-2 kms, 20% travel 2-3 kms, 20% travel more than 3kms.

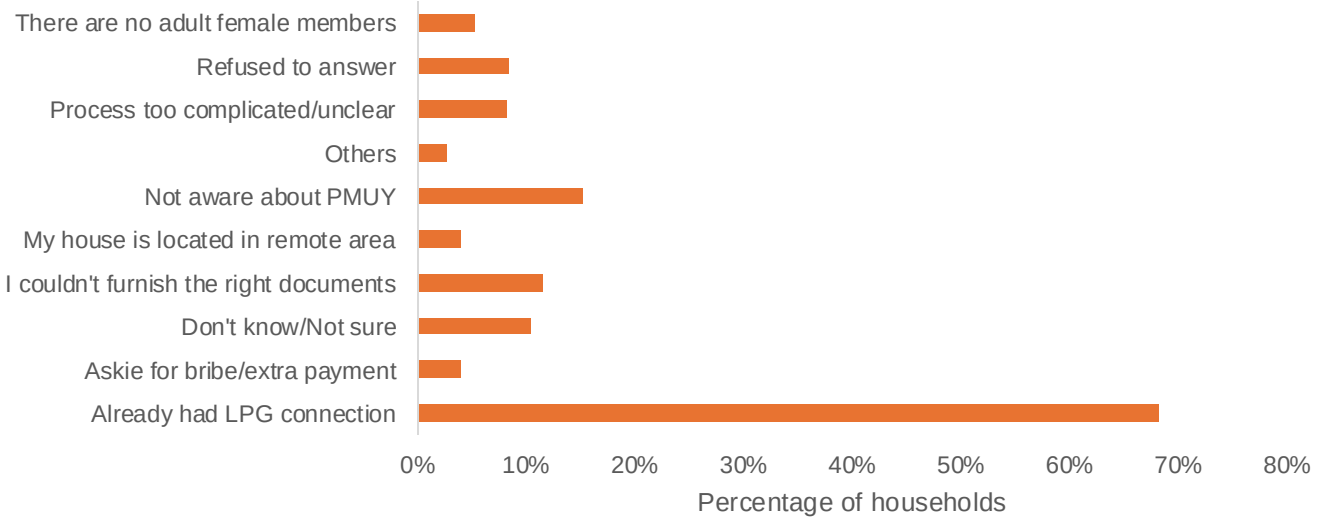
- Time to refill:
  - 13% on the spot, 36% same day, 33% 1-2 days, 31% 3-7 days, 2% more than a week, don't know/refused to answer 3%

1: Total is no 100% as it is a multiple tick question.

User experience: LPG

- Only 30% of LPG users got the connection under the Pradhan Mantri Ujjwala Yojna (PMUY). 55% got it from the open market[1]
  - This is because the scheme was launched only in 2016, and most respondents (68%) reported having connections from before while some reported issues around being unable to furnish all the documents and the process being unclear (Figure 7).
  - Overall, 94% of those who got the LPG connection under a scheme said that the process was easy.

Figure 7: Why did you not get an LPG connection under the PMUY?[2]



1: 11% reported refused to answer or don't know; 1% reported other scheme and 4% reported other; 2: Multiple tick question. Therefore, total may not be 100%.

User experience: LPG cooking

Cost of LPG connection:

- PMUY users paid a much lower price than those who got the connection from the market (Table 9). [1, 2]
- 706/3717 14kg LPG users (19%) (661 PMUY and 21 market) report getting the connection for free.

LPG Cookstove

- PMUY users paid similar price than those got a cookstove from the market (Table 10).[3]
- 2462 /3717 14kg LPG users (66%) (931 PMUY and 1428 market) report getting the cookstove free.

Table 9: Cost of LPG connection (14kg users)

Price of LPG connection (INR)	% of PMUY users (N=1299)	% of market users (N=1969)
0 (free)	51%	1%
1 to 2000	31%	8%
2001 to 3600	8%	15%
3601 to 5000	5%	33%
5001 to 6000	1%	20%
> 6000	1%	16%
Don't know	3%	6%

Table 10: Cost of LPG cookstove (INR)

Price of LPG cookstove (INR)	% of PMUY users (N=1301)	% of market users (N=1974)
0 (free)	72%	72%
1 to 2000	6%	3%
2001 to 3600	4%	4%
3601 to 5000	6%	7%
5001 to 6000	1%	4%
> 6000	1%	4%
Don't know	10%	7%

1: There are 3717 14kg LPG users - those who got connection under PMUY – 1299, market – 1969, rest report others) 2: According to the scheme, PMUY beneficiaries are supposed to get a free connection and other cash assistance for stove, cylinder, etc. 3: There are 3717 14kg LPG users - those who got stove under PMUY – 1301, market – 1974, rest report others.

User experience: LPG cooking

Cost of LPG cylinder refill:

- Households who buy cylinder under PMUY versus those who get it from the market report a slightly lower price for 14kg LPG cylinder refills upfront (Table 11). Most respondents report paying ~INR 950-1000 per cylinder. Subsidy is credited later into the bank accounts of PMUY users.

Table 11: Cost of LPG cylinder (14kg)[1]

Price of 14kg LPG cylinder (INR)	% of PMUY users (N=1493)	% of market users (N=1980)
1-950	18%	16%
950	43%	38%
951 to 970	7%	7%
971 to 1050	23%	20%
1051 to 1250	10%	19%
> 1250	0%	1%

1: This is a multiple tick question. There are 3717 14kg LPG cylinders – got refill under PMUY – 1493, got refill from market - 1980, got refill from other scheme – 16, don't know/refused to answer - 249.

User experience: LPG cooking

Subsidy on cylinder refill:

- Number of respondents reporting a subsidy is very small, for both PMUY (35%) and non-PMUY (26%) LPG users (Table 12). Others report (Table 13) subsidy not being received at all or not having knowledge of subsidy being received (which may be due to genuine lack of knowledge or inconsistent adhoc subsidy receipt).
  - Note that number of users who reported the actual amount of subsidy received is even smaller (Table 12).
- There is no significant difference in the findings by gender.

Table 12: Response rate of PMUY versus Non-PMUY LPG users (14kg cylinder)

	PMUY	Non-PMUY
Number of LPG users	1299	2418
Number of users who reported getting a subsidy	460 (35%)	622 (26%)
Number of users who reported the subsidy amount	381	529

Table 13: Do you get subsidy on the refill of LPG (14 kg cylinder)?

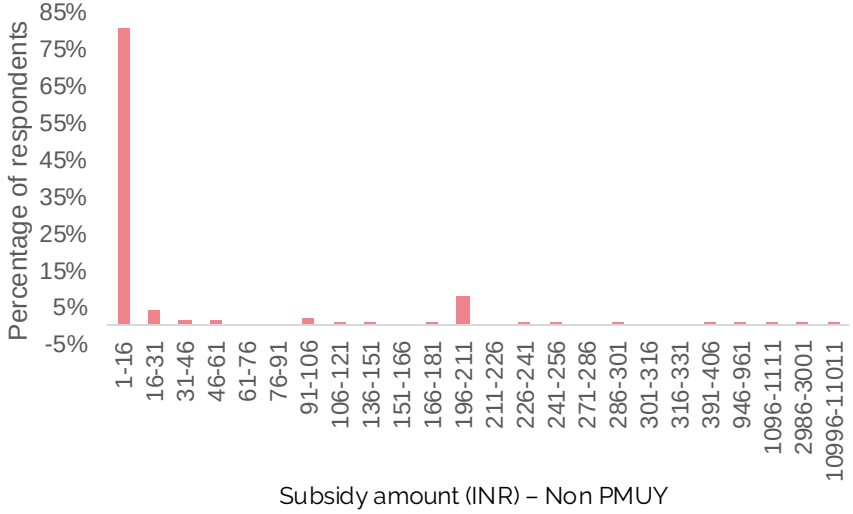
	Percentage of PMUY users	Percentage of non-PMUY users
Yes	35%	26%
No, I never have	35%	44%
Gave up subsidy	3%	4%
Not aware of the fact that subsidy is credited to bank account	8%	12%
Don't know/Not sure	14%	12%
Refused to answer	5%	4%

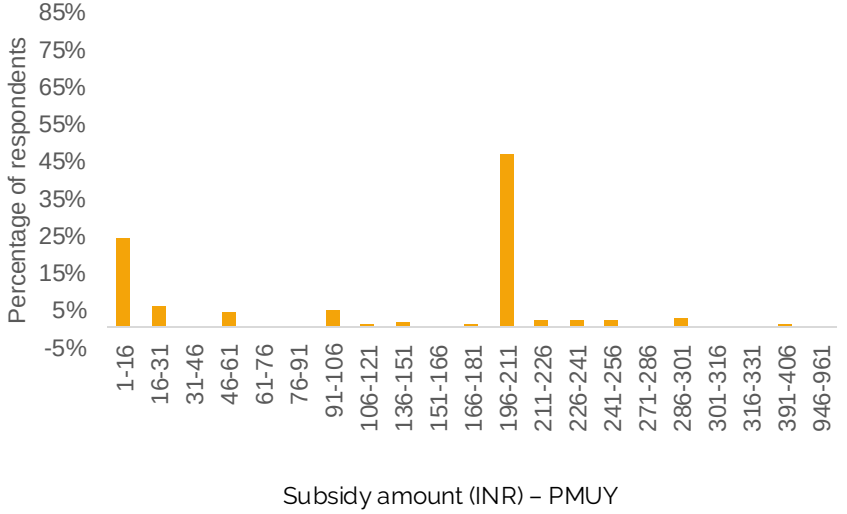
User experience: LPG cooking

Subsidy on cylinder refill (contd.):

- 80% of non-PMUY LPG users are reporting a subsidy are receiving a subsidy between INR 1-16 (Figure 8). 8% Non-PMUY users reporting a subsidy are receiving INR 196-211, similar to the PMUY subsidy. 47% PMUY LPG users reporting a subsidy are receiving between INR 196-211, while a large 24% report receiving INR 1-16. Some other adhoc amounts are also being reported by PMUY users – e.g., INR 16-31, INR 46-61, INR 91-106, and so on.
- There is no significant difference in the findings by gender.

Figure 8: Subsidy reported by LPG users (14kg cylinder) (PMUY and non-PMUY)





User experience: Firewood cooking

- Firewood is used to cook all types of food (e.g., rice, lentils, tea/coffee, vegetables, meat), less for boiling water for drinking.

- 55% firewood users only collect firewood from the fields, while 38% only purchase it from the market and 7% do a mix of both. Average price of those who buy wood from the market is INR 14 per kg (Table 14).

- 51% users go to source firewood a few times a week, while 38% go a few times a month. Only 6% do this daily. [1] Average distance travelled is 3.12 kms one way (including those who said 0km) (Table 15).

- Firewood collector report back pain – 48%, back, neck or shoulder injury – 40%, cuts/scrapes – 29%, and snake/animal bite - 19%.

Table 14: Cost of firewood

Cost per kg (INR)		% of firewood users
0 (only collect)		55% (898/1647)
Of those who buy from the market (749/1647 users)	1 to 6	18%
	7 to 10	18%
	11 to 19	11%
	20	19%
	=> 21	13%
	Don't know	22%

Table 15: Kms travelled one-way for firewood purchase/ collection[2]

Kms travelled one-way	% of firewood users
0	1%
0.1 to 1	26%
1.1 to 2	19%
2.1 to 3	10%
3.1 to 5	13%
>5	9%
Don't know	23%

1:4% - few times a year, Other-1%.

Note: Only 46 electric cooking users in the sample.

User experience: Electric cooking

- 52% of households have been using electric cooking for >5years, 11% for 4-5 years, 11% for 2-3 years (Figure 9).
- Top driver for transition is easy and quick cooking, followed by better for environment and health, and reliable and easily available (Figure 10).
- Households mostly (reported by ~70% households) use electric cooking to make rice and tea/coffee. ~43-48% households reported using electric cooking for vegetables and lentils, non-veg/meat and rotis.
- 50% households report using induction, 15% use electric cooker, 9% electric coil cookstove.[1]
- Average price paid for electric induction is INR 2876 (N=21), electric cooker is INR 2275 (N=6) and electric coil cookstove is INR 300 (N=4).

Figure 9: Since how long have you been doing electricity-based cooking?

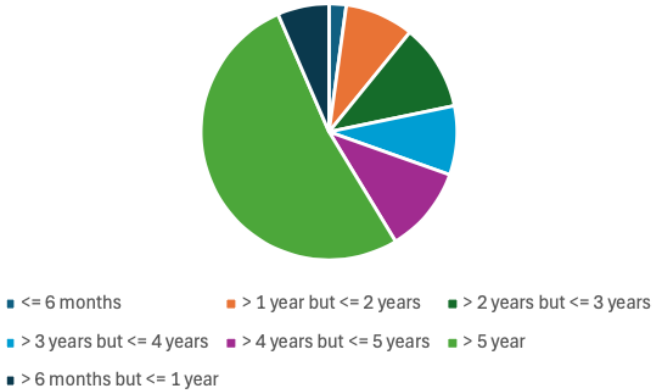
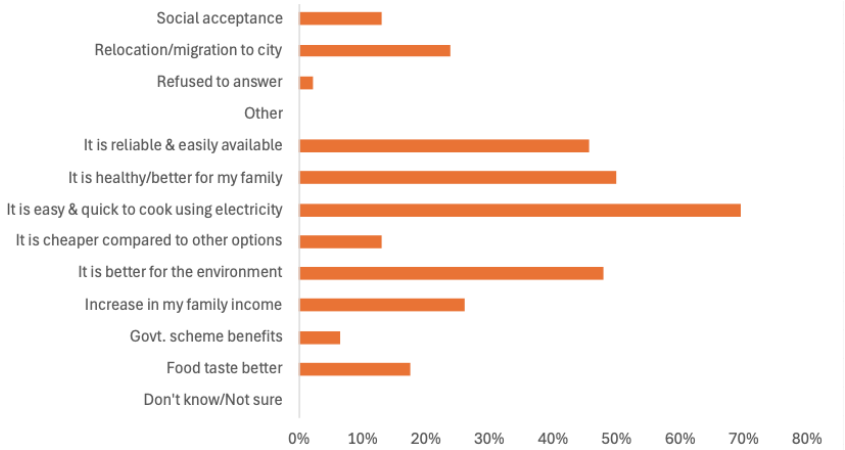


Figure 10: What encouraged you to start using electric cooking?



1: Other – 9%, Refused to answer/don't know – 19%. Also, this is a multiple tick question, so total may not be 100%.

Satisfaction with different cooking fuels

- Across the various aspects of cooking, those using electricity express higher levels of satisfaction, followed by LPG and firewood.
  - Firewood users are overall least satisfied with the fuel, except for taste of food. Negative impact on environment and health are key concerns for them firewood users.
  - While content on other aspects, LPG users express dissatisfaction (similar between PMUY and non PMUY users) in terms of cost/affordability and subsidy refund. Availability is also less satisfactory compared to other parameters.
  - Electricity is rated high on all parameters.

Figure 11: Level of satisfaction with different aspects of cooking by LPG, firewood and electric cooking users

** Note: These aspects were not asked to the user in the questionnaire.*

Knowledge of clean

- Over 70% (Table 16) of the respondents (not using the cleaner fuels)[1] have not heard of biogas, solar and biomass, making lack of awareness/knowledge a potential key barrier in their use (from the 'user perspective').
- Electric cooking is the most commonly known 'cleaner' type of fuel, and one can see its adoption to a small degree, as seen on previous slides.

Table 16: Percentage of respondents who have heard about the cleaner fuels for cooking but are not using them

Categories	Biogas (N=5369)	Solar (N=5369)	Biomass (N=1665)*	Electric (N=5323)
Yes	13%	11%	10%	29%
No	70%	72%	78%	56%
Don't know/Not sure	10%	10%	8%	9%
Refused to answer	6%	6%	4%	6%

**The question for biomass was routed to only those who use traditional fuels viz. firewood/coal/dung cake but do not use improved biomass cookstove.*

1: Biogas, biomass, solar and electric.

Considerations around transition to cleaner energy

- 40%-56% of non-users of LPG, biogas, solar, biomass and electricity are willing to shift to the cleaner fuels.
- For those not willing to shift, lack of awareness about the fuel in terms of usage, its potential benefits and how to access the technology emerge as key barriers. Poor feedback from other users is an important barrier for biomass. Lack of local vendors emerge as barriers for biogas, solar and biomass.

Table 17: Willingness to shift to each fuel by respondents who have heard of each of them but do not use them currently (Percentage of respondents)

Categories	LPG (N=746 out of 746 non-users)	Electric (N=1557 out of 5323 non-users)	Biogas (N=708 out of 5369 non-users)	Solar (N=606 out of 5369 non-users)	Biomass (N=172 out of 1665 non-users)
Yes	51%	52%	40%	53%	56%
No, Didn't get good feedback from current users	3%	2%	8%	7%	20%
No, Don't have space for it	6%	6%	22%	12%	16%
No, Don't know about the process to apply for it	7%	5%	13%	12%	20%
No, Don't know any locally available vendor for installing this	4%	4%	18%	12%	15%
No, Don't know how to get a loan for it	3%	3%	8%	6%	9%
No, Don't know how will it benefit me	9%	14%	21%	16%	15%
No, Don't know if it is reliable - lack of confidence on new technology	5%	8%	10%	5%	6%
No, not aware of this technology	24%	20%	31%	22%	21%
Other	1%	2%	1%	0%	0%
Don't know/Not sure	6%	5%	2%	2%	2%
Refused to answer	3%	3%	4%	3%	0%

Note: This is a multiple tick question. Those selecting 'no' may have selected multiple reasons for doing so.

Considerations around transition to cleaner energy

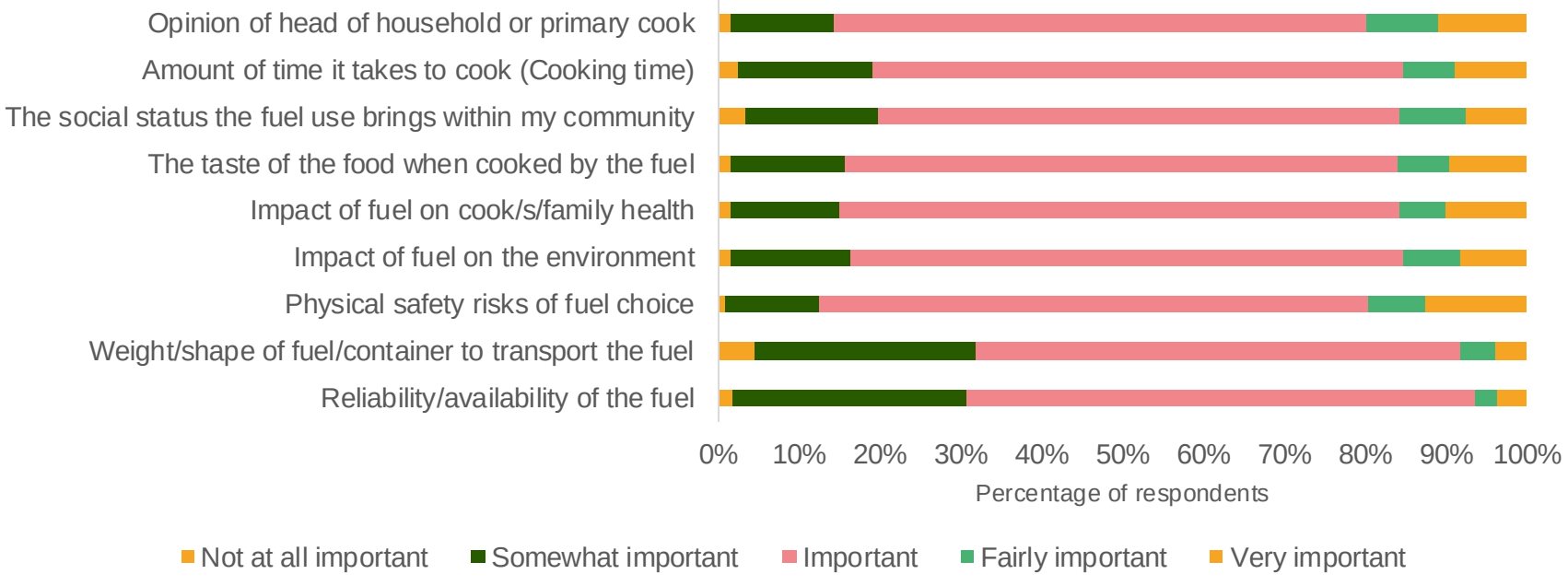
Fuel categories	Maximum willingness to travel for fuel (kms)	Maximum willingness to pay for cooking fuel per month (INR)	Maximum willingness to pay for cooking stove (INR)	Maximum cooking time for a meal of 4 people
Across fuel categories	1.4	490	932	65
100% coal	2	514	336	82
100% electric	6	100	1050	58
100% firewood	2	375	543	63
100% kerosene	2	600	584	42
100% LPG	1	510	1043	65
>50% LPG & <50% firewood*	1	561	832	67
<100% electric + LPG + firewood*	1	518	1184	72
<100% kerosene + LPG + firewood*	1	462	1177	87
>50% firewood & <50% LPG*	2	457	616	62
50%-50% LPG & firewood	2	450	955	67
Others	1	428	502	62

Note: The values include zeros. Out of 5369, number of respondents who said zero are 789 for travel, 124 for cooking fuel, 1140 for stove, and none for cooking time.

Considerations around transition to cleaner energy

- Besides cost, travel and cooking speed, there are other parameters important in decision making for cooking fuel including physical safety, opinion of the household head or primary cook, impact on health and environment, and food taste.
  - Households report reliability/availability of fuel and container to transport the fuel as relatively less important.

Figure 12: Importance of various parameters for households when making their fuel choice for cooking



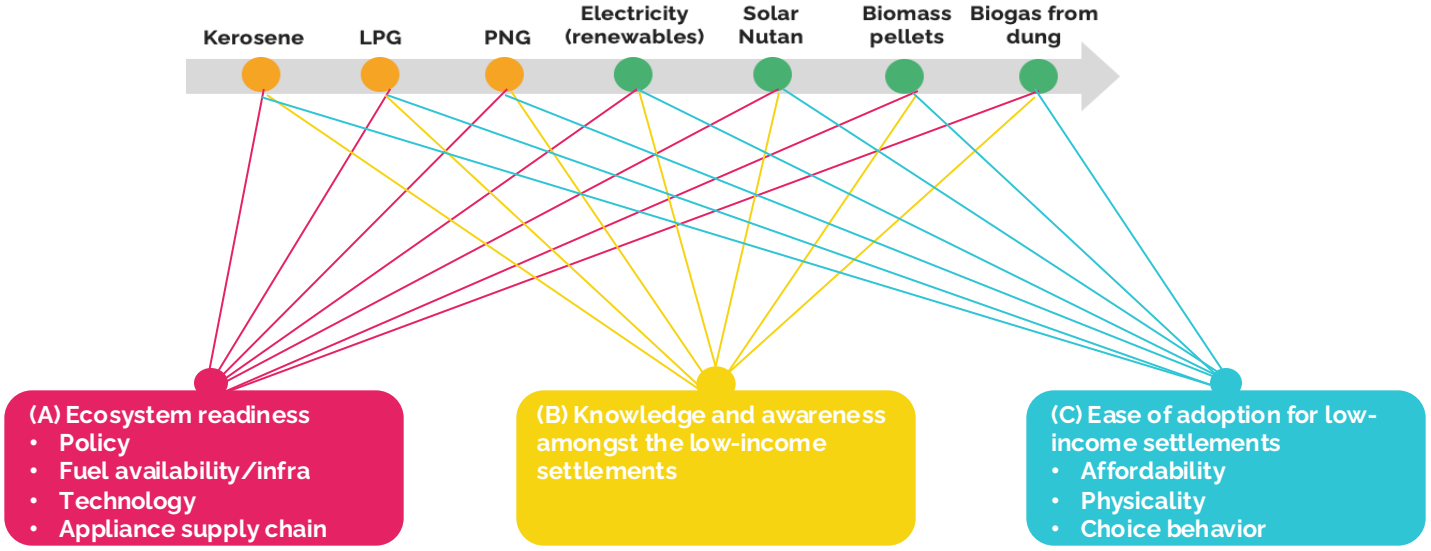
Landscape for Just Transitions

[COOKING]

Note: This diagram is not to scale and is only indicative.

Landscape for Just Transitions

In order to map out the landscape for Just Transitions, each of the cleaner fuels (from our clean energy framework) is evaluated against - (A) ecosystem readiness, (B) knowledge and awareness and (C) ease of adoption.



Notes:

- *For electricity, we have considered electric induction. Other electric cooking appliances not explored - electric pressure cooker (similar functionality as induction, higher cost – cost INR 3000-20000), and electric coil (technical limitations - poor efficiency, long time to heat and cool down, etc.).*
- *For solar cooking average, we have considered Solar Nutan. Other solar cooking devices not explored – box type solar cooker, panel type solar cooker, and parabolic solar cooker due to limitations such as non-availability of models and technology providers*, requiring too much space, long cooking time, not usable in cloudy weather, difficult to handle heated utensils, low thermal efficiency, poor quality, need for black utensils, etc.
- For biogas from dung, we have considered community biogas. Household biogas appliance not explored – Not many technological advancements, Kitchen waste may not be enough. Other raw material includes animal manure, crop residue - not much livestock with target group, not farmers. Needs large space. User feedback not good. Optimal temperature to digest bacteria is 37° C, etc.

Kerosene: Landscape for Just Transitions

Ecosystem readiness | Knowledge/awareness | Ease of adoption

Note: This diagram is not to scale and is only indicative.

LPG: Landscape for Just Transitions

Ecosystem readiness | Knowledge/awareness | Ease of adoption

Note: This diagram is not to scale and is only indicative.

PNG: Landscape for Just Transitions

Ecosystem readiness | Knowledge/awareness | Ease of adoption

Note: This diagram is not to scale and is only indicative.

Sources: 1: https://gailcgd.gail.co.in/CGD/pdf/Odisha%20Urja%20Ganga%20Brochure.pdf , https://pib.gov.in/Pressreleaseshare.aspx?PRID=1579087; 2: https://www.adanigas.com/en/png-residential/png-cost-calculators;

Electricity (renewables): Landscape for Just Transitions

[Electric induction]

Ecosystem readiness | Knowledge/awareness | Ease of adoption

Note: This diagram is not to scale and is only indicative.

Currently from (fossil-fuel heavy grid)

Sources: 1: Janaagraha calculations based on usage details from Niti Aayog study and Odisha electricity rates

Solar:
Landscape for Just Transitions

[Solar Nutan]

Ecosystem readiness | Knowledge/awareness | Ease of adoption

Note: This diagram is not to scale and is only indicative.

Biomass:
Landscape for Just Transitions

[Improved Biomass Cookstove]

Ecosystem readiness | **Knowledge/awareness** | **Ease of adoption**

Note: This diagram is not to scale and is only indicative.

Sources: 1: Interview with stove manufacturer; 2: https://www.sciencedirect.com/science/article/abs/pii/S0140988315003059; 3: https://www.frontiersin.org/articles/10.3389/fenrg.2022.880064/full 5: https://www.tradeindia.com/manufacturers/biomass-stove.html;

Biogas:
Landscape for Just Transitions

[Community biogas]

Ecosystem readiness | Knowledge/awareness | Ease of adoption

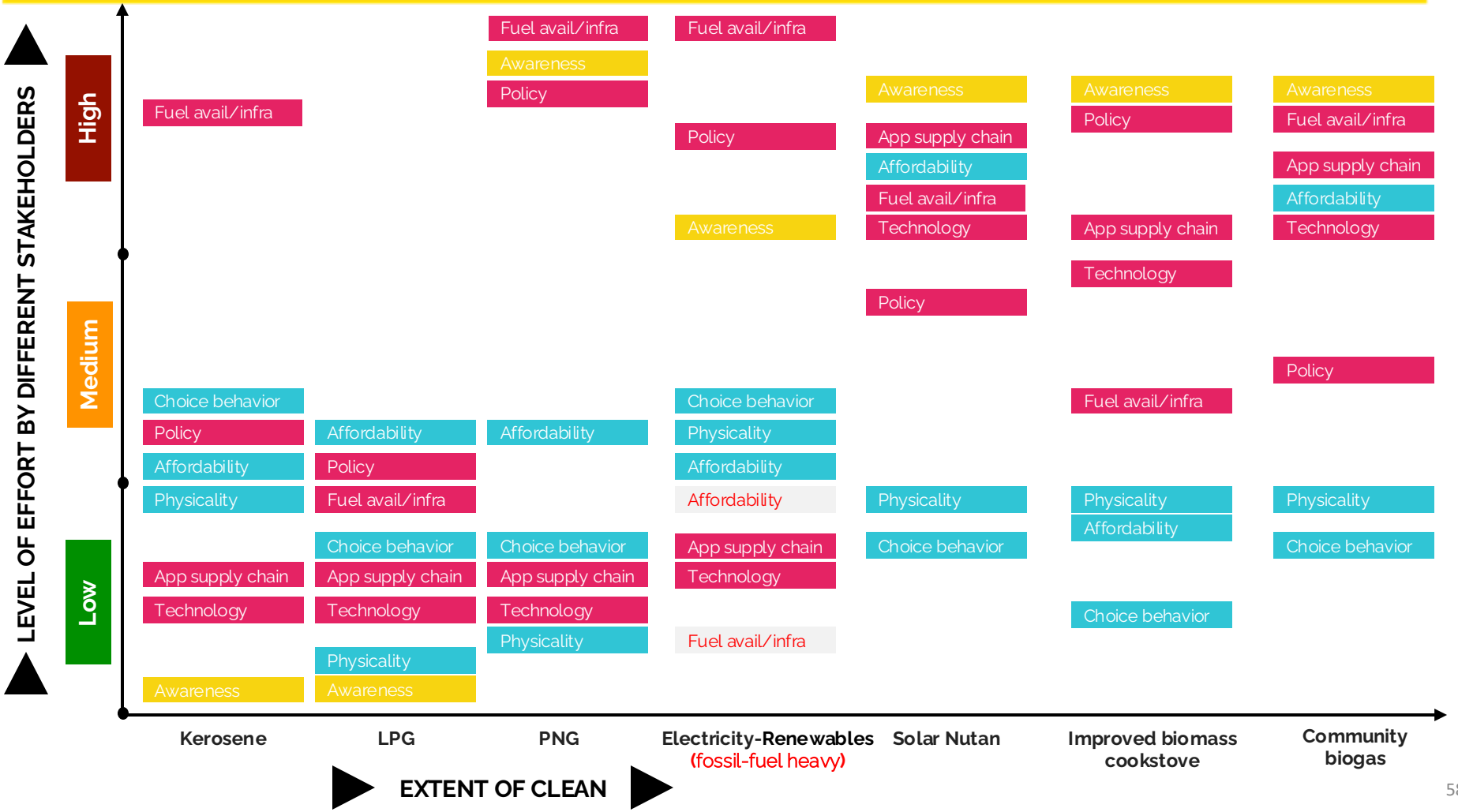
Note: This diagram is not to scale and is only indicative.

Sources: 1 Interview with technology provider;

Landscape for Just Transitions

Ecosystem readiness | Knowledge/awareness | Ease of adoption

Note: This diagram is not to scale and is only indicative.

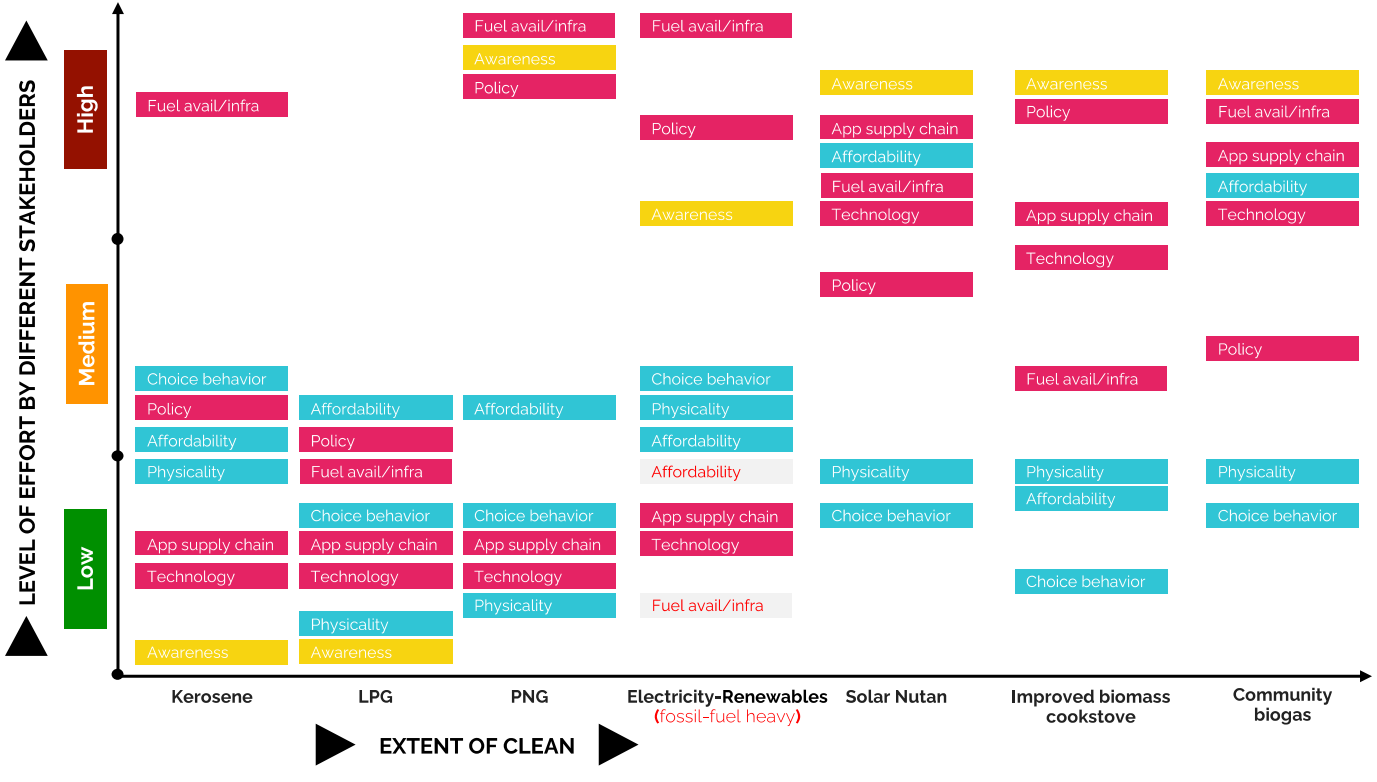


Ecosystem readiness | Knowledge/awareness | Ease of adoption

Landscape for Just Transitions

Note: This diagram is not to scale and is only indicative.

- ✓ **There is an inverse relationship between cleaner fuels and eco-system readiness.**
- ✓ **There is very low awareness about cleaner cooking fuel options amongst low-income settlements.**

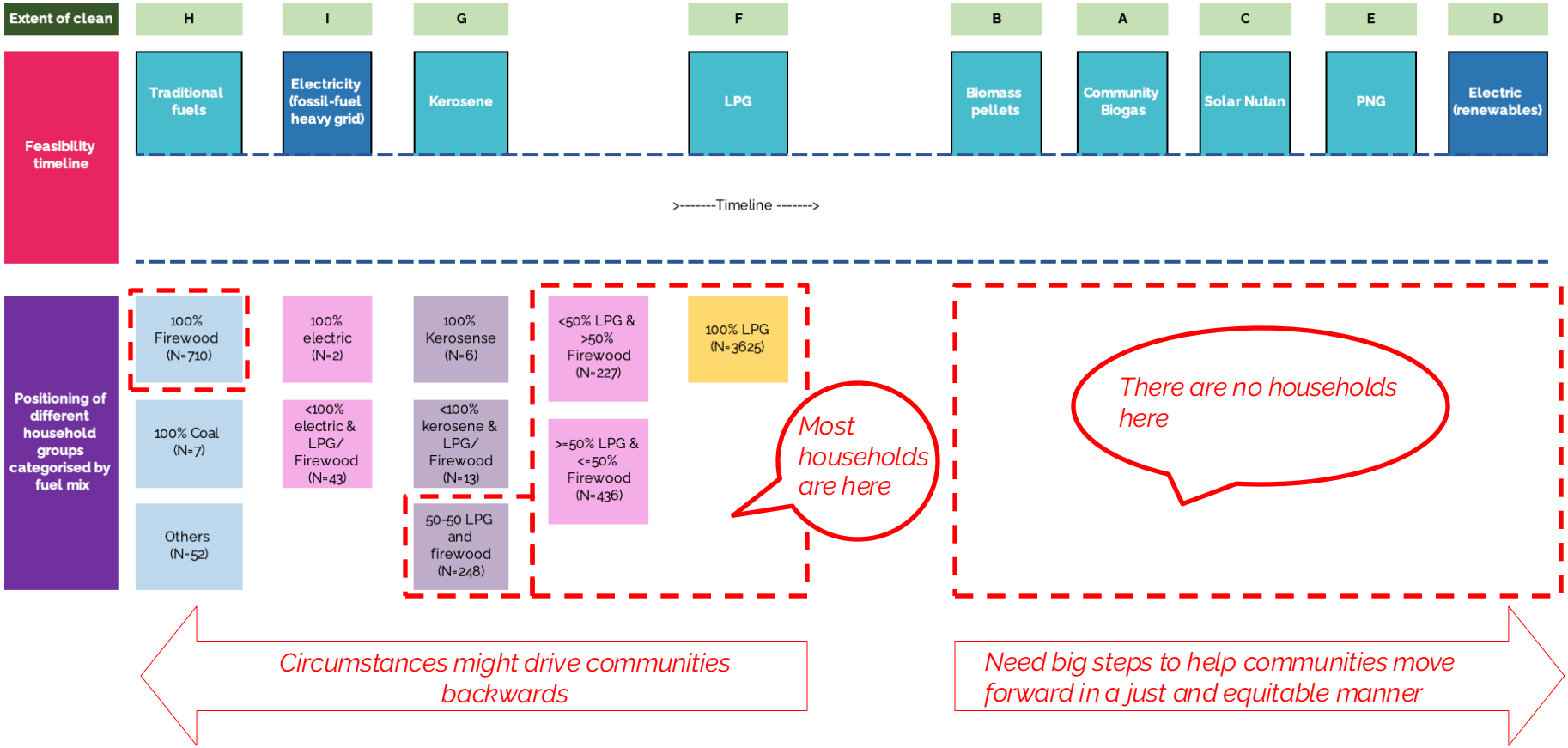


Pathways

[COOKING]

Diagram is not to scale

Direction and broad contours for clean energy pathways



Notes: (1) The diagram is not to scale. (2) The feasibility timeline only shows that it will take longer to transition to certain cleaner fuels as compared to others. However, this is not to be read in conjunction with household positioning on the timeline i.e., for instance, it does not mean that a household using traditional fuel will take longer to move to PNG than a 100% LPG household. The timeline just means that generally for a household, moving to the cleaner fuel PNG will take longer than moving to the cleaner fuel biogas. The positioning of households only shows where households are in terms of fuel usage and where they could move to..

Co-creation of pathways

- Objectives:
  a. Light touch validation of critical findings from the primary survey (e.g., willingness to pay for fuel, stove, etc.)
  b. Ideating design options for clean energy solutions for low-income settlements and assessing their willingness and conditions (contours) to accepting the cleaner technologies.
- Co-creation format (12 co-creation sessions across 3 cities and 4 fuel – mix groups, ~ 143 respondents):
  - Based on a role play format wherein groups of 4 residents each were created and asked to behave as if they are members of a '4-person dummy household'. Household composition : Typical mother and father in the household, 1 grand parent, 1 young child. Overall sample 50-50 gender balanced. 3 dummy households participated in each co-creation session.

Table 18: Participant and session details for cooking

	Bhubaneswar	Cuttack	Koraput
COOKING			
100% LPG users	**Session 1: 12 participants**	**Session 1: 12 participants**	**Session 1: 12 participants**
	HH 1: 4 100% LPG users	HH 1: 4 100% LPG users	HH 1: 4 100% LPG users
	HH 2: 4 100% LPG users	HH 2: 4 100% LPG users	HH 2: 4 100% LPG users
	HH 3: 4 100% LPG users	HH 3: 4 100% LPG users	HH 3: 4 100% LPG users
100% Firewood users	**Session 2: 12 participants**	**Session 2: 12 participants**	**Session 2: 12 participants**
	HH 1: 4 100% LPG users	HH 1: 4 100% LPG users	HH 1: 4 100% LPG users
	HH 2: 4 100% LPG users	HH 2: 4 100% LPG users	HH 2: 4 100% LPG users
	HH 3: 4 100% LPG users	HH 3: 4 100% LPG users	HH 3: 4 100% LPG users
Mixed LPG and Firewood users only	**Session 3: 12 participants**	**Session 1: 12 participants**	**Session 1: 12 participants**
	HH 1: 4 Mixed LPG and Firewood users only	HH 1: 4 Mixed LPG and Firewood users only	HH 1: 4 Mixed LPG and Firewood users only
	HH 2: 4 Mixed LPG and Firewood users only	HH 2: 4 Mixed LPG and Firewood users only	HH 2: 4 Mixed LPG and Firewood users only
	HH 3: 4 Mixed LPG and Firewood users only	HH 3: 4 Mixed LPG and Firewood users only	HH 3: 4 Mixed LPG and Firewood users only
Other fuel users	**Session 4: 16 participants**	**Session 4: 16 participants**	**Session 4: 16 participants**
	HH 1: 4 electric users (and any other fuel(s))	HH 1: 4 electric users (and any other fuel(s))	HH 1: 4 electric users (and any other fuel(s))
	HH 2: 4 electric users (and any other fuel(s))	HH 2: 4 electric users (and any other fuel(s))	HH 2: 4 electric users (and any other fuel(s))
	HH 3: 4 coal users (and any other fuel(s))	HH 3: 4 coal users (and any other fuel(s))	HH 3: 4 coal users (and any other fuel(s))
	HH 3: 4 kerosene users (and any other fuel(s))	HH 3: 4 kerosene users (and any other fuel(s))	HH 3: 4 kerosene users (and any other fuel(s))

Co-creation of pathways

- Session structure – mix of plenary and breakouts.

Table 19: Detailed session structure

S. No.	Activity	Setting	Time
1	Explain each of the technology solutions to the participants using PPT slides with information on the technology, cost, financing options, supply chain, cooking speed, utensils, etc. (see Appendix D for detailed slides presented)	Plenary	60 mins
2	Dummy households handed over the final technology solutions with proposed contours of technology, cost, financing options, supply chain, cooking speed, utensils, etc. (see Appendix D for detailed slides presented) The dummy households discuss and debate about which cooking solution they would choose going forward and why? (Select top 2)	Breakout session	30 mins
3	Each group shares with entire audience about their selection and rationale/thinking.	Plenary	30 – 45 mins

See Appendix D for detailed information presented to the low-income settlements.

Proposed solutions presented in co-creation

Expense				Financing	Travel			Indian cooking	Health and environment	
Proposed price of cooking fuel	Proposed price of appliance	Life span of appliance	Appliance repair/ maintenance		Appliance purchase	Appliance repair/ maintenance	Fuel delivery		Human health	Environment
(A) Community biogas										
•Pay as you go model, usage detected on an individual flo-meter. •Rs.500-600 per month.	•INR 930	•Life span 1-3 yrs.	•1 year warranty. •Rs. 0 - 200. •Requires more regular cleaning at home	•Not required	•Doorstep delivery.	•Doorstep delivery.	•Doorstep delivery through pipelines.	•Everything possible. •Regular pots and pans. •Almost same cooking speed as LPG. •Has heat control.	4	4
(B) Solar nutan										
•Rs. 0 (sunlight)	•Loan amount: Rs. 95,000 double (EMI: Rs. 500-600 per month), Rs. 56,000 single (EMI: Rs. 500-600 per month)	•Long life generally (stove – 10 yrs, solar panel 25 yrs)	•Negligible maintenance, panel needs dry dusting. •Repair cost Rs. 2000-3000.	•Loan - Single: EMI Rs. 500-600 per month for 10-12 years. Double: EMI Rs. 500-600 per month for 15-17 years.	•Doorstep delivery.	•Doorstep delivery.	•Doorstep Sunlight.	•Can cook 2 times in a day for 4 persons if fully charged. •Everything possible. •More effective for flat pots and pans. •Has flame control. •Speed of cooking same as LPG.	4	3

Proposed solutions presented in co-creation

Expense				Financing	Travel			Indian cooking	Health and environment	
Proposed price of cooking fuel	Proposed price of appliance	Life span of appliance	Appliance repair/ maintenance		Appliance purchase	Appliance repair/ maintenance	Fuel delivery		Human health	Environment(
(C) LPG										
•Rs. 650 per 14kg cylinder	•Rs. 930	•Life span over 10 years.	•Typically 1-2 years warranty. •Negligible repair and maintenance (<Rs. 200-300). •Recommended regular cleaning at home	•Not required	•Local shop (<1-2 km).	•Local shop (<1-2 km).	•Doorstep or local depot (<1-2 km).	•Indian cooking friendly (all types). •Can use regular pots and pans. •Easy to light and provides instant heat after lighting. •Cooks fast, convenient.	4	1
(D) Electric induction										
•Rs. 400 per month for family of 4 (all cooking)	•Rs. 930	•Life span over 10 years.	•Typically 1-2 years warranty. •Product usually replaced, not repaired.	•Not required	•Local shop (<1-2 km).	•NA	•Electricity from grid - door-step. •Stable electricity supply.	•Easily portable. Saves space. •Faster cooking than LPG. •Easy to clean, cools quickly. •Everything except rotis. •Needs flat pots and pans (typical cost Rs. 3,000). •Has heat control	4	3

Proposed solutions presented in co-creation

Expense				Financing	Travel			Indian cooking	Health and environment	
Proposed price of cooking fuel	Proposed price of appliance	Life span of appliance	Appliance repair/ maintenance		Appliance purchase	Appliance repair/ maintenance	Fuel delivery		Human health	Environment
(E) Improved biomass cookstove										
•Rs. 8-12 per kg for wooden pellets. •Rs. 0 (leaves, twigs, firewood) •Uses less wood than chullah.	•Rs. 930	•Life span 3-5 yrs.	•1 year warranty. •Rs. 0 - 200.	•Not required	•Doorstep delivery/ local shop (<1-2 km).	•Doorstep service/ local shop (<1-2 km).	•Local wood depot •Collection leaves, twigs, firewood.	•Everything possible. •Regular pots and pans. •Faster cooking than traditional chullah. •Stove size relatively small •Has heat control	2	4
(F) Firewood										
•Rs. 14 per kg	•Made in-house (Rs. 0)	•1-2 years.	•Done in-house.	•Not required	•Done in-house.	•Done in-house.	•Local wood depot •Collection from nearby areas.	•Indian cooking friendly (all types). •Can use regular pots and pans. •Favorable to local taste and utensils.	1	2

Co-creation of pathways

Community biogas and Solar Nutan emerge as the top 2 technology choices by low-income settlements, followed by LPG. The settlements do not choose firewood-based cooking technologies or electric cooking.

Table 20: Top 2 technology choices by different fuel–use groups

Note: Across the 3 cities, there were 9 groups of each fuel category. Each group discussed in breakouts and came back with their top 2 technology choices for cooking.

Fuel use category	Technologies proposed for adoption by low-income settlements					
	Traditional firewood chullah	Improved biomass cookstove	LPG – gas stove	Electric induction	Solar Nutan	Community Biogas
100% LPG users			1St 1St 1St 1St 1St	2nd 2nd 2nd	2nd 2nd 2nd 2nd	1St 1St 1St 1St 2nd 2nd
100% firewood users		1St 2nd 2nd	1St 1St 1St 2nd 2nd		1St 1St 2nd 2nd 2nd	1St 1St 1St 2nd 2nd
Mixed LPG and firewood users		2nd 2nd 2nd	2nd 2nd		1St 1St 1St 2nd 2nd 2nd 2nd	1St 1St 1St 1St 1St 1St 2nd
Users of other fuels (electric, coal, cow dung) + LPG/FW			1St 1St 2nd	1St 1St	1St 1St 2nd 2nd 2nd 2nd	1St 1St 1St 2nd 2nd 2nd

Co-creation of pathways

	COMMUNITY BIOGAS	SOLAR NUTAN	LPG
KEY REASONS FOR CHOOSING	1. Good for health. 2. Good for environment. 3. Financing model attractive, proposed gap price (INR 500-600per month) affordable (most had higher willingness to pay) + no plant cost. 4. Beautiful concept of converting waste to cooking gas. 5. Pay-as-you go model, metered billing. 6. Door-step delivery – piped gas. 7. Safety inside the house.	1. Financing model attractive, proposed EMI (INR 500-600) affordable (most had higher willingness to pay). 2. Good for environment. 3. Beautiful concept - cook using sunlight. 4. No fuel expense besides EMI. 5. Good for health. 6. Long product life + quick cooking + utensil friendly (all types usable, don't turn black). 7. Storage of charge.	1. Quick and convenient cooking. 2. Comfortable with proposed LPG price. 3. Utensil friendly (all types usable, don't get black, easy to clean). 4. Can cook in all weathers + no reliance on electricity. 5. Door-step delivery and easy cylinder booking. Available at local depot.
KEY REASONS FOR REJECTING	1. Plant installation challenges - all members in the community need to agree and one individual can't take it, space constraints, fuel inadequacy. 2. Safety issues – fear of pipeline blast/leakage, children can damage plant while playing.	1. Equipment too costly, proposed EMI high. Fear of loan repayment. 2. Difficult to install on kutcha roof. 3. Lack of understanding about the technology. 4. Unusable during continuous rain, may be damaged by cyclones.	1. Safety issues – fear of cylinder blast, gas leakage. 2. Cylinder booking and delivery issues (delivery time + doorstep delivery). 3. Proposed LPG cylinder price is high. 4. Relatively less clean for environment.

Co-creation of pathways

	ELECTRIC INDUCTION	IMPROVED BIOMASS COOKSTOVE	TRADITIONAL FIREWOOD CHULLAH
KEY REASONS FOR CHOOSING	1. Quick and easy cooking. Fast heat up and cool down. 2. Portable.	1. Improvement over traditional challah in terms of lesser firewood consumption, smoke and blackening of utensils. 2. Firewood cooking affordable for poor households.	None of the groups selected traditional firewood challah.
KEY REASONS FOR REJECTING	1. Fear of high electricity bill, unpredictable electricity bill. 2. Cannot cook without electricity (fear of power cut especially during rain and cyclones.). 3. Requires purchase of special costly flat bottom utensils. 4. Single burner – long cooking time, difficult to cook for a large family. 5. Safety issue - fear of electric shock.	1. Difficult to find small pellet size pieces of wood and time consuming to cut the wood to this size. 2. Not good for health. 3. Single burner – long cooking time, difficult to cook for large family. 4. Bad for environment.	1. Bad for health due to smoke emission. 2. Bad for environment. 3. Firewood (for free) not available easily, especially during rains. Cooking in rain using firewood also difficult once wood is wet. 4. Utensils become black and difficult to clean. 5. Safety issue - fire hazard. 6. Long cooking time, especially to ignite the fire.

Heterogeneity in settlements

Our settlements are heterogenous in terms household expenditure, occupation, education, religion, caste and land ownership, however, there is no clear link of any of these parameters to:

- Current fuel choice,
- Preferred cooking technologies selected by them in co-creation exercises.

Aspirations of low-income settlements

96% of respondents reported that meals they are currently cooking meet their cooking needs on a regular basis. Aspirations of the low-income settlements are not around cooking more (increasing quantity), but instead on quality of the cooking experience. It's a 'value story'

- ✓ Cooking faster and with most convenience.
- ✓ Spending less on cooking fuel and appliances.
- ✓ Having doorstep delivery of the fuel..
- ✓ Minimum travel to procure appliance and repairs and maintenance.
- ✓ Minimizing negative impact on human health and environment
- ✓ Safety of fuel and appliance.

Final pathways: Community biogas

✻ Community | o Supply chain | ◇ Government (Centre)
~ CSOs, funders | ▲ Government (City)
✤ Innovators | V Government (State)

Transition parameters	Current scenario	What low-income settlements accept/aspire?	Extent of gap	Opportunity areas for stakeholders
Price (average)	Stove: INR 2500[1]	Stove: INR 930[2] acceptable.[3] INR 1000—1500 max willingness.[3]		• Provide subsidy on biogas stove. ◇ V
	Gas price: INR 500-600 per month[1]	Gas price: INR 500-600[2] per month acceptable, INR 600-800 max willingness.[3]		
	Large capital expenditure (land, plant, pipeline, etc.)	Not able to invest into plant set up.		• Provide land, funding, permissions/ licenses. ◇V~▲
Delivery/ collection/ supply of technology	Large raw material requirement for community biogas plant	Negligible kitchen/ agricultural/ animal waste in urban low-income homes,		• Need tie ups (relevant laws) with homes/commercial establishments locally to source raw material. ✻▲✤o
	Doorstep delivery of gas – piped to each household.[1]	Doorstep delivery.		
	Doorstep delivery of gas stoves - distributed to all households. Gas stoves purchased off the shelf may not be compatible[1].	Doorstep delivery.		
	Community coordination for using biogas and collecting waste.	Minimum effort at the individual level.		• Need a champion to bring the community together. ✻ ~▲
Suitability of technology for cooking	Can cook all Indian food with existing utensils on double burner. Aligns with key transition drivers - speed, convenience, reliability, health, safety and environment.[1]			
Awareness/ knowledge	Negligible awareness about biogas.[3, 4]	Good understanding of technology.		• Awareness campaign and active reach out to community. ~ ▲

1: Based on Saaf's success case on the outskirts of Varanasi in India ; 2: Proposed in co-creation by Janaagraha; 3: Discussions with low-income settlements during co-creation exercises; 4: Primary survey

Final pathways: Solar Nutan

✻ Community	o Supply chain	◇ Government (Centre)
~ CSOs, funders	▲ Government (City)	
✤ Innovators	V Government (State)	

Transition parameters	Current scenario	What low-income settlements accept/aspire?	Extent of gap	Opportunity areas for stakeholders
Price (average)	INR 95,000 double burner, INR 56,000 single burner.[1] Zero interest loan[2] - Single: EMI Rs. 500-600 per month for 10-12 years. Double: EMI Rs. 500-600 per month for 15-17 years.	Financing model acceptable. Max willingness for EMI INR 700-1000.		• Easy zero cost financing without down payment. ~o • Subsidy on Solar Nutan ◇
Delivery/ collection/ supply of technology	Home installation of system.	Doorstep delivery.		
	Needs cluster sales for doorstep supply and service.[1]	Doorstep delivery. <1-2 kms travel for service.		• Proactive testing and scale up of technology supply chain. o ◇V✤ • Awareness campaign. ~▲V
Suitability of technology for cooking	Can cook all Indian food but cooks better with flat pots and pans. Burner options available. On full charge, can cook only twice a day for family of 4. Aligns with key transition drivers - speed, convenience, reliability, health, safety and environment.[1]	Can cook all Indian food with existing utensils on double burner. Aligns with key transition drivers - speed, convenience, reliability, health, safety and environment.		• Innovate towards using regular utensils and building more energy storage (to cook for larger families, more frequently, and during periods of continuous rain.) ✤
Awareness/ knowledge	Negligible awareness about solar cooking.[3, 4]	Good understanding of technology.		• Awareness campaign and active reach out to community. ~ ▲

1: Based on discussions with vendor; 2: Proposed in co-creation by Janaagraha; 3: Discussions with low-income settlements during co-creation exercises; 4: Primary survey

Final pathways: LPG

✻ Community	o Supply chain	◇ Government (Centre)	
~ CSOs	▲ Government (City)		
✤ Innovators	V Government (State)		

Transition parameters	Current scenario	What low-income settlements accept/aspire?	Extent of gap	Opportunity areas for stakeholders
Price (average)	Stove: INR 1557[1]	Stove: INR 930[2] acceptable, INR 1000—1200 max willingness.[3]		• Increase subsidy net to cover non-PMUY users also. ◇ V • Ensure timely receipt of subsidy into bank account, provide any paperwork support. ◇ V▲
	Cylinder (14 kg): INR 900-1000 (pre-subsidy)[1] - Not satisfied with subsidy. [1]	Cylinder (14 kg): INR 650 acceptable,[2] INR 650-850 max willingness.[3]		
Delivery/ collection/ supply of technology	Doorstep delivery of cylinders for most.[1] Issues reported by some (booking, delivery time, need to visit depot).[3]	Doorstep delivery. Maximum willingness to travel for fuel is 1-2 kms.[1]		• Strengthen LPG cylinder supply chain to make it seamless for all. o
	Gas stoves easily available and repairable in local stores.	Appliance purchase and repair <1-2 kms acceptable.[3]		
Suitability of technology for cooking	Can cook all Indian food with existing utensils on double burner. High levels of satisfaction with the technology on speed, convenience, reliability, health, safety and environment.[1,3]	Can cook all Indian food with existing utensils on double burner. Aligns with key transition drivers - speed, convenience, reliability, health, safety and environment.		
Awareness/ knowledge	High levels of awareness about LPG cooking.[1] Some concerns about cylinder blast and gas leakage.[3]	Good understanding of technology.[3]		• Awareness campaign about safety of LPG and required precautions. ~ ▲

1: Primary survey; 2: Proposed in co-creation by Janaagraha; 3: Discussions with low-income settlements during co-creation exercises

Final pathways: Electric induction

✻ Community	o Supply chain	◇ Government (Centre)	
~ CSOs	▲ Government (City)		
✤ Innovators	V Government (State)		

Transition parameters	Current scenario	What low-income settlements accept/aspire?	Extent of gap	Opportunity areas for stakeholders
Price (average)	Stove: INR 1600[1]	Stove: INR 930[2] acceptable,3 INR 1000—1500 max willingness.[3]		• Minor subsidy on induction. ◇ V
	High price of special flat bottom utensils INR 3,000	INR 500-600 max willingness.[3]		• Subsidy on pots and pans. ◇ V
	Electricity bill: INR 400 per month for family of 4[1]	INR 500-600 max willingness to pay.[3]		
Delivery/ collection/ supply of technology	Majority houses are connected to grid. Good quality and reliable electricity supply.[4] Some complains about power cuts, voltage fluctuations.[4]	Doorstep delivery of fuel.[4]		• Provide uninterrupted good quality electricity supply. ▲
	Induction stoves easily available and repairable in local stores.	Appliance purchase and repair <1-2 kms acceptable.[4]		
Suitability of technology for cooking	Can cook all Indian food (except rotis). Need special flat bottom pots and pans. Single burner.	Can cook all Indian food with existing utensils on double burner. Aligns with key transition drivers - speed, convenience, reliability, health, safety and environment.		• Innovate on utensils for making roti on induction. ✤
Awareness/ knowledge	Some awareness about electric cooking.[3, 4]	Good understanding of technology.		• Awareness campaign and active reach out to community. ~ ▲

1: Expert discussions and secondary research; 2: Proposed in co-creation by Janaagraha; 3: Discussions with low-income settlements during co-creation exercises; 4:Primary survey.

ELECTRICITY

Grid electricity

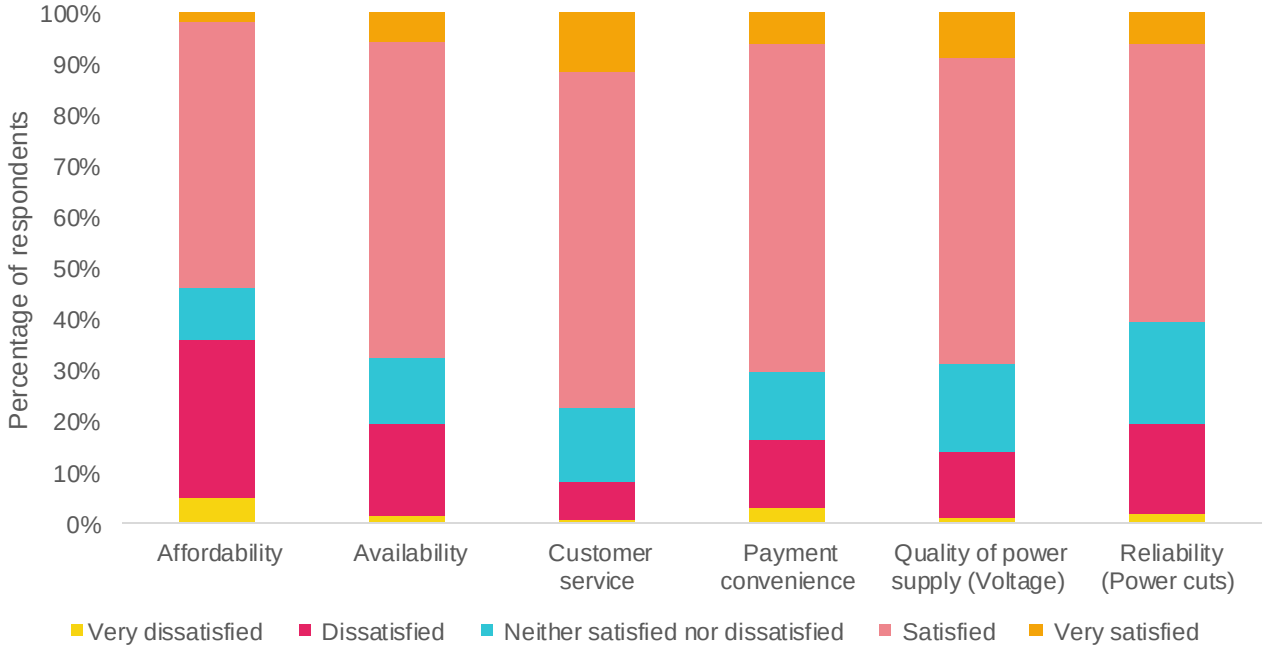
- 96% respondents surveyed are connected to the grid, 84% of them have been connected since >5years.
- 60% of respondents who answered the question[1] report that they spend less than INR 428 per month on electricity.
- 31% grid electricity users report getting the connection under the Saubhagya scheme, and 36% report having the connection from before launch of the scheme/or taking connection not part of any scheme.[2]
- Respondents report reasonable quality of electricity supply
  - Over 70% grid users,[3] report having electricity for 5-6 hours across the 4 six-hour cycles in a day.[4]
  - 80% grid users[5] report not experiencing problems with the voltage such that it affects the way their appliances work.
- 70% grid users report having a working electric meter[6] and 77% report receiving a monthly bill.

1: 2023/5368 responded to the question. Others said don't know/refused to answer. 2: 24% said don't know/refused to answer, 9% said other scheme (e.g., BPL card scheme and Biju Jana Jyoti Yojana). 3: Approximately 80% grid users answered the question. 4: 6AM-12noon, 12noon-6PM, 6PM-12midnight, 12midnight – 6AM. 5: 88% grid users answered the question. 6: 27% report no, 2% - yes but not working, and 1% yes – prepaid meter.

Grid electricity

- Respondents are least satisfied with grid electricity in terms of affordability, followed by reliability (power cuts).
  - Maximum willingness to pay for electricity is INR 236 per month.[1]

Figure 13: Level of satisfaction with grid electricity



1: Based on 1869 responses. Others did not answer the question.

Appliances

- Most commonly used appliances:
  - Lighting (used by *5298/5368 respondents)*: LED bulbs (93%), CFL bulbs (6%)
  - Water heating (used by *2163/5368 respondents):* LPG/PNG stove (44%), Chulha (Firewood/Charcoal/ Coal/ Dung cake) (30%)
  - Space cooling/heating (used by *4411/5368 respondents):* Ceiling fan (88%), table/pedestal/wall mounted fans (26%)
  - Infotainment (used by *3285/5368 respondents):* Mobile (97%), TV (48%)
  - Other appliances (used by *1770/5368 respondents):* Mixer-grinders-blenders (83%), refrigerators (42%), electric iron (36%), washing machine (10%)

- Star rating: Only 20% respondents are aware of BEE star rating in electrical appliances[1]

1: : No – 64%, don't know/refused to answer – 15%

Co-creation of pathways: Solar PV for household level electricity

Like the cooking co-creation exercises, solar PV was presented as a potential household electricity solution to low-income settlements. It was accepted by 10/12 co-creation discussions in Bhubaneswar, Cuttack and Koraput.[1]

KEY REASONS FOR CHOOSING

1. Lower or no electricity bill.
2. Interested because of government scheme/subsidy.
3. Good for environment.
4. Attractive proposed EMI/affordable. Max willingness to pay to payoff loan faster INR 500-600.
5. Longevity – will be good for future generations.

KEY CONCERNS

1. Difficult to manage without an inverter in days of regular rainfall.
2. Risk of damage of solar panels during natural disasters like cyclones or by monkeys.
3. Repair and maintenance may take 3-4 days.
4. Difficult to get loan from bank due to for example land documentation issues.

Discussion points for pathways for different stakeholders

- Can loans be provided at at 0% interest to communities?
- How can we ease availing loans for communities given limited collaterals, fear of engaging with banks?
- Can we provide insurance to protect from risk of damage to solar panels?
- Can we build a strong repair and maintenance network?
- How can we spread awareness and knowledge?

1: 2 co-creation sessions per city. In each session, participants were divided into 2 breakout groups. See Appendix D for detailed slides presented to the settlements.

Dashboard

Dashboard

- Cost of fuel is an important consideration when transitioning to cleaner cooking fuels. Also, as per our survey, the feature which reports the highest dissatisfaction among users if the cost and subsidy refund of LPG.
- Through this dashboard, we use data from our survey to provide a reference point for cooking fuel usage costs incurred by low-income urban settlements that may be used as a starting point for other cities in Odisha/India.
- The cost calculator which provides (a) current fuel usage costs, and (b) cost of transitioning to cleaner cooking fuels, to inform decision making by all stakeholders.
  - It allows for customizing household profile of interest by household size, cooking fuel mix, and household expenditure.
- Use cases:

Stakeholder	Use Case
Community	• Calculate cost of cleaner cooking fuel • Calculate savings (if any) if they choose to switch to cleaner fuel
Government	• Inform financial assistance/subsidy policy • Promote/develop infrastructure for cost efficient cleaner cooking fuels
Supply chain & innovators	• Set competitive prices for fuel based on willingness to pay
CSOs, donors, funders	• Understand cooking fuel expenditure profiles for policy recommendations • Communicate cost benefits of cleaner cooking fuels

Note: We are currently evaluating options to publish the dashboard.

Guiding thoughts for implementation

Note: These insights have emerged from a Symposium organized by Janaagraha in October 2024 in Bhubaneswar. The symposium brought together 5 key categories of stakeholders in the 'just transitions' eco-system: (a) government, (b) industry/supply chain - technology providers, manufacturers, vendors and distributors, (c) civil society, (d) academia/researchers, and (e) representatives of low-income settlements. The event facilitated discussions around 4 key questions::

1. *What did the residents of low-income settlements say about their fuel–appliance choices, their willingness to adopt cleaner technologies and the contours of transition acceptable to them?*
2. *How can we elevate/integrate perspectives of low-income settlements in shaping a Just Transitions journey?*
3. *Are the contours for cleaner technology adoption set by the low-income settlements feasible for the supply side? If not or limited, then what would it take for the supply side stakeholders?*
4. *What can the city government (elected and officials) and/or state government, do to help facilitate these transitions?*

Guiding thoughts for implementation on-ground

[Multi-stakeholder effort is required]

- There is a triad of stakeholders that need to work together to plan and implement a 'just' energy transition.
  - There are energy departments within the government that are mainly responsible for promoting clean energy and the transition. However, when we think of 'justness' of the transition, non-energy departments (e.g., urban development, health) and the local government need to play a strong role in facilitating the same.
  - The government doesn't own the cleaner technologies, so external technology providers are another key stakeholder.
  - The end-user also needs to have a buy-in and willingness to use/commit to the technology/solution. This is particularly pertinent for low-income communities because their contours of acceptance might be different for other end-user groups. [Note: The purpose of this Study is not put the burden of fighting climate change on the poor. Instead, it answers the question that if you would like everyone to transition, including the urban poor, what are the contours for their effective transition?]
  - Civil society can facilitate different aspects of the transition as a bridge.

[Reality check required for the demand side]

- For low-income settlements, thinking about clean energy technologies on paper/power point slides/workshops may be quite different to embracing them on ground. Need to consider in more detail:
  - Space and technology (e.g., weight of Solar Nutan) design in their homes (and outside),
  - Outlook towards personal finance (e.g., propensity to spend more today or in future, building assets for future generations, affordability through life-cycle of the technology rather than at a point in time, etc.),
  - Ability to obtain finance from financial institutions (e.g., eligibility. ability to furnish documents), and
  - Outlining a full risk-benefit analysis of different energy pathways for communities that needs to be clearly understood by them.

Guiding thoughts for implementation on-ground

[Push required for technology adoption]

- Need to demonstrate technologies through 'proof of concept' – showcase technologies locally – need local champions.
- Spread awareness through role models e.g., film stars as brand ambassadors.
- Need to think about technology stacks rather than individual technologies to optimize key transition drivers and aspirations of low – income settlements (such as speed, convenience, reliability, cost, practicality of cooking, safety, health and environment, door-step delivery.)
  - E.g., All electric cooking appliances will need too many sockets and counter space, so we need to balance with another technology such as an LPG stove.
- Pathways/technology stacks may need to be customized for households, communities
- Not a one-time activity. Need to maintain dialogue to refine pathways as per needs, insights and technological changes.
- Need monitoring, accountability, scaling and replication.

Thank you.

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