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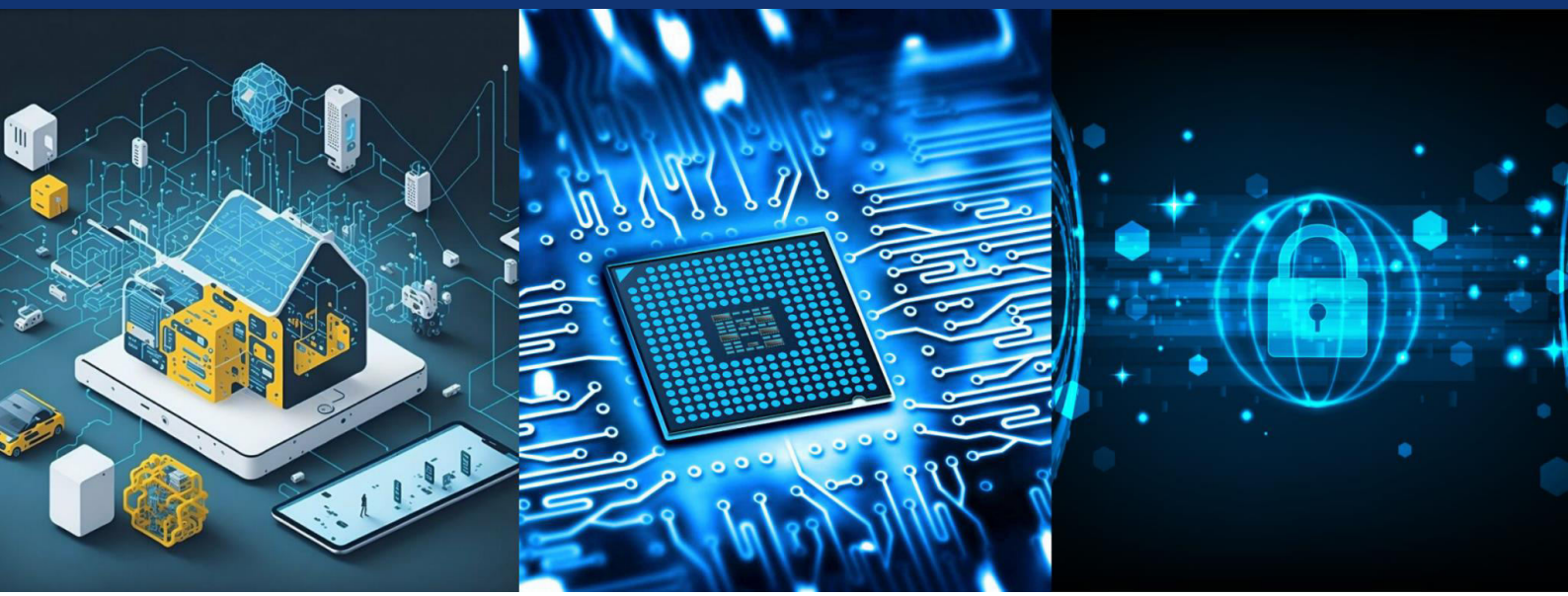

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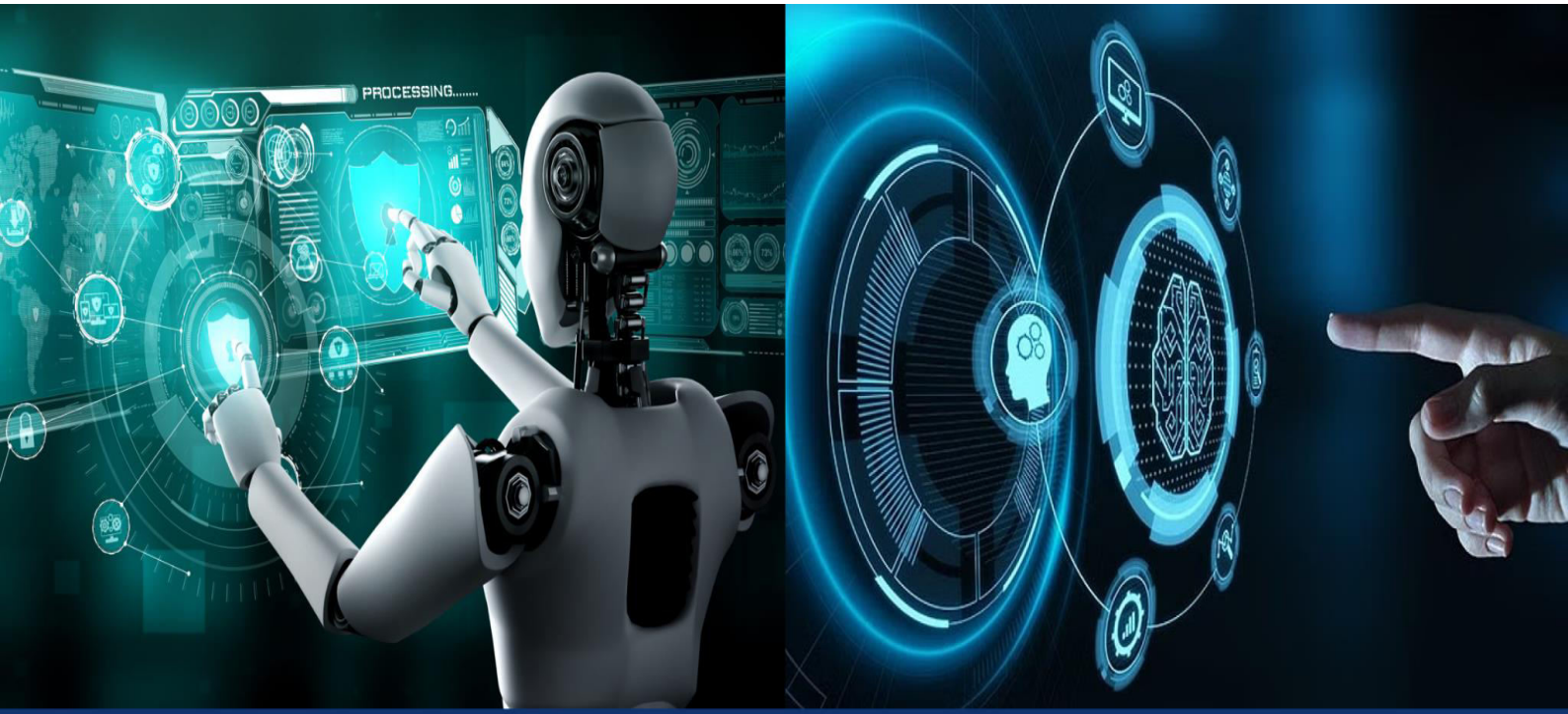

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Energy Insecurity and Environmental Burden: A Case Study of a Tribal Village in Dhar, Madhya Pradesh

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ABSTRACT: Having energy is one of the most important needs of a modern society. However, large sections of tribal communities in India are still without access to energy, and they continue to depend on traditional biomass for their daily needs, thereby causing severe environmental and health problems. This research focuses on the energy scenario of a tribal village in the Dhar district of Madhya Pradesh. Specifically, the study aims to (i) analyze the energy consumption patterns, (ii) assess the environmental impact resulting from these patterns, in terms of carbon emissions and deforestation, and (iii) explore the challenges as well as the potential for the implementation of sustainable energy solutions. To accomplish this, the researchers adopted a mixed methods strategy in a village with 120 households. A structured questionnaire survey of 60 households (50%) selected through stratified random sampling was conducted. The data was also cross-checked through observation checklists and three focus group discussions (FGDs) with men, women, and youth groups. For the purpose of analysis, energy consumption was translated into standard units (kWh, kg CO).

KEYWORDS: Energy Audit, Tribal Development, Biomass, Carbon Footprint, Gender, Renewable Energy, Dhar.

I. INTRODUCTION

India's pledge to provide universal energy access (SDG 7) can be well understood as the challenge of the most difficult test in the remote and tribal regions. National-level electrification has achieved a remarkable increase; however, the quality and sustainability of energy have been questionable. For instance, in a district like Dhar in Madhya Pradesh, which is mostly inhabited by the Bhil and Bhilala tribes, merely being connected to the power grid means opening up to a possibility of erratic power supply, and clean cooking is something that is hardly imagined. On the one hand, the continued usage of firewood and kerosene has caused environmental destruction, while indoor air pollution caused by the smoke from these fuels has a negative impact on people's health, and women spend so much time on fuel collection that their poverty cycle gets perpetuated.

This paper pitches a micro-level research paper analysing each link in this vicious cycle in a single village. It goes far beyond the measuring of access to get into a full energy audit and the questions of: What are the actual energy consumption patterns? What is the real environmental cost? And which way is up culturally to the sustainable energy future? The report intends that, by addressing the questions, it will contribute to the formulation of a well-reasoned plan of action based on the evidence produced through the study for the policymakers and development agencies that are running programs in almost identical ecological and social settings.

Energy Audit- It is a type of energy audit that is a detailed inspection and analysis of how a building or facility uses energy. A trained professional evaluates the building or facility and thoroughly examines all components, from insulation and lighting to HVAC systems and appliances, to identify areas of energy wastage. The primary objective is to figure out ways to cut down energy use and save on utility bills. Eventually, the energy auditor provides a series of suggestions for a more energy-efficient and comfortable space, ranging from simple changes in behavior to the installation of new equipment.

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Renewable energy is energy taken from sources that are naturally replenished on a human timescale. These sources are continuously renewed by nature and therefore cannot run out. Simply put, it's energy from sources that don't get exhausted, such as the sun or wind.

Biomass is any kind of organic matter coming from plants and animals that can be converted into a renewable energy source. It covers materials like wood, crops, farm leftovers, and organic waste. The energy lying in biomass is solar energy at its origin, as plants absorb it by photosynthesis. When biomass is combusted or turned into biofuels such as ethanol or biogas, it releases this stored chemical energy that can be utilized to produce heat, electricity, or fuel vehicles.

Tribal development is primarily focused on giving indigenous communities the power to be self-reliant and ensuring that they have access to education, healthcare, and economic opportunities without sacrificing their cultural identity. It is not about pushing them to the modern world, but it is rather about finding a balance between the traditional lifestyles and the advantages of the 21st century, such as clean water, schools, and just representation. Essentially, it is about providing tribal communities with a level playing field in a better future while acknowledging their heritage, wisdom, and rights to make their own decisions.

Carbon footprint- Imagine your carbon footprint as a sort of invisible trail of greenhouse gases that you leave unconsciously around you. In other words, it is the total impact of your activities on the natural environment. Each time you drive a car, use a phone charger, keep your home warm or even purchase a product that has been transported from the other side of the world, you are indirectly causing a certain amount of carbon dioxide to be emitted into the atmosphere. Think that everyone has a hidden exhaust pipe, and your carbon footprint is a way of figuring out how big your pipe is. If you have a large footprint, then you are heavily contributing to the issue of climate change, and that is why many people express their desire to reduce it by leading more environmentally friendly lives.

Tribes- A tribe is basically an extended family, or a community of people that share the same territory, language, culture, and ancestors. They are united by their strong traditions, customs, and a profound sense of belonging that has been passed down from one generation to another. In contrast to the city folks these days who might hardly know their neighbors, tribal communities function like a tightly woven web where everyone is looking out for each other, frequently making decisions collectively for the welfare of the entire community. For them, identity is not simply a matter of place; it's about who they really are as a people, a people united by history and the same lifestyle that has endured through the ages.

II. REVIEW OF LITERATURE

Existing research shows that tribal households in India rely heavily on biomass (firewood, dung cakes) for cooking, with over 80% using traditional stoves that cause severe indoor air pollution and health issues, especially for women and children (Barnes et al., 2011; Sinha & Joshi, 2010). Energy audits in rural areas have proven useful: they identify inefficiencies and help design effective interventions like improved cookstoves, which can cut wood use by 30% and reduce emissions (Kumar & Mohanty, 2019; Palit & Chaurey, 2011). However, environmental costs are high-biomass burning contributes to deforestation, soil degradation, and significant carbon emissions (Ravindranath & Hall, 1995; Smith et al., 2000). Renewable alternatives like solar microgrids, biogas, and improved cookstoves exist, but adoption is blocked by high upfront costs, lack of awareness, poor maintenance support, and cultural resistance (Nouni et al., 2009; Bajaj & Sharma, 2021). Government schemes like Ujjwala and Saubhagya have expanded access, but unreliable supply and unaffordable refills limit their impact in tribal areas (Singh et al., 2020).

Research gap

Few micro-level energy audits have been done in the Dhar district, and most studies do not integrate environmental metrics with community perceptions. This study addresses those gaps by conducting a detailed energy audit in a tribal village of Dhar, linking consumption patterns to environmental and health outcomes.

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Objectives

1. To quantify energy consumption patterns in a tribal village of Dhar district, Madhya Pradesh.
2. To evaluate the associated environmental impacts of current energy practices, specifically focusing on: Carbon emissions, Deforestation.
3. To identify barriers to and opportunities for sustainable energy adoption within the community.

III. MATERIALS AND METHODS

Study Site Selection:

A village of indigenous people in the Tirla block of Dhar district was chosen for the study. The selection criteria were: the tribal community population to be more than 80%, the village should be situated within 5 km of a forest (to study the dependency on biomass), the village is partially electrified, and the village council agrees to participate.

Sampling and Data Collection:

Out of the 120 total households, 60 (50%) were randomly chosen to be part of the household energy survey. The survey instrument collected information on:

- Demographics and socio-economic.
- Daily/weekly consumption of firewood, dung, kerosene, LPG, and electricity
- List of electrical appliances and their usage hours
- Monthly energy expenditure.
- Time spent on fuel collection by gender and age.

The three FGDs had the following structures and participants: one with 8 men, one with 10 women, and one with 6 youth (mixed gender). Energy, health, environment, and willingness to adopt new technologies perceptions were discussed in the FGDs.

Data Analysis and Calculations:

- **Energy Consumption**: Firewood was changed to kWh by using a calorific value of 3.9 kWh/kg and a stove efficiency of 25%, which was assumed. One litre of kerosene equals 10 kWh.
- **Carbon Emissions:** Emissions were worked out by using IPCC Tier 1 emission factors:

Firewood: 1.83 kg CO/kg; Kerosene: 2.5 kg CO/litre; Grid Electricity: 0.8 kg CO/kWh (reflecting India's coal, heavy mix).

➢ **Qualitative Analysis:** FGD transcripts were coded into themes to spot barriers, perceptions, and social norm changes.

IV. RESULTS

The Energy Mix: A Story of Dependence and Deprivation

The energy audit revealed a classic example of the 'fuel stacking' phenomenon, where households use a mix of traditional and modern fuels due to distrust of the supply and price.

Table 1: Household Energy Portfolio (N=60)

Fuel/Service	% of HH Using	Avg. Consumption (per HH)	Primary Use	Reliability/Cost
Firewood	90%	12 kg/day	Cooking	"Free" but high labor cost
Dung Cakes	30%	3-5 kg/day (seasonal)	Cooking	Supplement when wood is scarce
LPG	10%	0.33 cylinders/month	Cooking	High refill cost; rationed use
Grid Electricity	70%	20 kWh/month	Lighting, Fans	Unreliable (4-6 hrs/day)
Kerosene	40%	2-3 liters/month	Lighting	Expensive (₹50-60/litre), rationed
Diesel	25%	Variable	Irrigation (pumps)	High operational cost

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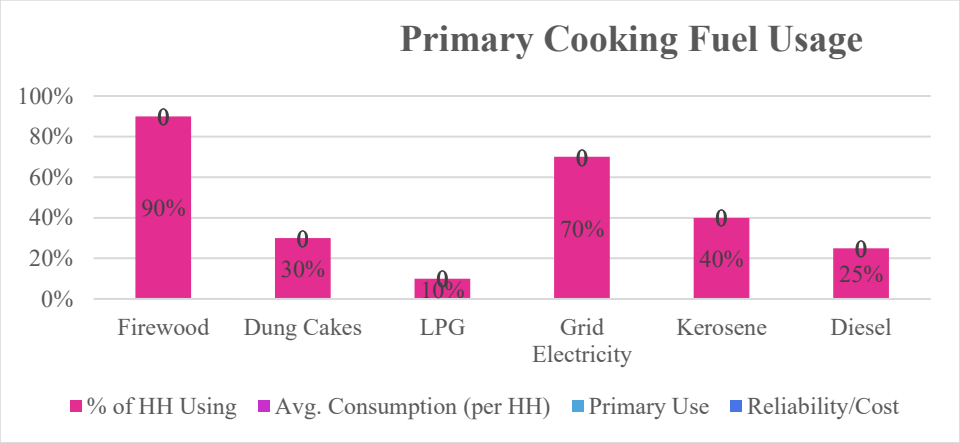
Figure 1: Primary Cooking Fuel Usage

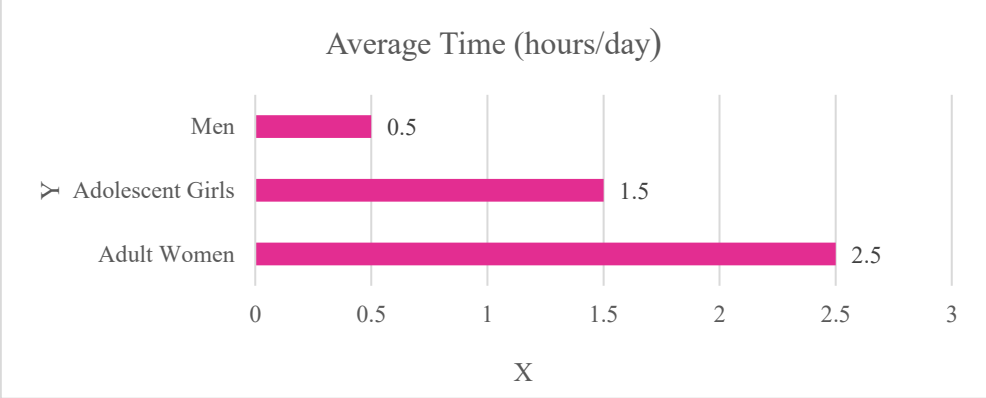


Description for Chart: A chart showing the primary cooking fuel. A large slice for "Firewood" (90%), a very small slice for "LPG" (10%). This starkly illustrates the dominance of biomass.

THE HIDDEN COST OF "FREE" FUEL: LABOR AND GENDER

Although firewood is free in monetary terms, it has a substantial opportunity cost, which women have to pay more than others. FGDs disclosed that the way to "good" firewood is now 2- 3 km away, and this distance has increased over the last ten years due to forest depletion.

Figure 2: Average Daily Time Spent on Fuel Collection by Demography



Description for Chart: A horizontal bar chart. The Y-axis lists three groups: "Adult Women, " "Adolescent Girls, " and "Men." The X-axis shows time in hours. Adult women have a bar going up to 2.5 hours, Adolescent Girls, 1.5 hours, and Men, 0.5 hours. It shows very clearly the gender disparity. Cook and clean, half the day is gone. We are not able to attend the Anganwadi meetings or get any education. This is the way we live our lives."

Environmental Accounting: The Carbon and Ecological Footprint

The reliance on biomass translates directly into a significant carbon footprint and contributes to local deforestation.

Table 2: Monthly and Annual Carbon Emissions (per average household)

Source	Monthly Consumption	Monthly CO_2 (kg)	Annual CO_2 (kg)	Share of Total (%)
Firewood	360 kg	658.8	7,905.6	94.9%
Kerosene	2.5 liters	6.25	75	0.9%

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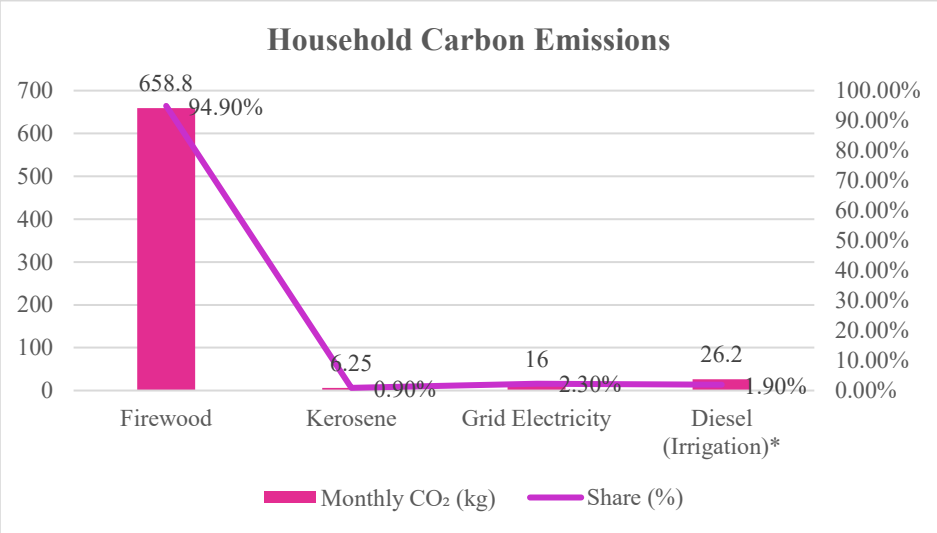
Grid Electricity	20 kWh	16	192	2.3%
Diesel (Irrigation)*	10 liters	26.2	314.4	1.9%
TOTAL		~707	~8,487	100%

➢ Diesel consumption is averaged only over the 15 households using pumps, but is included here for a complete household footprint. If averaged over all 60 households, the per HH diesel emission is lower, but the dominance of firewood remains unchanged.

Figure 3: Share of Household Carbon Emissions by Source



Description for Chart: A chart. The largest, most prominent slice is "Firewood," taking up 95% of the chart. Three tiny slices are shown for "Kerosene, " "Electricity, " and "Diesel." The title should read: "Firewood Dominates the Household Carbon Footprint.")

Household carbon emissions attributable to firewood alone for the total sample of 60 households are around 42.4 tons of CO per year. This corresponds to the carbon that would be absorbed by about 1, 700 mature trees in a year, hence showing the net loss of the local ecosystem.

Awareness, Attitudes, and Barriers to Adoption

The FGDs revealed critical insights into the social and psychological barriers to change.

Table 3: Thematic Analysis of Focus Group Discussions

Theme	Men's FGD	Women's FGD	Youth FGD
Perception of Firewood	It's our traditional right; the forest is ours.	It's hard work, but what else can we do?	It's old-fashioned, but we have no choice.
Knowledge of Solar	Heard of it, but think it's only for cities.	Seen panels on the school, don't know how they work.	Know it can charge phones and run lights. Want to learn more.
Barriers to LPG	Expensive refills. Cylinder lasts no time.	The cylinder is good, but we can't afford to refill. We save it for emergencies.	Refill cost is too high. The process is also difficult.
Health Concerns	Smoke is normal; our fathers survived.	Eyes burn, constant cough. It's part of getting old.	Our mothers are always sick. We think it's from the smoke.
Willingness to Change	Only if it's free and strong like wood.	Yes, if it reduces our work and smoking.	Absolutely. We want a better life.

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V. DISCUSSION

The results show that this tribal village, though it is on the grid, is still very much energy insecure. The phrase "energy access" here needs to be redefined to also cover reliability and sustainability. The 70% grid connectivity figure is deceiving since the supply is so bad that neither kerosene use can be totally done away with, nor can the running of productive appliances be facilitated. This is in line with Bhattacharyya's (2006) argument, supported by the empirical evidence here, that simply providing infrastructure is not enough.

Data reveals an alarming environmental paradox: it is often the communities closest to nature that are, by necessity, its most immediate degraders. Bhils are a case in point. The quantification of around 42 tons of CO emitted from firewood in the households that were sampled is a direct indicator of this degradation. The 2- 3 km firewood gathering trip, as mentioned in FGDs, is an actual observation of local deforestation (forest retreat) and is thus in line with Ravindranath & Hall's (1995) concerns. The absence of knowledge about the connection between this fuel gathering and forest degradation is a considerable gap that needs to be filled. The gender aspect runs deep in the matter. The 2–3-hour daily work load on women is not just a question of time; it's a structural roadblock to their education, self-help groups, and income generation (Sinha & Joshi, 2010). Any solution proposed must be scrutinized through a gender lens: will it help lessen that burden? Improved cookstoves (ICS) and biogas do not just provide energy; they give women a voice, a say in life.

FGDs show a community facing a big decision. The old generation is fixed in their ways, as they consider smoke and hard work as something that cannot be avoided. On the other hand, the youngsters criticize this attitude and show that they clearly want modern, clean energy. This divide between generations is a key point of leverage. Youth should be the focus of interventions as they are likely to be early adopters and lead the change within their families. The older people's skepticism towards solar is a typical obstacle for new technology that can be addressed by providing them with the example of a well, functioning, community, community-owned system (Palit & Chaurey, 2011).

VI. CONCLUSION AND POLICY ROADMAP

The study reveals that, although the tribal village in Dhar district is partially electrified, it is essentially in a state of energy poverty. The main source of energy, firewood, is not only deforestation but is also a health hazard and a major factor contributing to the inequality between women and men in the village. The way ahead entails a comprehensive intervention by the whole system rather than isolated technology distribution.

A Roadmap for a Sustainable Energy Transition:

Phase 1: Immediate Relief (0-12 Months)

- **Target:** Reduce kerosene use and indoor air pollution.
- **Action:** Distribute high-quality solar lanterns and task lights to all 120 households through a subsidized model, leveraging CSR funds.
- **Action:** Launch an awareness campaign in schools and women's groups on the health hazards of indoor smoke.

Phase 2: Systemic Change (1- 3 Years)

- **Target:** Reduce firewood dependence by 50% and ensure reliable power.
- **Action:** Install a community-owned solar microgrid (10, 15 kW) to power LED lights, fans, and mobile charging for all households, ensuring reliable lighting.
- **Action:** Implement a program for 50 Improved Cookstoves (ICS), prioritizing households with women, children, and the elderly. Provide training on use and maintenance.
- **Action:** Pilot 5, 10 household biogas plants for families with sufficient cattle, linking them to NABARD subsidies.

Phase 3: Empowerment and Enterprise (3-5 Years)

- **Target:** Generate new green jobs locally and connect energy with people's livelihoods.
- **Action:** Give local young people (especially girls) training as "Barefoot Solar Engineers" to run the microgrid and solar systems.
- **Action:** Check how power can be a dependable resource for village-level activities like flour milling, tailoring, and welding.

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- **Action:** Include energy consideration in the Gram Panchayat Development Plan (GPDP).
- The co-designed community roadmap serves as a guide to overcome the vicious circle of energy poverty and environmental degradation; thus, in a way that is both good for people's health and sustainable, the tribal communities of Dhar will be able to grow and develop.

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