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RESEARCH PAPER

Mapping the Household Energy Transition: Determinants, Measurement Approaches and Policy Lessons

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ABSTRACT

Energy transition is vital for developing countries, as their households rely on inefficient and dirty fuels, creating negative impacts on the environment. Urbanization, income growth, and demographic change are reshaping consumption patterns. Therefore, this study analyzes existing literature to examine the key drivers and patterns associated with household energy transition. Quantitative review approach is used to synthesize the literature on household energy transition. Under this approach, we reviewed cross-sectional and panel studies employing the methodologies of the multivariate probit model, multinomial logit model, Lewbel 2SLS, and MDCEV methods. The findings highlight that the transition process is influenced by a multidimensional set of factors, including household characteristics, market access, socioeconomic conditions, behavioral aspects, environmental concerns, and government policies. Household income, education, and policy incentives are among the significant factors associated with cleaner fuel adoption. Policy should expand access to clean energy, improve affordability through targeted subsidies, and strengthen rural infrastructure.

KEYWORDS Energy Transition, Household, Environment, Fossil Fuels, Energy Ladder, Energy Stacking, Energy Switching Behavior

Introduction

Provision of adequate supply of energy resources is vital for human welfare that has a strong bearing upon environmental quality, health outcomes, and living standards. Developing countries still rely on traditional fuels to fulfill their energy needs for cooking, heating, and lighting. These fuels have low thermal efficiency and cause severe indoor air pollution. The world is still far behind in achieving sustainable development goal-7, which relates to the provision of universal access to affordable, reliable, sustainable, and modern energy, as about 2.1 billion people around the globe still cook with polluting fuels. With the current pace, almost 1.8 billion people will remain without access to clean cooking fuels by 2030 globally (IRENA, 2023). Therefore, transition from dirty to cleaner fuels is imperative for ensuring reliable, secure, affordable, and sustainable supply of energy (Genc & Kosempel, 2023). Energy transition has crucial implications for climate change and long-term prosperity of nations. To achieve targets set in the Paris accord, the world needs to meet net-zero CO_2 emissions target by 2050, which requires a systematic transformation of energy systems at the global level (IRENA, 2023).

The energy transition refers to the shift away from fossil based energy systems such as coal, oil, and natural gas to renewable based systems such as solar, wind, biofuels, and hydrogen (Harichandan et al., 2022). The energy sector at the global level is in transition, showing a movement towards greater access to low-carbon and renewable systems for energy production, such as wind and solar, and away from the use of fossil based systems, including oil, gas, and coal (Genc & Kosempel, 2023). Irrespective of the commitments made at COP28, trend in energy transition remains off track because fossil fuels still dominate the energy mix in major countries. Therefore, the possibility to meet the targets set by Paris agreement is becoming increasingly remote (IRENA, 2023).

Household level energy transition results in environmental benefits, improves productive efficiency of an economy, and results in CO_2 emissions mitigation (Choumert-Nkolo et al., 2019). More than two third of the global CO_2 emissions are associated with the daily household activities (Acharya and Marhold, 2019; Jones and Kammen, 2011). Almost half of the global population consumes polluting fuels such as dung cake, firewood, coal, and charcoal for cooking. Furthermore, future projections reflect that 31% of the global population will use polluting cooking fuels by 2030 (Elasu et al., 2023). Studies also warn that the use of polluting fuels causes air pollution, which is responsible for approximately 3.5 million premature deaths globally (Elasu et al., 2023). Therefore, the policies are focusing on uninterrupted supply of energy and on achieving energy transition worldwide (Greenstone & Hanna, 2008; Tang & Liao, 2014). The developing countries such as Pakistan lack the estimates related to these energy dynamics and their fallouts.

Almost 74% of households in urban areas and 12% of households in rural areas of Pakistan use clean fuels for cooking, lighting and heating (PBS, 2020). Regional disparity is a significant factor in energy use patterns across regions and provinces in Pakistan (Awan et al., 2024). Pakistan's rural households mostly use biomass fuels for heating and cooking purposes, which raises serious concerns for health and the environment (Rahut et al., 2019). Pakistan has experienced a significant transition towards cleaner and modern fuels, such as solar photovoltaic (PV) systems achieving a significant penetration. At the beginning of 2025, solar growth was recorded at roughly 25%, which surpassed the US, at 11%, and China, at 8% (Ahmed et al, 2026). Pakistan, being an energy poor economy, is highly dependent on imported energy, which makes it an economic and strategic issue for the economy (Awan et al., 2022).

Energy transition is driven by a multifaceted interaction of household income, education, socioeconomic, environmental, market, behavioral, policy incentives, and government factors playing key roles in energy adoption patterns (Elasu et al., 2023; Liao et al., 2021; Guta et al., 2021). Studies reveal that while households' fuel switching often involves fuel stacking, where multiple fuels are used simultaneously (Zhu et al., 2018; Guta et al., 2021), rapid transitions have been observed in countries like China because of the policies that have promoted cleaner fuels (Wang et al., 2023; Chen et al., 2024). Behavioral aspects, including awareness, motivation, and trust, significantly influence household energy decisions regarding adoption of new energy technologies, emphasizing that user centric approaches are crucial for accelerating change in energy adoption (Gaspari et al., 2021; Chadwick et al., 2022). Therefore, understanding these multidimensional drivers and barriers is vital for designing effective interventions to support widespread household energy transitions.

This review paper thus aims to consolidate the fragmented literature on household energy transition and provide a clear overview of its theoretical foundations, empirical findings, and policy relevance. Further, the paper also provides theoretical and methodological foundations, identifies research gaps, and provides an evidence based foundation for policy formulation and future empirical investigation of energy transition in developing countries.

This paper is organized as follows. Section 2 provides the conceptual and theoretical foundations of household energy transition. Section 3 reviews the literature to provide an overview of the methodological approaches used by different studies to analyze household energy transition. Section 4 summarizes the key findings. Section 5 concludes the study with a discussion of potential gaps and suggestions for future research.

Literature Review

Conceptually, the literature of energy transition has been evolving over time. Leach (1992) is considered among the pioneers who analyzed the conceptual process of energy transition and related it to fuel substitution in developing countries (Segura, 2024). Because of its interdisciplinary nature, no single definition of energy transition is available, but several important formulations provide convergence of its core elements (Segura, 2024). Table 1 provides a conceptual framework of energy transition by reviewing different definitions provided by different scholars.

Table 1
Conceptualization of energy transition

Description	Reference
Energy transition as fuel substitution in developing countries	(Leach, 1992; Segura, 2024)
Historical synthesis highlighting the length and patterns of energy transitions	(Grubler, 2012)
Diffusion of energy sources and the associated technologies.	(Fouquet, 2016).
Define energy transitions as long-term, multi-dimensional, and socio-technical transformations	(Cherp et al., 2018; Coenen et al., 2021)
Energy transition is a process involving changes from one form, place, state, style, or scale of energy system to another, typically involving structural changes and shifts in energy production and consumption patterns towards low-carbon fuels	(Edomah et al., 2020)
Energy transition is a pathway toward the transformation of the energy sector from fossil-based to zero-carbon	(Irena, 2023)
Shifts in dominant energy fuels and technologies, such as from fuelwood to coal, coal to oil, and now from fossil fuels to low-carbon or renewable sources	(Edomah et al., 2020; Genc & Kosempel, 2023)

Synthesizing this literature, it can be inferred that energy transition is a structural and socio-technical long-term process involving technologies, and energy systems entailing a shift away from traditional and fossil based fuels towards low and zero carbon emitting, cleaner, and modern fuels. Understanding the dynamic nature of energy transition requires a theoretical understanding to inquire into how and why transition occurs, which factors enable it, which models are successful in capturing it, and what are the critical determinants of energy transition. Therefore, a conceptual understanding of the relevant aspects of energy transition is required.

Historical discussion on energy transition has revolved around some foundational theories, such as the energy ladder hypothesis, the energy stacking hypothesis, and related frameworks. The basic discussion on energy transition literature has its roots in the 1980s and 1990s, linking it to the energy ladder hypothesis (Ai et al., 2021). The energy ladder hypothesis links households' energy choice to economic factors and portrays that each higher step on the ladder is linked to more advanced energy sources. With the increase in income, a household moves up the ladder. Typically, lower income households rely on traditional energy fuels such as dung cake, firewood, and crop residue. As the economic status of a household improves, it improves its living standards by attaining modern appliances, and hence a household with a higher income level tends to move towards clean and modern fuels. Alam et al. (1985) suggested that higher income households have a stronger preference for petroleum based commercial fuels than for biomass. Reddy (1995) used the energy ladder concept as a framework for understanding household energy transitions and proposed that households move to higher quality, cleaner energy sources as their economic conditions improve. Masera et al. (2000) found that lower income households use traditional fuels such as dung cakes, firewood, and charcoal for traditional stoves, while higher-income households adopt modern technologies and therefore modern fuels respectively. Thus, when income increases households move towards clean fuels (Adamu et al., 2020). Similarly, Rajmohan and Weerahewa (2007) for Sri Lanka, Adamu et al. (2020) for Nigeria, and Ahmed et al. (2023) confirmed the existence of the energy ladder hypothesis.

In the evolution of energy transition literature, several studies found evidence of stacking fuels, where a household uses a mix of traditional and modern fuels simultaneously rather than switching to cleaner fuels entirely. Zhang et al. (2014) identified that per capita income, fuel prices, and renewable energy sources are the key determinants of energy consumption in Beijing. Han et al. (2018) analyzed panel data from China Statistical Yearbooks to investigate the patterns in the energy transition. Results from fixed-effects and random-effects models indicate that households' energy stacking behavior persists in rural China. The author found that income, residential areas, education, and regional differences influence energy consumption choices. Similarly, Ogwumike et al. (2014) found evidence of the energy stacking hypothesis and further found that variables such as household size, parents' education, and per capita expenditures influence household energy use decision making. Moeen et al. (2016) also found evidence of the energy stacking hypothesis for the case of Pakistan. Zhu et al. (2018) identified a clear shift towards fuel stacking, in which households stack different fuels rather than relying on a single one. The share of households using a single fuel source declined from 28% to 11% over the two decades in China. Koirala & Acharya (2022) investigated fuel choices in Nepal in the context of energy crises and confirmed the existence of fuel stacking in response to energy shortages. Many studies have used different statistical and econometric methods to identify energy transition level at the household level, such as Davis (1998) categorized households income-wise, Heltberg (2004) analyzed households across different countries, and Waleed & Mirza (2023) developed an energy transition index.

In conclusion, the energy ladder and energy stacking hypothesis have emerged as the two widely recognized theories in the literature to study energy transition. The empirical findings emphasize that this transition is neither linear nor uniform across regions and income groups. Therefore, disarray among researchers still exists regarding the direction of energy transition. Conceptual confusions still exist in understanding the steps related to energy ladder or energy stacking. Hence, a comprehensive measure is required to understand energy transition. Determinants of energy transition patterns extend beyond just income and include factors like household characteristics, urbanization, fuel availability, government policies, cultural preferences, socio-economic factors, ICT devices, building characteristics, and education of household heads which have a significant effect on energy-switching behavior.

Methodology

Quantitative review approach is employed to synthesize the literature. Through this method, we identified the main methodologies used by different studies to measure the energy transition. Vo & Ho (2024), and Wassie et al. (2021) employed a multivariate probit model to cross sectional data to investigate household energy consumption dynamics, while Tinta (2024) employed both multivariate probit model and Lewbel 2SLS methods to investigate the presence of either energy ladder or energy stacking hypothesis. Waleed & Mirza (2023) developed an energy transition index at an aggregated level for Pakistan using multinomial logit models to assess the level of energy transition. Acharya & Adhikari (2021) investigated household energy preferences using multiple discrete continuous extreme value method which has the power to estimate marginal utilities and satiation rates associated with each fuel to better represent the transition among fuels. Waweru et al. (2022) and Koirala & Acharya (2022) investigated the selection of energy choices by employing multinomial logit model, while Abubakar et al. (2024) applied binary logistic regression for the analysis. For the case of Pakistan, Awan et al. (2023) employed Tobit and Probit models to investigate fuel adoption and determinants of energy choice decisions. Davis (1998) made three groups of households comprising, high, low and middle income groups. By creating categories based upon income levels, the study witnessed a divergence from firewood to modern fuels as income levels increased. Moreover, high income households tend to follow energy ladder hypothesis while low income household still followed energy stacking. Heltberg (2004) examined household surveys from South Africa

(1993/94), Nepal (1995/1996), Brazil (1996/97), Vietnam (1997/98), Nicaragua (1998), Ghana (1998/99), India (1999/2000), and Guatemala (2000). Their study employed Logit and Probit models and found a positive association between per capita expenditures and modern fuel adoption. Nguyen et al. (2019) conducted a study in Vietnam using the Vietnam Household Living Standards Survey (VHLSS) to confirm the evidence of energy transition. Their findings suggested that the transition from traditional to modern fuels, but this transition varied across regions. Table 4 presents the table of methodological approaches used to analyze household energy transition from different perspectives.

Table 2
Methodological Approaches in Household Energy Transition Studies

Methodological approach	How transition is measured	Data Source	Strengths/limitations	References
Household surveys & econometric models (e.g., multinomial logit, OLS)	Fuel choice, fuel mix as dependent variable; tests energy ladder/stacking and effects of income, prices, demographics	Cross-sectional or panel household surveys	Quantifies determinants and probabilities of adopting cleaner fuels; limited in capturing practices, meanings, intra-household dynamics	(Wassie et al., 2021; Yadav et al., 2021; Ai et al., 2021)
Composite transition indices	Index of household energy transition (6Es framework)	Household surveys	Produces household energy transition across households; can mask heterogeneity and qualitative aspects of transition pathways	(Waleed and Mirza, 2023)
Systematic reviews & content analysis	Transition conceptualized through coded categories of determinants, domains, or decision types.	Published empirical studies coded using directed or thematic content analysis	Synthesizes wide evidence, builds conceptual frameworks; does not directly measure transition in primary data	(Guta et al., 2021; Chadwick et al., 2022)
Qualitative methods (interviews, focus groups, ethnography, case studies)	Narratives of fuel switching, stacking, barriers, meanings of energy practices; sometimes coded thematically	In-depth interviews, focus groups, key informant interviews, and ethnographic observation	Rich understanding of social, cultural, gendered, and contextual drivers; limited generalizability and quantification	(Neto-Bradley et al., 2021; Csutora et al., 2021; Usman et al., 2024; Ahmed et al., 2023)
Mixed-methods clustering / grounded survey / integrative designs	Clusters or typologies of households/paths combining quantitative indicators with qualitative narratives on transition pathways	Household surveys + interviews/focus groups; hierarchical clustering, participatory-systems-mapping, comparative analysis	Bridges quantitative patterns and qualitative explanations; methodologically demanding, sample sizes often modest	(Neto-Bradley et al., 2021; Csutora et al., 2021; Vavouris et al., 2024)
Behavioral surveys & psychometric analysis	Self-reported awareness, motivations, willingness to change, and behaviors as proxies for propensity to transition	Structured questionnaires, Likert scales, pilot tests, and potential use of reliability tests	Captures internal psychological drivers; often cross-sectional and may not link directly to observed fuel/technology changes	(Gaspari et al., 2021; Duan et al., 2023; Aguayo-Mendoza et al., 2024)
Meta-analysis of behavior studies	Pooled effect sizes linking internal (attitudes, norms) and external	Quantitative effect sizes from many studies	Identifies average drivers and heterogeneity across regions and	(Duan et al., 2023)

	(policy, price) forces to transition behaviors	(hundreds of thousands of observations)	technologies; depends on available empirical designs

Results and Discussions

The energy transition process is supported by the empirical evidence through the validation of energy ladder hypothesis in the literature (Masera et al., 2000; Ahmed et al., 2023). However, in lower and middle income households, fuel stacking is the most observed practice (Guta et al., 2022; Shankar et al., 2020). Energy transition is also seen as an energy investment decision because households try to balance costs, values, social influence, and technological attributes (Selvakkumaran & Ahlgren, 2019; Guta et al., 2022). Table 3 presents a summary of major themes discussed in the literature for household energy transition. Table 3 gives a brief review of different dimensions related to energy transition from conceptualization to determinants and to modeling, which are identified from different studies.

Table 3
Summary of major themes in household energy transition literature

Dimension / Theme	Main Insights for Review	References
Energy Transition	Fuel Switching, Change in fuel use-pattern	(Guta et al., 2021; Elasu et al., 2023; Muller & Yan, 2018; Zhang et al., 2021)
Determinant domains	Economic, socio demographic, market-based, infrastructural, institutional, environmental, behavioral, and psychosocial	(Guta et al., 2021; Chadwick et al., 2022; Selvakkumaran & Ahlgren, 2019; Elasu et al., 2023; Muller & Yan, 2018; Jiang et al., 2019; Zhang et al., 2021)
Stacking behavior	Concurrent use of traditional and clean options is widespread; undermines health and climate benefits	(Guta et al., 2021; Shankar et al., 2020; Schilmann et al., 2021)
Clean fuel supply chains	Each clean fuel faces specific production, delivery, and affordability constraints	(Shankar et al., 2020; Puzzolo et al., 2019)
Energy poverty & justice	Transitions can alleviate or worsen energy poverty; need for integrated frameworks linking poverty, justice, and mitigation	(Štreimikienė & Kyriakopoulos, 2023; Štreimikienė et al., 2020; Calver & Simcock, 2021; Zhang et al., 2021)
Gender & household labor	Women often bear higher energy labor and have less decision power; gender shapes energy-saving behavior	(Aggeli et al., 2022; Shrestha et al., 2021)
Regional patterns	Persistent rural urban and Regional gaps; strong reliance on fuelwood and LPG stacking, policy-led but often top-down programs	(Schilmann et al., 2021; Jiang et al., 2019)

The literature also identifies a range of key demographic, socioeconomic, and infrastructural determinants that influence households' decision making process and their capacity to transition from traditional dirty fuels to cleaner and more modern forms of energy. Household income, education, asset holdings, and access to subsidies or credit have positive associations with clean fuel adoption (Liao et al., 2021; Guta et al., 2022; Elasu et al., 2023). Higher income and assets are positively associated with the adoption of clean fuels, PV, and efficient heating appliances and vehicles. High upfront costs and energy price spikes constrain the poorest households (Elasu et al., 2023; Szymańska et al., 2023; Selvakkumaran & Ahlgren, 2019; Peng & Klöckner, 2025; Liao et al., 2021; Aguayo-Mendoza et al., 2024; Vo et al., 2024; Han et al., 2018). Higher education and awareness correlate with clean energy and efficiency upgrades (Niamir et al., 2020; Peng & Klöckner, 2025; Liao et al., 2021; Vo et al., 2024; Gaspari et al., 2021). Environmental aspects and social norms are as important as monetary factors for the adoption of cleaner energy sources (Niamir et al., 2020; Peng & Klöckner, 2025; Chadwick et al., 2022; Kyere et al., 2024). Building age, insulation quality, dwelling type, ownership, and urbanization are strongly positively associated with feasible technologies and upgrades (Niamir et al., 2020; Szymańska et al., 2023; Peng & Klöckner, 2025; Aguayo-Mendoza et al., 2024; Dominguez et al., 2021). Subsidies, credit, tariffs, and local energy institutions enable clean energy adoption while weak incentives or unreliable service create obstacles (Szymańska et al., 2023; Ai et al., 2021; Liao et al., 2021; Aguayo-Mendoza et al., 2024; Dominguez et al., 2021). Female decision makers often move earlier to cleaner fuels, and household size affects technology choice (Dominguez et al., 2021; Han et al., 2018; Vo et al., 2024). In Table 4, we presented some key domains that shape household behavior towards energy transition.

Table 4
Key Domains Shaping Household Energy Transition Behavior

Domain	Drivers	Barriers	References
Household characteristics	Household size, Income, education, number of rooms, employment status,	Poor households, Large household size	(Wassie et al., 2021; Muazu et al., 2020)
Socioeconomic	Higher income, Assets, Education, and urbanization	Energy poverty; low income	(Liao et al., 2021; Guta et al., 2021; Zhang et al., 2021; Elasu et al., 2023; Muller & Yan, 2018)
Technology & cost	Reliability, performance, and low running cost	High upfront cost, complexity	(Guta et al., 2021; Kyere et al., 2024; Elasu et al., 2023; Schwartz & Krarti, 2022)
Policy & markets	Subsidies, credit, favorable tariffs, and standards	Fossil subsidies, weak regulation, financing risk, Easy access	(Liao et al., 2021; Zhang et al., 2021; Wang & Xie, 2023; Aniello & Bertsch, 2023)
Psychosocial	Environmental concern, health awareness, and social norms	Preference for familiar tech, low trust, uncertainty	(Chadwick et al., 2022; Kyere et al., 2024; Selvakkumaran & Ahlgren, 2019; Duan et al., 2023)
Context & gender	Adequate infrastructure, women's agency in decisions	Lack of infrastructure, gender exclusion	(Liao et al., 2021; Guta et al., 2021; Shrestha et al., 2021)

Adoption of clean energy at the household level generates multiple benefits and outcomes, which create important implications for economic, health, and environmental protection. Clean energy usage is associated with time savings, improved health, and broader socioeconomic benefits, but results vary from country to country and are specific to the context of the respective countries (Liao et al., 2021). Clean energy adoption at the household level creates health benefits through better indoor air quality, which reduces respiratory illness, time savings, and thermal comfort (Liao et al., 2021; Wu et al., 2024; Maji et al., 2021). Further, studies also showed that households that adopted clean energy experience significant improvements in their development indices, especially in rural areas, often experiencing greater gains than the urban ones (Wu et al., 2024; Maji et al., 2021). The transition to cleaner fuels can also increase energy costs for low income households, which exacerbates energy poverty without targeted subsidies or social protections (Liu & Sheng, 2025; Li et al., 2023). Women's respiratory health improves with cleaner cooking fuels, and labor time spent on fuel collection also reduces (Maji et al., 2021). A number of studies analyzed household energy transition in Pakistan and table 5 provides a summary of such studies.

Table 5
Household Energy Transition in Pakistan

Citations	Objectives	Methodology	Data source	Main findings
Waleed and Mirza (2023)	Developed a household energy transition index (6Es) as an alternative to ladder/stacking and identified determinants of fuel choice.	Multinomial logit for fuel choice; OLS for transition index at national and provincial levels.	Household Integrated Economic Survey (2015-16)	Income, prices, household size, education, profession, area, and female bargaining power shape transition; rural households 22% more likely to use primitive fuels.
Yasmin and Grundmann, (2020)	Examine how women's empowerment affects adoption and continued use of biogas for cooking.	Multivariate econometric analysis	Individual-level household survey data	Older, educated, financially empowered women with higher agency strongly increase adoption and sustained use of biogas technology.
Awan et al. (2024)	Identify drivers of clean fuel adoption and consumption intensity for cooking, heating and lighting.	Probit and Tobit models	Household Integrated Economic Survey (HIES) 2018–2019, national sample.	76% rural and 14% urban households still use dirty cooking fuels; income, wealth, urban location, small family size, and fewer women and children promote clean fuel use; strong provincial variation.
Awan et al. (2023)	Analyze household fuel choices and clean fuel consumption intensity over 2001–2019.	Probit and Tobit models	Seven rounds of HIES 2001–2019.	Clean fuel adoption has risen, but total share remains low; female-headed, richer, more educated, and urban households adopt and consume more gas/electricity; age and household size have nonlinear effects.
Rahut et al. (2019)	Assess the roles of wealth and education in rural cooking-fuel choices.	Multinomial logit Model	Pakistan Social and Living Standards Measurement Survey (PSLM) 2014–15.	Most rural households rely on fuelwood, dung, and residues; low-income, low-education households depend on biomass; higher education and assets strongly increase use of natural gas; education is main driver of clean cooking adoption.
Khan et al. (2025)	Evaluate the impact of family resources and energy accessibility on rural clean-energy adoption.	Tobit model of the level and share of clean energy in expenditure.	Pakistan Social and Living Standards Measurement (PSLM) survey.	Human and economic assets, non-farm work, and education promote clean-energy adoption; proximity to clean-energy supply points increases both the level and share of clean-energy use.
Batool et al. (2022)	Explore energy poverty and renewable options in rural Punjab and Sindh; identify best renewable source.	Structured household interviews; comparative techno-economic assessment of renewable options.	Field survey in rural areas of Punjab and Sindh.	Severe energy poverty with reliance on candles, firewood, and dung; linked to health, time, and financial poverty; solar energy emerges as most suitable renewable, but affordability is a major barrier.

In conclusion, adoption of cleaner energy fuels supports socioeconomic development and health equity, but it requires policies ensuring affordability and sustained use, especially among vulnerable segments of populations (Liao et al., 2021; Wu et al., 2024; Wang & Xie, 2023). Subsidies and government support programs can help with initial adoption of cleaner energy sources, but do not guarantee sustained replacement of cleaner fuels with traditional fuels (Wang & Xie, 2023). In Pakistan, household characteristics, including household education, income, gender, household economic assets, and regional and provincial disparity, are the main influencing factors in determining household energy choice decisions. Urban households are showing evidence of transition towards cleaner energy sources, while rural households are still lagging with the consumption of traditional and dirty fuels, highlighting the significance of regional disparity in the household energy transition process.

Conclusion

In literature, the energy transition refers to the shift or switch from traditional fuels to modern and cleaner fuels broadly. Theoretically, this transition was assessed through "energy ladder" and "energy stacking" hypotheses. But in literature transition is neither linear nor uniform across regions and income groups, highlighting the gap in research to find out the direction of energy transition and factors affecting it across regions and income groups. Therefore, a comprehensive assessment is required to understand the direction of energy transition. Moreover, determinants of household energy transition extend beyond income and include factors like household characteristics, urbanization, fuel availability, government policies, cultural preferences, socio-economic factors, ICT devices, building characteristics, and education of household heads which have a significant effect on energy-switching behavior.

In the analyzed literature, descriptive analysis, multinomial logistic regressions, energy transition index, systematic reviews, qualitative methods, mixed methods, and meta analysis of behavior have been employed to assess the different dimensions of energy transition. Household energy transition is a multifaceted process influenced by several household characteristics, socioeconomic, behavioral, environmental, and policy factors. Household income, education, employment, and government incentives are critical drivers that facilitate the adoption of clean energy, but regional disparities and financial constraints often limit equitable access to clean energy sources (Elasu et al., 2023; Chen et al., 2024; Liao et al., 2021; Szymańska et al., 2023). Despite technological advancements, the persistence of fossil fuel dependence in rural and remote regions highlights the importance of integrated strategies addressing both supply and demand-side barriers.

Further, our study has identified some gaps in the literature, particularly in the determinants of energy transition at the household level. Factors such as housing infrastructure and characteristics like the nature of the house, kitchen space, and material used are not used in the majority of the studies. Although many aspects of household energy transition are explored, limited literature is available on behavioral, environmental, or governance-related determinants that influence the energy transition. Regional disparity and inequality that emerges during transition, especially in rural areas, and low income segments also needs to be addressed. Addressing these gaps involves interdisciplinary approaches with the combination of behavioral, socioeconomic, environmental, and policy dimensions to better support equitable and effective household energy transitions. In literature obstacles are also identified in the energy transition process, which mainly include as energy access, affordability, and infrastructural deficiency in the acquisition of modern energy technologies.

Recomendations

Income is strongly associated with the adoption of clean energy. Therefore, poverty reduction, employment generation, and rural economic development should be promoted to support energy transition. Improving education levels and women's participation in economic activities can further enhance household decision-making toward clean energy consumption. Governments should invest in renewable energy systems, particularly in rural regions. Clean fuels such as LPG, electricity, and renewable technologies should be made affordable through targeted subsidies for low-income households. Soft loans or tax incentives should be provided for purchasing clean cooking stoves, solar panels, and energy efficient appliances. These measures can also accelerate fuel switching behavior among economically vulnerable households. Therefore, Future efforts should focus on reducing inequalities in energy access while promoting sustainable practices to ensure that household energy transition contributes effectively to health improvements and achieves climate goals.

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