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ENERGY POVERTY DYNAMICS: ORIGINS, IMPACTS, AND ROADMAP TO SOLUTIONS

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Abstract

Energy is essential for human existence, significantly shaping the socioeconomic status of people worldwide by fulfilling various needs such as heating, cooking, lighting, transportation, and industrial production. According to the Energy Ladder Hypothesis, households' fuel-switching behaviour is primarily influenced by income and relative fuel prices, linking fuel adoption to income and determining energy poverty. Energy economists contend that reliance on traditional cooking fuels is tied to poverty factors like low income, limited electricity access, substandard housing, and household size. Additionally, energy plays a crucial role in economic development and poverty reduction. Access to clean and affordable energy is pivotal in combating energy poverty and environmental degradation, contributing directly and indirectly to Sustainable Development Goals 1 and 7. In essence, energy poverty is defined as a lack of access to sustainable traditional and modern energy sources and services

Keywords*: Energy Access, Energy poverty, Sustainable Development*

I. Introduction

Authors categorize energy needs into "fundamental" for survival, "basic" for a minimum living standard (cooking, heating, lighting, plus health, education, communications), "productive uses" for livelihood, and "recreation" for enjoyment **(Sanchez, 2010)**. Energy is vital for all economic sectors, impacting trade and socioeconomic factors. Energy crises, particularly in developed countries, lead to economic and infrastructure challenges, including energy poverty. This arises from systemic inequalities hindering access to affordable modern energy. Measuring energy poverty is complex, influenced by cultural contexts, and dynamic across time and space **(Simcock et al., 2017)**. Traditional definitions focus on the minimum energy quantity, but a broader view considers quality and cleanliness **(Stoppok et al., 2018)**. Poverty, including energy poverty, is spatially diverse. Energy poverty is a global challenge affecting both less and highly-developed countries. Various indicators, such as LIHC, TPR, HEO, and DCEN, are used to measure energy poverty **(Papada and Kaliampakos, 2020; Antepara et al., 2020; Sokołowski, 2020; Nussbaumer et al., 2012; Thomson et al., 2017; Maxim et al., 2016)**. It involves difficulties in maintaining a suitable temperature in residences and challenges with lighting, cooking, and appliance usage **(Thomson et al., 2019)**. Financial and technical factors contribute to the inability to achieve basic energy service standards, including the cost of energy/gas, payment capacity, and building/equipment efficiency. Energy poverty intertwines socio-demographic, technical, economic, and macroeconomic factors **(Primc et al., 2019; Meyer et al., 2018; Neacsa et al., 2020; Boemi and Papadopoulos, 2019)**. **Che et al. (2021)** identify energy availability and affordability as major barriers. In an international context, especially in developing countries, energy poverty is linked to basic energy service access and the transition from solid to "modern" fuels, such as electricity and gas. This phenomenon has diverse influencing factors, manifesting in various ways related to national and individual circumstances, from inadequate indoor temperature affecting living comfort to health issues due to mold, hypothermia, or social isolation. Domestic energy poverty occurs when households lack access to or cannot afford basic energy services for day-to-day living, including lighting, cooking energy, and heating or cooling **(Krauss, Alexander, 2016)**. Globally, energy poverty poses challenges, and understanding its diverse manifestations is crucial for developing effective strategies to address this complex issue.

II. Origins of Energy Poverty

The term "energy poverty" originated with Brenda Boardman's 1991 book, "Fuel Poverty: From Cold Homes to Affordable Warmth." Coined to signify the intersection of energy and poverty, it prompted the development of policies and research on its causes and effects. Energy poverty is broadly characterized as households' inability to afford adequate energy services. It is caused by the interaction of 3 factors **(Figure 1)**:

Figure 1 – Causative factors for energy poverty

Other factors impacting energy poverty levels should be considered, such as climatic variation, fuel availability, stock type and performance, tenure, high living costs, etc. Utilities and energy providers, holding such data, become key players. *Infrastructure Gaps*: Energy poverty stems from inadequate infrastructure, hindering reliable access, especially in underdeveloped regions. *Economic Constraints*: Limited finances impede energy investments, restricting infrastructure expansion for diverse populations. *Geographical Challenges*: Remote areas face economic barriers to extending traditional grids, causing urban-rural disparities in energy poverty. *Lack of Technological Adoption*: Energy poverty results from communities resisting modern and sustainable technologies, influenced by awareness gaps. *Political and Regulatory Issues*: Political instability and corruption hinder a conducive environment for energy access and investments. *Social Inequality*: Income inequality perpetuates energy poverty, disproportionately affecting vulnerable populations. *Environmental Impact*: Reliance on polluting energy sources in low-income settings exacerbates poverty and harms the environment. *Global Energy Inequities*: Disparities in energy access are influenced by unequal resource distribution, posing challenges for developing nations.

III. Definitions of Energy Poverty

The **EU Commission (2020)** defines energy poverty as the inability to access and afford sufficient energy services for basic needs. One such definition states that a person is in 'energy poverty' if they lack access to at least 35 kg LPG for cooking per capita per year and 120 kWh of electricity per capita per year for lighting and essential services. An 'improved energy source' for cooking is one meeting WHO air quality recommendations, requiring less than 4 hours per week per household for fuel collection, and with an overall conversion efficiency exceeding 25 per cent. **(Tennakoon, 2008). United Nations (UN 2015)** addresses energy poverty within Sustainable Development Goal 7 (SDG 7), striving for universal access to affordable, reliable, sustainable, and modern energy by 2030. UN's insights on energy poverty are frequently referenced in reports and publications on sustainable development, energy access, and poverty alleviation. **World Bank** recognizes the importance of energy access in attaining broader development objectives. While not presenting a standalone definition for "energy poverty," the institution actively contributes to discussions aimed at enhancing energy access and mitigating energy poverty worldwide. **International Energy Agency (IEA)** underscores the significance of access to modern energy services, defining energy poverty as the absence of reliable and affordable energy access, impeding basic human needs, economic development, and environmental sustainability. **International Renewable Energy Agency (IRENA)** tackles energy poverty in the transition to renewable energy, defining it as the absence of access to clean, modern energy services and emphasizing the role of renewable energy in addressing this challenge. **Energy Policy Institute (EPIC)** views energy poverty as a state where individuals or communities lack access to modern energy services, encompassing electricity and clean cooking facilities. Their research primarily concentrates on the economic and health repercussions of energy poverty. **Rocky Mountain Institute (RMI)** defines energy poverty as a state where communities lack affordable, reliable, and sustainable energy access, emphasizing the necessity for innovative solutions and market-driven approaches to effectively address this challenge. **Energy and Resources Institute (TERI):** Based in India, TERI frequently tackles energy poverty within the context of developing countries, emphasizing the necessity for inclusive and sustainable energy solutions to enhance energy access and alleviate poverty. **Center for Global Development (CGD)** examines energy poverty as restricted access to electricity and the associated health, educational, and economic challenges. Their focus involves exploring policy solutions and interventions for effective energy poverty alleviation. **Oxford Energy Institute:** Oxford Energy Institute addresses energy poverty by examining the socio-economic implications of insufficient energy access. Their focus involves exploring the roles of policies, technologies, and market mechanisms in addressing energy poverty on a global scale. **United Nations Development Programme (UNDP)** defines energy poverty as the 'inability to cook with modern cooking fuels and the lack of a bare minimum of electric lighting for reading or other household and productive activities at sunset. **Asian Development Bank (ADB)** defines energy poverty as 'the absence of sufficient choice in accessing adequate, affordable, reliable, high-quality, safe, and environmentally benign energy services to support economic and human development. According to **Laldjebaev et al. (2016)**, energy poverty is characterized by either the absence of access to electricity networks or reliance on burning solid biomass, such as wood, straw, and dung, in inefficient and polluting stoves to fulfil household energy needs. **Practical Action (2010)** and the **United Nations Conference on Trade and Development Statistics (2018)** assert that the lack of access to energy services is a form of poverty, constraining individuals' capabilities and serving as both a cause and consequence of financial limitations among low-income populations. Energy poverty worsens vulnerabilities in underprivileged communities, adversely affecting public and household health, education, and opportunities for women **(UNDP, 2015)**. The Energy Poverty Action initiative of the World Economic Forum emphasizes that access to energy is essential for enhancing quality of life and is crucial for economic development, particularly in the developing world where energy poverty persists.

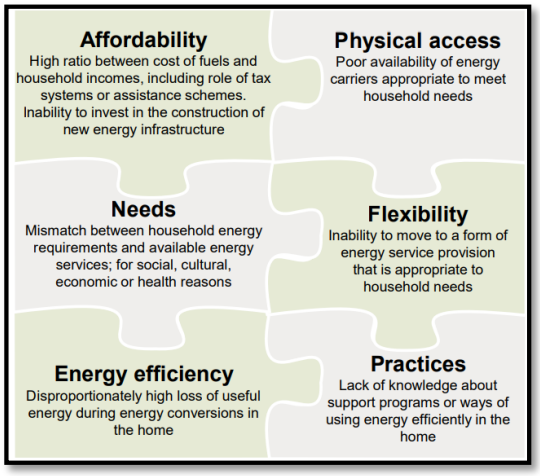
IV. More nuanced definitions of Energy Poverty

*Multi-Dimensional Deprivation***:** Energy poverty goes beyond access, involving deprivation in quantity, quality, affordability, and reliability. *Quality of Energy Services***:** It considers the reliability, safety, and diverse needs met by energy services. *Social Exclusion***:** Energy poverty marginalizes individuals or groups, hindering participation in various activities. *Temporal Dimensions***:** Involves issues of energy intermittency and seasonality, impacting vulnerable communities. *Affordability Challenges***:** Crucial in

energy poverty, even with available infrastructure, if not financially accessible. *Energy Access vs. Energy Equity***:** Differentiating between availability and fairness in distribution and benefits. *Institutional Dimensions***:** Influenced by governance, policies, and institutional effectiveness in sustainable energy development. *Human Development Lens***:** Views energy poverty through the lens of health, education, and gender equality. *Energy Justice***:** Framed within the context of ensuring equal opportunities for clean and reliable energy access. *Dynamic Nature***:** Evolves due to factors like population growth, technology, and economic shifts. One can conclude from the above that energy poverty involves the lack of access to reliable, affordable, and sustainable energy services, with implications for various aspects of human development and well-being. **(Figures 2 & 3)**

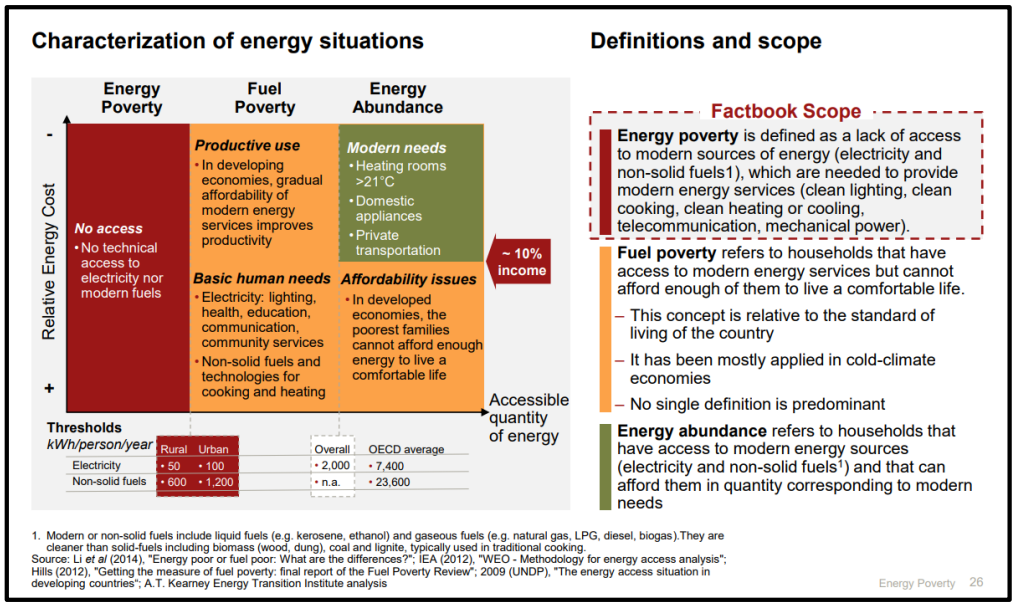
Energy poverty is a complex concept often associated with the challenges of accessing energy

Figure 2 - Key challenges to get access to energy



***Source**: A.T. Kearney Energy Transition Institute (2018)*

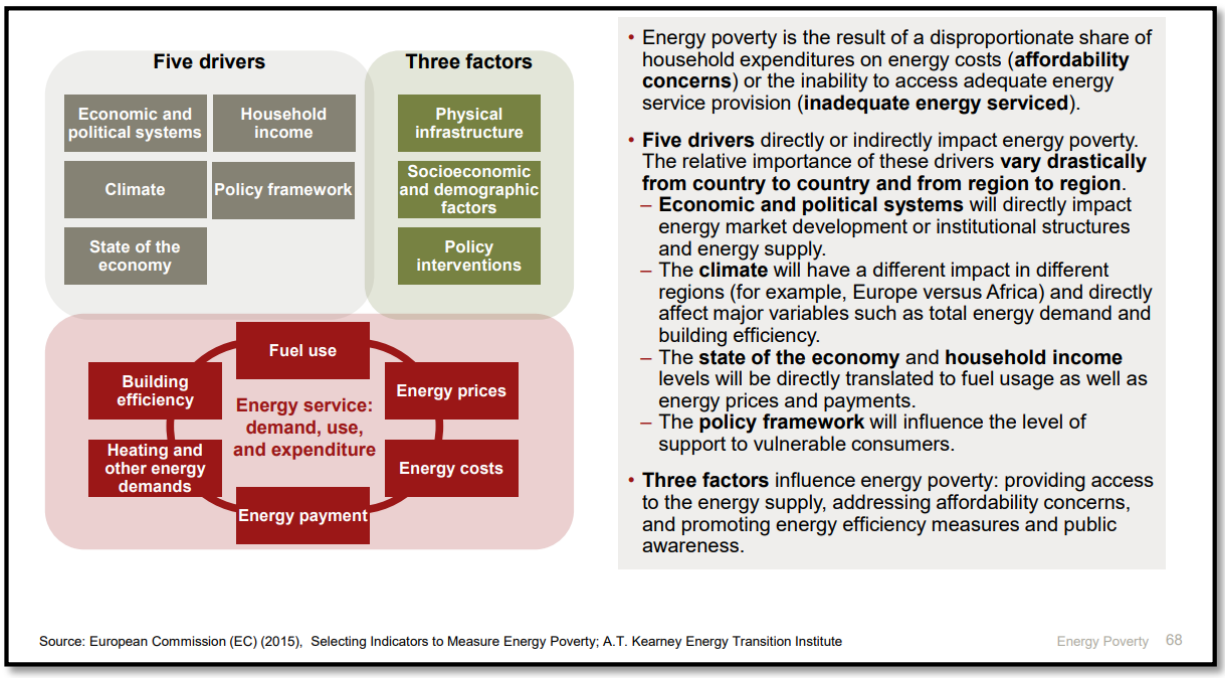
Figure 3 - Energy Poverty Nexus Fuel Poverty



V. Understanding energy poverty on a global, national, and regional scale

Moore (2012) and Nierop (2014) identified factors contributing to energy poverty, including insufficient supply, low household income, energy prices, efficiency, needs, preferences, and geographical location. Income and prices directly affect accessibility and affordability, with lower-income households spending more on energy services or opting not to connect to grids. Energy-inefficient housing and outdated equipment increase expenses for the same energy services. **(Figure 4)**

Figure 4 – Key drivers and factors that influence energy poverty



It involves examining the disparities in energy access, the causes and consequences of limited energy availability, and the efforts to address these issues. Here's an overview of energy poverty across different scales:

Global Perspective: Energy Access Disparities: Globally, a substantial energy access gap exists between rural and urban areas, particularly affecting rural populations in developing regions. The United Nations, through Sustainable Development Goal 7 (SDG 7), underscores the universal importance of affordable, reliable, sustainable, and modern energy. This goal, aiming for universal energy access by 2030, signifies a global commitment to combat energy poverty. Measurement tools, such as the Global Energy Poverty Index employed by various organizations, assess energy poverty worldwide, considering factors like access, affordability, reliability, and service quality.

National Perspective: Tailored Energy Solutions: Countries craft unique energy policies to tackle internal challenges, outlining strategies for broadening access, promoting sustainability, and ensuring affordability. National electrification rates serve as vital indicators of energy poverty, with lower rates often correlating with higher levels of energy poverty, affecting both economic development and quality of life. The energy mix differs among nations, with some heavily dependent on traditional biomass, while others boast diversified sources encompassing renewables and conventional fuels.

Regional Perspective: Addressing Geographical Disparities: Energy poverty exhibits significant regional variances within countries, with remote or challenging geographical areas facing more substantial barriers compared to well-connected regions. Climate and geography play a pivotal role, in impacting energy access in regions susceptible to extreme weather or challenging landscapes, such as mountains or islands facing grid connectivity challenges. Regional collaborations, involving shared resources and cross-border energy projects, play a crucial role in enhancing overall energy access, fostering cooperation, and promoting infrastructure development.

Case Studies: Addressing Energy Access Challenges: India: Empowering through Saubhagya India's Pradhan Mantri Sahaj Bijli Har Ghar Yojana (Saubhagya) aims to boost electricity access, yet challenges persist in reaching remote and marginalized communities **(Box 1)**. **Sub-Saharan Africa: Rural Electrification** Several Sub-Saharan African countries are undertaking rural electrification programs, incorporating renewable energy solutions to combat energy poverty and foster sustainable development. **Europe: Tackling Energy Poverty** Even in economically developed regions like Europe, specific communities may grapple with energy poverty, underscoring the importance of addressing socio-economic factors influencing access.

Box 1 – Urban and Rural Energy Poverty in India

In India, 28 per cent of urban residents experienced energy poverty, while 20 per cent faced income poverty. In rural areas, a substantial 59 per cent encountered energy poverty, whereas only 23 per cent grappled with income poverty. In urban India, where there's improved access to modern energy services, energy consumption is relatively consistent across income deciles, indicating that income poverty can mirror energy poverty. Urban India saw 17 per cent of income non-poor individuals experiencing energy poverty, contrasting with 41 per cent in rural India. On the other hand, 64 per cent of urban households were both income non-poor and energy non-poor, compared to only 37 per cent in rural households. While both income and energy poverty are expected to decrease with rising household income, the pattern may vary by income decile and geographic area. In rural India, the gap between expenditure on food and non-food items (including energy) and energy poverty is wide and consistent across all income deciles but considerably smaller in urban India. The connection between expenditure poverty and energy poverty hinges on access to modern energy sources and the efficient use of traditional ones. Urban India, with reliable access to modern energy services like electricity and LPG, exhibits a close correlation between energy poverty and expenditure or income poverty. However, in rural India, where households are relatively impoverished with limited access to modern energy services, relying predominantly on low-cost, inefficient energy sources, energy poverty surpasses income poverty.

***Source**: Barnes, 2011.*

Comprehending energy poverty at different scales necessitates a thorough examination of socio-economic factors, policy frameworks, and regional challenges. Recognizing the interconnection of global energy systems and emphasizing collaborative efforts are crucial for achieving universal energy access.

VI. Approaches to study and measure Energy Poverty

Various approaches measure energy poverty, often relying on physical energy or expenditure to establish a minimum threshold for considering households non-poor. These methods define the minimum energy required based on a basket of goods and services, encompassing direct energy needs (e.g., cooking, lighting, heating) and the energy embedded in additional goods and services used by households. Different models define energy poverty in diverse ways. **Bravo et al. (1979)** intricately quantify direct energy needs like cooking and lighting, suggesting 27.4 KgOE per capita per month for essential needs in tropical countries. **Goldemberg (1990)** widens the scope to 32.1 KgOE per capita per month. A universal interpretation suggests a lower minimum (50 KgOE per year) based on global surveys (**Modi et al., 2005**). Diverse assumptions lead to divergent results. The **second approach** defines energy poverty as the energy level used by households below the established expenditure or income poverty line **(Foster et al., 2000)**. Using the well-defined expenditure-based poverty line in most countries, this approach simplifies the process by eliminating the need to measure actual energy consumption. However, the drawback lies in equating energy poverty with income poverty trends, as the expenditure poverty line is influenced by general economic and social policies rather than specific energy policies. This assumes that expenditure-poor households are necessarily energy-poor, although, in reality, some non-poor households based on expenditure measures may still experience energy poverty. The **third approach**, outlined in studies like **Pachauri and Spreng (2004)**, examines energy expenditures as a percentage of total income. Poorer households typically allocate a higher percentage of their incomes to energy, ranging from 5 per cent to 20 per cent according to recent studies **(Barnes et al., 2006)**. As the share of income spent on energy increases, poor households may reduce energy use to essential levels, often cited at 10 per cent of total income. However, the drawback lies in the arbitrary nature of the 10 per cent threshold, making this approach susceptible to issues similar to methods based on physical energy measures. The **fourth approach** to measuring energy poverty, akin to expenditure poverty, considers the relationship between energy demand and household income. It defines the energy poverty line as the point where energy consumption begins to rise with increased income. Below this threshold, households consume a minimal amount of energy, signalling energy poverty. For those significantly below the poverty line, even with rising incomes, their energy use remains constant at the essential minimum for daily life. This results in higher energy expenditure proportions as income decreases, leading to lower household welfare levels due to reduced spending on necessities like food and other essentials. **Moore (2018)** identifies four key approaches to measuring energy poverty. Expenditure-based metrics assess energy poverty by comparing household energy spending to income. Consensual-based metrics rely on self-reported evaluations of housing conditions and energy service accessibility. The third approach involves directly measuring the achieved level of energy services within a home against established standards. Lastly, outcome-based metrics evaluate energy poverty through outcomes like disconnections, bill arrears, and cold-related mortality.

VII. Indices of Energy Poverty

First introduced in 2004 by the International Energy Agency **(IEA, 2011)**, the **Energy Development Index (EDI)** aims to measure a country's transition to modern fuels. It is calculated as the weighted average of four indicators: "1) Per capita commercial energy consumption as an indicator of the overall economic development of a country; 2) Per capita consumption of electricity in the residential sector as a metric of electricity reliability and customers' ability to financially access it; 3) Share of modern fuels in total residential energy sector consumption to indicate access to modern cooking fuels; 4) Share of population with access to electricity.

Energy Access Index (EAI), created by the *World Energy Outlook*, evaluates a nation's advancements in offering access to modern energy services, encompassing factors such as electricity and clean cooking access. **Energy Transition Index (ETI)**, developed by the *World Economic Forum*, gauges countries' performance in energy transition, considering aspects such as energy security,

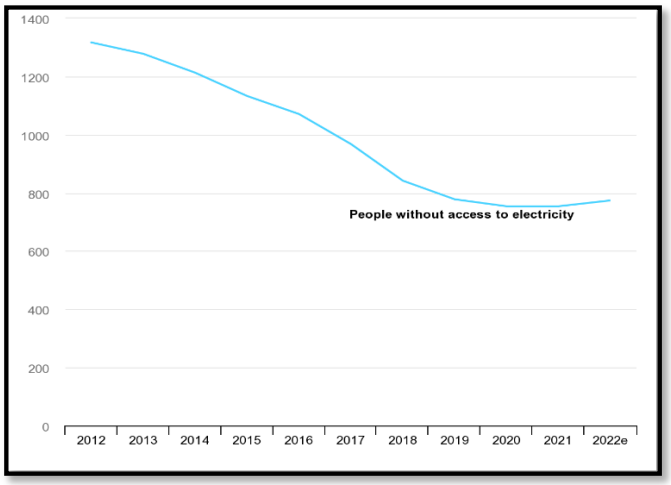
environmental sustainability, and affordability. **Global Energy Architecture Performance Index (EAPI)**, provided by the *World Economic Forum*, evaluates the energy systems of various countries, taking into account factors like environmental sustainability, access, and security. **Energy Intensity Index** measures the amount of energy used per unit of economic output, such as GDP, providing an indicator of the efficiency of energy use in a country's economy. **Renewable Energy Country Attractiveness Index (RECAI)**, published by *EY (Ernst & Young)*, ranks countries according to their appeal for renewable energy investments, considering factors like policy, infrastructure, and other relevant aspects. **Energy Poverty Index (EPI)** evaluates the extent of energy poverty in a region or country, taking into account factors such as energy access, affordability, and reliability. **Environmental Performance Index (EPI)** ranks countries based on their overall environmental performance, encompassing indicators related to energy and climate. **Global Energy Security Index (GESI)**, developed by the Institute of Energy Economics, evaluates countries' energy security, considering factors like the availability, affordability, and reliability of energy sources. **Energy Governance Index (EGI)**, created by the *World Bank*, evaluates the quality of energy governance in various countries, examining aspects such as policy, institutions, and regulatory frameworks. **Energy Democracy Index (EDI)** assesses the degree to which energy systems in different countries empower citizens and communities, promoting a more democratic approach to energy governance.

VIII. Energy Poverty in Different Countries

As of 2022, the World Bank Group reports that 774 million people lack access to electricity, **(Table 1 and Figure 5)** and 2.4 billion still use harmful cooking fuels. This lack of modern energy perpetuates poverty, as it hinders basic amenities like refrigeration and lighting. Notably, 43 per cent of Sub-Saharan Africa lacks electricity access, visible in night-time satellite imagery. The unequal distribution of energy access is evident, with nearly 3.5 billion people responsible for less than 10 per cent of total energy demand, while 1 billion people, with consumption levels comparable to Europe, account for half of global energy consumption (***worldbank, ourworldindata***). Addressing energy poverty is crucial due to its profound impact on the health and well-being of billions. Prolonged exposure to household pollution contributes to conditions like pneumonia, COPD, and lung cancer. Additionally, it is a primary risk factor for burns, raises the likelihood of cataracts, affects prenatal health, and correlates with a higher incidence of stillbirths ***(www.ourworldindata.org)***.

Table 1 and Figure 5 - People without access to electricity (millions)

S.No.	Year	People	per cent (+/-)
1.	2012	1317	
2.	2013	1278	-2.96
3.	2014	1213	-5.09
4.	2015	1133	-6.60
5.	2016	1071	-5.47
6.	2017	968	-9.62
7.	2018	842	-13.02
8.	2019	778	-7.60
9.	2020	754	-3.08
10.	2021	754	0.00
11.	2022*	774	+2.65



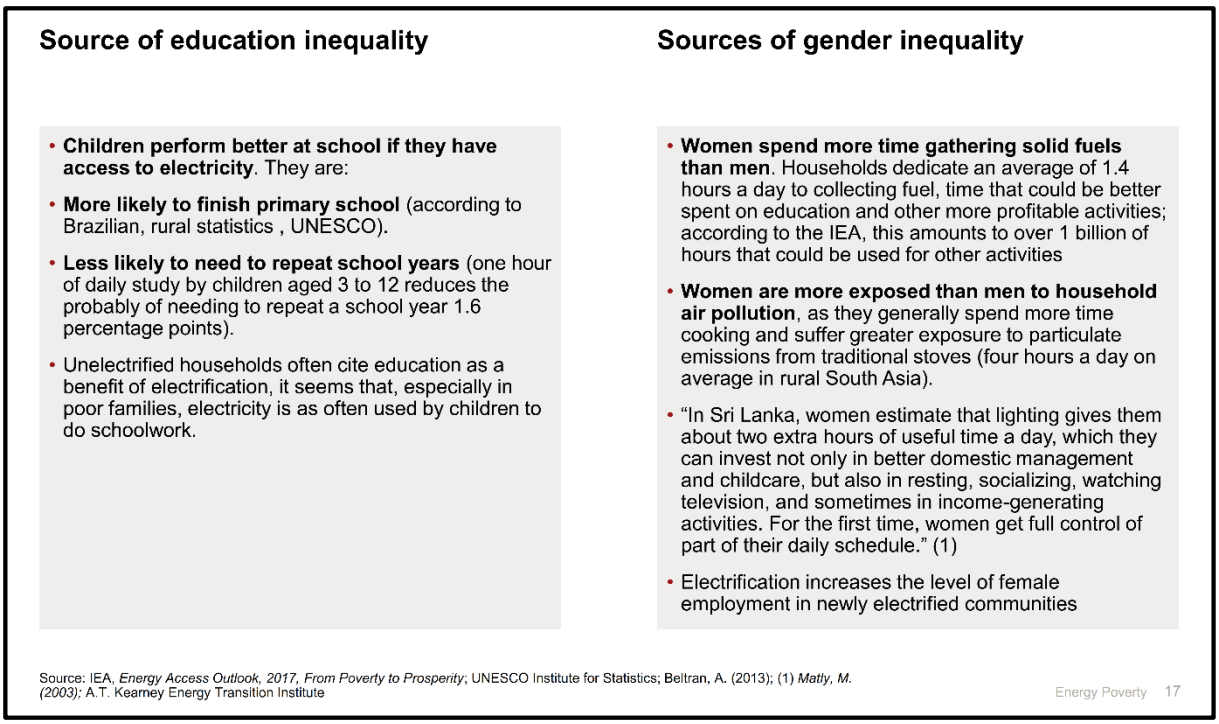
***Source**: IEA. Licence: CC BY 4.0.*
***Note**: *-estimated*

Energy poverty significantly affects life quality, health, and the environment **(Sovacool BK, 2012; Casillas and Kammen, 2010; Papadopoulou et al., 2019; Filippín et al., 2018; Zhu et al., 2018)**. Increasingly, attention is given to its link with adverse mental health effects **(Csiba et al., 2016; Lin and Okyere, 2020; Gilbertson et al., 2012)**. Current efforts are insufficient to achieve Sustainable Development Goal 7 by 2030, with 774 million lacking electricity and 2.4 billion using unhealthy cooking fuels **(IEA, 2022)**. The COVID-19 pandemic and the energy crisis from the Russian invasion of Ukraine are hindering progress, and projections indicate that 670 million will lack electricity by 2030. The access gap has widened globally, with the 20 least electrified countries representing 76 per cent of the population without electricity. Moreover, nearly 90 million in Asia and Africa, who gained access earlier, can no longer afford basic energy needs. Despite ongoing efforts, the world is falling short of achieving Sustainable Development Goal 7 by 2030. Approximately 774 million people lack access to electricity, and 2.4 billion rely on unhealthy cooking fuels **(IEA, 2022)**. The COVID-19 pandemic has impeded progress, and projections suggest 670 million people will remain without electricity by 2030. The energy crisis triggered by the Russian invasion of Ukraine is expected to further slow progress. Access gaps have widened globally, with the 20 least electrified countries representing 76 per cent of the population without electricity. Additionally, nearly 90 million people in Asia and Africa who previously gained access can no longer afford their basic energy needs. The optimal approach to alleviating poverty and social exclusion involves integrating energy modernization measures with suitable social, regional, and agricultural policies, alongside sustainable national strategies for energy transformation **(Mrówczyńska et al., 2020; Streimikiene et al., 2020; Księżopolski et al., 2020)**.

IX. Impact of Energy Poverty

Energy poverty affects education through increased absenteeism and illness, with children spending time collecting fuel and experiencing reduced school attendance. Measurement methods include tracking the minimum energy needed for basic needs, analysing the energy use of the poorest individuals, and assessing the percentage of income spent on energy services **(Figure 6)**. Families spending over 10 per cent-15 per cent are deemed 'energy poor' or fall into 'fuel poverty' **(Sovacool and Drupady, 2012)**.

Figure 6 - Energy Poverty Impacts: Education and Gender Equality



Gonzalez (2016) contends that energy poverty adversely affects human health, leading to premature deaths from respiratory and cardiovascular diseases due to indoor air pollution. Rural areas face heightened energy poverty challenges due to lower incomes compared to urban areas and specific energy requirements for agricultural use **(Kaygusuz, 2011; Lahimer et al., 2013)**. The vulnerability to energy poverty in rural settings is influenced by socio-economic factors, energy infrastructure development, and housing characteristics. Energy poverty's far-reaching impacts on individuals, communities, and economies are interconnected, influencing various aspects of daily life. Now, a detailed exploration of these impacts:

Health Impacts: Indoor Air Pollution: Reliance on traditional cooking methods causes indoor air pollution, leading to respiratory diseases. Over 3 billion people globally use solid fuels, resulting in 4 million premature deaths annually (**WHO**). **Healthcare Facilities:** Inadequate energy in healthcare facilities affects essential services, compromising vaccine storage and medical equipment. Globally, 1.1 billion people lack electricity in health facilities **(*World Bank*)**.

Education Impact: Limited Study Hours: Inadequate electricity access hampers nighttime study, impacting educational performance. In sub-Saharan Africa, approximately 90 per cent of rural households lack electricity (**IEA**). **Digital Divide:** The absence of electricity widens the digital divide, hindering access to online education tools. Disparities in internet access between urban and rural areas are reported by the International Telecommunication Union (***ITU***).

Economic Impact: Agriculture Productivity: Insufficient energy access hampers agricultural productivity, limiting modern equipment and irrigation. The Food and Agriculture Organization (FAO) notes its adverse effects on yields. **Entrepreneurship:** Energy poverty hinders small business growth, crucial for various economic activities. The International Finance Corporation (IFC) underscores the significance of reliable energy. In certain regions, up to 50 per cent of micro, small, and medium enterprises face challenges due to energy poverty.

Quality of Life: Lighting Challenges: The absence of electricity forces reliance on costly and inefficient lighting, compromising safety and overall well-being. The International Energy Agency (IEA) reports that over 800 million people lack electricity, resorting to inadequate lighting. **Cooking Struggles:** Traditional cooking methods, still used by around 2.8 billion people, disproportionately affect women and children, leading to health issues and time burdens. This, according to the World Bank, remains a significant challenge.

Social Equity: Gender Disparities: Women disproportionately bear the brunt of energy poverty, handling more unpaid domestic tasks, earning less, and facing health risks and violence. In 2020, global women's labour market participation was only 47 per cent, dropping to less than 30 per cent in certain regions. **Rural-Urban Divide:** Rural areas face greater energy poverty, contributing to disparities in living standards. The World Social Report 2021 notes that 5.3 per cent of urban residents experience extreme poverty, contrasting with 18 per cent in rural areas, highlighting the urban-rural divide (***www.un.org***).

Environmental Impact: Deforestation and Carbon Emissions: Reliance on biomass for cooking accelerates deforestation, affecting biodiversity and ecosystems. The World Resources Institute (WRI) notes its contribution to 11 per cent of carbon emissions, with global deforestation statistics revealing the loss of 420 million hectares since 1990. Limited access to cleaner energy intensifies carbon emissions, aggravating climate change. In 2022, carbon dioxide emissions grew by 1.3 per cent, totalling 37.1 billion metric tons from 2000 to 2020, and the Asia Pacific region contributed 53.3 per cent in 2020 (***www.statista.com***).

Public Safety: Emergency Services: Lack of reliable energy hampers emergency services, impacting response times during crises. The Institute of Medicine (IOM) notes the economic consequences, emphasizing delayed responses, increased morbidity, and loss of life. Community resilience is crucial, with reliable energy identified by the National Research Council as key for better disaster withstands and recovery. The UN Office for Disaster Risk Reduction stresses integrating sustainable energy for enhanced emergency service reliability.

Security: Lighting and Crime: Inadequate public lighting raises safety concerns, particularly in high-energy poverty areas, notes the World Bank. Poorly lit spaces foster crime opportunities, correlating with studies in criminology. Fear of crime limits mobility and affects mental health, according to the WHO. Traffic safety is compromised without proper lighting, increasing accident risks, per the World Bank's Global Road Safety Facility. Poor lighting reduces surveillance effectiveness, impacting personal security and contributing to gender-based violence, highlighting the importance of well-lit public spaces for community cohesion, social activities, and effective emergency response, as recognized by various studies and organizations.

Access to Information: Communication: Limited energy access hinders communication channels, impacting information dissemination and access to news and education. UNESCO emphasizes that information access is integral to freedom of expression, fostering the rule of law and promoting various rights, including health and environmental concerns. It is a crucial enabler for sustainable development, addressing poverty and combating corruption. While the ITU notes a significant increase in internet usage, with 67 per cent of the global population online in 2023, 2.6 billion people remain offline, emphasizing the ongoing digital divide.

Innovation and Technological Advancement: Technological Divide: Energy poverty contributes to a technological divide, restricting access to the benefits of advancements. Our World in Data notes the rapid pace of technological change, emphasizing the significant strides in recent decades. The World Economic Forum highlights key emerging technologies like artificial intelligence, blockchain, and gene editing. However, the persistence of energy poverty hampers equitable access to these transformative innovations.

Development Opportunities: Entrepreneurial Opportunities: Reliable energy access is crucial for fostering businesses and entrepreneurial ventures, stimulating economic growth and job creation. Entrepreneurial opportunities arise from identifying market needs and creating products or services to address them, whether through intentional search, serendipity, or addressing recognized problems with intentional solutions. (*https://openstax.org*).

Entrepreneurial Opportunities in 2023: Forbes Advisor provides a list of 19 small business ideas for the year, ranging from tutoring to dog grooming (www.forbes.com). Another valuable resource for identifying entrepreneurial opportunities is OpenStax, which offers a comprehensive guide in this domain.

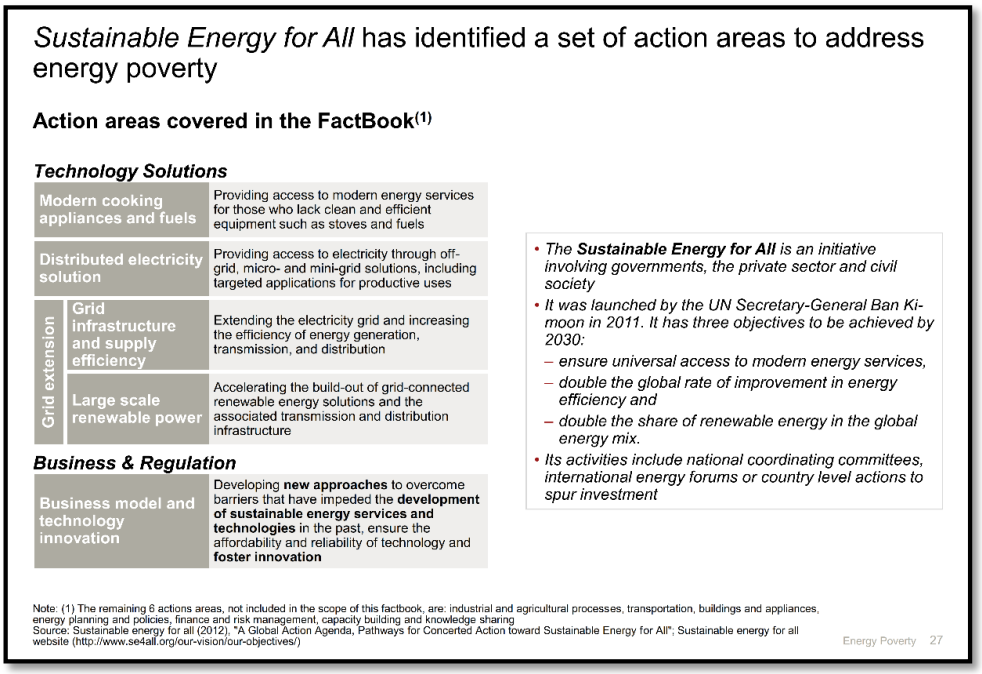
X. Remedial Actions

Understanding and addressing energy poverty necessitates a comprehensive approach that includes policy interventions, technological innovations, and community engagement.

Policy and Regulatory Measures: Inclusive Energy Policies: Develop and implement policies prioritizing inclusivity to ensure equitable access to energy services, particularly in underserved areas. **Regulatory Reforms:** Streamline regulatory processes to facilitate investment in energy infrastructure, fostering contributions from both public and private entities. **Investment in Renewable Energy: Promote Clean Energy Sources:** Advocate for the adoption of renewable energy sources like solar, wind, and hydropower to provide sustainable and eco-friendly solutions. **Investment Incentives:** Offer financial incentives and support mechanisms to attract investments in renewable energy projects, enhancing their appeal to investors. **Community-Based Solutions: Microgrids:** Deploy microgrid solutions at the community level, especially in remote areas, to deliver reliable and decentralized energy tailored to local needs. **Capacity Building:** Empower local communities through training programs covering energy management, entrepreneurship, and the maintenance of decentralized energy systems. **Technology and Innovation: Off-Grid Solutions:** Explore and implement off-grid technologies like solar lanterns and small-scale renewable energy systems to meet immediate energy needs in remote and off-grid communities. **Energy Storage:** Invest in energy storage technologies to address intermittency issues in renewable energy sources, ensuring a more dependable power supply. **Financial Inclusion: Microfinance Initiatives:** Facilitate access to financing for individuals and communities, making investments in energy infrastructure and clean technologies more accessible. **Public-Private Partnerships (PPPs):** Encourage collaboration among governments, private enterprises, and international organizations to fund and implement energy access projects. **Education and Awareness: Energy Literacy Programs**: Implement education and awareness campaigns to promote energy literacy, emphasizing the benefits of sustainable energy practices and energy conservation. **Community Engagement**: Involve communities in the decision-making process, ensuring that energy solutions align with their needs and cultural contexts. **Government Support and Coordination: Cross-Sectoral Coordination:** Foster collaboration between government agencies, NGOs, and private sectors to create comprehensive and coordinated strategies for energy access. **Subsidy Programs**: Implement targeted subsidy programs to make clean energy technologies more affordable for low-income households. **Rural Electrification Programs: Grid Extension:** Expand electricity grids to reach rural and remote areas, connecting these regions to centralized power sources. **Hybrid Solutions:** Implement hybrid solutions combining grid and off-grid systems to ensure a more robust and sustainable energy supply. **Data**

Collection and Monitoring: Impact Assessment: Regularly assess the impact of energy access initiatives to ensure effectiveness and identify areas for improvement. **Data-Driven Decision Making**: Use data and analytics to inform policy decisions, prioritize interventions, and allocate resources effectively. **International Collaboration: Global Partnerships**: Collaborate with international organizations, donor agencies, and neighbouring countries to share knowledge, resources, and best practices in addressing energy poverty on a global scale. **Capacity Building:** Support capacity-building initiatives in developing countries to enhance their ability to implement and sustain energy access projects.

Figure 7 – Sustainable Energy and Energy Poverty



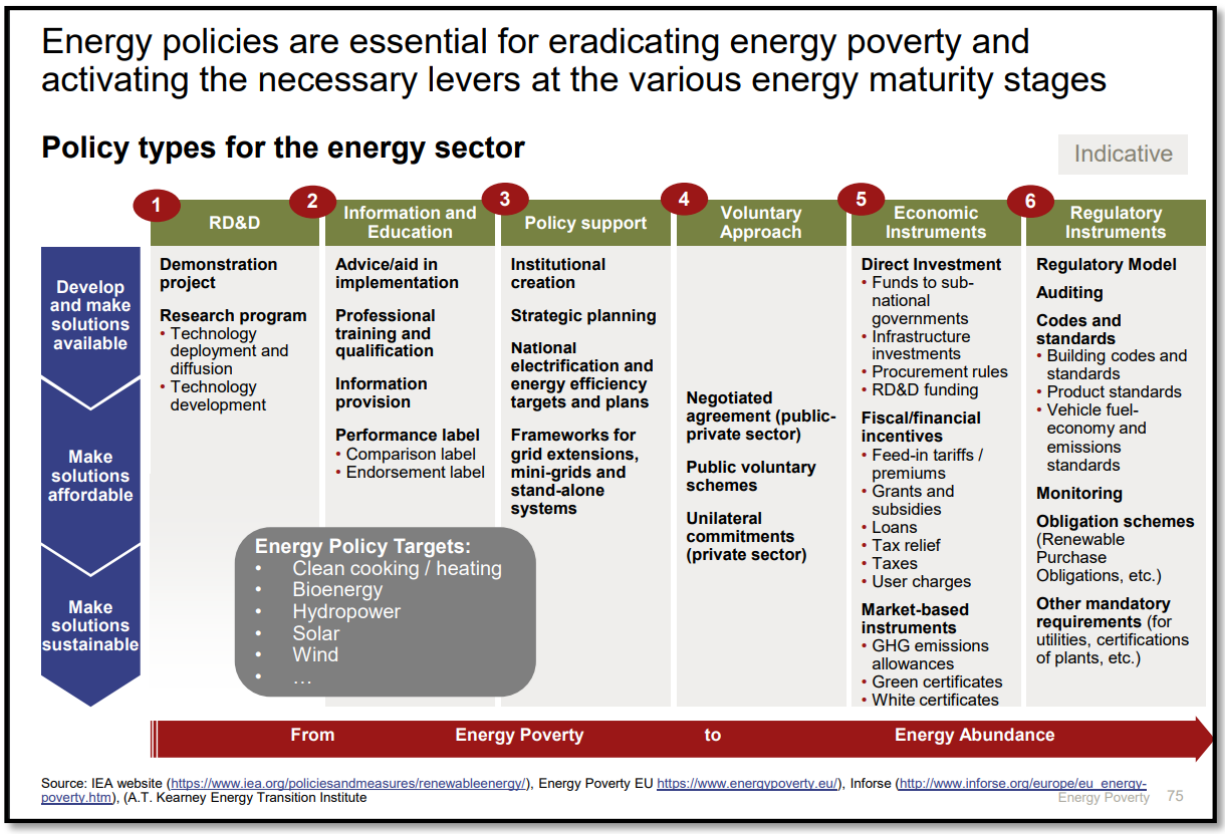
The Sustainable Energy for All Initiative **(Figure 7)** outlines key action areas to address Energy Poverty, including technological solutions and business regulations.

Quick Scanning of Energy Progress Report and SD Goals: The Energy Progress Report, an annual publication by five custodian agencies overseeing progress on Sustainable Development Goal 7 (SDG 7), serves as the global reference for information on achieving universal access to affordable, reliable, sustainable, and modern energy. The report provides a comprehensive overview of global advancements in energy access, efficiency, renewable energy, clean cooking, and international cooperation toward SDG 7 **(World Bank, 2023)**.

XI. Energy Poverty eradication and its directives

The Energy Performance of Buildings Directive (EPBD) requires actions against energy poverty in national renovation strategies, prioritizing the least efficient buildings. The Energy Efficiency Directive (EED) mandates measures for vulnerable households, including those facing energy poverty. Renovation investments promise multiple benefits, meeting energy-poor households' needs and supporting efficiency and climate goals.

Figure 8 – Policies for eradicating energy poverty



The Electricity Directive aims to enhance the flexibility of the electricity market, integrating renewables and empowering consumers. The Renewable Energy Directive (RED) promotes renewable access for low-income consumers, ensuring information accessibility. The Governance Regulation mandates governments to identify and address energy poverty in National Energy and Climate Plans. Besides, R&D information education policy support, voluntary approach, economic infrastructure and regulatory instruments are essential conditions for removing energy poverty.

XII. Conclusion

Policy, regulatory support, and subsidies play a crucial role in broadening access to clean, reliable, and affordable energy. An established energy system is essential for the functioning of various sectors, including businesses, healthcare, education, agriculture, infrastructure, communications, and high technology. Conversely, a lack of access to energy supplies and transformative systems acts as a constraint to both human and economic development. Affordable, reliable, clean, and sustainable energy contributes to enhancing health by providing access to clean water, using cleaner cooking fuels, generating heat for water purification, and improving agricultural yields. Health clinics equipped with modern fuels and electricity can refrigerate vaccines, sterilize equipment, and ensure adequate lighting. Furthermore, it aids in increasing household incomes by boosting productivity through savings, increased output, value addition, and diversification of economic activities. Energy for irrigation fosters higher food production and improves access to nutrition. Additionally, it creates opportunities for education by freeing up time and empowering women and children to engage in educational and productive pursuits rather than traditional energy-related activities. The use of cleaner fuels, renewable energy technologies, and energy efficiency helps mitigate environmental impacts at the local, regional, and global levels. Moreover, it enhances agricultural productivity and land use through the adoption of improved machinery and irrigation systems.

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