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RESEARCH ARTICLE

Assessing the role of sustainable strategies in alleviating energy poverty: an environmental sustainability paradigm

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Abstract

The rapid urbanization and industrialization of India have caused a demand–supply gap in the electrical sector, leading to higher electric bills. Lower-income households face the worst energy poverty in the country. Sustainable strategies like corporate social responsibility are the most effective way to combat the energy crisis. This study aims to assess the contribution of corporate social responsibility (CSR) to energy poverty alleviation (EPA) by developing the role of mediating variables such as assessment of renewable energy resource (RER), feasibility of sustainable energy supply (SES), and sustainable energy development (SED). We used hybrid research methodology such as partial least squares structural equation modeling (PLS-SEM) to analyze the collected data from professionals, economic experts, and directors in the country in 2022. The study proved that CSR directly affects energy poverty alleviation. Besides, the findings suggest RER, SES, and SED significantly lead the energy poverty alleviation. The findings of this study will divert the attention of policymakers, stakeholders, and economists toward the corporate social responsibility to mitigate the energy crisis in Indian context. A mediating role of a renewable energy resource (RER) as a value-added contribution to this study can be strengthened more in future research. Based on the results, the study illustrates that CSR acts as a catalyst to alleviate energy poverty.

Keywords Energy poverty · Corporate social responsibility · Renewable energy resource · Sustainable energy development · India

Abbreviations

BSR	Business for social responsibility
CSR	Corporate social responsibility
EPA	Energy poverty alleviation
MDGs	Millennium Development Goals
RER	Renewable energy resource
RPO	Renewable purchase obligation
SDGs	Sustainable Development Goals
SED	Sustainable energy development
SES	Sustainable energy supply
TBL	Triple bottom line
UN	United Nations

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Introduction

Currently, environmental pressure has significantly increased due to the economic growth and industrialization processes of some nations, making climate change the most significant problem that various countries are currently facing (Adebayo et al. 2022; Alola et al. 2021; Miao et al. 2022). The corporate social responsibility (CSR) approach has more than a 50-year history (Giffari et al. 2021) and has global concerns (Giffari et al. 2021). CSR is a business model that balances economic interests and environmental and social needs (Behringer and Szegedi 2016). Previous researchers also described CSR as an integral part of corporate strategy, as it helps maintain the reputation of the company in the market (Andronicean 2019; Siyal et al. 2022). Until the turn of the millennium, CSR was mainly understood as a voluntary corporate social

engagement built on charity and stewardship principles (Peña-Miranda et al. 2022). Handelman and Arnold (1999) argued that a CSR initiative is a crucial instrument of company use to show its commitment to stakeholder norms and expectations (Handelman and Arnold 1999). CSR integrates environmental and social responsibilities into business activity; a social entrepreneur resolves a social or ecological problem by applying a business model and establishing a positive social change (Barauskaite and Streimikiene 2021; Priede et al. 2014; Tiurina et al. 2023). In addition, CSR means the ethical behavior of a company toward society (Carroll 2021; Davis et al. 2017; García-Rosell et al. 2023; Singh and Misra 2022). Orlitzky et al. (2011) analyzed that CSR is a source of financial performance (Orlitzky et al. 2011), such as boosting sales revenue and reducing business risks (Barauskaite and Streimikiene 2021; Nizam et al. 2019). Corporate environmental commitment positively affects stakeholder and customer relationship management (Tong 2022). Therefore, cooperation is necessary to succeed over a sustained period (Adebayo and Kirikkaleli 2021; Jain et al. 2022).

In current situations, enterprise acts as a social cell and a significant development driver. Without social responsibility, businesses fail to attract and retain customers (Le 2022; Sharma 2019). Socially responsible enterprises should build trust with customers, investors, and communities to reduce risk and improve credit (Lu et al. 2022). Customers will keep buying from these companies and adopting their new technologies. As a result, enterprises can remain profitable and competitive (Ali Basah 2012; Tapang and Bassey 2017). Furthermore, the competitive company needs a viable strategy, good technology, and original perspectives. The firms that engage in CSR practice fulfil their environmental commitments, maintain their market position, and ensure further expansion (Boma-Siaminabo 2022; D'Cruz et al. 2022).

Energy drives economic growth because it is needed for all production and consumption (Destek et al. 2021). It is integral to socio-economic development because it raises living standards through GDP growth (Kumar 2020). Therefore, increasing renewable energy sources is essential to combat energy poverty in rural regions (Batool et al. 2022). Energy poverty alleviation is one of the main objectives of the Millennium Development Goals (Wang and Lin 2022). In India, most poor people still reside in those places where energy poverty is a significant issue. Therefore, advanced and affordable energy is required to boost employment in rural areas. In addition, it increases work prospects and raises living standards (Batool et al. 2022). Energy poverty refers to a lack of reliable and affordable access to energy sources (Halkos and Gkampoura 2021). The alleviation of energy poverty and achieving the MDGs internationally and domestically depend on corporate investment (Ehsanullah et al. 2021). Thus, corporations can promote this agenda more effectively than individuals. Business executives are encouraged to promote sustainable development by providing renewable energy technologies to low-income communities (Sesan et al. 2013). Renewable energy sources are the most effective solution to eliminate energy poverty (Hamed and Peric 2020).

The current energy supply–demand inequity threatens the economy and society (Perera et al. 2019). Sustainable energy can satisfy the current demands without negatively impacting the future. Ecology, business, politics, and culture all fall under the umbrella of sustainable development. Sustainable energy development helps to mitigate climate change, affordable energy access, energy security, and economic growth (Ainou et al. 2022). Sustainable development requires low-cost, reliable, modern, and renewable energy (Lecka et al. 2022). Renewable energy sources include geothermal, biofuel, wind, wave, solar, and tidal power (Dawn et al. 2019; Rahman et al. 2022).

India, the country studied in this research, has a population of 1.3 billion people and will overtake China by 2025 (Bansal 2021). India is the seventh-largest country, with an area of 3,287,263 sq. km. In addition, India is 3214 km north-to-south and 2993 km east-to-west; its land border is 15,200 km long, its coastline is 7,517 km long, and it has seven union territories and 28 states (Bhasin 2012). The country has been facing substantial challenges in producing enough energy at an affordable price. India has excellent renewable energy potential; however, energy poverty is severe in the country. CSR could be the most effective tool to alleviate energy poverty because it promotes the consumption of renewable energy sources (Nurunnabi et al. 2020).

Renewable energy is vital for future energy needs in rural and urban areas (Perišić et al. 2022). The sustainability of energy development is linked to the sustainability of energy consumption across the entire energy system, including sustainable energy supplies, processes, and technology. Furthermore, it requires these aspects, such as technological innovation, a varied range of renewable resources, customer availability, and price affordability (Saad and Taleb 2018). Energy sustainability has become a serious issue all around the world. Many countries are shifting towards a greener economy after reducing their reliance on fossil fuels and incorporating renewable energy into their national energy mix (Gansukh 2021). Furthermore, these conventional fuels are polluting and expensive and contribute to global warming (Al-Ghussain 2019). In contrast, effective renewable energy can reduce pollution caused due inefficient energy use; therefore, green technology is required to overcome this worldwide problem (Saqib et al. 2022; Sharif et al. 2023).

The term "sustainable transition" states to the fundamental change toward a sustainable society that might restructure production and consumption systems (Grin et al. 2010). Transitioning from fossil fuels to renewable energy sources has led to sustainable energy (Mutezo and Mulopo 2021; Philo and Happer 2013). Thus, developed and developing

countries should employ renewable technology to combat energy poverty (J. Zhao et al. 2022a, b).

India, the seventh-largest country, has a population of 1.3 billion (Bansal 2021). Even though we live in the twenty-first century, energy poverty is still in its worst condition because the global population is growing, and economic growth is unstable (Hamed and Peric 2020; Hassan et al. 2022). Sustainable energy is a promising strategy for alleviating energy poverty and financial stability (Nasir et al. 2022). The sustainability of energy resources is a primary concern for energy safety, productivity, and environmental protection in countries, regions, and the world. Sustainable energy is the efficient use of energy throughout the entire energy system, including energy service delivery, energy transportation, energy storage, processes, and technology for converting energy resources into usable forms. Therefore, renewable energy is essential for stable and sustainable energy supply (Tiep et al. 2021a).

Renewable energy resources include solar power, biogas energy, wind energy, hydro energy, and geothermal energy. Article 21 of the Indian Constitution requires uninterrupted electricity; hence, the country requires maximum renewable energy generation. Renewable energy started in the late 1990s; however, its contribution to generating electricity in India is 20%. The lockdown at COVID-19 caused Indian families to use more power; therefore, a sustainable energy supply was needed to satisfy all consumers (Stephan et al. 2022). India enjoys sun radiation all year round; hence, more solar power plants are needed to alleviate the poor energy crisis. Renewable purchase obligation (RPO) helps India to maximize electricity from renewable energy sources (Pachauri 2022). Therefore, the feasibility of renewable energy supply is the best source to alleviate energy poverty (Biernat-Jarka et al. 2021).

Sustainable development meets present requirements without compromising future basic needs (Tiep et al. 2021a); however, sustainable development relies heavily on good governance and natural resources (Safdar et al. 2022). In addition, poor energy development enhances the CO_2 emissions that affect economic sustainability and global warming (Khan et al. 2018; Wangzhou et al. 2022; Yu et al. 2022). In contrast, sustainable energy development mitigates global threats like carbon emissions, energy crises, starvation, and instability (Lu et al. 2019). During the last few periods, the energy utility industry experienced various environmental and social challenges (Hoang et al. 2021); all the risks outlined, including environmental, health, and safety concerns, hinder energy development. As a result, energy companies, particularly public utilities, are expected to meet more demanding performance requirements, including environmental considerations (Stjepcevic and Siksnelyte 2017). All aspects of the supply chain, including power generation, commerce, transmission, and distribution, are undergoing significant changes (Pollitt 2012). Due to climate change, renewable energy sources (RES) are needed in power generation, heating and cooling, transportation, and construction. In addition, renewable energy sources can generate four-fifths of global electricity by 2050 and reduce global warming (Ahmad et al. 2022). "Energy transition" is crucial to many national and regional political goals and objectives (Weder et al. 2019). Transformation is a term used to describe a continuous process characterized by structural and non-linear changes across time (Khmara and Kronenberg 2020). It is a protracted transition from one economic system with limited resources to another (Carley et al. 2018). The EU has set sustainable energy development goals for 2020 to 2030, and three primary criteria link 2050: improving energy efficiency, increasing renewable energy use, lowering emissions, and technical innovation (Burja and Burja 2014).

According to previous researchers, lower-income households facing the worse energy poverty in India (Amin et al. 2022; Chien et al. 2021; Fraser et al. 2023; Jessel et al. 2019; Lan et al. 2022; Nguyen et al. 2023; Sharma et al. 2019; Sovacool 2012; Streimikiene and Kyriakopoulos 2023). This research aimed to identify particular societal enablers in the Indian context that would catalyze sustainable energy development to mitigate the severe energy crisis. Corporate social responsibility is a brilliant initiative and focuses on four categories: ethical, philanthropic, environmental, and economic responsibility. The government of India enacted the initial step of mandating a CSR policy. This study explored that third parties like CSR foundation companies can alleviate energy poverty by implementing energy-related projects in the country. No prior study was conducted to determine the role of CSR in combating energy issues. This study is unique because it comprehensively analyzes the three mediators: assessment of renewable energy resource (RER), feasibility of sustainable energy supply (SES), and sustainable energy development (SED), which performs the mediating role between the corporate social responsibility (CSR) and energy poverty alleviation (EPA). Furthermore, this research contributes to the extensive literature in the context of India. This research will attract the attention of policymakers, entrepreneurs, contractors, shareholders, companies, stakeholders, agencies, and research scientists to understand the CSR-related driving forces for the higher consumption of renewable energy resources to alleviate energy poverty.

The rest of the paper is structured as follows: "Literature review" includes the literature review, and "Model of proposed study" presents the model of proposed study. "Research methodology" provides the research methodology, followed by the results and discussion in "Result and discussions." "Conclusions and policy recommendations" consisted of the conclusion, policy recommendations, and research limitations.

Literature review

The literature review starts with defining the term "energy poverty" in India. Further, we construct some hypotheses based on the existing literature to evaluate the potential of

the study to reveal the impact of CSR on reducing energy poverty.

A demand-based approach for defining energy poverty in India

According to the theory of energy poverty, health will be negatively impacted due to inefficient energy consumption. We consider cost, availability, and social impact in determining what percentage of expenses go toward energy and other categories. Electricity prices rise, forcing customers to limit food expenditure, which is terrible for everyone. The amount of energy consumption may go down, even if the budget were increased. There is a broad spectrum of price, efficiency, and usefulness. As a result, it puts a strain on household budgets. Rather than energy expenditures, the demand for energy services should be used to characterize the function of energy use in household well-being. Establishing a causality assessment methodology is necessary for determining the impact of household income and non-energy consumption on energy usage. Socio-economic affect household energy demand and consumption. The energy costs of the household will rise if its energy consumption rises (for example, if more kerosene lanterns or more electricity are purchased) or if new energy equipment (such as electric irons, lights, or fans) is purchased (e.g., TVs, refrigerators, VCRs, and air conditioners) (Khandker et al. 2010).

Modern energy methods can damage dwellings directly and indirectly; therefore, preventive measures should be adopted before using them. In addition, there is a correlation between well-being, financial status, and energy usage; the presence of light is a sign of success and wellness. Electricity-based lighting is one hundred times more efficient than kerosene-based (kupi) (Khandker et al. 2014). In addition, extra time in the office may be possible if the lights are good enough. Workers can be facilitated from a brighter home or office environment to increase their salary, and children might be more focused and attentive if classrooms are brightened (Jokhan et al. 2022). The researcher examined the correlation between household income and energy consumption to determine the standard lifestyle (Arshed et al. 2022; Lang et al. 2022). Furthermore, rural households' energy consumption depends on energy prices, village infrastructure, prevailing wage structure, and commodity prices. Like many other countries, India has faced the challenge of energy poverty (Sy and Mokaddem 2022). One in three Indian people lack electricity, raising the question of how energy-poor the country is (Mukherjee and Karmakar 2022).

Corporate social responsibility (CSR)

CSR is a brilliant initiative; it means doing something for everyone, but not always the same (Barbarossa et al. 2022). Carroll's pyramid focuses on four categories: ethical, philanthropic, environmental, and economic responsibility (Carroll 2021). Furthermore, CSR is called volunteer success sponsored to perform social welfare activities. Corporations should focus on beneficial business outcomes and practice CSR to reduce environmental health risk factors that attract investors and customers (Carroll and Shabana 2010; Partalidou et al. 2020; Xue et al. 2022). The most notable example of CSR institutionalization was the 1992 establishment of the group business for social responsibility (BSR), which initially included 51 companies to become a "power for positive social change"—a force that would conserve and restore natural resources, uphold human dignity and justice, and function transparently (Agudelo et al. 2019). Following an April 2014 amendment to the Companies Act 2013, India was the first country to mandate CSR (Jain 2015); as a part of any CSR enforcement, companies should spend their income on poverty, education, hunger, gender inequality, etc. (Dixit 2023). In addition, organizations should establish specific policies, plans, and priorities for their CSR programs and create separate budgets to fund them. These services focus on well-defined societal views and align with organizations' business spheres (Kaur and Tandon 2017). The Ministry of Corporate Affairs announced enterprise expenditures to battle COVID-19; it will be valid under CSR initiatives. Furthermore, COVID-19 funds can be used for several programs, including preventive health care and disaster risk management (Patel et al. 2020).

CSR can improve environmental sustainability and socio-economic development (Márquez and Pérez 2015). Corporate social responsibility drives sustainable energy development, benefiting the climate, environment, communities, and economy (Kuah et al. 2022). Measuring and addressing CSR problems in sustainable energy development can help energy sectors, companies, and investors keep consumer costs low while migrating to energy-saving technology and a renewable energy portfolio. Corporations have strongly supported ecological transition (Liu et al. 2023). Furthermore, CSR-related energy efficiency improvements, renewable energy source use, and GHG emission reduction "contribute to long-term energy development" (Lu et al. 2019).

Corporate social responsibility (CSR) and renewable energy assessment (REA)

India has excellent renewable energy potential; however, the country has severe energy poverty and power shortfalls (Lazanyuk et al. 2023). CSR is the most effective method to alleviate energy poverty because it promotes renewable energy consumption (Nurunnabi et al. 2020). Researchers argued that CSR-practicing energy companies contribute more renewable energy sources to reduce the heavy dependency on fossil fuels; it protects the environment by lowering greenhouse gas emissions (Khan et al. 2019). Furthermore, companies should innovate energy-saving products in the context of corporate social responsibility (CSR) because the results could be meaningful for

the economy, society, and the environment. To alleviate energy poverty, CSR-practicing companies should invest in renewable energy projects that increase energy sustainability (Lecka et al. 2022; Mastropietro 2022; Nisipeanu et al. 2011). Based on the above reviews, the first hypothesis is formulated as follows:

Hypothesis 1: corporate social responsibility (CSR) is significantly associated with renewable energy assessment (REA).

Corporate social responsibility (CSR) and feasibility of sustainable energy supply (SES)

Companies are under pressure to provide a sustainable energy supply through corporate social responsibility (Agudelo et al. 2020). CSR in India has evolved from Mahatma Gandhi's "Trusteeship model" to a statute in the Companies Act of 2013. However, this shift from voluntary to mandatory is in process. From the middle of the 1850s until the present, CSR has been practiced in India, focusing on the CSR mandate (Mitra and Schmidpeter 2017). CSR practical contribution is maintaining a sustainable energy supply to alleviate energy poverty and promote socio-economic development while protecting the environment and boosting social life (Lecka et al. 2022; Tiep et al. 2021a). Modern lifestyles require a reliable, long-term, and sustainable energy supply. Energy firms must prioritize CSR to control carbon emissions, such as CSR looking at social, environmental, and business-related factors. Using renewable energy resources, also known as sustainable energy sources, is crucial in reducing energy poverty and meeting the growing electricity demand (Gigauri and Vasilev 2022; Li et al. 2021). Based on the above reviews, the second hypothesis is formulated as follows:

Hypothesis 2: corporate social responsibility (CSR) is significantly associated with the feasibility of sustainable energy supply (SES).

Assessment of renewable energy resources (RER) and feasibility of sustainable energy supply (SES)

The transition from using non-renewable energy sources (gas, coal, oil, etc.) to renewable energy sources (wind energy, solar power, bioenergy, hydro energy, thermal power, etc.) leads to a sustainable energy supply (Philo and Happer 2013)**.** Renewable energy reduces greenhouse gas (GHG) emissions; however, it is important to consider the financial benefits while establishing sustainable power generation microgrids (Kiehbadroudinezhad et al. 2022). Biogas and solar microgrids can generate the cost-effective and reliable electricity to fulfil the energy need of consumers, particularly in remote areas (Nawab et al. 2022). Consequently, the assessment of renewable energy resources has the potential to maintain a sustainable energy supply. Therefore, innovative strategies should be explored to optimize the size of renewable energy power generation systems for energy efficiency (Kiehbadroudinezhad et al. 2022). Based on the above reviews, the third hypothesis is formulated as follows:

Hypothesis 3: assessment of renewable energy resources (RER) is significantly associated with the feasibility of sustainable energy supply (SES).

Assessment of renewable energy resources (RER) and feasibility of sustainable energy supply (SED)

Sustainable development becomes a reality with the help of sustainable energy (Guzović et al. 2022). Sustainable energy development is achieved when consumers access affordable and efficient energy sources. Assessment of renewable energy has the potential to maintain economic growth and reduce carbon emissions (Feng et al. 2023; Majid 2020; Zheng et al. 2023). Sustainable transition is a change towards a sustainable society that may restructure production and consumption systems (Berkowitz and Gadille 2022). In addition, energy and environmental challenges are interconnected and require a transition to maintaining sustainable energy. Renewable energy sources replaced fossil fuels due to public concerns about energy security and efficiency.

Furthermore, switching from fossil fuels to renewable energy decreases health hazards and preserves sustainable energy development (Farhan Bashir et al. 2022; Li et al. 2023; Tiep et al. 2021a). Transitioning to more sustainable energy sources can reduce the global carbon footprint (Sharif et al. 2021; Xie et al. 2022). Therefore, policymakers, stakeholders, and investors are trying to promote renewable energy power generation. Fortunately, these resources are becoming affordable to accelerate sustainable energy. All developing countries can be economically strong by using renewable strategic resources. Furthermore, technological innovation and the power market revolution can potentially reduce renewable energy costs (Amir and Khan 2022; Sharif et al. 2022). Renewable energy resource assessment can maintain a sustainable energy supply to meet rising demand and preserve vital resources for future generations (Tiep et al. 2021a). Based on the above reviews, the fourth hypothesis is formulated as follows:

Hypothesis 4: assessment of renewable energy resources (RER) is significantly associated with sustainable energy development (SED).

Feasibility of sustainable energy supply (SES) and sustainable energy development (SED)

Environmentally friendly energy sources are essential to maintain a sustainable energy supply (Ainou et al. 2022). Sustainable energy development requires innovative and affordable energy sources. Renewable energy sources can maintain a sustainable energy supply to develop sustainable energy (Tiep

et al. 2021a). Affordable access to contemporary energy services, sustainable energy supply, sustainable energy use, and energy security lead the sustainable energy development (Gunnarsdottir et al. 2021). Sustainable energy development is a practical approach to mitigate future climate change and increase economic growth (Kung and McCarl 2018). Based on the above reviews, the fifth hypothesis is formulated as follows:

Hypothesis 5: feasibility of sustainable energy supply (SES) is significantly associated with sustainable energy development (SED).

Corporate social responsibility (CSR) and sustainable energy development (SED)

CSR is a dynamic cooperative tool in promoting environmental sustainability by boosting an industry perception of CSR actual value and improving company behavior to effectively adapt to the socio-economic context of the country to ensure ecological sustainability and maintain the socio-economic development (Márquez and Pérez 2015; Pai and Chandra 2022). Most energy-related companies struggle with the best strategies to achieve sustainable development goals. Furthermore, many companies have different perceptions of CSR regarding its practical value and how it relates to sustainable development from both a demand and supply perspective. In addition, investors should improve their CSR strategy and energetic performance to preserve the environment through the contributions of renewable energy sources (Lu et al. 2019). Corporate social responsibility allows companies to address sustainable development issues like climate change (Fallah Shayan et al. 2022; Sidhoum and Serra 2017). Most energy companies know the value of CSR in attaining sustainability; however, they are still struggling to connect their CSR strategy to their core business (Weder et al. 2019).

Furthermore, CSR effectively eliminates corruption to achieve sustainability (Gigauri and Vasilev 2022; Krishnamurti et al. 2018). Long-term economic growth and renewable energy consumption promote sustainable development (Saad and Taleb 2018; Sharma et al. 2021). CSR initiatives and sustainable energy development have significant associations (Mapelli et al. 2016; Tiep et al. 2021a). Based on the above reviews, the sixth hypothesis is formulated as follows:

Hypothesis 6: CSR is significantly associated with sustainable energy development (SED).

Assessment of renewable energy resources (RER) and energy poverty alleviation (EPA)

Technology advancements in the field of renewable energy resources contribute to the alleviation of energy poverty (Wang et al. 2022). Energy poverty has become a serious issue worldwide (Liu et al. 2022; X. Zhao et al. 2022a, b). Incorporating renewable energy into their national energy mix is the best solution to alleviate energy poverty (J. Zhao et al. 2022a, b). Furthermore, the effective deployment of renewable energy resources will combat global warming (Dogan et al. 2023). Therefore, affordability and adaptation of renewable energy technologies should be part of government policies to alleviate energy poverty. Additionally, accepting renewable energy is a vital transition from fossil fuels to mitigate the energy crisis (Agyekum 2020; Batool et al. 2022; Emodi and Boo 2015). Based on the above reviews, the seventh hypothesis is formulated as follows:

Hypothesis 7: assessment of renewable energy resources (RER) leads to energy poverty alleviation (EPA).

Feasibility of sustainable energy supply (SES) and energy poverty alleviation (EPA)

A sustainable energy supply is essential to the fight against energy poverty (Kyprianou et al. 2019). Affordable access to modern energy services, sustainable energy supply, sustainable energy use, and energy security lead to energy poverty alleviation (Awan and Bilgili 2022; Wang et al. 2017). Furthermore, a sustainable energy supply must include eco-friendly energy sources, such as environmentally friendly renewable energy sources, which can assist in sustainable energy development (Abdullah-Al-Mahbub et al. 2022; Saqib et al. 2023). Thus, a sustainable energy supply can be an effective approach to mitigating future climate change (González-Eguino 2015; Papantonis et al. 2022). The following eighth hypothesis is developed in light of the reviews above:

Hypothesis 8: feasibility of sustainable energy supply (SES) leads to energy poverty alleviation (EPA).

Sustainable energy development (SED) and energy poverty alleviation (EPA)

Energy availability is necessary for economic growth at the national and global levels (Fankhauser and Jotzo 2018; Ning et al. 2022). Sustainable energy development requires access to clean, inexpensive, and reliable energy sources (Irfan et al. 2019). The term "energy poverty" refers to the situation in which the people of a country do not have sufficient access to power to meet fundamental needs such as lighting and cooking (Batool et al. 2022). Energy poverty still exists in India; although India possesses renewable energy sources potential, the country can utilize them effectively to combat the energy issues (Rafi et al. 2021). Furthermore, energy inefficiency threatens the economy, society, and ecosystem (Hassan et al. 2023; Jiao et al. 2022). Therefore, policymakers and stakeholders should transition their attention from non-renewable to renewable energy.

Sustainable energy development is the best tool to alleviate energy poverty (Diaz-Barriga and Barnhart 2022).

CSR foundation companies should promote renewable energy-related projects to create a reliable and sustainable energy supply (Gigauri and Vasilev 2022). Every country needs affordable, reliable, and eco-friendly energy sources for sustainable energy development (Gigauri and Vasilev 2022; Tiep et al. 2021a). In addition, sustainable energy development policymakers focus on expanding renewable energy sources to improve energy efficiency and mitigate carbon emissions (Li et al. 2022). The maintenance of sustainable energy development ensures energy security; therefore, European economic policy prioritizes renewable energy development to clean output (Brodny and Tutak 2021; Centurelli 2011; Emodi and Boo 2015; Georgiev 2022). Based on the above reviews, the ninth hypothesis is formulated as follows:

Hypothesis 9: sustainable energy development (SED) leads to energy poverty alleviation (EPA).

Corporate social responsibility (CSR) and energy poverty alleviation (EPA)

Lack of access to reliable energy is a serious problem in India (Sharma and Sood 2022). Like many other developing countries, India is also facing poverty issues; as a result, it cannot maintain its energy levels to lead the sustainable development goals (Gupta et al. 2020). Third parties like CSR foundation companies can alleviate energy poverty by implementing energy-related projects (Gigauri and Vasilev 2022). Corporate social responsibility programs significantly reduce energy poverty (Lecka et al. 2022; Sesan et al. 2013). Therefore, CSR contribution toward sustainable energy development is the best way to reduce the energy crisis in India. Based on the above reviews, the tenth hypothesis is formulated as follows:

Hypothesis 10: corporate social responsibility (CSR) leads to energy poverty alleviation (EPA).

Model of proposed study

CSR is linked to energy poverty alleviation through restructuring renewable energy resources to sustainable energy development as a comprehensive solution for society, the economy, and the environment. Additionally, this research generalizes the relationship between corporate social responsibility (CSR), assessment of renewable energy resources (RER), feasibility of sustainable energy supply (SES), and sustainable energy development (SED) and energy poverty alleviation (EPA). The model suggests that CSR practice led to RER, SES, and SED; these three variables also act as mediators between CSR and EPA. This study employed CSR as a driving force to alleviate energy poverty in India. The author conducted this model to cover the gap in the existing literature regarding the relationships between corporate social responsibility, energy poverty alleviation, and mediators (RER, SES, and SED). The researcher collected the data from respondents in the first phase to evaluate their research objectives. In the second phase, the researcher analyzed the received data by Smart-PLS 4 and described the results. This study concluded the findings and suggested possible strategies for future research. Figure 1 illustrates a study model after an in-depth literature review to describe the study framework. CSR acts as a catalyst to alleviate energy poverty, and their relations are interconnected. EPA is dependent on CSR, RER, SES, and SED.

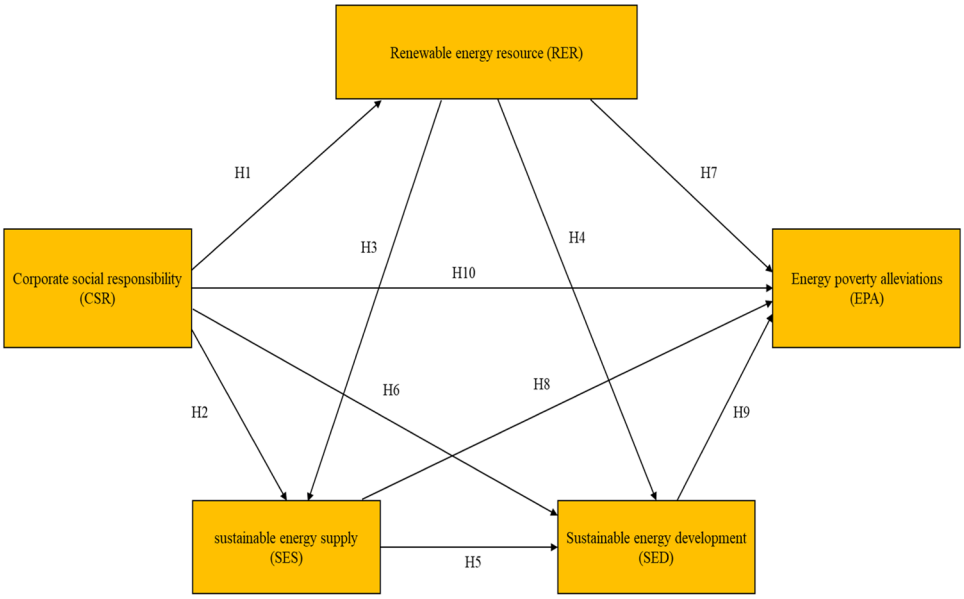
The variables for this study were built with the following item counts: CSR has 5, RER has 4, SES has 5, SED has 4, and EPA has 4. This model comprises a total of 22 items, including one independent variable (CSR), three mediating variables (SES, RER, and SED), and one dependent variable (EPA). The constructs of this model are listed in Table 1.

Research methodology

In this model, CSR is the independent variable, EPA is the dependent variable, and RER, SES and SED are the mediating variables. This study examined CSR items to alleviate energy poverty. This study methodology used a five-point Likert Scale to assess the performance of selected elements, with "strongly disagree" equal to one and "strongly agree" equal to five. This study evaluated how CSR variable impacts model variable interaction and learned more about CSR and SES, RER improvement, and SED maintenance to energy poverty alleviation in India. Researchers conducted the survey and collected responses to examine the reliability of the research questions.

Researchers used random sampling techniques to generate and distribute an updated version of the self-structured research questionnaires of selected elements to the target population. The researcher first described to respondents about the research objectives and assured them that data would be kept confidential. The questionnaire had two sections: section first evaluated the general information of respondents, such as gender, age, and education, and the second consisted of questions related to the respondents' perceptions of the practices of corporate social responsibility and how assessment of RER, the feasibility of SES and maintenance of SED mediates the relationship between CSR and EPA. The researcher distributed the questionnaires to 399 respondents through WhatsApp and LinkedIn to receive the required data and focused strictly on CSR foundations companies from the states of Haryana, Rajasthan, Uttar Pradesh, Maharashtra, and Uttarakhand in India. There are a lot of CSR foundation companies in these states; therefore, the authors selected these states and collected the data to meet their objectives.

Fig. 1 Study model



Researchers offered the respondents three weeks to understand and complete the questionnaires; however, experts responded late. Researchers evaluated all questionnaires after receiving responses from the participants. Based on accurate responses, researchers collected 302 questionnaires and tested them for accuracy. The response rate from the selected respondents was satisfactory (75.7%). The information is imported into Excel and analyzed the data by using smart-PLS 4.0.8.4. Additionally, 11 experts from CSR foundations companies, who had already contributed to the pilot study, were invited to offer their expertise and opinions on the results by interview.

Due to the unique nature of companies such as CSR foundation companies, the snowball sampling method was used to collect the data to meet the research objectives. To do this, researchers surveyed between June and September 2022, when the fourth wave of the delta coronavirus (COVID-19) had almost finished; however, moving from one country to another was a considerable risk. Therefore, the researcher preferred to distribute the questionnaires via WhatsApp and LinkedIn. Moreover, each expert has knowledge about CSR potential to alleviate energy poverty (see Table 14, Appendix).

Furthermore, Smart-PLS is the best model to measure the effect of CSR and energy poverty alleviation. The mediating effect of SES, RER, and SED is part of the satisfaction nexus and mitigates the energy poverty issues. In this study, PLS-SEM software was used, and the extensive application of this software in subsequent studies is evidence of its validity. For modeling, SEM is preferable than traditional statistical methods. The structural equation modeling (SEM) method is a multivariate analytic approach that can explore many variables simultaneously. Poor application of analytical methods can lead to inaccurate findings in social science research. However, a reliable and valid statistical approach is very important.

PLS-SEM is two-stage: testing the measurement model and structure model. The measurement model, also called the inner model, was used to evaluate the convergent validity via composite reliability (C.R.) and average variance extracted (AVE). Furthermore, this model was used to evaluate the discriminant validity via the Fornell–Larcker criterion, cross-loading, and heterotrait–monotrait ratio. Path analysis was used to evaluate the hypothesis in the structure model, also called the inner model. The interdependencies between the variables were discovered through bootstrapping analysis (Ali et al. 2023).

Result and discussions

A demographic analysis of the respondents showed that male participants (195) were in the majority (64.5%), while the number of female respondents was (35.4%). The majority of respondents were 26–30 years old (30.1%), and the lowest participants were > 41 years old (0.08%). The majority of participants were M.Phil. (44.7%) and bachelor degree holders (35.8%), while Ph.D. degree holders (19.5%), as shown in Table 2. Figure 2 of the measurement assessment model shows the variable influence loadings. All factor loading values are greater than 0.5, and each convergent validity of each item in this model is valid.

Measurement assessment model—outer model

The measurement model uses reliability analysis to examine the consistency of various measured variables (Hair et al. 2020). In this model, Cronbach's alpha and the composite reliability index have been used to evaluate the reliability of each factor of productivity values.

Table 1 Construct items

Construct	Items	Description	References
CSR	CSR 1	Corporate social responsibility (CSR) in the reporting of investments in renewable energy resources via promoting the renewable energy projects	(Fallah Shayan et al. 2022) (Lu et al. 2019)
	CSR 2	CSR performs a vital role in sustainable energy development	(Lu et al. 2019)
	CSR 3	CSR initiatives can potentially increase the consumption efficiency of renewable energy resources (RER) to sustainable energy supply (SES)	(Tiep et al. 2021a)
	CSR 4	CSR initiatives boost the sustainable energy supply to maintain the sustainable energy development	(Lu et al. 2019; Tiep et al. 2021a)
	CSR 5	Effectiveness of CSR strategies in alleviating energy poverty	(Garvi and Blankinship 2021)
RER	RER 1	Transit from non-renewable energy to renewable energy resources to meet the required result of alleviating the energy poverty	(J. Zhao et al. 2022a, b)
	RER 2	Increase the solar energy resources to combat electricity issues, especially in rural areas	(Batool et al. 2022)
	RER 3	Increase the biogas energy resources to maintain sustainable energy development to alleviate the energy poverty	(Agyekum 2020)
	RER 4	Increase wind energy resources to mitigate the carbon emissions	(Irfan et al. 2019)
SES	SES 1	Access the consumption of efficient energy	(Tiep et al. 2021a)
	SES 2	Access renewable energy at an affordable price	(Tiep et al. 2021a)
	SES 3	A sustainable energy supply is required to meet the increasing demand for sustainable and efficient energy	(Tiep et al. 2021a)
	SES 4	The feasibility of sustainable energy supply is the best source to alleviate the energy poverty	(Biernat-Jarka et al. 2021)
	SES 5	A sustainable energy supply is a vital tool for achieving the sustainable development goals	(Tsao et al. 2021)
SED	SED 1	Sustainable energy development goals are the reduction of carbon emissions	(Pata 2021)
	SED 2	Enhanced the technical innovations	(Tiep et al. 2021a)
	SED 3	More contributions of renewable energy resources in final year-based energy consumption	(Tiep et al. 2021a)
	SED 4	Improve energy efficiency while reducing costs	(Gunnarsdottir et al. 2021)
	SED 5	Sustainable energy development is crucial to combat energy poverty	(Emodi and Boo 2015)
EPA	EPA 1	Reduced health issues at the household level	(Dong et al. 2021)
	EPA 2	The opportunity for energy-efficient consumption in rural areas	(Wu et al. 2021)
	EPA 3	Jobs opportunity	(Dell'Anna 2021)
	EPA 4	Alleviation of energy poverty is necessary to promote the E-learning technology	(Batool et al. 2022)

The reliability analysis can be interpreted using the rule of Thumb as shown in Table 3. The analysis' findings demonstrate that all variables have Cronbach's alpha coefficients of more than 0.8, including CSR (0.923), EPA (0.905), RER (O.805), SED (0.834), and SES (0.901). The results depict that the measuring scale of this study model is good. For further analyses, the authors used a composite reliability value to strongly confirm the scale's reliability. The analysis results demonstrate that all variables have composite reliability coefficients of more than 0.8, CSR (0.927), EPA (0.907), RER (O.81), SED (0.835), and SES (0.901). Overall, this analysis showed that the reliability scale is satisfactory and good. The findings from this analysis are summarized in Table 4. Furthermore, the findings of the outer loading were also investigated to confirm the indicator reliability. The outer loading results showed that each indicator is reliable, as each value is more than 0.7 (see Table 5).

Convergent and discriminant validity are established to evaluate construct validity (Kersey et al. 2022). Convergent validity occurs when measured items converge on the

Table 2 Demographic information of respondents

Variables	Features	Frequency	Percentage
Gender	Male	195	64.5%
	Female	107	35.4%
Age	20–25	42	13.9%
	26–30	91	30.1%
	31–35	75	24.8%
	36–40	69	22.8%
	> 41	25	0.08%
Education	Bachelor	108	35.8%
	M.Phil	135	44.7%
	PhD	59	19.5%

underlying construct; AVE > 0.50 indicates convergent statistical validity (Hair et al. 2021). According to Götz et al. (2010), convergence is evaluated using average variance extracted (AVE) and external loading factor (Götz et al. 2010). After the analysis, results show that EVA values are more than 0.5, such as CSR (0.764), EPA (0.778), RER (0.63), SED (0.667), and SES (0.717), and external loading factors values are all greater than 0.7 (as shown in Table 6).

These results are higher than those mentioned above, demonstrating high convergent validity, which shows a latent variable account for more than half the variation compared to its corresponding indicators. The Fornell–Larcker criterion is used to verify discriminant validity measurement models. The square root of a construct average variance must be greater than its correlation with another construct. This requirement establishes discriminant validity (Ursule et al. 2022). Table 7 shows that the discriminating test is valid as the square root of AVE values is greater than the inter-construct correlation.

Cross loadings indicate that items should have greater loadings on their parent construct than other constructs. There are discriminant validity difficulties if an item loads well on another construct against its parent construct. Table 8 bold numbers show that the items have a high correlation, while the remaining elements have a

Table 4 Result of Cronbach's alpha and composite reliability

Variables	Cronbach's alpha	Composite reliability
CSR	0.923	0.927
EPA	0.905	0.907
RER	0.805	0.81
SED	0.834	0.835
SES	0.901	0.901

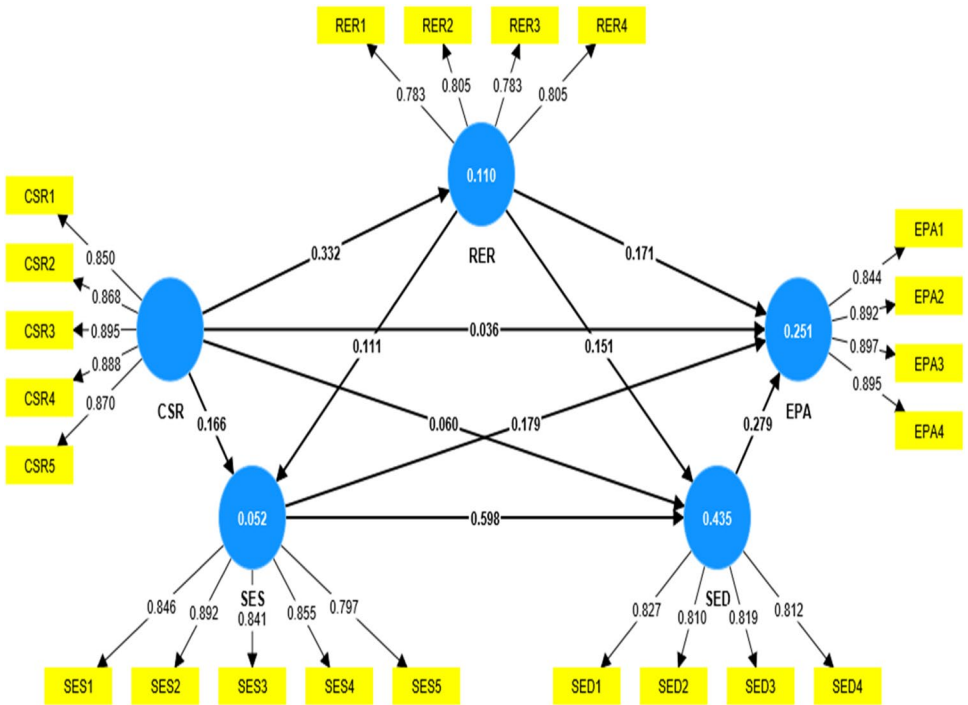


Fig. 2 Measurement model

Table 3 Strength of associations

Range	< 0.6	0.6 to < 0.7	0.7 to < 0.8	0.8 to < 0.9	0.9 >
Association strength	Poor	Moderate	Good	Very good	Excellent

Table 5 Outer loading results

Variables	CSR	EPA	RER	SED	SES
CSR 1	0.85				
CSR 2	0.868				
CSR 3	0.895				
CSR 4	0.888				
CSR 5	0.87				
EPA 1		0.844			
EPA 2		0.892			
EPA 3		0.897			
EPA 4		0.895			
RER 1			0.783		
RER 2			0.805		
RER 3			0.783		
RER 4			0.805		
SED 1				0.827	
SED 2				0.81	
SED 3				0.819	
SED 4				0.812	
SES 1					0.846
SES 2					0.892
SES 3					0.841
SES 4					0.855
SES 5					0.797

Table 6 Convergent validity results

Variables	External loading factors	Average variance extracted (AVE)
CSR	0.927–0.942	0.764
EPA	0.907–0.933	0.778
RER	0.81–0.872	0.63
SED	0.835–0.889	0.667
SES	0.901–0.927	0.717

poor correlation. These findings indicate that there is a genuine connection between the variables that have discriminant validity. Items with cogency and factor loadings exceeding 0.5 are both acceptable.

Numerous studies have criticized the Fornell–Larcker criterion; therefore, the heterotrait–monotrait ratio of correlations (HTMT) is also used to measure discriminant validity. It is confirmed if the discriminant validity value is less than 0.85 or 0.90 (Ali et al. 2023). The HTMT ratio was used in this study to evaluate how different variables interacted. HTMT data show that the values are less than 0.9 (see Table 9). According to the values of variables, values indicating a link with the variable are more significant than values indicating a connection with other variables.

Table 7 The discriminant validity of variable associations using Fornell–Larcker

Variables	CSR	EPA	RER	SED	SES
CSR	0.874				
EPA	0.194	0.882			
RER	0.332	0.288	0.794		
SED	0.232	0.447	0.27	0.817	
SES	0.203	0.392	0.166	0.635	0.847

Table 8 The discriminant validity of variable associations using cross loading

Items	CSR	EPA	RER	SED	SES
CSR1	**0.85**	0.203	0.333	0.234	0.185
CSR2	**0.868**	0.142	0.293	0.173	0.18
CSR3	**0.895**	0.186	0.255	0.199	0.17
CSR4	**0.888**	0.155	0.304	0.203	0.192
CSR5	**0.87**	0.156	0.253	0.195	0.155
EPA1	0.171	**0.844**	0.224	0.411	0.325
EPA2	0.129	**0.892**	0.248	0.385	0.315
EPA3	0.184	**0.897**	0.248	0.418	0.405
EPA4	0.197	**0.895**	0.297	0.361	0.332
RER1	0.27	0.216	**0.783**	0.2	0.066
RER2	0.269	0.263	**0.805**	0.191	0.06
RER3	0.212	0.231	**0.783**	0.202	0.169
RER4	0.298	0.209	**0.805**	0.258	0.216
SED1	0.168	0.345	0.243	**0.827**	0.496
SED2	0.194	0.38	0.182	**0.81**	0.481
SED3	0.186	0.415	0.262	**0.819**	0.485
SED4	0.207	0.323	0.195	**0.812**	0.607
SES1	0.172	0.297	0.139	0.525	**0.846**
SES2	0.209	0.278	0.12	0.53	**0.892**
SES3	0.181	0.328	0.182	0.514	**0.841**
SES4	0.164	0.38	0.113	0.531	**0.855**
SES5	0.134	0.368	0.148	0.581	**0.797**

Bold values indicate cross-loading values

Structural model—inner model

Structural models, often called "inner models," describe the relationship between latent variables (Ardi and Isnayanti 2020). This model focuses on the interaction between exogenous and endogenous variables. The structural model and the accuracy of model predictions are assessed using the R^2 value. *R*-squared measures the goodness-of-fit of a structural model and the effect of the exogenous latent variable on the endogenous latent variable (Ardi and Isnayanti 2020). All endogenous variables R^2 range refers to the degree to which each endogenous variable is specified. Falk and Miller (1992) said that the R^2 value must be satisfactory, meaning

both must be larger than 0.1 for the model to be considered excellent (Muhammad et al. 2022). The results of Table 10 demonstrate R^2 values and R^2 adjusted values, in which the R^2 value of RER (0.11), SED (0.435), EPA (0.251), and SES (0.052). The R^2 value of SES is just less than 0.1, although overall, the inner model has been considered satisfactory.

The path coefficients of the study models' variables are also included in Table 11. It shows that among the relationships of CSR with other variables, CSR on RER has the strongest positive effect, with a path coefficient of 0.332, while that between CSR and SES is at 0.166, and that between CSR and SED is at 0.06, is the lowest. Regarding the remaining factors, RER has the highest positive impact on EPA at 0.171, SES on EPA at 0.299, and SES on SED at 0.598. It suggests that in the framework of CSR foundations companies in India, promoting renewable energy resources is crucial for developing sustainable energy systems and reducing energy poverty. Additionally, CSR implementation is an independent factor in promoting renewable energy sources and energy efficiency. Therefore, CSR foundation companies in India should concentrate on CSR strategic activity that adds value for the company's stakeholders in society, the community, and the government, while encouraging renewable energy consumption for efficient energy development to stay proactive and competitive to alleviate the energy poverty.

In the next step, evaluate the variance inflation factors (VIF) to test for multicollinearity for each predictor latent variable. Collinearity occurs when the independent variables are substantially connected. The most cited threshold values for detecting multicollinearity are 10, 5, and 3.3, respectively, indicating that a VIF equal to or greater than the threshold value would indicate the presence of collinearity among the variables. A VIF value above 10 is generally accepted as a threshold (Abbas et al. 2019; Hair et al. 2012; Tiep et al. 2021a). All VIF values in this study is below 10, indicating that the research model revealed no multicollinearity issues. The VIF values for this model are summarized in Table 12

The bootstrapping approach used 5000 subsamples and a significance level of 5% (two-tailed) to assess the significance of the hypotheses. The bootstrapping result demonstrates that the statistical t-value greater than 1.96 and P value is less than 0.05, which support the hypotheses of the study model, respectively. The total positive effect of CSR on RER, CSR on SES, CSR on SED, CSR on EPA, RER on SED and EPA, and SES on SED and EPA are supported in this study. At the same time, RER has no significant impact on SES. On the other hand, overall results confirmed the suitability of this study model. Figure 3 and Table 13 depict the results of bootstrapping.

The findings of this study supported hypothesis (H1), which states that CSR is positively correlated with the assessment of renewable energy resources. It suggests that that overall companies in India should know their social responsibility and the benefits of CSR to stakeholders, the environment, and the national economy, as businessman should incorporate CSR into their core business operations by changing the composition of their energy resources to increase the supply of green energy and alleviate energy poverty in India. Previous researches also support this alignment; CSR firms should invest in renewable energy projects to alleviate energy poverty (Lecka et al. 2022; Mastropietro 2022; Nisipeanu et al. 2011). Additionally, the findings of this research support the acceptance of hypothesis (H2), which states a positive and statistically significant connection between CSR and SES. It suggests that when a company in the energy sector executes its CSR strategy well, it is possible to maintain the energy supply from a safety perspective. Previous work also supports this fact; CSR's functional role is to ensure a sustainable energy supply to alleviate energy poverty, promote socio-economic development, protect the environment, and boost social life (Lecka et al. 2022; Tiep et al. 2021a).

Furthermore, the third hypothesis (H3) is not supported; there is no positive correlation between the assessment of renewable energy resources (RER) and the feasibility of

Table 10 R^2 value results

Variables	*R*-square	*R*-square adjusted
EPA	0.251	0.241
RER	0.11	0.107
SED	0.435	0.429
SES	0.052	0.046

Table 9 The discriminant validity of variable associations using HTMT

Variables	CSR	EPA	RER	SED	SES
CSR					
EPA	0.21				
RER	0.38	0.339			
SED	0.262	0.515	0.327		
SES	0.222	0.43	0.189	0.728	

Table 11 Results of path coefficient

Variables	CSR	EPA	RER	SED	SES
CSR		0.036	0.332	0.06	0.166
EPA					
RER		0.171		0.151	0.111
SED		0.279			
SES		0.179		0.598	

Table 12 Results of variance inflation (VIF) factor values

Variables	VIF
CSR1	2.262
CSR2	2.811
CSR3	3.458
CSR4	3.252
CSR5	2.959
EPA1	2.117
EPA2	3.012
EPA3	2.791
EPA4	3.062
RER1	1.653
RER2	1.737
RER3	1.611
RER4	1.571
SED1	1.98
SED2	1.848
SED3	1.827
SED4	1.723
SES1	2.964
SES2	3.749
SES3	2.364
SES4	2.607
SES5	1.818

sustainable energy supply (SES). These findings are supported by prior research; renewable and non-renewable energy resources are necessary (Opeyemi 2021). The findings of this study supported hypothesis (H4), there is a significant correlation between the assessment of renewable energy resources (RER) and sustainable energy development (SED). Renewable energy resources can potentially maintain sustainable energy development for future generations in India. Furthermore, it can boost economic growth, energy security, energy access, and carbon emissions. A previous work also supports this fact; policymakers and stakeholders' priorities renewable energy. These resources are potentially inexpensive, enabling an immediate transition to sustainable energy. Consequently, a renewable strategic plan may assist all emerging countries economically, and technical innovative power markets can reduce energy costs (Amir and Khan 2022; Sun et al. 2022; Tiep et al. 2021b).

The results of this study supported the fifth hypothesis (H5), which stated that a sustainable energy supply (SES) has a satisfactory correlation with sustainable energy development (SED). Access to affordable modern energy services, a sustainable energy supply, sustainable energy usage, and energy security are the driving forces to develop a sustainable energy system to combat the energy issues of the Indian population. These findings are supported by prior research of (Gunnarsdottir et al. 2021; Tiep et al. 2021b). The findings of this study supported hypothesis (H6), which states that corporate social responsibility (CSR) is significantly associated with sustainable energy development (SED). Corporate social responsibility helps marketers to address sustainable development challenges, such as climate change. Most energy companies know about CSR to maintain sustainable development but struggle to link their CSR strategy to their core business. Renewable energy sources and economic growth ultimately facilitate sustainable energy development. This finding supports the conclusion reached by (Mapelli et al. 2016; Tiep et al. 2021a; Tsalis et al. 2020; Ye et al. 2022).

The findings of this study supported hypothesis (H7); there is a significant correlation between the assessment

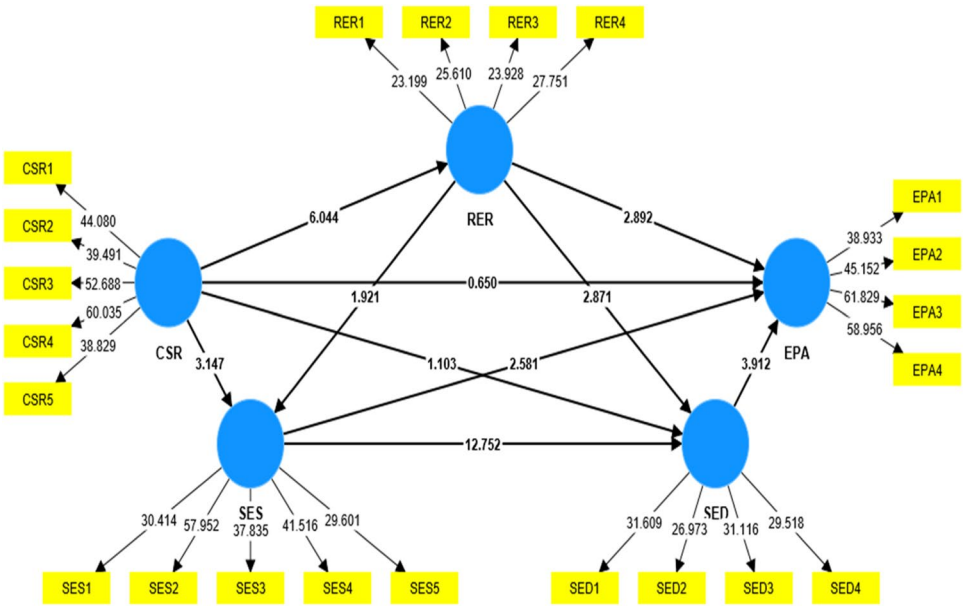


Fig. 3 Structural model

Table 13 Bootstrapping results

Hypothesis	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	*P* values	Supported
CSR—> EPA	0.194	0.195	0.059	3.264	0.001	Yes
CSR—> RER	0.332	0.337	0.055	6.044	0	Yes
CSR—> SED	0.232	0.232	0.057	4.051	0	Yes
CSR—> SES	0.203	0.204	0.051	3.981	0	Yes
RER—> EPA	0.251	0.255	0.059	4.233	0	Yes
RER—> SED	0.217	0.221	0.061	3.553	0	Yes
RER—> SES	0.111	0.114	0.058	1.921	0.055	No
SED—> EPA	0.279	0.28	0.071	3.912	0	Yes
SES—> EPA	0.346	0.346	0.051	6.826	0	Yes
SES—> SED	0.598	0.598	0.047	12.752	0	Yes

of renewable energy resources (RER) and energy poverty alleviation (EPA). The lack of access to energy has become a major problem in India. The best way to reduce energy poverty is to incorporate renewable energy into the Indian energy mix. However, efficient and clean utilization of renewable energy sources will reduce energy problems. Therefore, government policies should include the affordability and adaption of renewable energy technologies to alleviate energy poverty. Accepting and promoting renewable energy projects is crucial to alleviate energy poverty. Previous works also support this fact; technical innovations in renewable energy resources contribute best to alleviating energy poverty (Emodi and Boo 2015; Wang et al. 2022). The results of this study supported the fifth hypothesis (H8), the feasibility of sustainable energy supply (SES) leads to energy poverty alleviation (EPA). Previous works also support this fact; a sustainable energy supply is vital to alleviate energy poverty (Biernat-Jarka et al. 2021), and eco-friendly energy sources are essential for long-term energy infrastructure in India (Villanthenkodath and Mahalik 2022). Consequently, a sustainable energy supply is an effective force to mitigate future climate change (González-Eguino 2015; Papantonis et al. 2022).

The findings of this study supported hypothesis (H9), there is a significant correlation between sustainable energy development (SED and energy poverty alleviation (EPA). Sustainable development depends on an energy strategy, including the availability of renewable energy sources that enhance energy effectiveness and lower carbon emissions in India. Furthermore, maintaining sustainable energy sources is the most effective strategy to combat energy issues, and energy security is necessary for developing sustainable energy. This finding supports the conclusion reached by (Brodny and Tutak 2021; Centurelli 2011; Emodi and Boo 2015; Georgiev 2022). Additionally, the hypothesis (H10) is supported; there is a significant correlation between corporate social responsibility (CSR) and energy poverty alleviation (EPA). However, CSR contributions toward sustainable energy development are the best way to reduce the energy crisis in India. Third parties like CSR foundations companies can alleviate energy poverty by implementing energy-related projects. Previous works also support this fact; there is a positive relationship between CSR practices and efforts to alleviate energy poverty (Ahmed and Gasparatos 2020; Lecka et al. 2022; Sesan et al. 2013).

Overall, there is current literature on a study relating CSR to energy poverty. The assessment of RER, feasibility of SES, and SED performs the mediating role between relationships between CSR and EPA. According to the overall conclusions of this study, CSR and EPA have a significant relationship. This study is unique because it comprehensively analyzes the relationship between CSR, RER, SES, SED, and EPA. This research also contributes to the literature in the context of India.

Conclusions and policy recommendations

Conclusions

This study has made some truly noteworthy contributions to the energy field—first, understanding CSR and its useful function in energy poverty alleviation. The second contribution discusses the potential sustainable strategies for reducing energy poverty from a supply and demand perspective. This study illustrates the potential of renewable energy sources to meet the rising energy demand in India. The assessment of renewable energy resources (RER), sustainable energy supply (SES), and sustainable energy development (SED) performing the meditating roles between corporate social responsibility (CSR) and energy poverty alleviation (EPA) is the most significant contribution to the literature.

Assessment of renewable energy sources has a significant correlation with corporate social responsibility. In India, investors should generally integrate CSR into their core

business operations by changing the composition of their energy resources to enhance the supply of green energy, such as assessing renewable energy resources as efficient and economical. It could be the best alternative solution to overcome energy poverty in India. CSR and SES are statistically linked; when an energy company implements its CSR strategy appropriately, it can maintain a sustainable energy supply to the target populations. There is no positive correlation between the assessment of RER and feasibility of SES; renewable and non-renewable resources are needed to ensure a sustainable energy supply. However, there is a positive correlation between the assessment of RER and SED. Renewable energy can ensure future energy sustainability by boosting economic growth and mitigating carbon emissions. SES leads the SED; inexpensive energy services, a sustainable energy source, clean energy consumption, and energy security drive a sustainable energy supply. Furthermore, CSR is linked to SED, as it helps marketers address challenges related to sustainable development, such as global warming issues. The lack of affordable energy access is the most problematic issue in India, and renewable energy resources could be the ideal solution to combat the energy crisis as the country have the potential for renewable energy sources such as biogas, wind, and solar power. Sustainable energy development enhance renewable energy sources, improves energy efficiency, and reduces carbon emissions. Sustainable energy development is the effective driving force to mitigate the energy crisis. Finally, there is a significant correlation between corporate social responsibility and energy poverty alleviation. Consequently, third parties like CSR foundation companies can alleviate energy poverty by implementing energy-related projects in India. Except hypothesis (H3), all other hypotheses (H1, H2, H4, H5, H6, H7, H8, H9, and H10) are supported and accepted. Following the above arguments and acceptance of the hypothesis, the findings show that CSR acts as a catalyst to alleviate energy poverty.

Policy recommendations

After this conclusion, the researcher suggested some recommendations that CSR foundation companies should promote energy-related projects to alleviate energy poverty. CSR is a brilliant initiative. For the best practice, address CSR problems to sustainable energy development. Companies that engage in CSR initiatives could increase energy efficiency and consumption of renewable energy sources and uphold the development of sustainable energy sources to alleviate energy poverty. To maintain sustainable development goals 7, boost the CSR activities to promote energy-related projects. A single person, group, or country cannot achieve sustainable energy development. Donations at the national and international levels are necessary as part of CSR efforts to combat energy poverty. Government should encourage CSR performance to achieve sustainable development goals for businesses, their stakeholders, and the country.

Companies should practice CSR in their core business activities. A powerful society depicts a powerful country. Social responsibility and business ethics are often considered the same term, as business ethics is also known as corporate ethics. Poverty, climate change, and energy resource depletion should be controlled to boost business progress. The World Business Council for Sustainable Development predicted that both countries and companies could improve their attractiveness through CSR implementation. To behave as socialists, not just economists, as empty promises lack constancy; real commitment means real revolution. Performance in social responsibility also attracts investors and customers. Lack of clean energy leads to energy poverty. Like poverty, energy poverty is a hurdle to sustainable development. The stakeholders and government should also take innovative steps to access clean, affordable energy in India.

Research limitations

The conventional survey technique of distributing questionnaires cannot be employed in this study due to the COVID-19 pandemic and government restrictions to prevent its spread (such as protective human-to-human contact). Consequently, the information was collected via WhatsApp and LinkedIn. The survey questionnaire was constructed for statistical measurement from 399 respondents of CSR foundation companies; data collection takes time, and we just received 302 responses. The hybrid research approach should be used in future studies to learn more about the perspective of CSR-engaged businesses on sustainable energy development to energy poverty alleviation. Due to these limitations, the future study will be able to contribute to the existing body of literature on CSR and its impact on the EPA in various research situations. Further study should be conducted in the locations where CSR initiatives have been successfully implemented, measuring the ratio of energy poverty before and after implementing the CSR energy-related projects. Furthermore, it should be conducted to determine the barriers behind CSR's low performance towards the specific goal, such as alleviating energy poverty.

Appendix

Table 14 List of major interview questions about corporate social responsibility and energy poverty access

Construct	Items	Questions	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Corporate social responsibility (CSR)	CSR 1	Corporate social responsibility (CSR) in the reporting of investments in renewable energy resources via promoting the renewable energy projects					
	CSR 2	CSR performs a vital role in sustainable energy development					
	CSR 3	CSR initiatives can potentially increase the consumption efficiency of renewable energy resources (RER) to sustainable energy supply (SES)					
	CSR 4	CSR initiatives boost the sustainable energy supply to maintain the sustainable energy development					
	CSR 5	Effectiveness of CSR strategies in alleviating energy poverty					
Assessment of renewable energy resources (RER)	RER 1	Transit from non-renewable energy to renewable energy resources to meet the required result as alleviate the energy poverty					
	RER 2	Increase the solar energy resources to combat electricity issues, especially in rural areas					
	RER 3	Increase the biogas energy resources to maintain sustainable energy development to alleviate the energy poverty					
	RER 4	Increase wind energy resources to mitigate the carbon emissions					
Feasibility of sustainable energy supply (SES)	SES 1	Access the consumption of efficient energy					
	SES 2	Access to renewable energy at an affordable price					
	SES 3	Sustainable energy supply is required to meet the increasing demand of sustainable and efficient energy					
	SES 4	The feasibility of sustainable energy supply is the best source to alleviate the energy poverty					
	SES 5	Sustainable energy supply is a vital tool for achieving the sustainable development goals					
Sustainable energy development (SED)	SED 1	Sustainable energy development goals are the reduction of carbon emissions					
	SED 2	Enhanced the technical innovations					
	SED 3	More contributions of renewable energy resources in final year-based energy consumption					
	SED 4	Improve energy efficiency while reducing costs					
	SED 5	Sustainable energy development is crucial to combat energy poverty					

Table 14 (continued)

Construct	Items	Questions	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Energy poverty alleviations (EPA)	EPA 1	Reduced health issues at the household level					
	EPA 2	The opportunity of energy-efficient consumption in rural areas					
	EPA 3	Jobs opportunity					
	EPA 4	Alleviation of energy poverty is necessary to promote the E-learning technology					

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Data availability The data supporting to findings of this study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate This research study was conducted according to the Declaration of Helsinki guidelines. The Institutional Review Board of North China Electric Power University has approved (protocol code 00437–8 on 27 March 2022) the study.

Consent for publication Informed consent was obtained from all respondents belonging to this research study.

Competing interests The authors declare no competing interests.

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