Threefold Sustainable Neighborhood Energy Systems: Depicting Social Criteria in Decision Support Systems

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Abstract

Despite the consensus that considering social factors is as important as economic and environmental dimensions for long-term successful, sustainable energy development projects, there is a lack of quantifiable assessments in multi-energy simulation decision support systems. Therefore, we applied a design science research approach to develop an energy system simulator that includes all three dimensions of sustainability. Based on a rigorous literature review and expert interviews, we establish a framework for assessing social sustainability. We then implement the derived criteria and indicators in the open-access software NESSI and validate it in an applicability check for a Madagasi neighborhood. With our framework, we aim to provide guidance to researchers and stakeholders on incorporating the social sustainability dimension into their approaches, tools, and decision-making process. The user-friendly, web-based simulation software enables various stakeholders to explore the interrelationships of threefold sustainability in specific energy systems.

Keywords

Social sustainability, multi-energy system simulation, decision support system, design science research, sustainable development goals.

Introduction

Access to electricity proved pivotal to a modern society capable of surviving in today's globalized world, participating in economic growth, and fostering human development (Praene et al. 2021, Ayaburi et al. 2020). As more than 3.5 billion people still lack access or reliable supply, the target towards affordable, modern, reliable, and sustainable energy for all is deeply anchored in the United Nations' Sustainable Development Goals (Ayaburi et al. 2020, United Nations 2015). Decentralized, hybrid renewable energy systems enable vulnerable stakeholders to increase the share of green electricity, foster resilient supply, and/or electrify remote areas. However, planning sustainable energy development projects is a complicated process that requires to enhance and balance inter-correlated, often conflicting economic, ecological, technological, and social conditions (Atilgan and Azapagic 2016). For this purpose, multi-criteria energy system simulators such as HOMER Pro (HOMER Energy LLC 2023), iHoga (Dufo López 2022) or NESSI (Eckhoff et al. 2023), are often used as decision support by stakeholders such as citizens, building owners, NGOs, energy consultants, and policy-makers. Consistent with the prevailing focus on economic and environmental factors in the public and scientific discourse, these models often do not include social criteria (Li et al. 2018). However, social sustainability is one of the key aspects of successful energy development projects (Evans et al. 2009). Ignoring social and cultural issues of target communities has proven to result in low local acceptance leading to project failures in the long term (Urmee and Md 2016). Specifically in developing countries, studies on threefold sustainability assessment in energy planning and management is lacking (Luthra et al. 2015). Although this issue has been gaining recognition in the recent decade, the social dimension still lacks a coherent and clear definition and inhibits philosophical and conceptual