

SOFTWARE

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Accessible decision support for sustainable energy systems in developing countries

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Abstract

With rising electricity demand through digitization and innovation, the urgency of climate change mitigation, and the recent geopolitical crisis, stakeholders in developing countries face the complex task to build reliable, affordable, and low-emission energy systems. Information inaccessibility, data unavailability, and scarce local expertise are major challenges for planning and transitioning to decentralized solutions. Motivated by the calls for more solution-oriented research regarding sustainability, we design, develop, and evaluate the web-based decision support system *NESSI4D^{web+}* that is tailored to the needs and capabilities of various stakeholders in developing countries. *NESSI4D^{web+}* is open access and considers location-specific circumstances to facilitate multi-energy planning. Its applicability is demonstrated with a case study of a representative rural village in southern Madagascar and evaluated through seven interviews with experts and stakeholders. We show that *NESSI4D^{web+}* can support the achievement of the United Nations Sustainable Development Goals and enable the very prerequisite of digitization: reliable electrification.

Keywords: Web-based decision support system, Decentralized energy system simulation, Renewable energy, Sustainable development goals, Design science research

Introduction

An electrical infrastructure is the prerequisite to use and benefit from digital technologies, and thus digitization itself (IEA 2017). It is estimated that up to 3.5 billion people still lack a reliable electricity supply and more than 700 million citizens have no access to electricity at all (Ayaburi et al. 2020). Without a reliable supply, they are unable to compete in today's fast-paced, globalized world, thereby being deprived of economic growth and human development (Ayaburi et al. 2020). The United Nations Sustainable Development Goals (SDGs), therefore, explicitly target global access to affordable, modern, reliable, and sustainable energy, see SDG 7 (United Nations 2015). Decentralized, hybrid fossil and renewable solutions for individual buildings up to entire neighborhoods play a key role in these efforts. These are not only capable of electrifying the most remote areas, but also strengthen reliability, increase resilience to future shocks, and support the energy transition towards a more sustainable future (IEA 2021). Due to fast population growth, increasing electricity demand, the urgency of climate change mitigation, and the