INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title:
A Study of Design Intervention for Discrete Off-Grid Photovoltaic Home System in Rural Lifestyle Context

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For a developing country like India, which currently has more than 239 million people without access to energy, propagation of decentralized energy utility especially solar photovoltaics is of utmost importance, as the country has enormous potential for it. The existing literature emphasized the need for energy research towards energy systems in a broader socio-cultural context. Due to 'top-down' approach for the dissemination of decentralized energy, design and technology aspects never recognized the needs of rural society leading to the failure of most of existing decentralized energy applications and programs in regional context of northeast India. Thus, there exists an opportunity to bridge the gap between rural photovoltaic utility and shaping its social relevance with product design intervention. This doctoral study aimed to build the impetus of research to look into the design and development of a discrete off-grid photovoltaic system considering local imperative needs in the context of the rural background of northeast India.

Study deliberates the scope to facilitate the productive usage of photovoltaic energy through design intervention. To achieve the research objectives we set to explore, design, and develop different aspects of the discrete off-grid solar photovoltaic home system considering inter-household energy exchange, and household enterprise productivity in a localized context to assess the impact of proposed design intervention in the context of a rural lifestyle with specific reference to the northeast region of India.

The methodological approach followed in this research takes inspiration from research through design and ethnography. As part of the methodological approach, an intervention is designed, implemented, and investigated with a mixed-method study, conducted at seven off-grid villages of district Sonitpur and Majuli in rural Assam for approximately one year (1 August 2017 – 31 September 2018). Design criteria and specifications for design intervention were concluded from the field study. Besides, the system architecture and design concepts were shortlisted using fuzzy multi-criteria decision-making method. In the context of the above, Matlab@Simulink based simulations were done for context-specific hardware development. Hardware assembly and testing were done for the fabrication of the high-fidelity prototype. The design intervention reported assisting energy exchange and rural enterprise productivity in the studied region.

Theory of change framework was applied to formalize design evaluation by providing evidence concerning the anticipated impact of design. In this quasi-experiment study, conventional and proposed design groups were selected as two user groups, and pre-intervention, the post-intervention variance was examined between the groups. The independent sample study was made for the comparison between the conventional and proposed system. It captured the actual field condition that arrived while validating the design intervention. Study witnessed that discrete SPVHS design improved household enterprise work productivity. Besides, the intervention also resulted in mutual energy exchange benefits when compared with a conventional system. The qualitative data reveals three types of mutual energy exchanges: 'mutual energy sharing' (MuES), 'mutual energy trading' (MuET), and 'mutual energy lending (MuEl). The study defines a 'mutual energy sharing' as a social and personal energy exchange where an energy-giver and energy-receiver participate for the sake of social relationship between them. In contrast, 'mutual energy trading' is a social and personal energy exchange where an energy-giver or donor and energy-receiver participate in a calculated exchange for monetary gains. Furthermore, study witnessed that MuES and MuEl encouraged social cohesion between households as the proposed intervention found coherent with rural lifestyle needs.

Overall, the research highlights that to address the array of challenges related to solar photovoltaic energy in the northeast region, it requires a systemic approach for design development. The study indicated that for design development; alone cannot provide an acceptable energy solution if not embraced to societal relevance. In particular, it is crucial to develop design solutions that take into account the localized context. Present research recommends to energy researchers and practitioners that design development of small-scale off-grid system needs to enable diversity in peer-to-peer energy exchange, and is found critical for the dissemination and sustainability of photovoltaic interventions in the regional context.