WHITE PAPER

EXPLORING THE TOOLS AND METHODS FOR COMMUNITY-ENGAGED SOLAR DESIGN AND DEVELOPMENT

Arup Bhattacharya*, Department of Construction Management, LSU
Soo J. Jo, School of Architecture, LSU
Zhihong Pang, Department of Construction Management, LSU
Chris Kees, Department of Civil and Environmental Engineering, LSU
Yimin Zhu, Department of Construction Management, LSU

Contents

state of the knowledge in solar deployment from peer-reviewed literature and reports, focusing on the fluid-structure interaction (interaction between solar panel mounts and wind), community engagement for renewable energy projects, and renewable energy integration aspects of the project.

Methods:

A systematic literature review process was applied to collect, categorize, analyze, and summarize the current state of the knowledge. Various journals were screened using a set of pre-determined criteria that targeted the primary keywords, year of publication, citation index, and contributions to the broad subject topic. Databases like Google Scholar, Scopus, IEEE Library, and Web of Science (WES) were utilized to find the relevant targeted peer-reviewed articles. In addition, relevant reports from research firms were also screened and added to the body of literature. To avoid the plethora of published data on the broad topics of ‘renewable energy’ and ‘solar energy,’ topic-specific keywords were selected for topics discussed in this manuscript. Some previous review paper’s references were also checked to find similar topic-related highly cited publications. A total of 125 publications were considered and analyzed by the team, and 73 publications were chosen to gather information on our research focus to provide the summary, which is delineated below.

Solar development in Louisiana

Louisiana is one of the most vulnerable areas in the nation to flood and storm damage because of its unique geographical features. While the petroleum industry in the state is one of the most crucial industrial sectors in the nation, it is widely understood that the transition to clean energy is critical for the future of the state and the nation. Louisiana is ranked 38th in the US for solar deployment, with only 276 megawatts installed [9]. Historically, Louisiana has been less involved in clean energy research projects [10] due to its reliance on the petroleum and derivative chemical industry. Louisiana is uniquely poised to have industry-academia collaboration for applied research to settle strategic plans for the deployment of solar farms and to further expand renewable energy harvesting p[(ao9-4.6 (i)-4.6 (67 0 Td[(. H)4.6 l3l (l)-2.6 6a.1 (p)12v.8

emerge. These larger projects are driven by the economics of solar energy and, in some cases, by renewable portfolio standards and corporate renewable energy goals. With the decreasing cost of solar panels and the increasing demand for clean energy, traditional energy companies started investing in solar farm projects, recognizing the potential of renewable energy. The future of solar farms in Louisiana looks promising, particularly as the state and the nation continue to move towards more sustainable energy sources. The solar energy landscape in Louisiana is dynamic and influenced by a combination of technological advancements, policy changes, and economic factors. Solar farms will likely play an increasingly important role in Louisiana's energy mix as solar technology continues to improve and become more cost-effective. The floating solar module emerged as a way to utilize water bodies for solar energy generation without using valuable land space. Such a facility has several advantages, including reduced water evaporation and a cooling effect on the panels, which can increase efficiency. Since their inception, these systems have seen considerable development, especially in countries with limited land areas or competing land use needs. However, solar energy from floating farms remains an untapped resource in Louisiana.

free, and effective for unstructured meshes and varying refinement levels. Meanwhile, Dimakopoulos et al. (2019) developed a numerical wavemaker capable of generating random wave fields (free surface elevation and velocities) by reconstructing them in time and space from a reference time series using window processing [16].

$O(10^1)$~$O(10^2)$ wave components, as opposed to the $O(10^3)$~$O(10^4)$ components required for direct reconstruction from a single spectrum.

In addition to the Navier-Stokes model, some reduced-order models have also been considered. Conventional models include the dispersive shallow water model and potential flow model. They usually

interface, such as the kinematic and dynamic conditions. To ensure equilibrium conditions, Sen (1993) developed an iterative scheme to mitigate numerical instability at the intersection of fluid and solid surfaces [35]. Van Daalen (1993) integrated the motion equations of the rigid body into the Bernoulli equation applied to the embedded interface [36], resulting in an additional integral equation that simultaneously satisfies continuity. Guerber et al. (2012) and Dombre et al. (2015) evaluated the performance of both iterative and simultaneous schemes for addressing the FSI of a fully submerged body.[37], [38]. Rakhsha et al. (2021) employed the Immersed Boundary Method (IBM) in conjunction with Nitsche's technique to evaluate the deflection of an elastic gate subjected to a hydrostatic force (typical dam break problem) [39]. Tsao et al. (2023) solved the structural vibrational control of a floating platform with a mooring system [40]. In general, the iterative scheme can be helpful when the time interval is small enough, while the simultaneous scheme may cost extra computational resources. The other important issue is the mesh regrinding technique, which avoids cell distortion during large deformations or occurs on complex embedded surfaces. To tackle this challenge, the Cut Finite Element Method (CutFEM) was proposed to solve the multiphase Navier-Stokes flow model involving structures with complex geometry. This method alpTaTw 11.163 0 Td15..098

Soares (2010) decomposed the fluid domain to analyze the eigenvalue problem involving a floating box [46]. Nokob and Yeung (2020) applied the fast multipole method to BEM to speed up the numerical process but adhered to linear wave theory [47]. Nevertheless, their numerical solution for the angular motion of a floating body is still questionable due to the inviscid potential flows, which neglect eddy-making damping around the submerged body. Hyo et al. (2006) conducted a wave flume experiment demonstrating that the potential-flow assumption negatively impacts numerical accuracy in predicting the roll motion of a floating body [48]. Instead of viscous models, Lin and Kuang (2008) included a roll-damping term in the motion equation of a ship [49]. Gaeta et al. (2020) calibrated coefficients in their potential model by comparing numerical and experimental results [50]. Tsao et al. (2022) applied the potential-based method to solve the vibration mitigation of a floating structure and an LNG vessel by an improved tuned liquid damper [51]. Both sloshing waves and ambient wave responses were successfully simulated. The results were validated by viscous models [52].

Thus, with the advancement of computing procedures and innovative methods of CFD simulation, it is essential to understand the design problem to be able to obtain reliable results that are accurate, precise, and not computation-intensive. With specific methods being available to provide insights on the system's physical properties under fluid flow at their normal level and during extreme events, the design framework would provide a guideline to use proper tools at the design stage for a reliable and sustainable infrastructure.

Stakeholder Engagement

A significant body of research explores the fundamental mechanisms behind emerging technologies and their applications, such as integrating renewable energy integration. In contrast, some research focuses on practical aspects and approaches to maximizing these energy sources' efficiency, affordability, and scalability. Moving on from engineering and/or technological research, the following sections focus on the literature, identifying key stakeholders, the mechanisms of data collection, and predicting challenges faced during the implementation of renewable energy projects. "Stakeholders" refer to any group or individual who can affect or is affected by the achievement of the project [53], and getting stakeholders involved is the key to the success of the project. When stakeholders are actively involved, projects can be better shaped by the contributors and meet the users' needs, making their participation in project planning critical [54]. This review delves into this crucial research landscape that engages stakeholders, examining the current state of knowledge and identifying key trends shaping the future of renewable energy.

Social acceptance in advancing renewable energy projects

In the past, communities were often excluded in the planning process of large-scale renewable energy projects and did not share the benefits of the project, which caused pushbacks and conflicts. In response, a new participatory design approach is gaining ground, in which communities play a role in the project design process. This approach is employed in smaller projects led by local people with the benefits of staying local [53]. While the implementation process of renewable energy technologies underestimated the importance of social acceptance in the 1980s, social acceptance is considered a significant factor recently, in disseminating renewable energy systems [54]. Social acceptance can be categorized as socio-political, community, and market acceptance. Socio-political acceptance ensures policy and legislative support, community acceptance secures local backing and minimizes resistance, while market acceptance validates the project's economic viability and consumer demand. These three aspects are multifaceted, influencing project design and implementation, and thus, all crucial for the success and sustainability of renewable energy initiatives [54], [55]

Identifying stakeholders and data collection methods

Developing a framework for gathering data from the stakeholders on renewable energy projects in an urban area involves a meticulous approach. The process starts with investigating the existing methods for conducting renewable energy systems projects and analyzing how these practices align with the community's needs. Factors such as rooftop conditions, energy use, and socioeconomic and environmental considerations need a thorough examination. A design framework for an urban area should encompass a detailed plan for collecting and managing data incorporating innovative technologies, as ensuring the accessibility and transparency of collected data to facilitate stakeholder engagement is also fundamental.

Such as the study by Musall and Kuik (2011) utilizing interviews to explore the impact of community co-ownership models on local acceptance of renewable energy [56] and the study by Belmonte et al. (2015) that employed an online survey with a sample size of 3,963 responses [57], the process of collecting data generally has two distinct phases: structured interviews or surveys to gain information on stakeholders' perceptions and the

for Electric Renewables (HOMER) was utilized to analyze and optimize the renewable energy required by the university [68]. In their study, they considered the system architecture, daily radiation, clearness index, location, temperature, daily solar PV, and average electric load demand. They also developed a suggestive methodology with two different combinations of solar PV and wind turbine, which contributed 62% and 20%, respectively. The analysis concluded that wind turbines and solar PV systems connected to the local grid may provide up to 82% of the needed electricity at a lower cost of energy (CoE) of $0.0446/kWh as opposed to $0.060/kWh.

The analysis by Mekonnen et al. (2021) provides important information for Ethiopian policymakers implementing alternate energy supply options [69]. To supply the residential load in Mekelle City, Ethiopia, they studied grid-connected and islanded photovoltaic (PV) power systems using PVGIS, PVWatts for the technical viability of the suggested supply option, and HOMER Pro for the analysis of the economic and environmental optimization aspects. They also presented output comparisons and sensitivity analyses between the three renewable energy simulation tools. The findings show that the grid/photovoltaic system's COE is approximately 12% lower than that of the utility grid, with a simple payback period of 7.81 years. Along with describing the effects of the inflation rate, nominal discount rate, and PV capital cost as economic parameters, it also discussed the technical parameters of inverter efficiency and variations in solar radiation while generating 80,485 kWh of energy annually from solar PV, or 57.1% of the location's total load. The payback period of the study seems more realistic than the previous study mentioned above.

Barrera et al. (2021) propose a methodology for integrating residential photovoltaic solar systems in Bogotá, Colombia. Their estimates suggest annual savings between USD 29.72 and USD 293.27 in two distinct regions. As stated in their environmental analysis, this will decarbonize 20.41 and 20.39 tons of CO_2, respectively, over the next 25 years [70]. Considering the study location, incentives offered, and bulk purchase of PV cells augmenting faster payback and better ROI, the simulation runs on the PVsyst software indicate that the characteristics of the solar system are feasible and lucrative. Kumar et al. (2020) presented a PV integration study that estimated how an academic department building would fulfill its required load by installing a rooftop PV unit of an off-grid PV framework and accumulating homogeneous strings of PV modules [71]. This resulted in the generation of 1143.6 kWh of energy, compared to the department's total requirement of 1086.24 kWh, with an average performance ratio of 72.8% in a year as determined by computational modeling and PVsyst simulation analysis. In both cases, the researcher suggested the PV module was the most economical and lucrative option of the CoE, lacking a good picture of the usability, maintenance, overall user point of view, and ease of operation.

Eight hybrid renewable energy source configurations that combine solar, wind, diesel, and battery power are shown in a 2020 study by Zhang et al. to meet the electrical needs of a medium-sized workshop in an industrial district of Ardabil, Iran [72]. They analyzed various distribution system configurations using HOMER with two optimization algorithms, the original grid search algorithm and a proprietary derivative-free algorithm, to determine the system's viability and its optimal Net Profit Cost (NPC) given the system's 20-year lifespan, specified investment cost, and operating expenses. A higher percentage of wind energy is used in the simulation study, as the wind turbine produces more energy than a photovoltaic panel due to the local climate. The Levelized Cost of Energy (COE) for the study was USD 0.471 per kWh, signifying a 7.17-year payback period. This study records more convincing data than a few of the others, though the model described is localized, and the effectiveness of the system for generalized use might be questioned. Bagherian and Mehranzamir (2020) tested the integration of single or multiple renewable energies in

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