ST.GALLEN SYMPOSIUM

Global Essay Competition 2024

Title: Addressing Land Scarcity in Renewable Energy: A Multifaceted Approach to Local Interests, Social Equity, and Data Gaps

Essay:

Introduction

At COP 28, over 100 countries committed to tripling their renewable energy capacity by 2030, a lofty and ambitious goal. However, this commitment was met with skepticism due to various obstacles hindering the radical expansion of renewable energy (Mcfarlane & Twidale, 2023). These challenges, including financial, infrastructural, and integration issues, are especially prevalent in developing countries. A critical barrier to the growth of renewable energy is the substantial land use requirement and scarcity of suitable land, further intensified by the "energy sprawling" phenomenon. This term refers to the widespread expansion of energy infrastructure, driven by the escalating demands of burgeoning populations and improving living standards (Trainor et al., 2016).

Effective land use planning, a regulatory process by central authorities to achieve economic growth, environmental conservation, urban sprawl restraint, and risk minimization, is pivotal in addressing land scarcity (Akimoto, 2009). This process requires balancing diverse socio-political-economic factors, often a complex task due to the challenges in comparing different types of benefits. For example, the increase in solar energy's share in future electricity mixes could lead to replacing or preventing land conversion currently used for commercial purposes. This shift might necessitate using previously untouched arable land, potentially resulting in the loss of natural land cover.

This essay explores the complexities of land use planning within renewable energy development, beginning with an overview of optimization modeling factors. It then examines three different land use planning systems and highlights the challenges of the planning process as documented in the literature. The essay concludes with strategic recommendations for optimizing land use in the expansion of renewable energy, which include establishing Renewable Energy Zones, fostering synergy in land use, and enhancing community inclusion and participation.

Modeling land use planning

In the modern era, computer modeling can represent almost any issue, including land use dilemmas. In these models, subjects are presented as variables, interrelations as constraints, and objectives are defined through an objective function, typically aiming to minimize system costs or maximize utility. Applying this approach to land use involves assigning values to variables representing different land areas, which are then characterized and aggregated geospatially. These areas must adhere to various constraints, such as maintaining a minimum threshold of agricultural land for food security. To count towards the objective function, the model assesses the implications of each land use plot, accounting for environmental impact, economic viability, and social acceptability.

However, precision in modeling necessitates considering numerous options within each land use category, such as different crops or renewable energy technologies. This variety leads to a large number of combinations, rendering the model computationally intensive. Simplifications, like grouping options or averaging values, can aid computability but may reduce precision. Additionally, the difficulty in comparing factors like long-term environmental impact, immediate economic benefits, and social acceptance further complicates the process. Complexity also comes from dynamic variables and uncertainties, including technological advancements, policy changes, environmental shifts, and the varied interests of stakeholders, all potentially altering the model's assumptions (Wei et al., 2016). Therefore, while theoretically possible, land use planning is rarely done as a single, definitive attempt.

Comparative land use planning practice

In practice, land use planning is a segmented, iterative process with responsibilities shared across different government levels. In OECD countries, responsibilities are roughly evenly distributed among national (37%), regional (32%), and local governments (31%), with national and regional levels typically focusing on spatial planning and local governments on specific land uses (OECD, 2017).

United States: zoning system

In the U.S., land is frequently zoned into residential, industrial, commercial, agricultural, mixed-use, and special-purpose categories. This system aids community planning and reduces development management costs (Hirt, 2012). However, integrating large-scale renewable energy projects into these predetermined zones can be challenging. For example, wind farms or large solar installations might be confined to industrial zones, potentially not optimal for renewable energy generation due to wind patterns or sun exposure. While zoning provides clarity for developers in identifying suitable zones, bureaucratic challenges can arise in obtaining necessary permits or variances for zones not initially designated for renewable projects.

Netherlands: plan-led system

The Netherlands adopts a coordinated, plan-led approach, integrating urban planning elements like public transportation, green spaces, and water management, focusing on sustainability and resilience against climate change (Buitelaar et al., 2011). Such a system can facilitate the development of multifunctional areas that combine renewable energy with other land uses, like agricultural solar farms or wind turbines in coastal defenses. However, the comprehensive nature of this planning can extend the development time for renewable projects due to extensive coordination and consultation.

Germany: mixed-use development

Germany advocates for mixed-use development, combining residential, commercial, and light industrial uses (Hirt, 2012). This approach promotes efficient land use and quality urban life, facilitating the integration of smaller-scale renewable energy projects, such as solar panels on residential and commercial buildings. It offers flexibility and innovation in land use, which benefits urban renewable energy projects such as rooftop solar installations or small wind turbines. However, locating larger-scale renewable projects within mixed-use zones can still pose challenges, necessitating careful planning and community engagement.

Challenges in renewable energy land use

Siting and social equity concerns

The siting of renewable energy sources is frequently dictated by the availability of natural resources like wind and sunlight rather than proximity to existing infrastructure or populated areas, leading to unique challenges. Renewable energy typically requires more land per unit of power generated than fossil fuel-based plants, which can lead to arguments against its land use efficiency in certain contexts. Additionally, the integration of power plants and transmission lines into areas not accustomed to industrial development often meets with local opposition (Gross, 2020)

Marginalized communities, including those in poverty and indigenous groups, frequently do not benefit from state-run renewable energy projects, resulting in limited access to cleaner energy (Bedi, 2021). Energy justice issues are prevalent in large-scale renewable projects, impacting vulnerable communities in proximity (Sankaran et al., 2022). In the United States, the development of wind projects may result in distributional injustices affecting specific demographic groups, characterized by younger populations, rural residency, lower education levels, and lower participation in the labor market (Mueller & Brooks, 2020). Similarly, in rural Indonesia, community-based renewable projects have been noted to reinforce exclusions and inequalities (Fathoni et al., 2021).

Local interests and community opposition

Local power dynamics and geographical considerations contribute to land use conflicts in renewable energy development (De Boer et al., 2015). For example, the growth of renewable energy, such as floating photovoltaic power plants, often ignites conflicts over environmental concerns and competition with existing land uses like agriculture and fishery (Lee, 2022). In India, renewable initiatives may impact up to 12,000 km2 of forest land and 56,000 km2 of agricultural land, posing challenges due to high population density and complex land ownership rights (Kiesecker et al., 2019). The expansion of hydropower in India also exemplifies the complex nature of energy transitions, marked by land dispossession and social injustices (Roy & Schaffartzik, 2021). In Korea, conflicts between ecosystem preservation and sustainable energy development highlight the importance of effective land use management (Kim et al., 2022).

National support for renewable energy often contrasts with local resistance, especially in rural areas, leading to a 'Not in My Backyard' phenomenon (Natarajan, 2019). Public acceptance can be influenced by perceived environmental impacts and the absence of direct financial benefits for local communities (Bigerna & Polinori, 2015). Strong opposition is often seen in transmission projects that transport power over long distances without directly benefiting the local area. This leads to widespread resistance to infrastructure, solar farms, and wind farms (Clifford, 2022; Dantas et al., 2019; Groom, 2022).

Data limitations

Local governments face significant challenges in identifying suitable lands for renewable energy development due to resource limitations and land constraints (Delphin et al., 2022; Guo et al., 2020). Assessing the environmental impacts of utility-scale solar energy, encompassing biodiversity, land-use changes, soil integrity, water management, and human health, heavily depends on comprehensive data availability (Hernandez et al., 2014). Accurate environmental assessments are crucial for mitigating these impacts and ensuring sustainable, efficient renewable energy developments. A significant challenge in renewable energy planning is the lack of reliable assessments of potential sources, compounded by the scarcity of comprehensive terrestrial data series necessary for reliable trend analysis and planning (Pham et al., 2022). This data gap can lead to suboptimal decisions in the siting and scaling of renewable energy projects, potentially exacerbating environmental impacts and provoking community resistance.

Recommendations

Establishment of Renewable Energy Zones (REZs)

Countries are encouraged to undertake a national assessment to establish their Renewable Energy Zones (REZs). This vital procedure involves collaboration among key agencies, including the Department of Energy, the Department of Agriculture, and the Federal Energy Regulatory Commission (or their international equivalents). The objective of REZs is to identify optimal areas for developing renewable resources and transmission systems, emphasizing minimizing environmental and social harm. This approach is critical in developing countries, where challenges like data scarcity and infrastructural limitations are prevalent. Broad-scale assessments also help address the planning impacts on marginalized groups, including ethnic minorities and rural communities.

Effectively establishing REZs hinges on the skilled management and utilization of data. This includes actively engaging stakeholders, employing less data-intensive models, prioritizing data collection, and sustaining ongoing communication with decision-makers. Innovative approaches from land-use planning projects in Paraguay and other Global South regions provide valuable insights for addressing data-related challenges in similar contexts (Delphin et al., 2022). Transparent and open communication among stakeholders at various governmental levels is essential to integrating inputs from all relevant parties while ensuring the successful establishment and management of REZs. Effectively addressing data gaps is crucial for laying the foundation for sustainable energy development that mitigates land use conflicts and enhances social equity.

Synergy in land use

It is recommended that planners and policymakers actively pursue integrative strategies to co-locate renewable energy infrastructure with existing land uses, thereby maximizing efficiency and minimizing environmental impact. For example, situating wind turbines in agricultural landscapes can prevent habitat fragmentation, and placing solar arrays on rooftops and in urban areas effectively localizes energy production. This approach, which includes technologies like photovoltaic panels on buildings and micro wind turbines, forms a multi-layered energy system that merges technology, organization, and physical development. Developing renewable energy sources near areas already modified for agricultural or industrial purposes and leveraging existing fossil fuel infrastructure for grid connection can further mitigate sprawl and conflicts. Moreover, prioritizing energy development on lands already impacted by human activities rather than in untouched habitats or high-yield agricultural areas helps reduce cumulative environmental impacts and land use conflicts (Kiesecker et al., 2019). Similar to Germany's mixed-use development, flexible planning strategies are instrumental in achieving synergistic benefits for biodiversity, ecosystem services, and social values.

Community inclusion and participation

Effective community participation in renewable energy initiatives is essential for gaining public acceptance and ensuring successful implementation. Proactive engagement is necessary to address potential sources of disagreement at the local level, such as differing perceptions of environmental, landscape, and cultural impacts (Van Veelen & Haggett, 2017). Employing GIS-based technologies can enable community members to understand visually and thus interactively engage with project impacts from the outset. This improves public participation, moving beyond conventional methods that limit community involvement to later planning stages (Santé et al., 2019). Furthermore, community ownership in renewable energy projects plays a vital role in advancing economic and social welfare. It helps build a sense of community identity, promote local benefits, and encourage self-sufficiency (Zapata, 2022). For example, involving local communities in part-ownership schemes offers them a tangible stake in the project, thereby aligning its success with their prosperity. This approach can take various forms, including local cooperatives, shared revenue schemes, or community investment opportunities. Adopting a community-centric approach in planning goes beyond merely achieving public acceptance; it actively promotes social equity and aligns with broader sustainability and social justice goals.

Conclusion

The stark reality is that there is a risk of reverting to massive fossil fuel expansion without sufficient, equitable, and optimal land allocation for renewable energy development. This essay underscores the urgent need for effective land use planning that carefully considers local interests, ensures social equity, and bridges data gaps. Implementing Renewable Energy Zones, fostering strategic land use synergy, and ensuring community inclusion are crucial approaches to mitigating the risk of land use conflicts. As we forge a path towards a sustainable energy future, it is essential to pursue these strategies with commitment and foresight to ensure a transition that is both environmentally viable and socially equitable.

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