Renewable Energy Landscapes:

DESIGNING PLACE-BASED INFRASTRUCTURE FOR SCALE

Pacific Northwest
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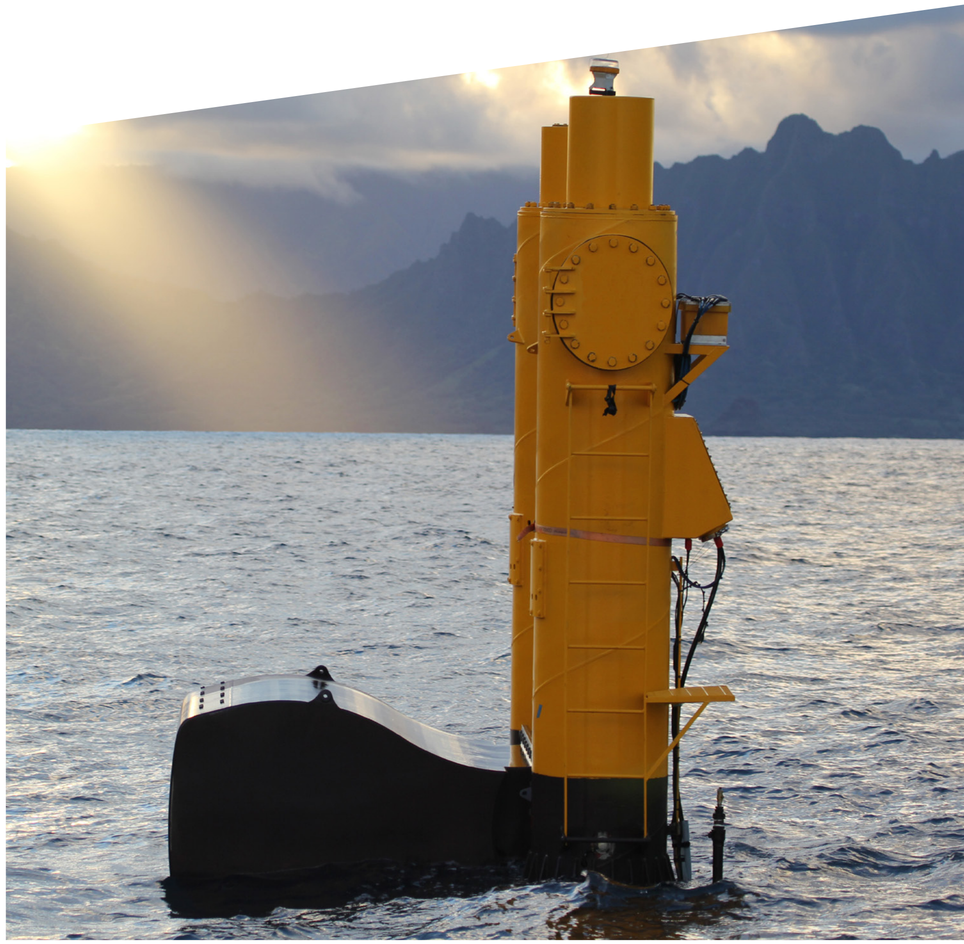
July 2022



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Summary

Clean energy goals and policies have dramatically shifted commerce, resource portfolios, and technology innovation in the last 20 years. As we plan ahead, we see an energy transition that creates disruptive levels of uncertainty and even greater change to our economic and energy systems. Part of planning for the future means grappling with the full significance of the transition: its tradeoffs and its effects on people and on culture.

Even looking back, questions remain as to how this shift has contributed and been visible to communities and culture. Renewable energy developments have often focused on optimizing economies of scale and maximizing incentives, and the impact of technologies on the landscape and the different meanings they carry for people are typically considered as local or regulatory matters. We see practical roadblocks are ahead given the massive acceleration proposed in renewable energy policy, enormous investment in infrastructure, and more communities envisioning their future in relationship to clean energy infrastructure.

To that end, this paper offers a pathway for developing community-centered renewable energy *at scale*, outlining how renewable energy landscapes can be envisioned alongside the high environmental and social equity standard that is at the heart of the future clean energy system.

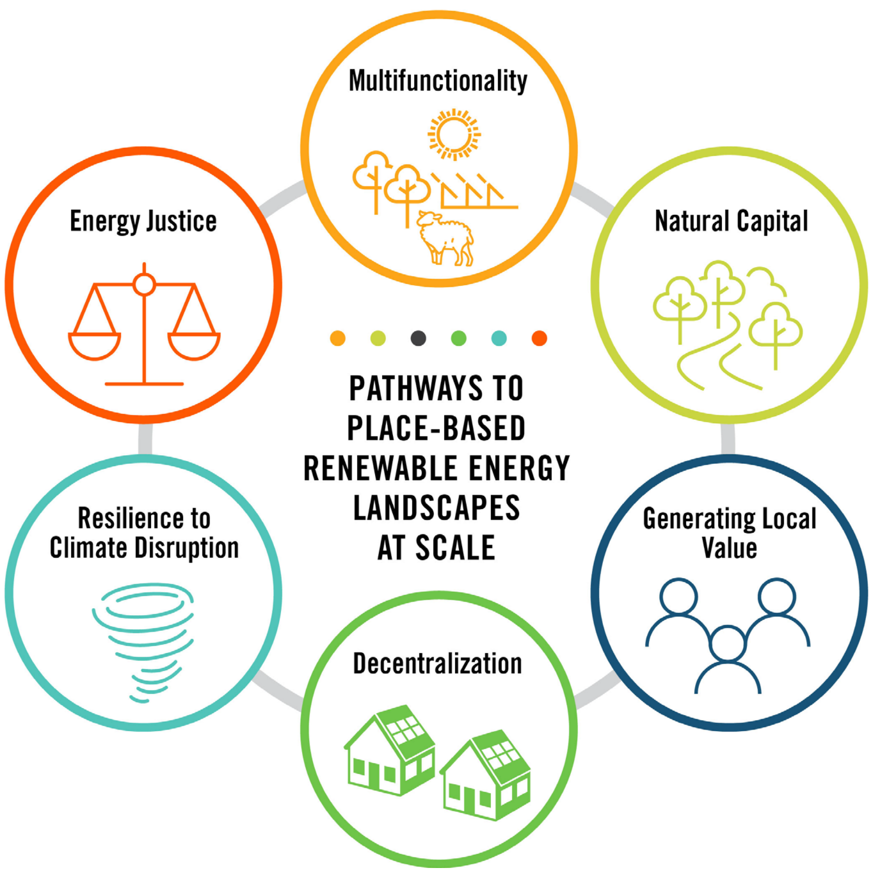

Figure ES 1 Pathways for renewable energy landscapes at scale.

We call this “place-based at scale” and “renewable energy landscapes” because the ultimate aim is to adapt technology and infrastructure coherently and collectively toward community objectives, and to organize it to allow replicability and scaled approaches across the country.

Realizing this type of development in practice will require reconciling the challenges and tensions that currently exist between top-down and bottom-up approaches. It will also require reckoning with greenhouse gas emission goals, large investments in infrastructure, and community self-determination as the driving priority in those investments. We believe a window of opportunity is presenting itself to shape and envision the future of renewable energy installations and move into action to create them.

We envision six pathways (Figure ES 1) that draw upon new cooperation between disciplines for designing renewable energy landscapes at scale. Each of these pathways prioritizes the community in which they are built and works to create local value.

- **Multifunctionality** embraces collocating renewable energy technologies with other technological purposes as well as land uses in urban, suburban, rural, and coastal communities. The resulting configuration of collocation will depend on the type of site, renewable energy, and components that comprise the system. While multifunctionality may result in trade-offs in efficiency for energy generation, the more efficient use of land can promote place-based deployment at scale.

- Like other types of infrastructure, renewable energy development can have an impact on ecosystems. Well-planned and thoughtfully designed installations can capitalize on the positive value infrastructure can generate for ecosystems while also mitigating harm. Assessing **natural capital** when siting projects will allow communities to meet objectives that serve both people and nature.

- To **generate local value** through renewable energy landscapes requires attention to the uniqueness of place. To understand what communities value requires redesigning community engagement strategies and economic structures, as well as reaching a broader typology of data-supported benefits and mitigation efforts. Continuous and durable actions will generate this value. A thorough design process can bring attention to place and align energy development with that value.

- With distributed energy resources and **decentralized** energy systems poised to play a key role in decarbonization, there is a need to develop design approaches that integrate technologies into communities and their built environments. Reflecting the physical and social environments of a landscape in energy development can open more physical opportunities for technology adoption through innovation and a reimagining of space.

- Prioritizing the benefits of increased climate and energy **resilience** through design can motivate communities to become early adopters of renewable energy in their nearby landscapes. By understanding the critical services—water, sustenance, cooling, heat, communication, and protection from hazards—that support communities, energy developments can be designed to serve them.

- To design for **energy justice** in renewable energy landscapes means both configuring the physical infrastructure in a way that distributes the benefits and costs of the installation as well as fairly constructing the financing schemes and ownership models for energy projects. Doing so can put vulnerable or historically burdened communities at the forefront of renewable energy deployment, utilizing design-based approaches to support them in envisioning their energy futures and realizing the value that can accompany it.

While these pathways help envision lanes for developing technologies for a just and clean energy future, historical analogs in energy infrastructure development offer insights into the technological, cultural, and natural layers of landscape that can be altered in the process. Developments during the New Deal, such as the Tennessee Valley Authority designing its "Multi-Purpose System of Dams" to combine flood control, navigation improvements, and electrical power generation along with publicly accessible reservoirs, fertilizer production, and improved forest land management, illustrate the potential of multifunctionality in this context. However, historical developments have negatively affected nearby communities, such as the case with the many Native American communities displaced from dam flooding. These examples and historical lessons highlight the longevity of infrastructure on the landscape, that the tradeoffs apparent in the moment of decision may not last over the horizon of the investment, and the foresight to avoid past practices of harm and move towards a future where communities are fairly consulted in the development of energy projects and allowed to co-manage and co-design their energy futures.

As society continues to deploy renewable energy sources at a rapid pace, there is real need to thoughtfully consider how technologies and installations are designed with attention to place to enable deployment at scale. This will require further research to understand how and where design should come into energy planning processes, convening stakeholders in large-scale, well-designed conversations to set the vision, and learning from other infrastructure that has had success in transforming landscapes for local value. Now is the time to move beyond traditional, incremental thinking around energy development to ensure that the journey ahead is truly transformative and maximizes the benefits that our energy system can provide.

Acknowledgments

The authors wish to acknowledge the sponsorship and imaginative leadership of the U.S. Department of Energy's Water Power Technologies Office in creating space for this research. Simon Geerlofs and TJ Heibel at PNNL were instrumental in building the vision for this paper, supporting it through to its delivery and the concepts explored within. We acknowledge the Landscape Architecture Magazine for publishing an integrated vision of how landscape architecture offers unique tools and strategies for planning a better clean energy future. This article, co-created by Nick Pevzner, Yekang Ko, and Kirk Dimond titled *Designing for Just and Multifunctional Energy Landscapes*, made it possible for clean energy futurists to find and combine forces with this formidable group and their vision. We also extend our gratitude to Yeongseo Yu, Ph.D. candidate at University of Oregon, for his contributions to several of the pathway sections of this paper.

Cover Photos

Sharlissa Moore and Herbucks Organic Poultry Ranch: sheep grazing among a 1.9 MW solar installation.

Danielle Preziuso: students approaching wind turbines at Lynetten in Copenhagen, Denmark.

Azura point absorber wave energy converter being tested at the U.S. Navy's Wave Energy Test Site in Kaneohe Bay on Oahu.

Acronyms and Abbreviations

DES	Decentralized energy system
DER	Distributed energy resource
NDC	Nationally determined contributions

Contents

Figures

Tables

1.0 Introduction

Clean energy goals and policies have dramatically shifted commerce, resource portfolios, and technology innovation in the last 20 years. But how has this shift contributed and been visible to communities and culture? Increasingly wind and solar facilities carry cultural and political meanings, encoded with socio-political attitudes regarding climate action, social responsibility, and the energy transition. They are emblems of responsive action to climate change, even juxtaposed with melting sea-ice and polar bears, but these encoded meanings are generalized, rather than designed specifically to reflect local values. Part of the visual power of wind energy is its iconic design: a wind turbine in America today is white, very large, uniform, slow-moving. It is reaching for the sky, full of optimism and hope yet also a lightning rod for charged emotions about the landscape. Wind turbines are also growing taller. Steadily increasing hub heights capture improved wind profiles, and offshore facilities will be even more massive than onshore installations. But although they are physically impressive, turbines are designed to produce the most energy they can within technical potential and cost efficiencies; all development incentives are aimed at the greatest economy of scale and maximizing electricity production at all times.

Energy development, like most modern industries, has focused on cost and efficiency: the building blocks of business. Margins are tight, and for many renewable energy developments, finding optimal locations for electrical interconnection, available renewable resources, and favorable compensation strategies introduces enough challenges. These challenges have focused development toward optimization of economic scale, avoiding penalties, and accessing incentives, but not toward public value, and certainly not toward local value. Part of what has enabled the transition of the electricity grid toward clean energy is the mobility and financial nature of electricity production and delivery. It has made it possible to develop large renewable projects where the resource exists, where the transmission exists, and to access more favorable markets and consumers. The impact of energy technologies on the landscape and the different meanings they carry for different people are typically considered elective. For most businesses, this is a normal hierarchy. For renewable energy, however, there is a public mission associated with its development – that of combatting climate change, enabling cleaner air and water, supporting remote energy supply, among others – and this mission is reflected in the broad policy space in which renewable energy deployment thrives. Driving forward into a technically, economically, and culturally challenging transition to clean energy must then adopt more functional goals than project cost-effectiveness.

When we collectively look up from this conventional framework, we can see that there are practical roadblocks ahead. With massive acceleration in development, enormous public investment in infrastructure, and more communities envisioning their future in relationship to clean energy infrastructure, there is a critical path that needs more investment and insight: delivering new clean energy infrastructure that meets public interests, social and cultural acceptance, and community goals. This is simply not a part of business as usual today.

1.1 The Problem with Business as Usual

In trying to identify what people care about when it comes to interacting with renewable energy development, we analyzed trends in siting and permitting renewable energy projects as well as utility customers that voluntarily pay more on their bills to support clean energy investment.

At the local level, zoning and permitting are expressions of community preferences on how new development fits culture and future interests. Often these are the communities' mechanism for delaying or blocking the construction of renewable energy projects. Zoning barriers may be designed intentionally to obstruct renewable energy development or may arise as an unintentional adverse consequence. Either way, they are products of community concern that less desirable characteristics of renewable energy infrastructure may outweigh its local benefits. Restrictions on renewable energy deployment in local zoning ordinances is a nationwide phenomenon: analysis from Columbia Law School's Sabin Center for Climate Change Law found examples of zoning ordinances written to block or significantly restrict renewable energy project development in all 50 states (Aidun et al. 2021). These local limits have been imposed using a range of tools and approaches, including limits on system size or location; limits on where energy generated from a renewable energy project may be consumed; or outright moratoria or bans on types of energy projects, either in certain zoning areas or within a city or county entirely. Some jurisdictions impose multiple layers of restrictions: a county may require both height limits and lengthy setbacks for wind turbines, or a city may limit a ground-mounted solar system's location within a property while also limiting that system to energy generation for on-site use at that property.[1]

But what do individuals and communities want from their energy technologies? And what value do they see in a personal choice to invest in renewable energy? Existing interactions between end-users and renewable energy, such as voluntary green power programs, can shed insight on this. Voluntary green power programs that provide consumers with choice in provision of their energy enable to participate in the renewable energy marketplace and may be a key component of renewable energy futures (Kotchen and Moore 2007). These voluntary programs are offered by utilities directly to consumers, often through unbundled renewable energy certificates (RECs) or cooperative partnerships such as community choice aggregations (CCAs). Despite their wide availability and significant share of non-hydropower renewable energy, most voluntary green power programs have low enrollment numbers and struggle to maintain participation over time, resulting in an overall small share (approximately 5%, totaling 192 million MWh in 2020) of the wider electricity retail market (NREL 2021). Additionally, recent analyses demonstrate that compliance markets for renewable energy (e.g., renewable portfolio standards) compete with voluntary programs, leading to declining enrollment in states with more stringent regulatory structures (Zhou and Solomon 2021).

Both internal (i.e., psychological) factors and external (i.e., economic) factors have been shown to influence participation in green power programs for residential consumers (Clark, Kotchen, and Moore 2003). Several studies suggest that various approaches to communications, social marketing, normative interventions, and regulatory incentives can affect participation in voluntary green power programs (e.g., Wiser 1998; Momsen and Stoerk 2014; Clark, Kotchen, and Moore 2003; Matek 2016). There is a paucity of empirical and actionable insights, however,

[1] Waldo County, Maine, for example, is home to the 4.5-MW, three-turbine Beaver Ridge Wind Project, which began operations in 2008 ("Beaver Ridge Wind | Patriot Renewables, LLC" n.d.). After expressing concerns about the noise and visual impacts of the wind farm, residents of the neighboring town of Montville passed an ordinance in 2010 imposing strict limits on future wind projects (Curtis 2010). The ordinance requires that all turbines be set back either one mile or thirteen times the height of a turbine from the property line, whichever is larger; that turbines may not raise noise levels at neighboring properties more than 5 audible decibels (dBA); and that no turbine cause any flickering shadows or blade reflections to impact any occupied building ("Town of Montville Wind Turbine Generator Ordinance" 2010). In Klickitat County, Washington, concerns from property owners about potential viewshed impacts from a proposed utility-scale solar farm led the county to adopt a six-month moratorium on utility-scale solar projects in the county in March 2021 (Flatt 2021). As of July 2021, the county is in the process of reviewing more permanent restrictions on utility-scale solar, including setback requirements (Board of County Commissioners 2021). In both examples, and in hundreds of other communities nationwide, residents' concerns about the impacts of large renewable energy projects on their neighborhoods and local landscapes have driven local governments to take steps to prevent those projects from being developed entirely. Acknowledging these concerns and reforming renewable energy development to better quantify and display local values that resonate with community members is necessary to support widespread technology adoption.

into the characteristics of voluntary green power customers or the value such programs provide (beyond econometric assessment), which limits the ability of utilities to successfully promote and grow participation over time (Matek 2016). This also points to gaps in knowledge of the social nature of renewable energy uptake more broadly, which presents barriers to meaningful engagement with community partners who may support renewable energy programs, but do not actively participate in the voluntary market (Momsen and Stoerk 2014). Research, development, and innovation have often focused on technological fixes such as increased efficiency and cost reductions, rather than seeking to understand the heterogeneous makeup of the marketplace and how social influences at multiple scales affect the diffusion of support for renewable energy. A better understanding of the diverse values, attitudes, and behaviors of individual consumers is needed to help policymakers, renewable energy developers, and organizations build the trust necessary to engage and empower communities to leverage and mobilize existing support for renewable energy projects, as well as understand oppositional views to better anticipate barriers to development.

1.2 The Promise of Place-Based Design

To that end, this paper offers a new perspective for developing renewable energy at scale, widening our aperture beyond the machine and out into the landscape, folding in the social, economic, and environmental fabric. We outline a new way to conceive of renewable energy landscapes, one in which we open a new chapter in the story of large public investment in clean energy infrastructure. We call this *place-based at scale* and *renewable energy landscapes.* The ultimate aim is to make it possible to adapt technology and infrastructure to community objectives, but to do it in a way that fosters replicability and scaled approaches across the country in order to accelerate toward a cleaner energy system. While the magnitude and pace of climate change demands action now and speed is an important goal of current government policy (i.e., 2035 and 2050 goals), in this chapter of large public investment in clean energy infrastructure, our challenge is not just to build more of the same facilities in less ideal resource locations or stimulate more of the same projects to be built much, much faster. The practice of conceiving and building at scale with the full temporal and spatial scope in mind is a different practice than of incremental development. If we apply incremental development thinking to what is truly intended to be transformative, it will offer fewer benefits and more burdens to the very public that funded the venture.

Renewable Energy Landscapes: A landscape whose physical characteristics have been significantly transformed by renewable energy infrastructure.

Place-Based at Scale: Deployment of infrastructure systems in a way that balances the ability to be replicated widely (at scale), with careful attention to unique local character of specific places.

This transformation requires that a high environmental and social equity standard is at the heart of the future clean energy system, one in which we account for the direct and systemic footprints of our energy consumption. Creating renewable energy landscapes means recognizing that there is an enormous opportunity in this challenge, engaging cultural and local benefits and human dimensions to re-imagine energy infrastructure, and then re-designing the technology to deliver on the higher standard we should all expect. How does energy infrastructure not only avoid becoming a nuisance as it is built closer to more communities, but in fact add value to those nearby communities? Historically, the primary beneficiaries of the electricity generated from centralized power plants were located far away. New renewable energy infrastructure investment could be contributing credible and relevant value to the places in which it is installed, not just to a relatively abstract emissions goal for which there are many possible remedial measures.

But how do we create value? Historical lessons from prior periods of energy transition offer examples of infrastructure imbued with civic aspirations, which endeavored to advance local economic development and improve local landscapes while introducing the public to novel forms of energy. The clean energy future can be designed and built to stimulate civic interests—environmentally, economically, aesthetically, socially, and for all communities. This requires vision, new cooperation between disciplines, and proactive work. Everyone is at this table, including the next generation of clean energy innovators.

Landscape here implies something more than mere space, or even land use. According to Dirk Sijmons, a Dutch landscape architect, “landscape is a rich and layered concept that speaks as much to the relationship between humans and nature as it does to the relationship between people themselves. Landscape is loaded with values, from individual memories to social symbols” (Sijmons 2014: 12). Carefully designed clean energy landscapes would help renewable energy infrastructure touch down in site-sensitive ways, so that they become just one more new layer in the cultural landscape—while strategically combining multiple functions to head off land use conflicts between energy production and pre-existing land uses, or cleverly introducing new hybrid land uses that benefit local communities. Designing place-based renewable energy landscapes also places new focus on the value that communities get by meaningfully participating in stakeholder engagement processes through iterative design processes or from being prioritized for energy system upgrades that reduce climate vulnerabilities.

Embracing landscape design through place-based development at scale invites an entirely new format for community engagement: one of visualization of the future. Traditional approaches to community engagement in energy development involve strategies for achieving “community acceptance” or eliciting input on the regulatory process. However, new approaches are gaining traction. Federal and state initiatives and funding opportunities are increasingly aiming to put communities in the driver’s seat. For example, the Communities Local Energy Action Program[2] aims to facilitate sustained community-wide economic and environmental benefits to low-income, energy-burdened communities that experience direct environmental justice impacts or economic impacts derived from a shift away from a historic reliance on fossil fuels. As another example, the Energy Transitions Initiative Partnership Project[3] supports remote, island, and islanded communities who seek technical assistance as they transform their energy systems, increase their energy resilience, and implement solutions that address their specific challenges. While much progress is being made in understanding the need for community-driven initiatives, operationalizing locally driven processes is a challenge. Design thinking has the potential to help us confront this challenge. By incorporating hands-on strategies for visualizing alternative futures through participatory mapping, drawing, and building exercises, these strategies can help communities envision how renewable energy can help them meet their community goals. These strategies are powerful for communicating ideas and considering alternatives in an open setting, a creative corollary to planning and necessary predicate to a project siting decision.

[2] https://www.energy.gov/communitiesLEAP/communities-leap

[3] https://www.energy.gov/eere/about-energy-transitions-initiative-partnership-project

This paper offers a series of creative ideas and pathways on how to imagine and capture value from clean energy investment by considering the role of design, techniques for evaluating infrastructure attributes, new tools for envisioning integrated energy futures, articulating multi-functional technology potential across non-traditional domains, and giving due weight to longer-term financial and social structures that will buoy us on this journey. This paper shines a light on the role of design principles in informing place-based energy transitions at scale, outlining the potential for design thinking to illuminate and realize local values of renewable energy. The remainder of this paper is structured as follows:

- **Section 2.0** describes existing challenges and tensions that arise between community-informed goals and at-scale renewable energy development.
- **Section 3.0** highlights windows of opportunity to conceptualize what integrated energy landscapes might look like and avenues through which they can be developed in practice.
- **Section 4.0** details the potential pathways for accelerating localized clean energy deployment with a focus on the role of design.
- **Section 5.0** provides historical perspectives and lessons to inform design-focused, place-based energy development.
- **Section 6.0** offers concluding remarks, summarizing the key takeaways from each of the potential pathways for accelerating localized clean energy deployment.

2.0 Challenges and Tensions

The clean energy transition will, to some degree, relocate energy generation close to communities who have not previously had their generation sources in proximity, posing new challenges and opportunities to society and its relationship with energy infrastructure. Both the scale of development and the resulting proximity are challenging the evolution of these relationships. Developing renewable energy technologies at scale is amplifying the perceived dichotomy between community-informed goals and national decarbonization goals, exacerbating the underlying tensions that create it. These tensions relate to the approaches to development, the processes enabling deployment, the effects of energy projects, the attributes of technologies, and the manner through which projects are developed (Figure 1).

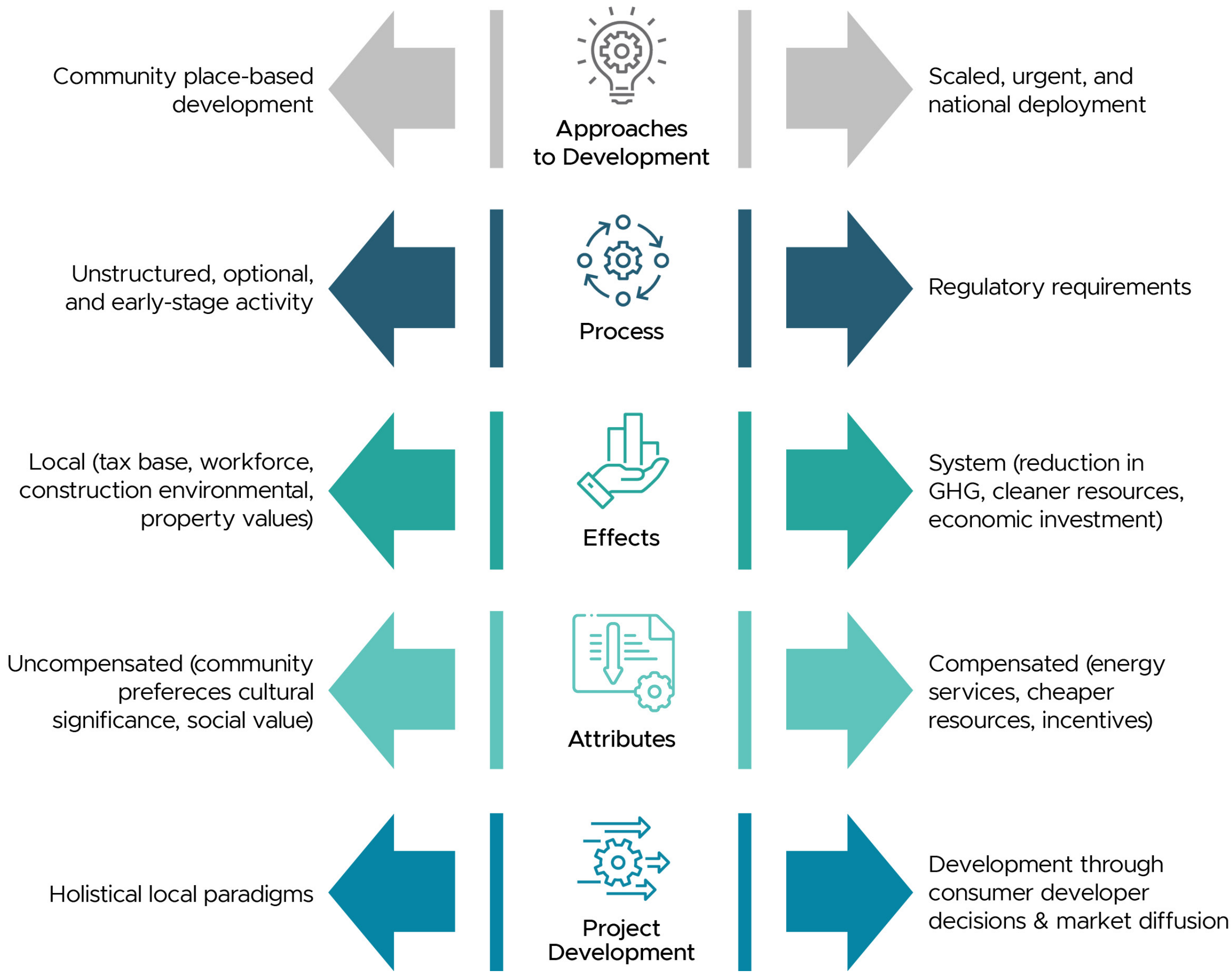

Figure 1 Challenges and tensions in developing renewable energy technologies at scale.

With efforts underway to decarbonize the grid, these tensions are slowly rising with some already escalating in communities where adoption of renewable energy technologies is quickly increasing. The success of at-scale renewable energy deployment rests in reconciling the opposing ends of these tensions to show that community-informed goals and national decarbonization goals can, and must, be synergistic to enable the clean energy transition. By exploring why these tensions arise and how they manifest, we can better address them in the energy landscapes we design, transforming our infrastructure into meaningful contributions to specific, local goals and broader initiatives.

2.1 Approaches to Development

Existing approaches to development are often driven by the need for scaled, urgent, and national deployment to reach decarbonization goals. Many largescale studies explore the technical feasibility of such deployment (Jacobson et al. 2015; Kroposki et al. 2017; Hand et al. 2012; K. Hansen, Breyer, and Lund 2019), recognizing the complex and intricate economic and physical details necessary for a decarbonized energy future. But the pace and scale of these studies is not designed to handle the different needs of each community that would be required to develop these technologies in practice; the topology of the grid, regulatory environment, and thin margins rarely create space for creative design and locally beneficial additions.

On the other hand, implementing place-based development strategies can be time consuming, requiring an understanding of the uniqueness of place and how it motivates community ideals and goals. In the absence of doing so, however, communities and local siting jurisdictions may decide that renewable development is not worth it. As noted in Section 1.0, recent moratoriums (e.g., Board of County Commissioners 2021; Kennedy 2021) on commercial solar and wind energy development show this tension manifesting. In some communities with significant increases in deployment, the pace and scale became overwhelming ("Ordinance No. 21-080-CC" 2021; Kennedy 2021; Gannon 2021). In these situations, questions arise as to why the projects were needed and what value they were providing, ultimately leading to prolonged periods without any development to allow for local decision makers to assess community concerns. Deploying technologies with urgency is necessary but without place-based developments that resonate with community members, the risk for delays or no development at all becomes real. While place-based development can come into tension with urgent and at-scale deployment, the two are inherently interconnected and interdependent on one another, both necessary for the clean energy transition.

2.2 Process

The processes enabling deployment can range from unstructured, optional, and early-stage activities to well-defined regulatory requirements that have been the historic passthrough for development. Regulatory requirements for energy development differ from state to state and often from municipality to municipality, sometimes designed to promote safety within projects and other times requiring explicit renewable energy development through renewable portfolio standards. These regulations are intended to standardize processes, streamlining decision making and specifying future activities. Renewable portfolio standards, for example, can specify timelines and types of energy technologies to be developed, but poorly designed renewable portfolio standards hold the potential to create complex barriers.

Other efforts, such as New York State's newly established Office of Renewable Energy Siting, seek to ease the process for large-scale renewable energy developments (New York State Office of Renewable Energy Siting). As part of the Office's requirements, they will develop permits for public comment and local community input. While this process guarantees a forum through which the public can participate, it could deter optional and early-stage activities to engage with the public, instead funneling those engagements through the approved mechanism. Flexibility in unstructured and early-stage activities, such as educational programs, capacity building, and community engagement, has the tendency to bring a broader group of stakeholders to the renewable energy decision-making table, and in doing so, can garner support and tailor projects to community goals when possible. Because these activities may lack a place in the regulatory process given their lack of structure, the onus may be on key actors in the development process – industry, local government, utilities, stakeholders, local leaders – to be creative and make space for these engagement processes. These sorts of processes have been well-explored and established in other natural resource sectors and in the sustainable development space. There are opportunities to learn from these other examples to set a new precedent for renewable energy.

2.3 Effects

Deploying renewable energy at scale has known effects on the electric grid. Greenhouse gas emissions will significantly decline, and the investments in renewable energy can pay off economically. The system-wide benefits of renewable energy development are well-established and often prioritized over the local effects of deployment. Negative local effects are typically minimized to the extent possible but rarely viewed as the desired outcomes of development. Local effects may include the impacts on surrounding ecosystems, workforce, tax base, and property values. Common approaches in development are to mitigate any negative impacts on local effects rather than try to proactively generate local benefits before the systemwide values are realized.

Retiring coal plants and replacing them with renewable technologies, for example, provides a clear reduction in greenhouse gas emissions and generates air quality benefits, but the local workforce could very well suffer if not appropriately considered in the transition (Lessick, Tarekegne, and O'Neil 2021). The development of renewable technologies on their own can also achieve positive net environmental effects while jeopardizing local ecosystems. With the potential of generating more than 35 million GWh of wind energy each year (Elliott et al. 2010), the development opportunities are massive and greenhouse gas emissions would surely decline, but the local effects on birdlife or construction effects on the local community are ignored in that potential. Local and system effects are rarely considered alongside one another in existing practices, necessitating innovation in methods and technology to enhance goals at both scales and understand any trade-offs that might be necessary.

2.4 Attributes

Many attributes of energy technologies are compensated either directly or indirectly, motivating developers to design for the highest compensation. Most often developers design technologies and projects to generate maximum production for which they receive monetary value. Incentives for development are often linked to the amount of energy that a project can produce, and ultimately, developers are inclined to build projects that are the most cost-effective. Energy technologies offer benefits beyond what is compensated, though. For example, the visual impact of their presence has value to those who see it every day and its presence can interact with long-standing cultural values.

To realize many of the uncompensated values that our energy technologies offer, such as desired aesthetics and community preferences, might require a tradeoff with compensated values, but those values could also empower communities in their energy futures. Historically, the monetary function of the development comes first, and uncompensated benefits are seen as a bonus. Concerted effort to quantify these uncompensated benefits can help reconcile this tension. This may also be realized by advancing existing valuation practices to accommodate uncompensated attributes that are absent from the financial system yet hold real power over decision-making. Through such actions, technology design can evolve to respond to uncompensated values without forfeiting compensated ones.

2.5 Project Development

Nearly all renewable energy project development occurs through consumer and developer decisions, not a centralized decision-making and development authority. Developers ask: Where is the most cost-effective location? Where is the resource? Where can I easily interconnect to the grid? What is the regulatory climate? Natural market diffusion puts the decision-making process into the hands of consumers and developers, and many factors influence what consumers and developers will choose.

There are many strategies to changing the context of consumer and developer decision-making. Some of the most well-known are regulatory constructs that pull down certain costs, offer certainty, and work in a more transparent programmatic way. Competitive renewable energy zones, such as what has been developed in Texas, are one way to offer more holistic approaches to development, building transmission to enable renewable energy adoption in places where the outcomes are cost-effective and resources are abundant. However, such zones can work against natural market diffusion, deterring development outside of those locations. Other market transformation activities change the nature of the technology, analyzing how decisions are made and narrowing the gaps between a more energy efficient or more environmental selection and the usual selection. These strategies are common in energy efficiency and buildings approaches, and often grapple with people's impressions of the technology rather than its current performance.

Illustrating these tensions is not intended to lead to a stalemate. Rather it is a challenge space that generates wholly new ideas. This paper posits six pathways to manage and move past some of these tensions. We also suggest that these tensions require technology innovation, rather than viewing technology commercialization and deployment conditions as wholly separate ideas.

3.0 Windows of Opportunity

Government actions, such as newly introduced policies, development of new programs and missions, and funding directions from Congress, are broadly opening windows of opportunity to conceptualize integrated energy landscapes, and how they could be achieved, providing both direction and dynamic vision for the energy transition. Like past successes, such as the moon-landing, development of internet technologies, or large-scale energy-water projects, strategic public sector policies and actions can influence long-term planning horizons and broad forms of innovation to enable technical and social advancements. The Biden administration has taken several actions to put climate change at the forefront of energy policies and initiatives, providing investments to both reimagine the energy sector and to force rapid change in the near future Establishing the goal of reducing greenhouse gas pollution from 2005 levels by 50% in 2030 (White House 2021), rejoining the Paris Agreement to limit global warming to two degrees Celsius (White House n.d.), and creating the Justice40 Initiative ("Executive Order on Tackling the Climate Crisis at Home and Abroad" 2021), highlights the need to design and deploy energy technologies that can promote rapid growth that is supported by and directly benefits communities. The recent $1.2 trillion infrastructure bill (DeFazio 2021) approved by the Senate in August and signed by President Biden in November 2021 will provide direct investments to the electric grid in addition to funding for a range of renewable energy projects and other major infrastructure upgrades. This funding also encourages key actors to consider the intersection between energy landscapes and other infrastructure, opening new lines of thinking that can be informed by historical successes of infrastructure investments that embraced design. Application of design techniques to energy landscapes fit within past government approaches to innovation, ultimately leading to new social and technological benefits.

Congress has directed the Office of Energy Efficiency and Renewable Energy to develop an energyshed management system (DOE 2021) which parallels a watershed in that it requires an understanding of where energy comes from for a given location and what types of resources are used to generate that energy. This concept promotes efficiency and resiliency within the electric grid and also highlights the increasing proximity that energy technologies will have to communities and the value that they generate. While such direction must address the technical bounds and implications of an energyshed, effectively implementing energy technologies to realize an energyshed in practice requires strong community acceptance and participation given the technologies' potential visibility. Some suggest that implementing an energyshed will require a complete socio-technical transformation, prompting consumers to think more intentionally about their energy choice, creating both individual and community accountability and responsibility (DOE 2022b). This opens a lane to imagine energy landscapes in proximity to communities and the designs that would enable them.

Deploying energy technologies at scale through an energy landscapes vision requires evolution in policies and other situational windows of opportunity towards an enabling environment for design innovation and energy infrastructure. Most notably, the recent United Nations Climate Change Conference brought together world leaders to update their countries' Nationally Determined Contributions (NDCs) under the Paris Climate Accord. NDCs detail the plans each country will take to reach their goals, prompting efforts to move goals into action. Place-based energy landscapes and design practices could help inform evidence-based, robust, and locally achievable targets for updated NDCs. For example, landscape design could elucidate opportunities to integrate renewable energy technologies into built environments and underutilized lands across scales, from helping municipalities and regional governments to achieve their climate action goals, to designing multifunctional transmission and distribution corridors. These opportunities parallel an increased deployment of distributed energy resources, which are particularly well-suited to support communities in their energy futures.

In communities that have experienced natural disasters, there is often a clear understanding of the need for new forms of energy sources and technologies, both temporarily and permanently. Disasters shift equilibrium points, transforming energy landscapes and reforming existing energy systems into ones more responsive and better serving communities (Ko et al. 2019). A similar situation arose in the dramatic response to the Covid-19 pandemic, specifically large-scale stimulus, vaccine development, and other coordinated measures that are unprecedented in scope and speed. The Covid-19 response has shown that massive stimulus can, to some degree, improve livelihoods while also forcing society outside traditional ideological boundaries around economics and health. Stimulus measures to promote cleaner energy sources and create jobs provide direct and practical ways to rethink how and where energy is deployed.

Reimagining energy landscapes stands at a critical crossroads of opportunity and time. There is very real potential to shape and transform how we envision the future of renewable energy installations and move from research and ideas into action to create them.

These windows of opportunity are vehicles for change. This paper discusses six pathways for change, but the vehicles are essential. We offer the following summary recommendations to adapt these opportunities to place-based at scale approaches. In brief:

- Take advantage of large-scale national stimulus and infrastructure funds to drive regional and landscape-level cooperation that engages *tradeoffs*, not just information stacking;
- Organize solution packages, from concept to tools to development, for community-scale investment and benefit;
- Use “place-based” information as fuel for design, vision, and action, rather than a process consideration or a difficult unique arrangement to fit existing solutions;
- Promote strategies for new cooperation and a wider set of constituents;
- Create more drivers to ensure that the clean energy transition offers local benefits and a local value proposition that is commensurate with the timescale that infrastructure lives on the landscape; and
- Engage innovation sectors in developing technology that meets the high standard of renewable energy landscapes.

4.0 Pathways to Accelerating Place-Based Clean Energy Deployment

A number of potential pathways could capture local value from the deployment of renewable energy at scale, each one prioritizing a distinct set of benefits for communities (Figure 2). These potential pathways encompass both place-based and renewable energy development at scale, highlighting the unique opportunity in envisioning landscapes through such practices. Place-based development that prioritizes design requires an understanding and demonstration of value to take hold.

Figure 2 Pathways for renewable energy landscapes at scale.

Communities are different, with different needs and desires, and different relationships to their nearby landscapes and energy systems. By consulting with communities and enabling them to determine which factors they find most salient within the potential suite of pathways, a more targeted approach to clean energy deployment can be pursued, one that embraces the factors that resonate with communities. Design-driven engagement embedded within energy planning enables local communities to envision their renewable energy future. By demonstrating what values and co-benefits renewable energy resources bring to a community and design-driven engagement helps people explore how transitioning to renewable energy supports their long-term vision.

To that end, we propose these concepts:

- Seeking meaningful **MULTIFUNCTIONALITY**,
- Respecting and utilizing **NATURAL CAPITAL,**
- Generating **LOCAL VALUE** for communities,
- **DECENTRALIZING** and distributing generation at a local scale,
- Providing **RESILIENCE** against climate disruption, and
- Promoting **ENERGY JUSTICE.**

Energy infrastructure is typically kept away from other land uses, and when energy development occurs, it replaces former land uses with a new monofunctional land use of energy infrastructure. A pathway seeking multifunctionality can diffuse the contestation over land use by allowing energy to co-exist and co-locate with other land uses and can be a useful pathway for scaling up renewable energy in communities where land use conflicts arise.

A pathway that respects and utilizes natural capital reduces harm to natural ecosystems during energy infrastructure development and seeks to enhance and work with existing ecosystems.

A pathway that focuses on generating local value is cognizant of the tension between benefits for distant energy users and nearby neighbors of energy systems and focuses its efforts on keeping the generated value close to the site of the energy production, through a range of economic policies and financial models.

Other pathways take advantage of decentralization and distributed energy resources, use energy infrastructure as a means to advance local resilience goals, or prioritize a more just and equitable energy system.

Within each of these pathways is a strategy for accelerating renewable energy deployment with local benefits. Below, we delve into these six pathways, capitalizing on a design-driven strategy that may resonate with community concerns.

4.1 Seeking Meaningful Multifunctionality

Today's energy infrastructure routinely carries the weight of traditional management of fossil energy systems, continuing to be classified in many places as an industrial land use. Many current land-use regulations and ordinances confine, limit, or compel a specific land use due to social resistance, property ownership, and safety, keeping energy infrastructure separate from other land uses and vice versa. These regulations tend to disincentivize cities and towns from retrofits with new innovative renewable energy technologies that might enable energy consumers to instead become energy prosumers (Bergstrom, Goetz, and Shortle 2004; Scognamiglio 2016; Schindele et al. 2020; Valle et al. 2017). Also, there are concerns in that adding extra physical functions onto existing land-uses may possibly spark new land-use conflicts by interrupting established uses.

Multifunctional land-use may be a game-changer in energy planning by promoting land-use efficiency and productivity while also imposing diverse added functions into the existing landscape (Lovell and Taylor 2013; Charoenkit and Piyathamrongchai 2019; van Broekhoven and Vernay 2018; R. Hansen et al. 2019; Heinstein, Ballif, and Perret-Aebi 2013; Ghosh 2020). Multifunctionality conceptually refers to “stacking of ecological, production, and cultural functions to achieve greater overall performance" (Lovell and Taylor 2013). The multifunctional approach has the potential to synergize with ecosystems and local communities, which ultimately benefit the communities by contributing to mitigating climate change and adding resilience to external or internal shocks (van Broekhoven and Vernay 2018; Connop et al. 2016; Jerome et al. 2019).

The concept of multifunctionality can be physically applied to energy landscapes (Figure 3). For example, solar photovoltaic systems could be overlayed with another land-use such as agricultural farmlands under photovoltaic panel arrays—an arrangement known as “agrivoltaic” systems. Grasses and wildflowers that constitute good habitat for pollinator insects can similarly be grown under and around solar panels, resulting in “pollinator-friendly” solar installations (see 4.2 Respecting and Utilizing Natural Capital). Solar photovoltaic systems could also be integrated into existing buildings or land surfaces such as building applied photovoltaics and building integrated photovoltaics, resulting in a visual integration. Offshore wind turbines can be combined with some forms of ocean farming or mariculture to help sustain coastal nature-based economies (Fitzpatrick 2021). And multifunctional energy corridors could combine energy transmission lines with other linear land uses, such as highways or railways, as well as hiking and biking trail networks and opportunities for other bundled linear systems, such as broadband.

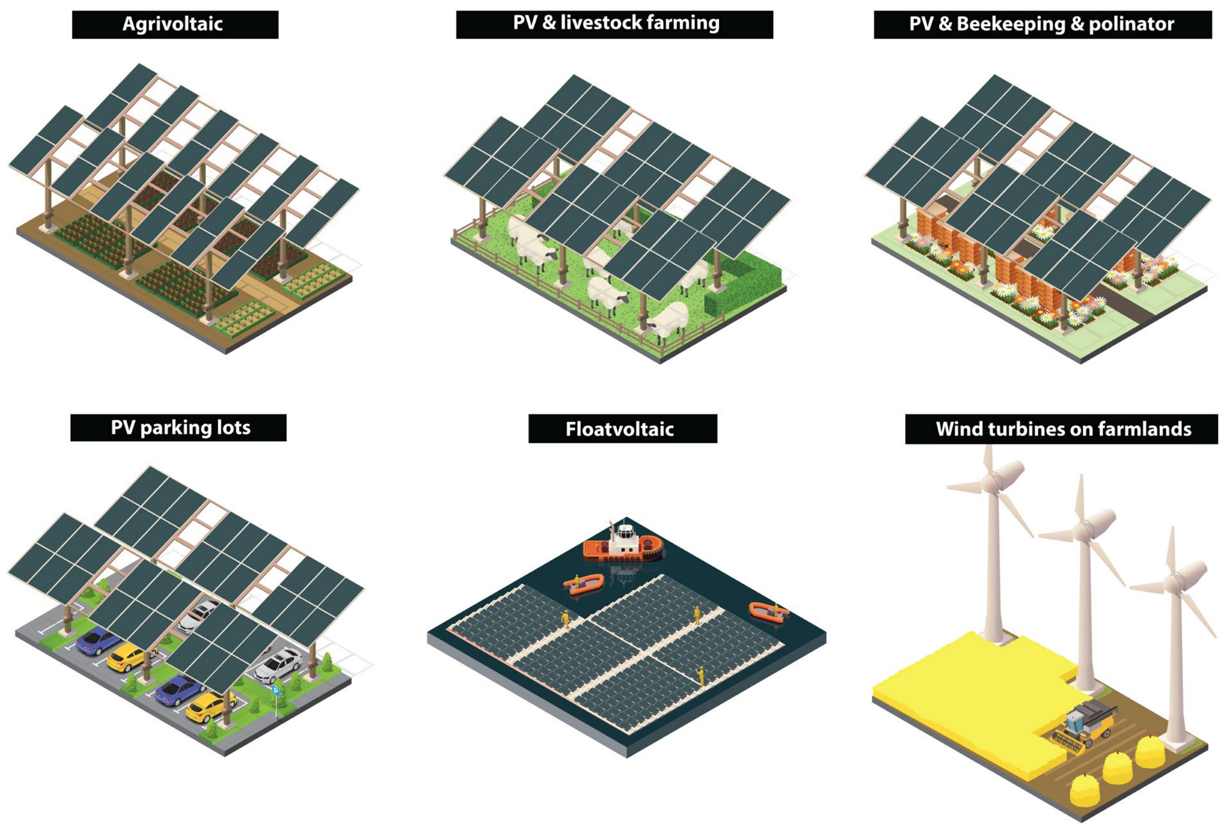

Figure 3 Examples of overlaying renewable energy technologies with other land uses.

Myriad research papers, built prototypes, and conceptual design proposals have revealed benefits of renewable energy colocation with other land uses, in a range of landscape contexts including urban (e.g. building roofs, facades, and windows, right of ways, transportation infrastructures), suburban (e.g. residential rooftops, parking lots, big box retails), rural and coastal areas (e.g. agricultural lands, aquaculture, and water infrastructure) (Table 1). The configuration of multifunctional energy landscapes varies depending on the type of renewable energy, the type of site, and the system components. These multifunctional renewable energy collocations may result in some trade-offs in efficiency for energy generation; however, renewable energy deployment at scale allows more efficient use of lands (including those that are close to where most energy consumption occurs) and the supplementing of traditionally-developed, utility-scale renewable energy development for rapid energy transition.

For wide implementation of the multifunctional energy landscapes, design and planning approaches should address physical and social integration of renewable energy technologies with surroundings, fair distribution of co-benefits, revisions of ordinances and regulations, and further develop coupled RET-land-use typologies that can minimize conflicts and maximize co-benefits (R. Hansen et al. 2019; Lovell 2010; van Broekhoven and Vernay 2018; Ravi et al. 2016; Ghosh 2020; Barron-Gafford et al. 2019).

Multifunctionality with existing industrial uses may offer more acceptable pathways for innovation and demonstration technologies. There may already be appurtenant infrastructure (roads, substations) and a greater capacity to tolerate performance risk, with the potential of vastly improving the value.

Table 1 Energy colocation typologies over the landscape transect and major co-benefits.

URBAN AREAS

Colocation Opportunities	***Co-Benefits***
Solar PV Building Surface Integration (Rooftop, façade, windows) Right of Ways (ROW) PV parking lots Urban Agrivoltaic *Geothermal* Wells placed under sidewalks, under parking areas, or under buildings Heat pumps or direct use in business complexes or university campuses *Thermal Energy Storage* Aquifer Thermal Energy Storage (ATES)/Borehole TES (BTES/Underground TES (UTES) *Waste Heat Recovery Units (WHRU)/Combined heat & Power(CHP)* MicroCHP CHP District Heating Heat Recovery System Generator (HRSG) *Hydropower* Water conveyance and water treatment	• Urban Heat Island mitigation, cooling benefits & Building energy use saving by reducing the building surface temperature • Synergies with transportation infrastructure (EVs, AVs, and public transit), industrial and commercial facilities • Efficiency direct energy production and consumption, which reduce energy loss occurring in transmission process • Cost savings by sharing land • Public engagement and education around climate and energy literacy • Reuse and store waste heat • Reduce thermal and air pollution

SUBURBAN & RURAL AREAS

Colocation Opportunities	***Co-Benefits***
Solar PV Farmlands: Agrivoltaic (PV+Agriculture) Farmlands: PV Beekeeping (PV+Agriculture) Grasslands: PV on wild grasslands/pollinator habitats Floatvoltaic on water surfaces PV on water infrastructure (dams, irrigation canals) *Wind Energy* Farmlands: Croplands Farmlands: Dairy Farms *Hydropower* Water conveyance and water treatment Pumped storage	• Commercial scale possible close to energy demand • Dual incomes (energy & crop yields) for property owners • Streamlined management benefits (e.g. reduction of water evaporation in farmland, reservoirs, and irrigation canals, Reuse of PV cleaning water for irrigation, reduction of lawn mowing) • Dual carbon reduction benefits

COASTAL AREAS

Colocation Opportunities	***Co-Benefits***
Wind Energy Offshore wind turbines with aquaculture *Marine Energy* Wave energy embedded in piers, jetties, and breakwater structures	• Aquacultural benefits (farming seaweed, floating fish farming) and its dual incomes for local residents • Synergies with eco-tourism, recreation, trails along transmission, and coastal community resilience hubs for adding local values • Opportunities for scientific research and monitoring for coastal resilience and ecosystems. • Shoreline protection • Desalinated water supply

4.2 Respecting and Utilizing Natural Capital

All people and all communities depend on ecosystems – a concept referred to as "ecosystem services" or more recently as "nature's contributions to people" (Daily 1997; Díaz et al. 2018). Natural capital is the stock of natural resources that generate ecosystem services. Forested watersheds retain sediments and cycle nutrients, maintaining clean water for drinking and recreating (Rocha et al. 2012; Keeler et al. 2012). Healthy soils and pollinator habitat support agriculture (Kremen and Chaplin-Kramer 2007). Coastal habitats such as wetlands, coral, oysters, seagrass, and dunes help to attenuate waves and surge, reducing flooding and stabilizing shorelines (Arkema et al. 2013). Nearshore vegetation and reefs provide nursery habitat for fish, supporting commercial and subsistence fisheries that provide sustenance and livelihoods (Grabowski et al. 2012; Beck et al. 2001). All types of vegetation, on land and in the ocean, store and sequester carbon, stabilizing the climate (Mcleod et al. 2011). If we account for the ways in which healthy ecosystems provide societal and economic benefits, we can use this information to design and deploy renewable energy technology that fosters ecosystem services, ensuring that both nature and people thrive (Fig. 1 (Polasky et al. 2008; Spillias et al. 2020).

Large renewable energy developments can affect ecosystems and the benefits they provide to people. Much like the infrastructure that underpins other sectors, such as transportation, commerce, or housing, construction of the infrastructure that is needed for renewable energy production can lead to habitat loss, pollution, displacement of sensitive species, and other drivers of change (Gasparatos et al. 2017). However, the relationship between infrastructure and environment isn't just about impacts of people on ecosystems and ecosystem services. Informed infrastructure development and stewardship of ecosystems can also enable communities that rely on natural resources to prosper (Mandle et al. 2019). For example, sustainably designed investments in processing plants for fisheries, agriculture, or other products can enable communities to reap higher profits from locally harvested goods, both through production of higher value goods and through the long-term health of the soils and waterbodies that support these nature-based industries. Well-planned roads, reliable ferries, and green accommodations can facilitate tourism in beautiful places, both by enabling people to access these locations and by ensuring the long-term health of the attractions drawing tourists to those sites in the first place.

Renewable energy has the same potential. Place-based renewable energy projects could help cities and towns achieve sustainable prosperity; natural capital approaches and tools can help to realize this goal. The key steps for researchers, governments, and investors are to 1) quantify the ways in which renewable energy development can influence—both positively and negatively—ecosystems and the benefits they provide to people (Randle-Boggis et al. 2020) and 2) use this information in collaboration with stakeholders and communities to co-develop and evaluate innovative designs at scale that will reduce trade-offs and create synergies between renewable energy technology, nature, and the contribution of natural systems to economic development and human wellbeing.

Since the publication of the millennial ecosystem assessment nearly two decades ago, scientific understanding of the myriad ways in which nature benefits people has exploded (Millennium Ecosystem Assessment 2005; Díaz et al. 2018). So too has the development of natural capital approaches and tools that allow practitioners, government, and industry leaders to explore how climate and development scenarios lead to changes in water quality, climate regulation, resilience to natural hazards, agricultural productivity, and many more of nature's services (Kareiva et al. 2011; Ruckelshaus et al. 2015). Going beyond assessing the impacts of people on ecosystems to be able to understand and quantify how people *benefit from* ecosystems—in metrics that resonate with stakeholders like dollar values rather than just biodiversity—allows us to design, site, and more efficiently implement development projects to bolster humans and nature. The time is right, and the science is there to leverage natural capital tools and approaches to inform renewable energy development and implementation (Holland et al. 2018).

Analysis of multiple benefits provided by ecosystems can help support place-based approaches to renewable energy development and take it to scale by quantifying the benefits and costs of renewable energy development scenarios. The first and most fundamental step of assessing ecosystem services is explicitly recognizing and assessing how changes in natural features as a result of infrastructure development may lead to changes in ecosystem functioning and in turn the provision of societal benefits (Olander et al. 2018). For example, with “pollinator-friendly solar” installations, photovoltaic solar panels can support pollinator habitat (Figure 4). Evidence is growing from several case studies around the world that best management practices for solar farms can increase the diversity and abundance of birds and insects that pollinate agricultural crops (Randle-Boggis et al. 2020; Graham et al. 2021) by providing partial shade for flowering plants, while shielding a larger area from constant mowing or tilling.

An increase in the diversity and abundance of pollinators throughout the growing season could in turn support agricultural production, especially in regions suffering from warming temperatures and drought. Improved stewardship with implementation of solar in previously barren areas could also support water quality through sediment and nitrogen retention. On the other hand, poor management or uninformed siting of solar arrays and associated infrastructure could lead to loss of carbon stored and sequestered in soils, increase soil erosion and run-off, and impact water quality. Farmers and developers seeking to deploy and manage solar understories would benefit from assessments of nearby agricultural production and other ecosystem services such as erosion, flooding, and water quality to direct solar development decisions to reduce costs to agricultural production and increase benefits. Although research into the integration between renewable energy development and natural capital is still in its infancy, the photovoltaic solar panel and agriculture example highlights the promise of integrating assessment of natural capital into the design and implementation of renewable energy systems to meet multiple objectives for people and nature.

Certain attributes of natural capital assessments lend themselves well to place-based renewable energy design and implementation. First, ecosystem service assessments are inherently spatial. Because key social and ecological variables that influence benefits vary spatially, models that quantify ecosystem services tend to take in spatial information and produce spatial outputs. These have the advantage of supporting planning, siting, and other landscape-level processes related to energy generation, transmission, and storage and allow for exploring alternative scenarios at multiple scales: community, utility, interconnection, and physical landscape. Second, ecosystem services are frequently quantified using a diverse set of metrics (Tallis et al. 2011; 2012). While monetary metrics are useful for shining a light on previously unrecognized ecosystem services, other metrics such as numbers of people or demographic groups benefiting, or the production of goods can resonate more with certain stakeholders. Both the spatial information and the multiple metrics for valuing ecosystem services can in turn be used to understand market conditions to renewable energy, engage communities more fully by quantifying potential for local values, and inform financing mechanisms for participation in renewable energy programs through payments for ecosystem services, a practice used to incentivize best management strategies in other sectors (Naeem et al. 2015).

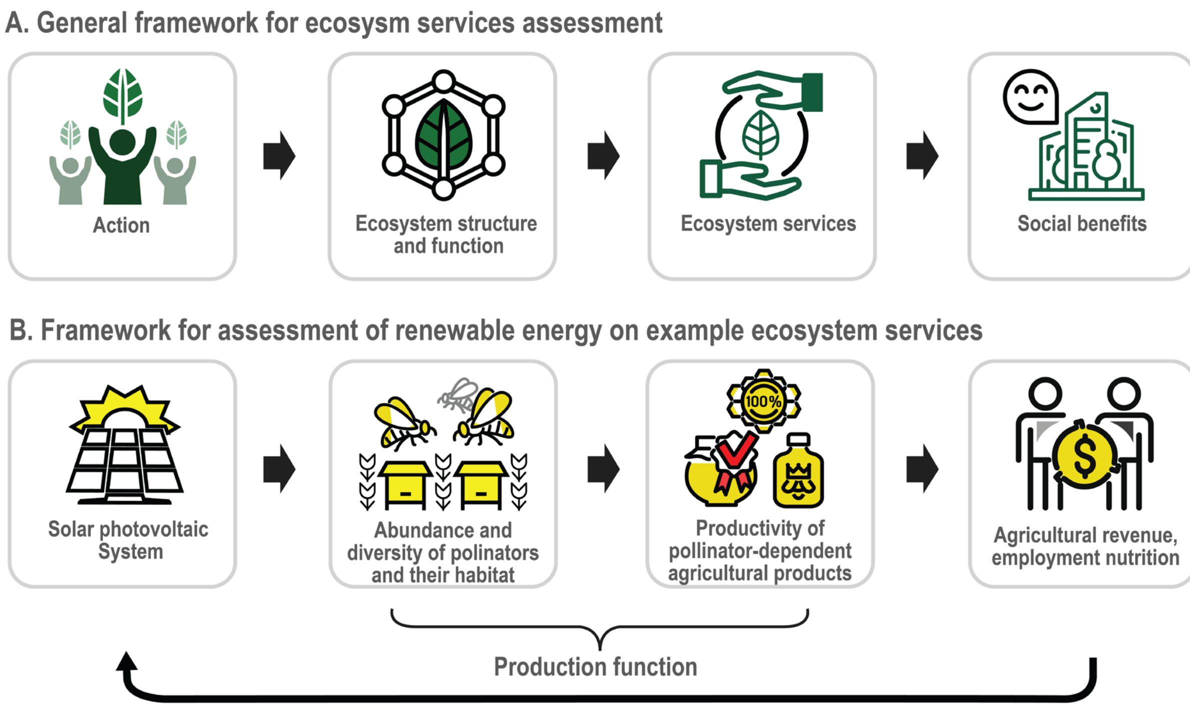

Figure 4 The general framework for assessing the influence of management/development scenarios on ecosystem services and applied to renewable energy technologies/services. Adapted from Olander et al. (2018).

4.3 Generating Local Value

While the development of typical utility-scale renewable energy resources routinely generates value for the company that owns the energy generation and can generate value for distant ratepayers in the form of reduced energy rates, the value for nearby local communities tends to be less tangible. Tensions between the perceived costs borne by rural residents and the perceived benefits to distant cities can result in antipathy towards renewable energy development in rural landscapes valued by nearby communities (Sovacool 2009; Phadke 2011). Generating local value is a pathway to responsible deployment of renewable energy infrastructure that responds to the needs and goals of local communities and landscapes. It works against the conventional paradigm of mitigating negative impacts of renewable energy infrastructure and seeks to transform that infrastructure into a source of value that resonates with those who interact with it (Figure 5). This pathway requires attention to the uniqueness of place with demonstrated commitment for a sustained partnership beyond the typical stakeholders and negotiation periods. This may involve rethinking community engagement strategies, economic structures, and reaching a broader typology of data-supported benefits or mitigation efforts focused on infrastructure through design. Traditionally many of the negative community impacts are rooted in landscape degradations spanning both short- and long-term timelines (Orland and Murtha 2015). The act of generating local value reimagines the development process to create and/or align with perpetual systems of health and improvement in the landscape, responsive to the place-based opportunities, goals, and values.

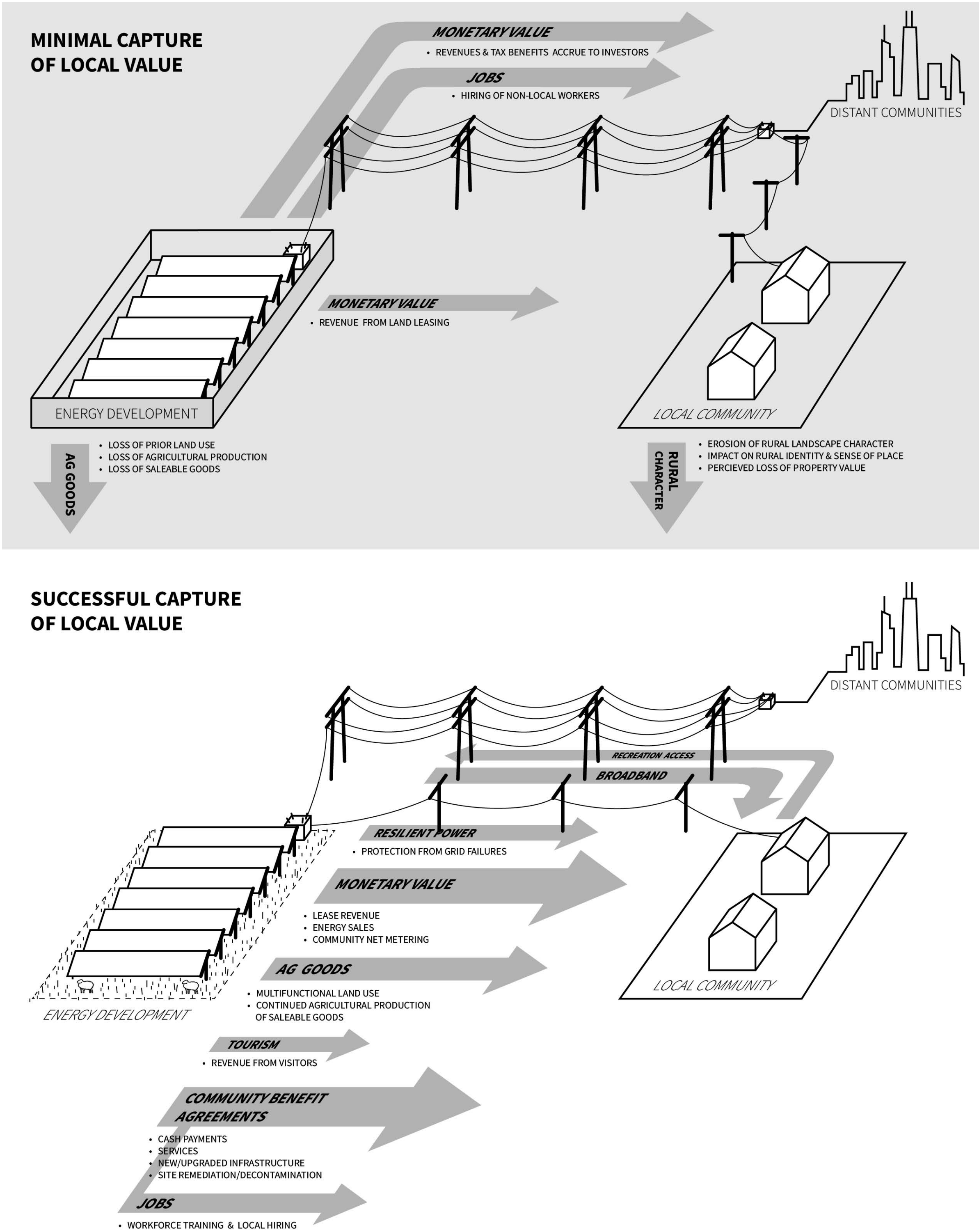

Figure 5 Comparison in the capture of local value from energy developments. Minimal efforts in generating local value from energy developments result in exported benefits while renumerations to local communities are dwarfed by land-use impacts, real or perceived. Successful generation of local value synergizes land uses and place-based opportunities to prioritize benefits directly to the broader community.

Careful planning and study to identify and understand local goals, challenges, and values among affected communities are critical to generating value through renewable energy deployment. It cannot be assumed that blanket applications can be effectively applied across communities and regions without diminishing place identity, especially as we enter higher rates of renewable energy implementation. Efforts must be responsive with attention to place. Responsiveness in design and planning allows for identification and prioritization of synergies and tradeoffs by considering analyses of the genuine opportunities and constraints that occur on particular sites and within particular contexts. This process should involve early participatory and community-based engagement to first avoid becoming a liability, and second to explore possibilities of adding value.

Given the modularity and scalability of renewable energy infrastructure, particular attention should be given to the appropriateness of scale to maximize integration. Scale in relationship to the context responds to existing and planned forms and patterns to fit visually and spatially (Lynch 1964; Dee 2004). Temporal and sequential factors, like speed of movement through a landscape and serial vision—or interest created in the juxtaposition between existing views and emerging views in the progression through a landscape (Cullen 1962)—should also play a role in the scaling and layout of renewable energy systems. Multipurposed and collocated developments may aid in adding value (4.1 Seeking Meaningful Multifunctionality), especially when used restoratively on already degraded or underutilized sites. Regionally responsive renewable energy technologies also play to the natural capital found within a region to promote the uniqueness and community pride (4.2 Respecting and Utilizing Natural Capital) especially if the energy is first used locally before capitalizing on opportunities of exportation. Through these actions and approaches, renewable energy landscapes can be designed to support local goals and overcome challenges, generating value to the communities in which they are built.

However, existing economic models for energy projects must be challenged to realize many local value streams. Traditional models tend to favor only a few local beneficiaries with taxes, jobs and revenues not directly adding value to the local community, and environmental degradations offsetting any real returns (Ruddell 2017). Historical examples of energy booms and busts have resulted in depressed communities dealing with serious environmental problems still today (Gilmore 1976; Lehman and Kinchy 2021). Alternative financial models that perpetually generate local value may be necessary to overcome obstacles toward social acceptance and equity. The objective of these should be to aid in the creation of a shared public/private investment strategy with value appreciation rather than depreciation. Partnerships with local governments and non-profit organizations may facilitate establishment of locally determined shared revenue models such as Community Benefit Agreements, methods for localized offset programs, fee generation for local reparation funds or other economic strategies to be used locally toward the health, safety and welfare needs or risks of community members. Land trust agreements or strategic Transfer of Development Rights models may be explored to maximize long-term value and revenue generation to be calibrated at a minimum to cover potential expenses for the remediation efforts for any tradeoffs and implications.

Local value generation of course is not limited to monetary forms. Public/private partnerships may bring amenities that otherwise may not be implemented on their own. In many cases, renewable energy infrastructure is generally safer than conventional infrastructure and may be more approachable for public accessibility, such as a photovoltaic shade canopy. From a planning standpoint, accessible infrastructure may facilitate physical community connections through paths and trails or synergized with other public uses under a possibly subsidy in paring the uses. Simultaneous community improvements, such as remediation of superfund sites with renewable energy development further adds value. Cues from sustainability rating programs such as SITES, Leadership in Energy and Environmental Design (LEED), and the Living Building Challenge prompt a process to target, monitor, and document data-driven performance metrics with interdisciplinary teams throughout the process of design, construction and management. By using a broad suite of indicators, balance in social, environmental, and economic considerations through strategic synergies and calculated tradeoffs may be more clearly communicated, planned, and executed in conjunction with local communities. Looking beyond implementation, incentivizing decommissioning plans for the infrastructure toward alternative future uses may also help in mitigating concerns of the long-term relationship of the site with the community and give assurances of perpetual investment.

Generating local value must have long-term impact and should not be pursued solely to achieve local support and approval for initial project implementation. In this frame, generating local value respects common conditions and resources with equity and balance beyond the cultural notions of property lines and traditional economic structures. Synergizing renewable energy infrastructure with community needs and goals through a thorough design process brings attention to place that can facilitate the broadening of local value to offset potential negative consequences and expedite the rapid deployment needed in this great energy shift.

4.4 Decentralizing and Distributing Generation at a Local Scale

Distributed energy resources (DERs) and decentralized energy systems (DESs) open a new chapter for decarbonization by generating energy near where it is consumed. This chapter describes significant developments in small-scale renewable energy generation and combined heat and power systems. DERs encompass a range of small and modular energy generation and storage technologies sited close to the location of consumption, most often at the distribution level, and DESs consist of three main parts: distributed energy generation, energy storage, and smart energy flow systems that can manage energy demand response (Adil and Ko 2016; Sharifi and Yamagata 2016; Koirala, van Oost, and van der Windt 2018). DESs in particular are expected to play a critical role in mitigating power outage risks as well as ensuring continuous energy delivery during energy peak times by securing supplementary energy generation sources near end-users (Ko et al. 2019; Adil and Ko 2016; Sharifi and Yamagata 2016; Jasiūnas, Lund, and Mikkola 2021).

One of the challenges of integrating DERs and implementing DESs is a lack of a design approach on how such technologies could be integrated into communities as well as their built environments. Beyond physical and technological feasibility of energy production and storage, design consideration can support DESs to be well-accepted by local residents with fewer conflicts (Meuer, Lamaro, and Vetterli 2021; Thomas and Erickson 2021; Jasiūnas, Lund, and Mikkola 2021; Wolsink 2018; Koirala et al. 2016). DESs containing renewable energy technologies offer a low-carbon, and resilient pathway towards carbon neutrality. Major advantages of DESs over centralized energy systems include supporting low to zero-carbon emissions, offsetting capital intensive investments for network upgrades, imparting local energy independence and network security, and motivating social capital and cohesion (Adil and Ko 2016). However, DESs and DERs can also exist alongside centralized powerplants.

Recently, the concept of the energyshed has increasingly emerged as a key tool in energy planning and management, supporting a wider implementation of localized DESs across landscapes. An energyshed is a spatial extent of energy networks, including the places of energy production, transmission and consumption, and relevant internalities and externalities, describing how far and broad energy systems may be provided and distributed (DeRolph et al. 2019; Thomas and Erickson 2021). This concept could be useful to organize and comprehend the fragmentedly dispersed but organically connected DESs (DeRolph et al. 2019; Thomas and Erickson 2021), ultimately supporting place-based renewable energy development and offering communities a new way to engage with their energy choices.

For example, in an energyshed, the distributed energy generation, storage, and flow control systems can be implemented across the landscape by reflecting physical and social environments including regulations, ordinances, and geophysical conditions. Figure 6 shows a conceptual overview of a DES over landscape transects (urban, suburban, rural, and coastal areas) and how they can be interconnected across the landscapes. The urban core has the highest energy demand per area because of high population and activity density but least available space for energy generation, which demands designers more innovative collocation strategies with existing land uses and surfaces. As we move to suburban, rural, and coastal areas, more land opportunities become available for deploying energy infrastructure but requiring more cost for transmission and storage, and socio-ecological impacts on wildlife habitats and scenic values. Given the increase of urban DES integration, the scale of such ex-urban renewable energy production could be scaled down in size and distances, which will ultimately help renewable energy integration into communities and landscapes. Each area, especially coastal areas, can increase its resilience through storage and microgrids.

A design approach to energy planning can facilitate the place-based DES combined with transmission infrastructures based on geographical characteristics along the landscape transects: a gradient of landscape across urban, suburban, rural, and coastal areas in an energyshed. For example, as renewable energy technologies become more affordable and continue to penetrate the market, urban areas where most energy consumption occurs, open up physical opportunities for much tighter integration of energy in its fabric with emerging and innovative applications of technologies (Kammen and Sunter 2016; Ghosh 2020; Lobaccaro et al. 2019; Macknick, Beatty, and Hill 2014; Broto 2017; Heinstein, Ballif, and Perret-Aebi 2013). Figure 6 shows opportunities of emerging solar PV technologies such as PV pavement, kinetic energy paver, transparent PV modules, and flexible PVs. These can be layered into various surfaces in urban areas including building roofs and facades, right of ways, and underutilized open spaces. Suburban, rural, and coastal areas in an energyshed can provide regional opportunities for semi-commercial/utility-scale energy production and increase the community resilience. The transmission corridors can be retrofitted as an ecological and/or recreational corridor through appropriate design while maintaining their energy infrastructural uses (Hoctor et al. 2007). In the end, the spread and redundancy of well-designed DESs would contribute to creating a resilient energy network system from a single household to a local community and even up to a national level, which will be able to flexibly cope with unexpected energy peak demands as well as climate risks (Ko et al. 2019; Sharifi and Yamagata 2016; Barbour et al. 2018; Koirala et al. 2016; Koirala, van Oost, and van der Windt 2018).

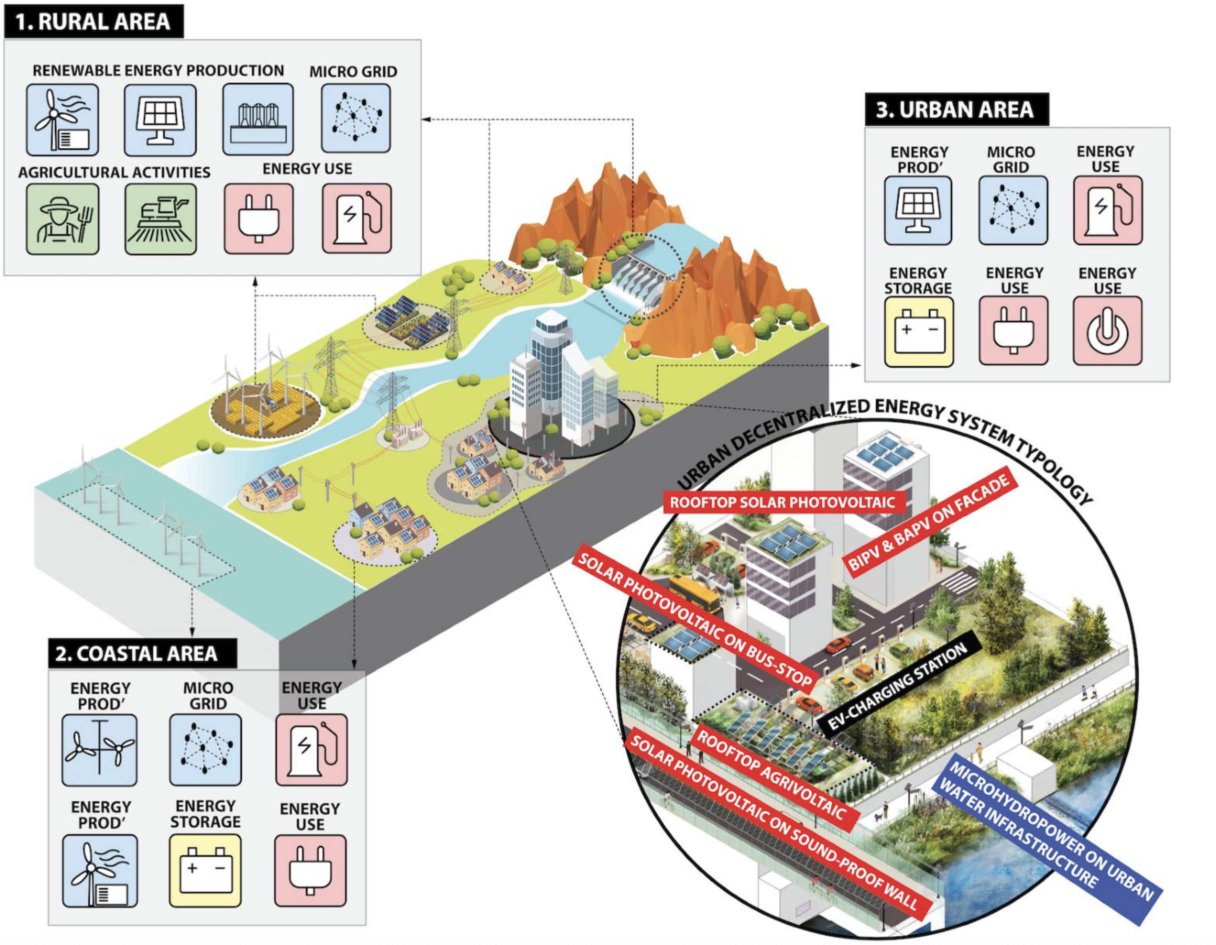

Figure 6 Conceptual overview of place-based renewable energy landscapes over landscape transects and the design typologies of urban DES. Credit: Yeongseo Yu.

4.5 Providing Resilience Against Climate Disruption

Clean energy goals are centered on carbon emissions reductions to mitigate climate change on a planetary scale. Yet communities are already facing vulnerability to climate-driven extreme weather events, such as record flooding, heat waves, bomb cyclones, and wildfires (Masson-Delmotte et al. 2021; IPCC 2021). As extreme weather events confront a brittle grid and outdated estimates of energy demand, cities and towns suffer from climate-driven blackouts and a loss of critical services. Major energy initiatives and investments are needed across the country to bolster resilience of communities to climate change (National Academies of Sciences, Engineering, and Medicine 2017). While the buildout of renewable energy broadly helps to reduce emissions and chip away at the global impacts of climate change, place-based renewable energy design and implementation can offer a measure of local resilience to the *impacts* that communities face in the near term. A resilience-driven pathway to clean energy deployment would prioritize the benefits of increased climate and energy resilience as a motivating factor for communities to become early adopters of renewable energy in their nearby landscape.

Communities that can reduce their reliance on distant energy sources (4.4 Decentralizing and Distributing Generation at a Local Scale) may be better prepared to safely weather climate shocks, especially as long-distance transmission emerges as a common point of failure in the case of hurricanes, windstorms, ice storms, and wildfires. To further help vulnerable communities withstand extreme weather events, development of locally powered “resilience hubs” (Baja 2018) that can retain power during outages (such as through solar energy with battery backup), could be provided by respected local institutions or emergency service providers so that renewable energy can gain credibility within the community while reinforcing the status of local actors and facilities (Farthing, Craig, and Reames 2021). Microgrids can extend such locally resilient systems to incorporate more members of the community, and a greater number of structures (Newman et al. 2021).

Higher resilience of energy systems demands higher flexibility on both the supply and the demand side (Nik and Perera 2020; Auffhammer, Baylis, and Hausman 2017). With a portfolio of energy resources, one source helps to compensate supply when another is low or unavailable. Renewable energy generation, such as through distributed solar, wind, or tidal energy sources, can leverage local resources and offer a strategy for increasing capacity within a service area. Rather than continuous energy generation, smarter demand-side management can help to ensure access to a suite of energy services that renewables can help to provide – electricity, heating, and cooling. Populations with higher vulnerability to electricity outages will require special strategies and accommodations under a grid disruption and given resilience context (flooding, heat wave). Renewable energy can enable critical interdependent functions to be restored (e.g., water service) or take care of higher-needs populations within a community (e.g., medical device dependent, low mobility). Flexibility in supply and demand and targeting energy delivery to the populations that depend on it most is not straightforward to do. Utilities require the motivation, capacity, and resources to plan (Cooke et al. 2021). Designing, planning and accounting for these multiple values is an important component of understanding and communicating the costs and benefits of renewable energy technology for the climate and energy resilience of communities.

Understanding the critical services that support communities —water, sustenance, cooling, heat, communication, and protection from hazards—may help to inform more transformative visions of place-based renewable energy transitions. Integrated energy projects developed with an eye towards these fundamental services could help to enable both climate and energy resilience. Renewable energy development results in physical infrastructure that with creativity and ingenuity, informed by community aesthetics, can be envisioned and designed to not only deliver clean energy, but also other services (Figure 7). However, integrated design adds complexity and cost, so there is a need to understand from communities if these values resonate with them and then to use quantitative analysis to show that these other values are real and meaningful. Strategic deployment of renewable energy can be half the work as is the case with passive solar dwellings. Designing a home to properly orient windows, absorb and distribute heat, and implement control strategies requires attention to detail. These considerations must be made early in the design stage and show that they speak to homeowner preferences in aesthetics as well as provide fundamental services.

Another example of the potential for integrated energy design is ocean thermal energy conversion (OTEC). OTEC leverages temperature differentials in tropical areas to not only generate electricity by bringing colder deeper waters to the surface, but also to supply desalinated water as a by-product (OES 2021). This cold freshwater can be used for air conditioning, refrigeration, and drinking. OTEC facilities are expensive and require a significant temperature differential to generate power (usually ~20 degrees Celsius). Pipes also must reach significant depths (usually around 1000 meters). However, the OTEC example is useful for illustrating the multiple factors that need to be considered to truly fulfill a vision for climate and energy resilience. Development of coastal OTEC facilities—or any coastal energy facility (this would also apply to seawater air conditioning (SWAC) for example)—should consider the role of coastal ecosystems in helping to reduce the risk of communities and infrastructure to natural hazards made worse by climate change. Coastal OTEC pipes need to be laid from the onshore facilities to offshore areas with the proper depth and temperature gradient. Such development can impact the coral reefs, mangrove forests, wetlands, and dunes that help to attenuate waves, reduce storm surge, and stabilize sediments. By carefully siting OTEC facilities and storage capabilities inland from these natural buffers, and running pipes around, rather than through ecosystems, energy facilities can benefit from nature-based reductions in flooding and erosion and support coastal community safety. Meanwhile, communities benefit from a local source of energy that also supplies freshwater and cooling capabilities. As another example, heat island effects in urban areas can lead to increased exposure of vulnerable communities to extreme temperatures. Designing renewable energy infrastructure to cool down impervious surfaces, enhance publicly accessible green space and support vegetated features in cities could help improve climate resilience, supporting stronger social ties and more robust social infrastructure (Klinenberg 2018), especially for Black, Indigenous, and People of Color and lower income communities where green space is often sparse and heat more extreme.

In Puerto Rico, where residents lived through the extensive blackouts following Hurricanes Irma and Maria in September 2017, renewable energy microgrids and resilience benefits go hand in hand. Hurricane Maria knocked out 80% of Puerto Rico's power lines, plunging the island into the largest blackout in U.S. history (Houser and Marsters 2018). In the mountain town of Adjuntas, which was among the last to have power restored, a full 10 months after the storms (Coho 2018), the environmental nonprofit Casa Pueblo benefitted from solar panels on the roof of its headquarters, enabling it to act as a hub of communication, electricity charging for personal devices and emergency medical equipment, and to continue operating its community radio station in the months after the hurricanes—an "energy oasis" in otherwise dark Adjuntas (Massol-Deyá 2020). Casa Pueblo had installed the solar panels in 1999 with a goal of energy autonomy, and after the hurricanes helped residents install solar on their own roofs.

Another nonprofit, Resilient Power Puerto Rico (RPPR), which grew out of post-disaster relief efforts by Marvel Architects, has been equipping dozens of community facilities with rooftop solar energy systems, with 38 freestanding solar installations to date, as part of their Community Solar Energy Initiative (Resilient Power Puerto Rico n.d.). They focus on historically underserved communities across the island, identifying sites that would "generate the greatest community impact" (Resilient Power Puerto Rico 2018). By strengthening the resilience of existing community facilities such as community centers, schools, and churches which already serve as hubs of daily life and activity, energy transition efforts receive added legitimacy, while strengthening the status of these institutions and their leaders within the community, who now have direct control of their local energy generation in case of future grid failure.

Growing technical capabilities in climate risk assessment, energy resource analyses, and ecosystem modeling are making it easier to identify and prioritize the most vulnerable communities. Through stakeholder and citizen engagement, it is possible to identify which communities may have the most interest in, and benefit from, climate resilience initiatives and energy transitions that address their vulnerabilities. A key part of these engagement processes is understanding—from the people on the ground—the climate and energy challenges they are facing. How are these challenges affecting their lives and livelihoods and what are the barriers preventing them from realizing their vision for the future of their communities? Through such engagement, citizens, scientists, decision-makers, and industry leaders can explore the suite of renewable energy options and quantify the outcomes of alternative scenarios for energy transition and climate resilience.

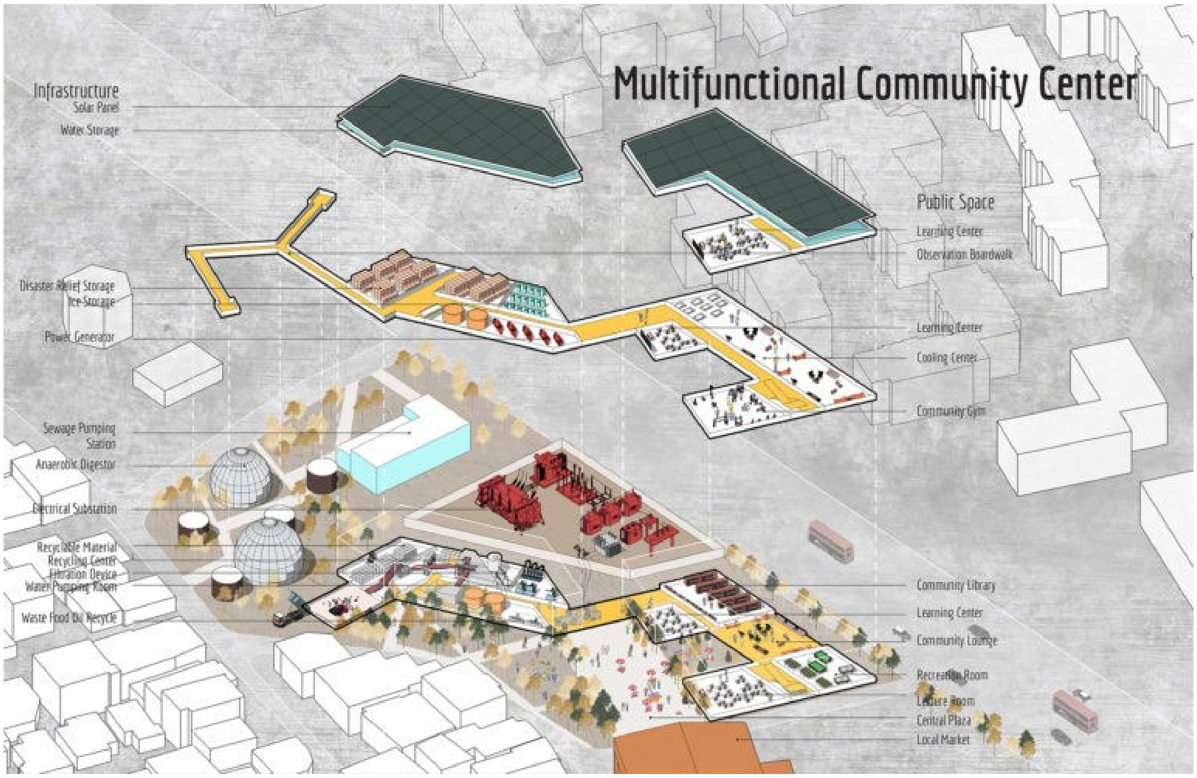

Figure 7 A proposed multifunctional community hub for the Playita neighborhood in San Juan, Puerto Rico, with both the infrastructural and the public space functions articulated. Such hubs would serve the social and infrastructural functions of the community's daily life, but also stand ready to provide emergency functions in case of a grid-wide power outage. Credit: Zhiyu Wei.

4.6 Promoting Energy Justice

Energy equity not only highlights systemic problems, it gives us a vision for how technology can be deployed to create a more equitable energy system.

All too often, the siting and development of historic energy infrastructure has created environmental burdens for vulnerable communities or reinforced and exacerbated harms that those communities were already facing. Although energy systems have a pivotal role to play in mitigating climate change and the corresponding climate threats, the transition to a clean energy future does not, on its own, guarantee that there will be equitable outcomes across communities (Finley-Brook and Holloman 2016). Many communities—particularly communities of color, those with low to moderate incomes, and frontline communities—have not had the same kind of inclusion or participation in the energy system compared with other communities. This has manifested in the absence of their voices in when and where energy projects are developed, leading to adverse health effects and discrepancies in energy-related wealth accumulation (Lennon 2017). An energy justice pathway to place-based clean energy at scale recognizes these inequalities and strives to correct for them through sensitive clean energy development as well as through thoughtful decommissioning of older projects.

Energy justice as a concept is based on the principle of the fair distribution of both the benefits and costs of energy, "representative and impartial energy decision-making" (Sovacool and Dworkin 2015), and the equitable participation of all people in the energy system, from both a social and economic perspective (Cooper 2019). Energy justice builds on environmental justice scholarship and definitions, including the emphasis on the spatial distribution of benefits and burdens (what is referred to as *distributive justice*), as well as the way that decisions are made and how communities are involved (referred to as *procedural justice*). Distributive justice within the energy justice discourse builds on classic environmental justice investigations of the unequal spatial siting of hazardous waste sites and other harmful facilities, extended to questions of energy infrastructure. Other aspects of distributive justice include impacts from sourcing of materials for renewable energy and how waste produced through the life cycles of materials could disproportionately impact certain communities. Procedural justice focuses on fair process and includes things like having accurate environmental impact assessments prior to energy infrastructure development and having fair and meaningful participation in energy decision-making. The third tenet of energy justice, *recognitional justice,* considers the cultures and values of the affected parties and grapples with how society and culture are structured. It also seeks to counter non-recognition, cultural domination, and disrespect of some communities and social groups (Jenkins et al. 2016).

Designing for greater distributional justice is a powerful paradigm for change in energy infrastructure. Its goals can be supported through siting decisions that apply spatial filters to prioritize place-based clean energy investments to counter legacies of harm to communities from prior energy development. This might mean siting clean energy projects to replace and retire the most polluting coal, oil, or gas-fired power plants based on the distribution of pollutants harmful to human health such as SOx, NOx, mercury, or volatile organic compounds emissions, rather than an evaluation that looks only at greenhouse gas emissions. It could mean designing local clean energy projects such that their development supports the remediation of legacy pollution or damage, such as abandoned coal mines and polluted streams that plague many coal communities, or uranium mines that harm many Native American communities. It could also mean identifying communities facing disproportionate energy insecurity (inconsistent and unreliable energy) and/or energy burden (excessive cost of energy), prioritizing clean energy development there, and structuring these projects so that these communities can benefit economically.[4]

Where renewable energy projects are sited determines which communities have the effects – positive and negative – from hosting renewable energy production, such as which workers are able to benefit from their installation. Energy justice in place-based renewable energy development would site and develop projects in ways that make reparation for historical inequalities in investment (i.e., *restorative justice*), by enhancing equity in prioritizing disadvantaged communities in clean energy jobs and career development. The building stock in many low-income communities, for example, suffers from legacies of underinvestment or deferred maintenance, and the design of local clean energy projects in such contexts could be configured for such conditions; they could be designed to improve the existing built environment through building upgrades that tangibly improve living conditions. By actively seeking out a larger suite of energy upgrade opportunities for building performance, renewable energy

[4] The energy justice pathway is nonlinear and unique to each community, whether in terms of a community's goals and values, its particular historical and cultural context, and its physical environment, which makes it necessary to design projects that can be tailored to given conditions.

installations can be designed to incorporate custom solar, geothermal, battery storage and thermal energy storage for a wide variety of building types and configurations, while minimizing displacement of residents during upgrades.

Clean energy investments can be coupled with new appliances and deep energy retrofits, which can improve buildings' energy performance and reduce residents' exposure to extreme weather events such as heat waves, cold snaps, or flooding. Clean energy projects can be designed to reinforce public spaces in the community, leading to more social interactions and stronger social infrastructure (Klinenberg 2018), further strengthening communities climate resilience (4.5 Providing Resilience Against Climate Disruption). Designing these public investment programs, upgraded building systems, and clean energy systems to amplify their public visibility can advance energy literacy in the community, increasing community involvement in the design and governance of subsequent community energy projects (Figure 8).

Designing for energy justice doesn't stop at the configuration of the physical technological installation, but extends to the design of the financing, ownership, and fee structure of these projects. Energy investments need to address communities' economic vulnerabilities and empower them in energy decisions that will affect them. Procedural justice can be supported by ensuring community ownership or other directly controlled wealth-building opportunity, local control over decision-making, and community engagement that involves the community in the design of clean energy projects. This may entail privileging local ownership of renewable energy generation over more traditional utility models, such as through communal energy cooperatives or private ownership of energy producing equipment, accompanied by well-designed financing and generous net metering rates (Baker 2021). These types of ownership models and incentives can serve as a tool for connecting communities to their energy technologies directly, igniting new conversations and visions for what able energy development looks like and the value it can create.

Grappling with questions of recognitional justice within the energy justice discussion is perhaps trickier, as it entails highlighting larger structural questions of societal and cultural recognition and value. For example, for many Indigenous communities, for whom the system of private property itself is a harmful vestige of settler colonial power dynamics, how does one pursue energy development projects in ways that recognize the harm of historical patterns of dispossession and try to make amends? How does one rebalance environmental impact assessments in ways that recognize the inherent value of non-human animal species that carry special cultural significance? Even clean energy sources such as hydroelectricity have perpetuated acute legacies of harm for some Indigenous communities through their transformation of the pre-existing landscape (5.0 Historical Perspective).

From a recognitional justice perspective, an energy justice pathway will need to critically consider the history that has led to the existing energy system, including the structures of power and influence that privilege incumbent players and wealthier communities. In the absence of doing so, reconciling historic harms and generating equitable outcomes in the future is difficult, and risks replicating patterns of extraction and exploitation within the new clean energy system. An energy justice pathway will also need to reassess the processes by which decisions are made about the future directions of the energy system,(Kazimierczuk, Demenno, and O'Neil 2022) and who is empowered to participate in the decision-making. And it will have to expand the definition of what constitutes value—not limiting the definition to monetary value but including other values of importance to communities in energy decision-making, in consultation with those communities to ensure energy landscapes are designed to produce them.

By utilizing design-based approaches to support place-based renewable energy development, vulnerable or historically burdened communities can be put at the forefront, supporting their energy goals within a broader portfolio of needs by visualizing what that future looks like. In doing so, local energy infrastructure begins to serve more than one purpose for the energy system. It moves beyond its historic value as strictly an energy technology, and it begins to strive towards equity in social and economic participation in energy development. This pathway is nonlinear and unique to each community.

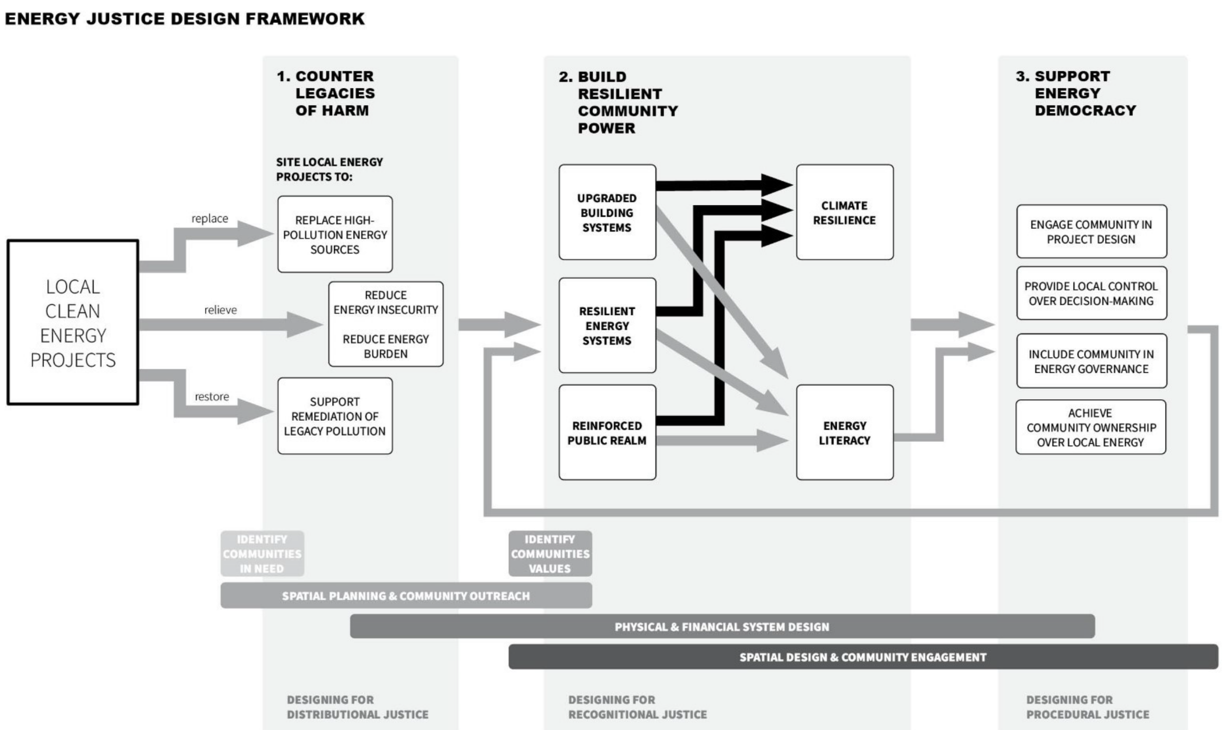

Figure 8 A framework for designing for energy justice. Clean energy projects should try to counter legacy harm from prior energy development and/or counter energy vulnerability through their siting, should be developed with community involvement in design and governance, and should be designed to increase energy literacy, improve the existing built environment, and build community empowerment.

5.0 Historical Perspective

Climate change is a new challenge, but the question of rapidly building up new energy infrastructure has historical analogs. We can look back at historical deployments of energy infrastructure and see their impact: not only the extent to which they altered the technological landscape, but how they impacted the cultural and natural layers of the landscape as well. Nor is the renewable energy transition the first time that the "technological object" of an energy regime has "collided head-on … with the quintessential object of the natural sublime," (Nye 1996: 137).

Hydroelectric infrastructure offers some clear historical precedents of such confrontations—such as when hydroelectric power plants and factories transformed the waters of Niagara Falls or when the Hoover Dam and other Bureau of Reclamation dams were built across a variety of Colorado River canyon landscapes (Reisner 1993). In each of those cases, design was deployed to help the technological object itself take on qualities of the sublime. The infrastructures drew visitors and onlookers, both during their construction and upon their completion, who used language very similar to that used to describe sublime natural landscapes—awe and grandeur—but evoked here by the scale and power of these feats of engineering, a "technological sublime" (Nye 1996: 136-7, 140) (Figure 9).

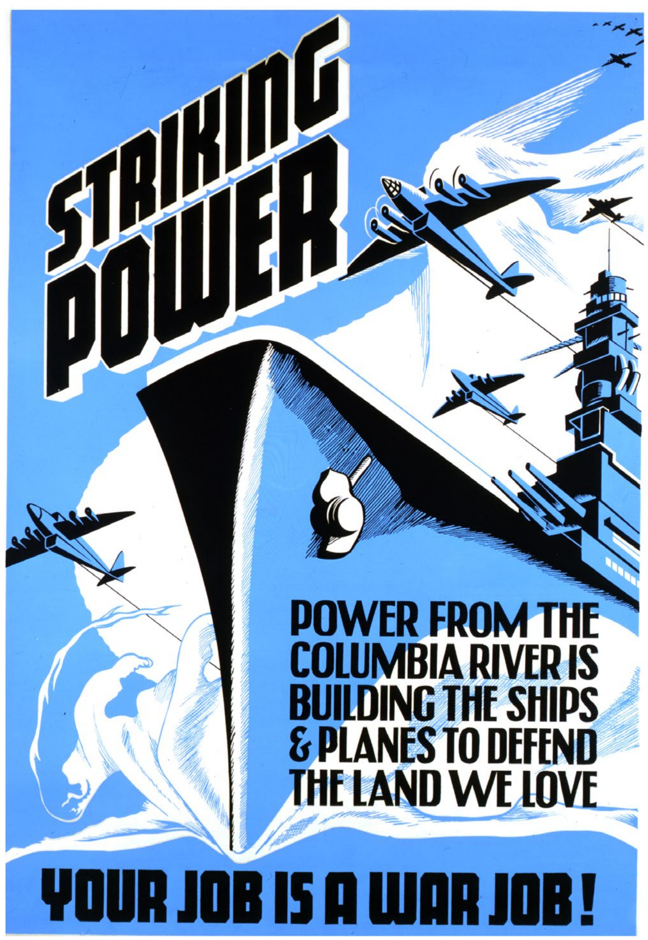

Figure 9 Bonneville Power Administration poster from World War II.

The language of multifunctionality that this paper argues for similarly has historical precedent, especially during the New Deal: the Tennessee Valley Authority (TVA) repeatedly described its individual facilities as units of its “Multi-Purpose System of Dams,” which combined flood control, navigation improvements, and electrical power generation along with publicly accessible reservoirs, fertilizer production and new industries, and improved forest land management (“The TVA System of Multi-Purpose Dams Historical Marker” n.d.). In order to provide the maximum public benefit to the new resource it had created, the TVA initially sought to retain at least a quarter-mile buffer around the new reservoir lakes, to dedicate to recreational public access and wilderness. At least as initially planned, TVA lakes were to be fringed by scenic publicly owned forests and picnic areas, provided with public boat launches, and managed for free public recreation, such as hiking, hunting, and fishing (Creese 2003: 268). Such multifunctionality and integrated resource development supported the ideas of New Deal reformers who believed that New Deal programs should promote cross-cutting benefits for a larger collection of actors, such as farmers and stockmen on the one hand, as well as hunters and nature lovers on the other, assembling in this way a durable political coalition—an approach that Rural Electrification Administration director Morris Llewellyn Cooke called “total conservation” (Maher 2008: 204).

TVA visitor centers at the various dams told this story of multifunctionality, of improved natural resource development, and of the local economic benefits and improved quality of life that resulted from the TVA’s efforts. It did so by using explanatory outdoor signage and detailed visitor center exhibits. Visitor centers responded to and supported strong interest from the visiting public—TVA dams were intended by design to be destinations, and they were, receiving over a thousand annual visitors in the decade after World War II, half of them international visitors (“Classroom for the World” n.d.). The visitor centers were part of a carefully curated architectural and landscape design agenda, which landscape architect Jane Wolff has catalogued: “Each dam had a visitor center that recapitulated the TVA’s story of the Valley...Picture windows and balconies framed views of the dams and their surroundings, which had been reconfigured so subtly and so gracefully that the pouring of hundreds of thousands of tons of concrete did not seem to have entailed any disruption.” Deliberate roadway design carefully curated views of the dams from both the distant view and from up close, strengthening the connection between visitor center, dam, and reservoir. As Wolff puts it, “The roads created sequences of images—dam from afar, wooded hillsides, visitor center, dam from nearby, view of dam and visitor center from middle distance...Foreign visitors were heard to comment on the fortunate location of so many dams in such beautiful parks” (Wolff 2007: 57).

Design was extensively deployed in New Deal-era dams for its powers of persuasion, including a wide range of design formats. The architecture of the visitor centers, the turbine halls, and the dams themselves conveyed feelings of modernity and efficiency, a welcome change from the depravations of the Great Depression (Creese 2003). Murals, mosaics, terrazzo inlays, and even the typography reinforced the TVA’s Progressive values, and the messaging of the dams as being “built for the people of the United States”—a message inscribed on every TVA powerhouse (Wolff 2007: 57). The Bonneville Power Administration (BPA), like the TVA, produced documentary films promoting its accomplishments, and the BPA even went as far as commissioning folk singer Woody Guthrie to record an album about the Columbia River dams (Menig 1975).

The TVA offers an instructive precedent in spatially aware large-scale energy development; it was an example of extensive public works overseen by generally well-intentioned government officials operating across an extensive rural region—in this case one characterized by extreme poverty, severe soil erosion, and very low rates of electrification. The TVA pioneered an early form of ecological planning that attempted to balance natural and human development, following the urging of New Dealers like Cooke to “get the whole thing mapped out” and “plan the whole job” in order to help multiple agencies coordinate efforts and avoid duplication or cross-purposes (Maher 2008: 203). It incorporated planners and designers in pursuit of a mission of public benefit. Between their stimulation of civic interests, their provision of free public recreation, their channeling of the technological sublime, and their earnestness in demonstrating improved land stewardship and the latest in technology, these public works were perhaps the best example of a multifunctional energy infrastructure deployed at scale, with the improvement of local values as a major driving principle.

5.1 Contestation

Large hydroelectric dams of course are also iconic not just for their engineering prowess, but for the extent of their environmental transformation: their great scale, the extensive flooding of land for reservoirs, their interruption of the natural flow of rivers. Wherever it be in the Pacific Northwest, in the Missouri River Basin, or in the Tennessee Valley, these large energy infrastructures are inscribed with deep cultural significance but also long histories of harm and contestation.

Construction of the Bonneville Dam in 1933, Dalles Dam in 1957 and John Day Dam in 1972 across the Columbia River, for example, resulted in the displacement of Native American villages and treaty-guaranteed fishing sites belonging to the Nez Perce, Umatilla, Yakama, and Warm Springs tribes (Estes 2019). The construction of the Dalles Dam resulted in Celilo Falls (or Wyam), a culturally significant gathering and trade site and tribal fishing grounds located 14 miles upstream to be completely submerged within a day. Although there was a cash settlement with the Tribes, the US government did not purchase the Tribes’ fishing rights as established in the 1855 treaties and the fishing sites were never recovered (CRITFC n.d.). When in 2019 the Yakama Nation Chairman JoDe Goudy called for the immediate removal of the Columbia River dams, he said that the Congressional acts authorizing the dams did not have the tribes’ “free, prior, and informed consent as required by the Treaty of 1855,” and that they “were built on this false legal foundation, and decimated the Yakama Nation’s fisheries, traditional foods and cultural sites” (Goodykoontz 2019; Flatt 2019).

Similarly, the 1947 Garrison Dam across the Missouri River flooded more than 150,000 acres of the Fort Berthold Reservation, displacing hundreds of Mandan, Hidatsa, and Arikara Nation families and denying the tribes’ land and water rights, guaranteed in perpetuity by the Fort Laramie Treaty (Berman 1988). As Indigenous scholar Nick Estes put it, “four-fifths of the tribe was removed, and 94 percent of their agricultural lands were flooded” thanks to the Garrison Dam (Estes 2019). Between the 1953 Fort Randall Dam and the 1962 Oahe Dam and other dams on tribal reservation lands, “in Lakota and Dakota communities, 75 percent of the indigenous plant and wildlife was destroyed; 90 percent of commercial timber was lost; and one-third of the reservation-based populations were removed” according to Estes (Estes 2019).

Between the loss of rich fertile valley bottomlands, where many Indigenous villages were located and where crops were primarily grown, to the loss of traditional fishing sites (and the larger damage to fish populations), hydroelectric energy infrastructure construction has done much harm to many Indigenous nations. It has damaged treaty fishing rights, treaty land rights, and treaty water rights. It is no surprise, then, that Indigenous communities have been demanding the removal of this historic dam infrastructure, despite the cultural and economic value it continues to play for non-Indigenous populations in the dams’ respective regions.

5.2 Lessons from History

What lessons do these historical examples hold for the new renewable energy landscapes of today? As in these hydroelectric precedents, with their dedication to design and public access, we can see a value today in opening facilities to the public and inviting the public to appreciate both the scale and, perhaps, the careful integration of these energy infrastructures into their surrounding landscape—as well as their economic and resilience contributions to the grid. To be successful in this message, the design of the infrastructures has to demonstrate a care and nuance in how the energy systems land on the ground, successfully amplifying or enhancing some quality of the site rather than damaging it. Multifunctionality makes a good case for doing more with less and of demonstrating good responsible land management, as exemplified by the better examples of New Deal hydroelectric reservoir watershed development.

Scale can be a powerful experiential factor, giving the visitor the feeling of being dwarfed in the proximity of a powerful technological object or feeling the productive efficiency of spinning generators producing electricity. The siting and placement of an energy facility can enhance or frame existing natural or cultural features either through juxtaposition or through engagement—a clean Cartesian geometry of energy infrastructures playing up, juxtaposing against, or arrayed in dialogue with notable natural site features of a similar scale. These qualities can be appreciated from afar when the energy infrastructure is visible from prominent moments in the landscape, as New Deal dams were visible from their approach roads and reservoir overlooks, or from up close, with the infrastructure perhaps supplying its own vantage points to enhance the appreciation of both itself and its surrounding landscape. We can imagine massive renewable energy infrastructures such as wind turbines or concentrating solar-thermal power plants granting visitors controlled access, curated to help them appreciate the scale, height, or organization of these infrastructures much as New Deal dams enabled visitors to do from the public roadway atop the dams themselves. With extensive horizontal energy landscapes, the vantage point may be different, but there can be ways of designing public access or curated vantage points into the edges of vast solar arrays or other such facilities, or into selective public passage right through their very center.

But we can similarly draw lessons about the kinds of practices that should be avoided. Certainly the kinds of exclusionary, unequal, and prejudiced hiring practices and workforce housing policies that were documented must be forcefully rejected, and a premium placed instead on policies and practices that can benefit low-income communities and communities of color. And the targeting of Indigenous lands and foodways for the externalities and harms of energy development that characterized major New Deal-era and post-war hydroelectric projects is a historic harm that continues to reverberate for many Indigenous communities today; such unequal impacts must not only be assiduously avoided in energy development today, but opportunities for reparation pursued.

New renewable energy development must carefully consult with—or better yet, co-manage and co-design with—communities so that impacts to important cultural sites, to Indigenous treaty land, water, and hunting and fishing rights are not infringed upon, and so that these communities can reap direct short- and long-term benefits from new energy development. This means both a full assessment of environmental impacts, including impacts to culturally important plant and animal species and their habitat, as well as proactive mitigation measures in case of unavoidable harm. In prior deployments, community concerns were often overruled in favor of benefits for more powerful, more distant actors but equally a concern today when major utility-scale renewable energy facilities are being built with the goal of exporting the vast majority of the produced electricity to far-away cities. This is why this paper discusses the role of decentralization as opposed to central systems (4.4 Decentralizing and Distributing Generation at a Local Scale) as well as the importance of generating local value (4.3 Generating Local Value for Communities) as remedial pathways. The disconnect between where people live and where their energy is generated is also the motivation for the concept of energysheds, so that people have a greater understanding of the spatial relationship between energy generation and consumption.

By including the public as a stakeholder, integrating local values into the design of the engineering and the landscape elements, but also by treating energy facilities as sites of energy education, demonstration, and appreciation, clean energy projects can model civic values, good land and planetary stewardship, and enable the public to become more comfortable and accustomed to the dramatic changes of the modified energy landscape.

6.0 Conclusions

As society continues to deploy renewable energy sources, there is a real need to thoughtfully consider how technologies and installations are designed with attention to place to enable deployment at scale. Inviting a diverse group of people and disciplines to the table to imagine what this looks like is key to enabling that and ensuring that deployment is both sensitive to and considerate of local communities. For what gets built is not just a moment, but a legacy of infrastructure over time and space where people, animals, industries, and the environment must also thrive alongside energy infrastructure. It requires innovation and rethinking how our existing landscapes can intersect with renewable energy (Figure 10).

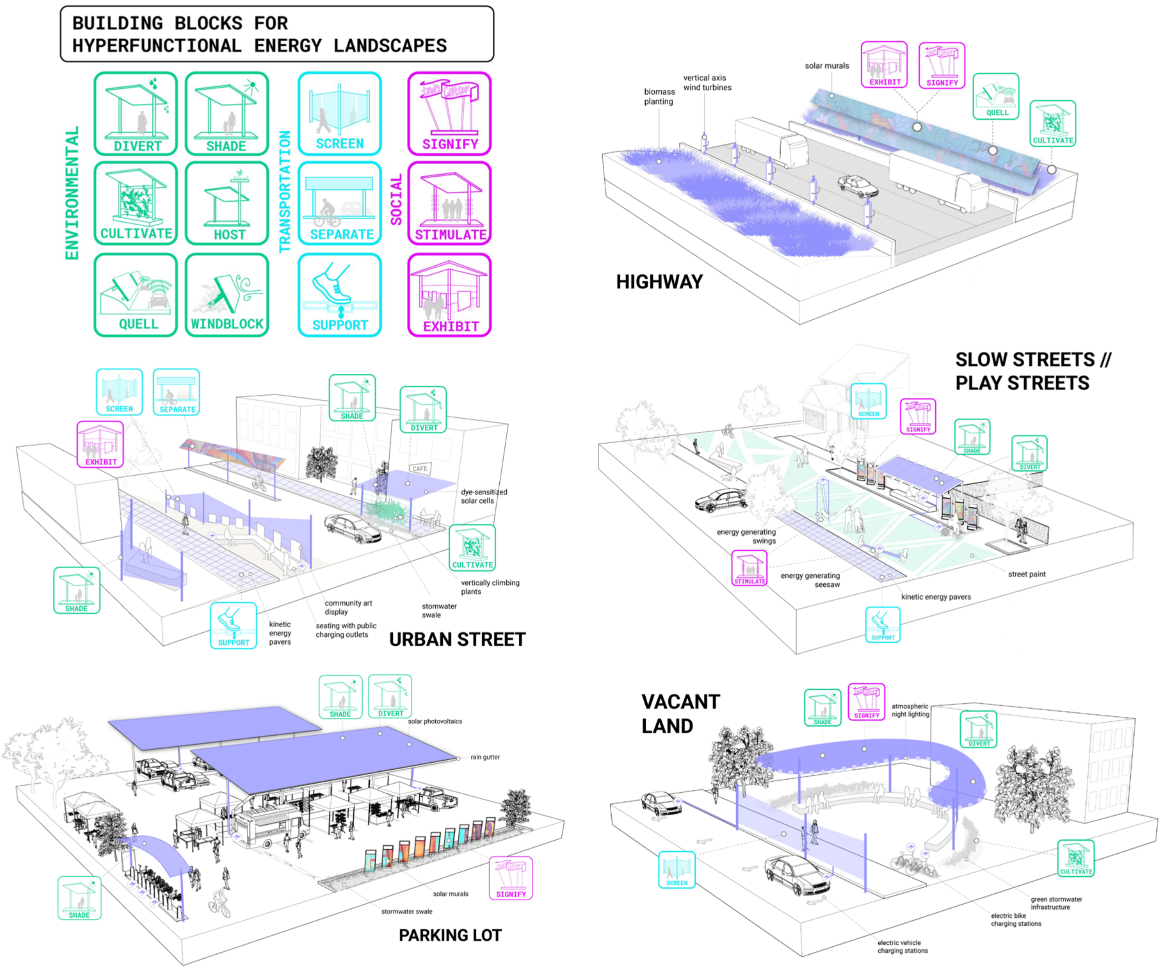

Figure 10 Innovative design opportunities for distributed PV systems on urban environments including the right-of-way and public spaces to create synergies with urban ecology, social spaces, and sustainable transportation. Credit: Alison Grover (Grover 2021).

This paper has illustrated that the challenges and tensions that lie ahead in the development of renewable energy require innovation in methods, commerce, value, and technology design. Six pathways highlighted the ways through which renewable energy landscapes can be imagined, each one offering a perspective on prioritizing communities and creating local value.

- Multifunctionality embraces collocating renewable energy technologies with other land uses in urban, suburban, rural, and coastal communities. The resulting configuration of collation will depend on the type of site, renewable energy, and components that comprise the system. While multifunctionality may result in trade-offs in efficiency for energy generation, the more efficient use of land can promote place-based deployment at scale.

- Like other types of infrastructure, renewable energy development can have an impact on ecosystems. Well-planned and thoughtfully designed installations can capitalize on the positive value infrastructure can generate for ecosystems while also mitigating harm. Assessing natural capital when siting projects will allow communities to meet objectives that serve both people and nature.

- To generate local value through renewable energy landscapes requires attention to the uniqueness of place. To understand what communities value requires redesigning community engagement strategies and economic structures, as well as reaching a broader typology of data-supported benefits and mitigation efforts. Perpetual action must be taken to generate this value. A thorough design process can bring attention to place and align energy development with that value.

- With distributed energy resources and decentralized energy systems poised to play a key role in decarbonization, there is a need to develop design approaches that integrate technologies into communities and their built environments. Reflecting the physical and social environments of a landscape in energy development can open more physical opportunities for technology adoption through innovation and a reimagining of space.

- Prioritizing the benefits of increased climate and energy resilience through design can motivate communities to become early adopters of renewable energy in their nearby landscapes. By understanding the critical services—water, sustenance, cooling, heat, communication, and protection from hazards—that support communities, energy developments can be designed to serve them.

- To design for energy justice in renewable energy landscapes means both configuring the physical infrastructure in a way that distributes the benefits and costs of the installation as well as fairly constructing the financing schemes and ownership models for energy projects. Doing so can put vulnerable or historically burdened communities at the forefront of renewable energy deployment, utilizing design-based approaches to support them in envisioning their energy futures and realizing the value that can accompany it.

These pathways look forward to a future clean and just energy system, but lessons derived from historical developments can serve as guideposts both in how to achieve the desired outcome and how to avoid harm. To move these pathways into practice will require further research to understand how and where design should come into energy planning processes, convening stakeholders in large-scale, well-designed conversations to set the vision, and learning from other infrastructure that has had success in transforming landscapes for local value. Now is the time to move beyond traditional, incremental thinking around energy development to ensure that the journey ahead is truly transformative and maximizes the benefits that our energy system can provide.

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