

Urban Sustainability

Ali Cheshmehzangi  
May Tan-Mullins  
Martin de Jong  
Rob Raven *Editors*

# Transforming Cities

Urban Growth, Resilience, and  
Ecological Innovation

 Springer

# Urban Sustainability

## **Editor-in-Chief**

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The Urban Sustainability Book Series is a valuable resource for sustainability and urban-related education and research. It offers an inter-disciplinary platform covering all four areas of practice, policy, education, research, and their nexus. The publications in this series are related to critical areas of sustainability, urban studies, planning, and urban geography.

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*For the victims of misguided development,  
i.e., vulnerable communities with limited  
resilience, facing environmental degradation  
and social deprivation.*

# Preface

Cities are humanity's boldest experiment; they are living, breathing organisms that reflect our goals, failures, and potential rather than being static reminders of the past. The future will either be won or lost there. Urbanization, however, is all too frequently viewed as a numerical game of population expansion, building goals, and financial rewards. The city loses its social cohesion, ecological context, and global obligations in this simplistic calculus. A drastic shift from that perspective is advocated in "*Transforming Cities: Urban Growth, Resilience, and Ecological Innovation*." It advocates for cities to grow intentionally, wisely, and within the bounds that support life rather than by accident.

This book's premise is straightforward but challenging: "Transformative Growth" is about evolution rather than expansion. It is a pledge to rebalance the forces of urban growth such that each new neighborhood, street, or skyscraper enhances rather than degrades ecosystems and communities. Growth that causes soil erosion, landscape fragmentation, and a widening of disparities is not progress; rather, it is managed decline that passes for achievement. Cities must be transformed by moving away from growth driven by profit and toward stewardship motivated by purpose. It is to view development as an opportunity to restore living systems, foster trust, and ensure lasting value rather than as a zero-sum trade-off between the economy and ecological.

The pathway to such transformation is neither singular nor straightforward. It necessitates reconsidering our investment, governance, and planning practices. In an era that demands accuracy and innovation, traditional methods such as parcel-by-parcel approvals, top-down masterplans, and checklist-style sustainability are ineffective tools. Coherent ecological frameworks take the role of patchwork urbanization in landscape-first planning. Greenwashing is replaced with measured performance, which links investment to observable social and environmental results. Collaborative governance takes the place of unilateral decision-making in co-regulation, where communities, governments, and the private sector share accountability.

If cities are to prosper in a century characterized by resource restrictions and climate volatility, these changes are fundamental, not optional.

At the heart of this transformation lies resilience. The increasing frequency of climate shocks, such as heat waves, fires, floods, and sea level rise, has revealed the vulnerability of the urban systems that we previously thought were unchangeable. Resilience cannot be viewed as a technical add-on or an afterthought. It needs to be ingrained in the infrastructure, culture, and urban form. This entails planning for disruption, incorporating adaptable features into energy, water, and transportation systems, and enabling communities to take an active role in their own defence. Digital twins and citizen science projects serve as examples of how civic engagement and technology can work together to improve readiness. Resilience, as demonstrated by case studies from cities at the forefront of climate risk, is about moving ahead after each shock, becoming stronger and more equal in the process.

However, transformation is profoundly creative as well as defensive. The third pillar of this book, ecological innovation, challenges us to think of the city not as a consumptive machine but as a regenerating landscape. These interventions take us beyond sustainability as minimum compliance, from heat-mitigating green corridors and solar-optimized building forms to circular water systems and biodiversity networks interwoven throughout the urban fabric. They see cities as dynamic planetary healers that can restore habitats, absorb carbon, and bring people back in touch with nature. They also face the more sinister side of urbanization, which includes contaminated streams, deteriorated beaches, and industrial pollutants. Addressing these legacies is a moral requirement as well as an environmental one.

The following pages are neither a naïve celebration of urban creativity nor an intellectual exercise in urban theory. They serve as a model for a new urban compact that rejects decline as inevitable while acknowledging the harsh realities of our planet's situation. These lessons are derived from global design revolutions, policy innovations, and lived experiments. They are intended to challenge people, practitioners, and decision-makers to renounce antiquated beliefs and see cities as essential components of Earth's living systems rather than as separate entities.

Transformation will not be delivered by a single policy or project. It will result from a thousand interrelated acts, all driven by the belief that cities can be both vibrant and respectable, prosperous and global in their perspective. Anything less will commit us to a future of ecological collapse, growing inequality, and brittle infrastructure. However, cities may become our most powerful tools of renewal if we make a commitment to "Transformative Growth," plan for resilience, govern for inclusivity, and innovate for ecological regeneration. They have the potential to transform from representations of human overreach into catalysts for global healing.

Finally, this book is a challenge and an invitation to reconsider growth as restoration rather than accumulation, to embrace resilience as a creative strategy rather than a defensive one, and to pursue ecological innovation as a civilizational necessity rather than an aesthetic preference. Cities are changing, and this is no longer

a choice. It is both the greatest opportunity of our time and a prerequisite for our collective survival.

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# Acknowledgments

We gratefully acknowledge the contributions of all those involved in bringing this book to life. Our sincere thanks go to the authors, co-authors, chapter contributors, and collaborators who generously shared their expertise, passion, and creativity. We also recognize the foundation laid by our earlier collaborative research project on “smart-eco-cities” (2014–2018) and the continued dedication of those who contributed to its development. Four of us collaborated on the smart-eco-cities projects and have stayed in contact since its completion. These collaborative efforts not only shaped this publication but also helped foster new dialogues, expand research networks, and create a platform for meaningful scholarly exchange across the globe.

# About This Book

*Transforming Cities* provides a focused exploration of how urban areas can evolve by balancing growth, resilience, and ecological innovation. Central point of argument is focused on “transformative growth,” including rethinking urban growth, investment, and governance to ensure that development enhances social and ecological systems rather than undermines them. This book demonstrates how to change the paradigm from parcel-by-parcel monetization to landscape-first planning, from box-ticking sustainability to measured performance, and from top-down control to co-regulated stewardship with communities as urbanization speeds up and climate threats increase. In doing so, we explore methods for improving climate resilience, reviving urban areas, and incorporating ecological frameworks into city planning through a variety of case studies and research-driven insights.

This book provides useful strategies for creating cities that are both dynamic and ecologically conscious by tackling important topics like urban redevelopment, disaster preparedness, and sustainable land use. The result is a field manual for cities that refuse false trade-offs between prosperity and planetary limits. Therefore, transformative growth is a design, finance, and governance program that restores living systems, establishes trust, and creates long-lasting value. It is not just a catchphrase. Leaders who desire cities that are economically vibrant, culturally rooted, and climate-ready should read this book because anything less is only managed decline. In line with this perspective, the book covers three critical areas, i.e., Urban Growth, Resilience, and Ecological Innovation.

*Urban Growth*, when managed effectively, can drive economic vitality while fostering sustainable development. By highlighting the significance of resilient urban planning, brownfield redevelopment, and creative infrastructure design, this book explores how cities can manage growth without sacrificing ecological integrity. It draws attention to the conflict between sustainability and development and provides guidance on tactics that reduce environmental damage and advance social inclusion. Furthermore, the idea of degrowth shows up as a crucial alternative to

conventional urban growth, promoting different routes for cities that are healthier and more balanced.

*Resilience* is fundamental in the face of climate-induced risks and growing urban vulnerabilities. This book examines how flood mitigation, digital technology integration, and earthquake-resilient design can help cities adjust to environmental shocks. To ensure that communities are actively involved in forming their adaptive capacities, the role of digital twins, citizen science, and participatory governance in enhancing urban resilience is investigated. Case studies show how cities around the world are using both community-driven tactics and high-tech solutions to increase resilience, especially in regions that are vulnerable to extreme weather events and natural disasters.

*Ecological Innovation* is at the forefront of reimagining urban landscapes, integrating biodiversity conservation, sustainable water management, and energy-efficient urban design. From cooling structures and solar-optimized urban forms to placemaking strategies that promote post-disaster recovery, this book explores nature-based solutions that improve climate resilience. It also promotes a more comprehensive urban ecological framework by addressing the growing problem of industrial pollution and its effects on marine and coastal environments. Cities can develop into flexible, regenerative environments that promote the welfare of people and the environment by incorporating sustainability into urban transformation.

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**Prof. Rob Raven** is an interdisciplinary scholar, professor of sustainability transitions and deputy director (research) at Monash Sustainable Development Institute. He is also a visiting professor at the Copernicus Institute of Sustainable Development at Utrecht University. His interest is in understanding the dynamics and governance of sustainability transitions and socio-technical innovation. Originally trained as an electrical engineer, he has turned his gaze to the social, institutional, political, and spatial factors that influence successful innovation and transitions towards sustainable development. Rob has made major contributions to multi-level theories of transformative change, socio-technical experimentation, and strategic niche management. His empirical work has covered urban, energy and mobility transition processes in Europe, Asia and Australia. Rob holds several editorial positions, including *Environmental Innovation and Societal Transitions*, *Global Sustainability*, *Nature Urban Sustainability*, *Technological Forecasting and Social Change* and *Routledge Studies in Energy Transitions*. He has published over 130 articles, three books and eight special issues. He has won the equivalent of more than AUD\$ 18M research funds. His current research agenda is focused on the analysis of transformative change in urban contexts such as smart, sustainable, and net-zero cities and precincts.



## Chapter 7

# Solar-Optimized Urban Form: Reimagining the Sustainable Block for Energy Resilience and Social Connectivity

Shadi Galehdar and Mahmoud Ghalehnoee

**Abstract** Solar energy, one of the most abundant and accessible renewable resources, has become increasingly central to the vision of sustainable urban futures. Yet, much of the existing research has been confined to its morphological potential—optimizing building orientation, roof geometry, and shading—while paying limited attention to the social dimensions that condition its acceptance and long-term success. This study addresses this gap by reimagining solar integration through the lens of the Community Block (Oikonomou, 2015), an urban design framework that foregrounds the interactions between buildings, streets, open spaces, and shared social life.

Adopting a mixed-method approach that combines urban morphological analysis with participatory design case studies, the study evaluates how seven key urban design qualities—flexibility, enclosure, adaptability, ownership, diversity, sense of belonging, and permeability—mediate the relationship between energy efficiency and community needs. The findings reveal that participatory-designed blocks not only optimize solar performance but also foster stronger resident engagement in energy stewardship, reinforce networks of collaboration, and cultivate shared spaces that support social cohesion.

By advancing a solar-optimized urban form that unites technical efficiency with socio-cultural vitality, the chapter contributes both a theoretical framework and practical insights for planners, designers, and policymakers seeking to align energy resilience with inclusive and connected urban living.

**Keywords** Solar Energy • Urban Form • Social Connectivity • Community Block

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## 7.1 Introduction

Urban areas account for approximately 75% of primary energy consumption and 60% of greenhouse gas emissions (Shi et al., 2021). Under current climate projections, the cooling demand for buildings is expected to increase significantly 70% by 2030 and 115% by 2050 compared to 2017 levels (Mohajeri et al., 2019). Despite the urgency of these trends and notable advances in solar technology, much of the research and practice remains focused on technical optimization, often overlooking the multifactorial influences—social, ecological, and governance-related—that shape success at the neighborhood scale. No comprehensive methodology yet holistically assesses how renewable energy, particularly solar power, can be meaningfully integrated into urban form to simultaneously enhance energy resilience and social connectivity.

A central approach to sustainable urbanism is the study of urban form, which intersects with diverse social, economic, environmental, and ecological parameters. Moreover, urban morphology can alter the amount of shading and the level of desirable or undesirable solar radiation in urban areas (Perera et al., 2021). In recent years, numerous studies have integrated solar energy considerations into building design, urban planning, and urban design as a combined approach (Shi et al., 2021).

With the accelerating transition to zero-energy neighborhoods and buildings, the deployment of renewables has become essential for the future of sustainable cities. Policy frameworks reinforce this momentum—such as the European Union’s directive mandating on-site energy generation for all new buildings after 2019 (Zeng, 2011). The Community Block concept (Oikonomou, 2015) aligns with sustainable urban futures, combining buildings, blocks, streets, and open spaces into integrative frameworks fostering resident interaction and participatory design. This study investigates how solar infrastructure can be embedded into these blocks to optimize energy use and strengthen social networks, recognizing that such integration requires balancing technical morphology with socio-cultural dynamics.

Current strategies for sustainable urban development increasingly emphasize the importance of interventions at the local and micro scales (Pakzad and Salari, 2018). However, the implementation of optimal solar solutions demands a multi-scalar perspective—addressing city, regional, neighborhood, and building levels (Manni et al., 2023). This chapter therefore, adopts a holistic approach, employing both urban morphological analysis and participatory design case studies to explore how key design qualities—flexibility, enclosure, adaptability, ownership, diversity, sense of belonging, and permeability—mediate the integration of solar energy and social resilience.

To anchor this investigation within the evolving research landscape, Fig. 7.1 presents an overlay visualization generated using VOSviewer, based on the principal sources referenced in this study. This Overlay Visualization captures the thematic development in solar urbanism over the past decade, highlighting how research trends have shifted over time. Notably, the visualization traces the journey

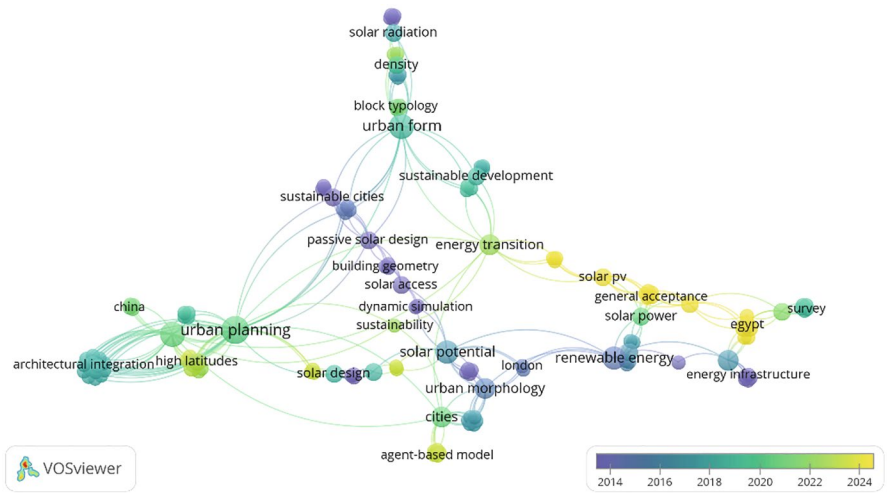


**Fig. 7.1** Overlay visualization of the present research.

from early emphases on technical aspects—such as “urban form,” “solar radiation,” and “density”—toward more recent focus areas, including “social acceptance,” “survey,” and site-specific studies like “Egypt.” This temporal layering reflects the field’s growing interest in integrating societal dimensions alongside technical optimization.

**7.1.1 The Community Block Framework**

The concept of the Community Block was first articulated by Oikonomou (2015) as a future-focused approach to urban block design. It reframes the built environment as fundamentally shaped by open space, reconstructing the dynamic between user and environment. At its core, the Community Block positions accessible open space as the locus for socializing and interaction, while pedestrian pathways—acting as “social nodes”—facilitate movement and connection between blocks, public spaces, and the broader street network (Oikonomou, 2015). Fig. 7.2 illustrates the evolutionary process of the Community Block, emphasizing an “inside-out” growth model. Urban development begins from shared open spaces and progressively organizes surrounding buildings and streets to foster social connectivity and participatory use.

Aligning with principles of climate-adaptive urban design, the Community Block is envisioned to respond to environmental imperatives and human needs through flexible spatial arrangements and integrated green infrastructure. This approach enhances both environmental quality and the potential for community interaction. As shown in Fig. 7.3, the layered structure of the Community Block encompasses

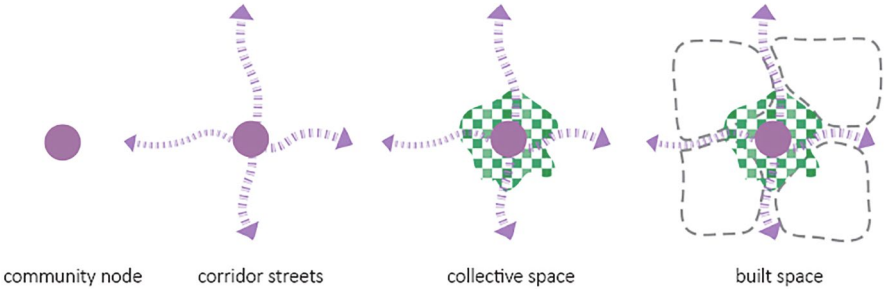


**Fig. 7.2** The urban process of the community block (Source: Adapted from: Oikonomou, 2015).

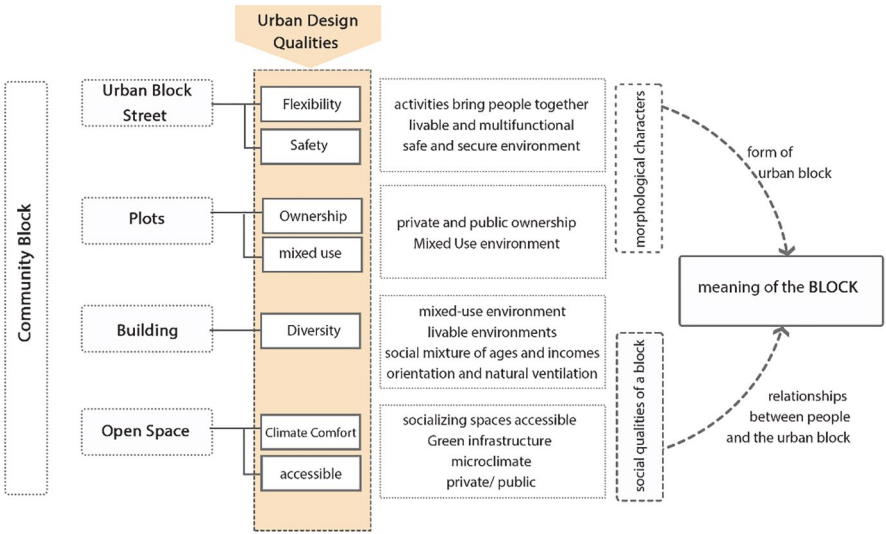


**Fig. 7.3** Community block layers (Source: Adapted from Oikonomou, 2015).

streets, plots, buildings, and open spaces, each contributing to both its morphological character and social meaning (Oikonomou, 2015).

When spatial characteristics are examined collectively, they define the physical shape of the urban block; when social qualities are combined, they illuminate the evolving interactions between residents and their built environment. Together, these features serve both as practical design guidelines and as symbolic anchors, enabling a holistic understanding of urban form as a framework for social and ecological resilience. The indicators identified by Oikonomou—streets, plots, buildings, and open spaces—are elaborated in detail in the following sections to clarify their respective roles in achieving energy-efficient, socially cohesive blocks.

## ***7.1.2 Elements of Urban Form in Four Layers Related to Solar Energy***

### **7.1.2.1 Block**

In the hierarchy of urban formation, the foundational layer emerges from the arrangement of urban block fabric, shaped by the adjacency of basic elements like buildings (Zekavat, 2012). Urban blocks, defined by the spatial boundaries of plots, play a critical role in mediating the interplay between public and private edges along adjacent streets. The spatial positioning of these blocks determines the configuration of edges, influencing both their connectivity and users' experiential interactions inside and outside the blocks (Al-Saaidy and Alobaydi, 2021).

Recent studies highlight the significance of block layout for solar energy performance. Liu et al. (2023) found that blocks exhibiting high energy efficiency often feature centrally located open spaces, which maximize solar access, and taller buildings oriented toward the western edge to minimize shading effects. Meanwhile, Shi et al. (2021) examined the interaction between solar energy and urban design by defining urban design criteria in three categories: block size (area and elongation), building footprint (building pattern), and building density (floor area ratio and site coverage).

Further advancing these insights, Li et al. (2022) introduced the Block Surface Ratio (BSR) as an important new indicator. BSR demonstrates a stronger and more practical correlation with solar radiation received by buildings than the commonly used Sky View Factor (SVF), providing a more efficient tool for urban analysis.

### **7.1.2.2 Street**

Street functions serve primarily as spaces for movement, enabling access between the street and the urban block, and vice versa (Oikonomou, 2015). Additionally, street design is a crucial parameter that, through building orientation, influences the amount of solar radiation received, thereby affecting energy consumption (D'Almeida, 2022).

Martins et al. (2014), in their work "From Solar Constraints to Urban Design Opportunities," highlighted street width and aspect ratio as the most influential factors affecting urban morphology and solar optimization. Their findings indicate that while verticality and building width had comparatively minor effects, metrics like floor area ratio and plot ratio serve as important constraints influencing overall block design.

These findings highlight the importance of street dimensions and configurations. When strategically designed, streets not only enhance connectivity and accessibility but also serve as key levers for maximizing solar access and enabling energy-resilient urban blocks.

### 7.1.2.3 Building

Buildings represent the smallest organizational units of the city, with the urban form fundamentally emerging through the adjacency and arrangement of these physical elements (Zekavat, 2012). Rafiyan et al. (2011) demonstrated that building height and density, building plan form, and building orientation are key physical characteristics that significantly affect daylight availability.

Research by Rafiyan et al. (2011) demonstrates that building height and density, as established through urban planning and design, can significantly impact access to sunlight and the extent of shading effects among adjacent structures. Without considered control of these parameters, residential blocks may experience uneven solar exposure, affecting both livability and renewable energy generation potential.

Building density, in particular, is closely linked to social interaction: Shakibaei Bidaruni and Tabibian (2018) argue that optimal neighborhood population densities foster stronger community connections. Building orientation has a direct relationship with solar access. Specifically, the angle between the building's axis and the north-south direction, considering the site's latitude, influences the number of hours of direct sunlight the building receives throughout the day, thereby impacting its energy requirements (Rafiyan et al., 2011). Consequently, design guidelines commonly recommend elongating the building form along the south-facing direction. Moreover, the optimal building orientation relative to the sun is one that maximizes heat gain during cold days and minimizes it during hot days (zahri, 2017).

Consequently, design guidelines typically recommend elongating buildings along the south-facing direction to maximize solar gain in winter and minimize it during hotter periods. This integration of morphological and solar principles is central to effective sustainable urban block design.

### 7.1.2.4 Open Space

Urban open spaces constitute essential elements for environmental comfort and social interaction, particularly in the context of solar energy utilization. Achieving a balanced mix of sunlight and shade within these areas is vital for maximizing usability across changing climatic conditions. However, spatial requirements for solar access to open spaces may sometimes conflict with those for interior buildings, as ground and façade surfaces often require different solar orientations (Van Esch et al., 2012).

Current literature often isolates the examination of geometric parameters and solar indices to either buildings or open spaces, overlooking their combined effects at the block scale. This gap necessitates a more integrated approach—assessing how the geometric interplay between buildings and open spaces influences overall solar exposure, including both façades and outdoor areas (Lan et al., 2022).

In dense environments, sky exposure is highly variable. Large squares and rooftops offer substantial visible sky and thus higher solar access, whereas narrow streets and enclosed courtyards beneath tall buildings experience diminished exposure (Redweik et al., 2013). Strategic design of open spaces, therefore, is required to harness the energy and social potential inherent in the block, supporting both sustainable performance and community well-being.

### ***7.1.3 Social Connectivity in Solar Urbanism***

#### **7.1.3.1 Solar Acceptance**

Ensuring the widespread adoption of solar energy systems within residential developments hinges as much on social factors as on technological innovation. One of the most decisive elements is the degree of public acceptance, which is shaped by engaging citizens throughout the planning and implementation process (Marzouk et al., 2024). Urban and architectural features that nurture social cohesion, such as participatory design and community consultation, are instrumental in fostering support for renewable initiatives. For instance, the Halifax solar project demonstrated that involving a broad cross-section of residents from various backgrounds led to exceptionally high acceptance rates (Lobaccaro et al., 2019).

Research consistently shows that regardless of technological advancement, community buy-in and active involvement remain foundational for the success of sustainable energy strategies (Cohen et al., 2014). Early, cross-disciplinary planning that integrates solar energy goals with considerations such as local building density and construction costs is essential for realizing projects that are both efficient and socially supported (Lobaccaro et al., 2019).

Major challenges in deploying solar strategies involve technology choices, stakeholder conflicts, and social acceptance, with visual impact being a significant concern in urban areas (Lobaccaro et al., 2019). While some studies recommend minimizing the visibility of solar panels in sensitive contexts, others argue that greater visibility can enhance social acceptance and promote adoption (Formolli et al., 2023). The quality of integration, especially in visible or heritage areas, is critical to public approval (Florio et al., 2018).

Urban authorities may default to standardized architectural templates in pursuit of acceptance, yet these can constrain the flexibility needed to respond to unique site conditions (Florio et al., 2018). Broadly, acceptance of renewable technologies spans political, market, and local dimensions. The role of community-level engagement and the sharing of benefits among stakeholders is particularly significant (Sovacool and Ratan, 2012).

Lastly, policy success relies on accounting for user habits and routines, as behavioral choices have a substantial impact on actual energy demand. Effective approaches combine strategic incentives with education and best-practice demonstrations, leading to real and measurable reductions in energy consumption (Legény et al., 2014).

#### **7.1.3.2 Neighborhood Scale: Strengthening Social Relations Through Solar Energy Integration**

A growing body of research has explored how the distinctive morphological features of neighborhoods—such as building density, orientation, and patterns of shading—affect the viability and effectiveness of solar energy systems (Veisi and Shakibamanesh, 2022; Sarralde et al., 2015; Lobaccaro et al., 2019). These studies

emphasize that tailoring urban design and planning to local context is critical for maximizing solar potential and ensuring robust outcomes.

Lobaccaro et al. (2019) argue that evaluating solar energy at the neighborhood scale uncovers spatial variability—such as differences in direct sunlight and shadowing effects—that broader analyses might overlook. Fine-grained assessments can reveal how factors like building arrangement and nearby structures influence solar access, which in turn impacts long-term sustainability. Planning neighborhoods for optimal solar utilization not only reduces energy consumption and greenhouse gas emissions but also supports a transition away from non-renewable resources. Thus, neighborhood-level solar analysis has become an essential tool for informing environmentally responsible urban design.

The concept of “solar neighborhoods” refers to urban areas that incorporate both photovoltaic and thermal energy systems to meet local energy needs. For these neighborhoods to succeed, planners must strategically configure building form, overall density, and site layout to harness available sunlight (D’Almeida, 2022). According to Manni et al. (2023), solar neighborhoods share the mixed-use characteristics of conventional urban districts—housing residential, commercial, and public functions—but prioritize comprehensive solar integration in their development. However, most comparative studies rely on hypothetical models or manipulate variables such as density, plot ratio, and building orientation to assess solar performance at the block or cluster level (Hachem-Vermette and Singh, 2019; Lan et al., 2022).

Planning and design strategies for solar neighborhoods can be applied to both new developments and existing urban areas, helping cities achieve positive energy budgets and carbon neutrality. These guidelines contribute to achieving favorable energy balances and advancing carbon-neutral goals for modern cities. Findings of the study by Manni et al. (2023) illustrate the intersection between solar neighborhoods and related concepts such as zero-emission neighborhoods (ZEN) and positive energy districts (PED), providing a visual roadmap for how these approaches are linked within the current literature.

A fundamental aspect of effective solar neighborhood planning is the coordinated alignment of human-centric activity patterns and energy management strategies, which can lead to more equitable and efficient energy usage, particularly in mixed-use areas. These strategies inevitably impact a range of design factors—from building massing and height to spacing, orientation, and aspect ratios—all of which are conditioned by local latitude and climate (Manni et al., 2023). Their study also demonstrates key passive solar strategies as applied to neighborhood-scale planning and design, emphasizing design techniques that maximize natural energy flows and minimize external energy demand.

Sovacool and Ratan (2012) highlight the role of community ownership and cooperative models in the expansion of local solar energy systems, reporting that an overwhelming majority of installations are owned by homeowners and local groups rather than large utilities. This shift in ownership fosters inclusive decision-making processes, broad stakeholder involvement, and ultimately, higher levels of public engagement. The Vauban district exemplifies community-driven sustainable development: initiated through grassroots collaboration among building groups

and architects, Vauban's participatory approach resulted in a vibrant, socially connected neighborhood that combines architectural diversity with shared green spaces (Coates, 2013).

## 7.2 Urban Design Qualities in Solar-Integrated Community Blocks

### 7.2.1 *The Importance of Urban Design in Addressing Urban Energy Challenges*

The significance of urban design in tackling urban energy challenges has been continuously emphasized. Concepts such as energy-based urban design, energy-saving urban design, and low-carbon urban design have emerged. Thoughtful urban design can maximize the use of solar energy at the urban scale while simultaneously reducing energy consumption through inter-building effects. To develop effective urban design guidelines, implement energy-efficient urban design practices, and create sustainable urban environments, a comprehensive and quantitative assessment of the impact of urban form on building energy consumption and solar energy potential is essential (Liu et al., 2023).

Early integration of solar energy considerations into urban design is crucial to ensure that future cities not only consume energy but also locally generate energy through solar power (Akrofi and Okitasari, 2022). Urban design components relevant to solar energy assessment have been identified in various studies: street width and urban density (Sanaieian and Ghorabi, 2020), street width and orientation (Van Esch et al., 2012), and, focusing on solar energy at the human scale, maximum solar energy utilization potential (Zeng, 2011). Solar urban design emerges as a distinct phase within the broader sustainable planning agenda, linking the efficiency of building stock to the surrounding urban fabric and becoming a foundational element in the pursuit of Net-Zero Energy Buildings (NZEB) (Amado and Poggi, 2012).

Significantly, involving local residents in monitoring and maintaining system performance enhances solar system outcomes and supports broader community goals (Amado and Poggi, 2012). Other research by Natanian et al. (2019) proposes a categorization for solar-oriented design parameters, spanning from sky view factors and aspect ratios to typology, geometry, density, and orientation—providing designers and planners with a framework for maximizing urban solar exposure.

Building on these insights, this study systematically reviews diverse sources from urban design and solar energy literature, grouping key parameters into two domains: morphological, representing physical and spatial characteristics that shape solar potential, and social, reflecting community dynamics and demographic factors. This dual framework enables a comprehensive assessment of both technical and social requirements for successful solar integration in urban blocks. The full set of parameters is detailed in Table 7.1.

**Table 7.1** Extracted parameters of urban form at the community block scale.

|            | Category              | Parameters                   | Abbreviation | Detail                                                                                                                                                             |
|------------|-----------------------|------------------------------|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Morphology | Block Dimension       | Block Area(m <sup>2</sup> )  | BA           | Shi et al., (2021); Al-Saaidy and Alobaydi, (2021).                                                                                                                |
|            |                       | Block Surface Ratio          | BSR          | Li et al., (2022).                                                                                                                                                 |
|            |                       | Block Elongation (-)         | BE           | Shi et al., (2021); Shi et al., (2020).                                                                                                                            |
|            | Vertical Distribution | Distance Between Building(m) | DBB          | Sarralde et al., (2015); de Lemos Martins et al., (2016); Tian and Xu, (2021).                                                                                     |
|            | Building Footprint    | Building Pattern             | BP           | Shi et al., (2021); Zhang et al., (2019).                                                                                                                          |
|            |                       | Open Space Ratio             | OSR          | Liu et al., (2023); Zhang et al., (2019).                                                                                                                          |
|            | Building Density      | Floor Area Ratio (-)         | FAR          | Shi et al., (2021); Martins et al. (2014); de Lemos Martins et al., (2019); Natanian et al., (2019); Li et al., (2022); Tian and Xu, (2021); Zhang et al., (2019). |
|            |                       | Site Coverage (%)            | SC           | Shi et al. (2021); Sarralde et al. (2015); Zhang et al. (2019); Li et al. (2022).                                                                                  |
|            |                       | Plot Ratio                   | PR           | Sarralde et al., (2015); Martins et al., (2014); de Lemos Martins et al., (2016); de Lemos Martins et al., (2019).                                                 |
|            |                       | The Average Number of Floors | AF           | Liu et al., (2023); Tian and Xu, (2021).                                                                                                                           |
|            | Aspect Ratio          | Height to Width Ratio (h/w)  |              | Robinson, (2006); Martins et al., (2014); de Lemos Martins et al., (2016); Natanian et al., (2019); Sharifi and Yamagata, (2018); Li et al., (2022).               |

**Table 7.1** (continued)

|        | Category    | Parameters                    | Abbreviation | Detail                                                                                                                                                   |
|--------|-------------|-------------------------------|--------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
|        |             | Sky View Factor               | SVF          | Robinson, (2006); Morganti et al., (2017); Liu et al., (2023).                                                                                           |
|        |             | Street Aspect Ratio           | SAR          | Van Esch et al., (2012); Vititneva et al., (2021); Natanian et al., (2019); Martins et al., (2014); de Lemos Martins et al., (2016); Liu et al., (2023). |
|        | Orientation | Building Orientation (degree) | BO           | Van Esch et al., (2012); Sarralde et al., (2015); Lan et al., (2022); Natanian et al., (2019); Oikonomou, (2014).                                        |
|        |             | Street Orientation (degree)   | SO           | Vititneva et al., (2021); de Lemos Martins et al., (2019); Oikonomou, (2014); Liu et al., (2023).                                                        |
|        |             | Block Orientation (degree)    | BO           | Liu et al., (2023).                                                                                                                                      |
| social | Ownership   | Rented/Owner                  | –            | Delmastro et al., (2015); Oikonomou, (2014), Marzouk et al., (2024),                                                                                     |
|        |             | Public/Private                | –            | Shakibamanesh and Ebrahimi, (2020); Kosorić et al., (2019); Oikonomou, (2014).                                                                           |
|        | Education   |                               | –            | Amado and Poggi, (2012); Legény et al., (2014), Marzouk et al., (2024).                                                                                  |
|        | Age         |                               | –            | Amado and Poggi, (2012); Legény et al., (2014), Marzouk et al., (2024).                                                                                  |

## **7.2.2 *Urban Design Qualities***

Urban design qualities cover a diverse spectrum of attributes, tailored to suit specific urban objectives. Previous research has highlighted dimensions such as imageability, enclosure, human scale, and legibility for walkability (Abdeldayem et al., 2023), as well as robustness, flexibility, and adaptability for urban resilience (Sharifi and Yamagata, 2018). However, there is no research that directly addresses urban design qualities as a framework for categorizing indicators for measuring solar energy in urban environments. Yet, few works propose a unified framework for evaluating these qualities in relation to solar energy integration. The following subsections present those qualities identified as pivotal for connecting solar adoption and community resilience at the block scale.

### **7.2.2.1 Ownership**

In the context of solar urbanism, ownership influences not only residents' investment in their environments but also their willingness to adopt and maintain energy technologies. Understanding the nuances of ownership helps clarify pathways for successful solar integration in community blocks.

Though not always classified as a design quality, ownership strongly influences resident engagement and solar energy acceptance. In Community Block settings, homeownership encourages active participation and investment in the local environment, while the division between owner and renter, and between public and private domains, shapes the feasibility of energy upgrades (Oikonomou, 2014; Delmastro et al., 2015). Creating avenues for resident involvement in planning and implementation fosters community approval and successful adoption of solar solutions (Sovacool and Ratan, 2012).

### **7.2.2.2 Sense of Belonging**

Fostering a sense of belonging is key to encouraging collective engagement with sustainable technologies. In solar-integrated blocks, participatory design and community identity drive acceptance and long-term stewardship.

A pronounced sense of belonging serves as a foundation for advancing social support and long-term adoption of solar energy within communities. When urban design prioritizes opportunities for resident participation—such as collaborative planning and the integration of mixed-use environments—it helps nurture a shared identity and strengthens willingness to accept new energy technologies. The alignment between green infrastructure, participatory approaches, and local interaction fosters this collective spirit, particularly at the neighborhood scale.

This dynamic is visually illustrated in Fig. 7.4, where the overlap between the Community Block and Social Acceptance is shown to be mediated by a

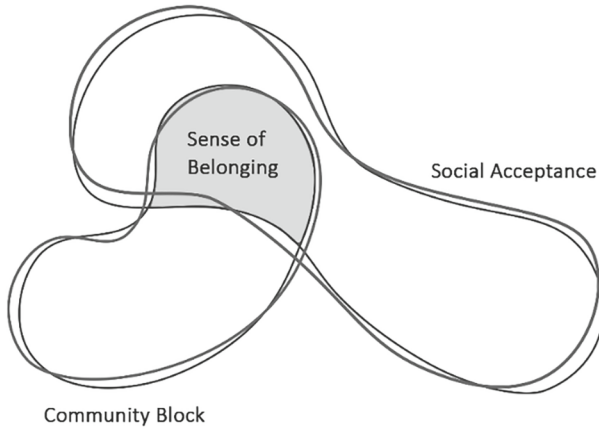


**Fig. 7.4** Sense of belonging: Overlapping the community block and social acceptance.

shared Sense of Belonging. The figure highlights how spatial and social integration within a block can directly enhance social acceptance of sustainable urban innovations, reinforcing both environmental goals and the social resilience of the community.

### 7.2.2.3 Permeability

Permeability determines how movement, sunlight, and social interactions are facilitated within the built environment. Its optimization ensures that solar access and community connectivity go hand in hand.

Permeability describes how easily individuals move and interact within urban blocks, impacting both solar access and social connections. Efficient layouts—such as grid plans with smaller blocks and wider streets—facilitate movement and sunlight penetration, while irregular patterns with narrow passages are less permeable. Block size, surface ratio, elongation, and spacing are key factors in optimizing permeability for solar and community outcomes.

### 7.2.2.4 Flexibility

*Flexibility allows built environments to evolve alongside technological breakthroughs and shifting user needs. In solar urbanism, flexible design and planning accommodate new energy solutions as they emerge.*

Flexibility denotes adaptability in built environments, allowing for the integration of emerging energy technologies like photovoltaics. Diverse building forms, responsive open spaces, and the potential for incorporating solar systems into

various structures and materials ensure urban blocks remain resilient to future shifts in energy demand and technology (Formolli et al., 2023).

### 7.2.2.5 Enclosure

*Enclosure shapes both the spatial and climatic experience of public spaces. For solar design, enclosure ratios alter sunlight penetration, influencing comfort and energy performance.*

Enclosure refers to the physical framing of public spaces—by buildings, vegetation, and structural elements—which influences microclimate and solar exposure. Metrics such as the height-to-width ratio, sky view factor, and street aspect ratio help assess the comfort and shading patterns within enclosed areas, informing pedestrian experience and energy performance (Abdeldayem et al., 2023).

### 7.2.2.6 Adaptability

*Adaptability is vital for neighborhoods that must cope with climate changes and integrate renewable energy. Solar urbanism relies on adaptive frameworks to ensure longevity and effectiveness of energy systems.*

Adaptability is crucial for enabling urban blocks to respond to environmental change and integrate renewable energy. Design principles that prioritize climate responsiveness advance the ability of urban form to absorb emerging technologies and address challenges like carbon neutrality (Fonseca, 2016; Masson-Delmotte et al., 2018).

### 7.2.2.7 Climate Comfort

*Prioritizing climate comfort in urban design harmonizes solar exposure and shading, directly affecting livability and energy efficiency within solar-integrated blocks.*

Climate comfort encompasses access to sunlight, effective shading, and pedestrian well-being. Orientation and configuration of buildings and streets play a central role in shaping microclimatic conditions, balancing exposure for livability and energy efficiency.

Collectively, these urban design qualities determine the social and functional vitality of urban spaces, forming the foundation for successful solar energy integration and broader sustainable urbanism.

The analytical process and findings of this study are graphically summarized in the following figures. Fig. 7.5 depicts the mapping of key urban form indicators—spanning both morphological and social domains—onto the identified urban design qualities, highlighting the layered connections shaping solar-optimized blocks. This

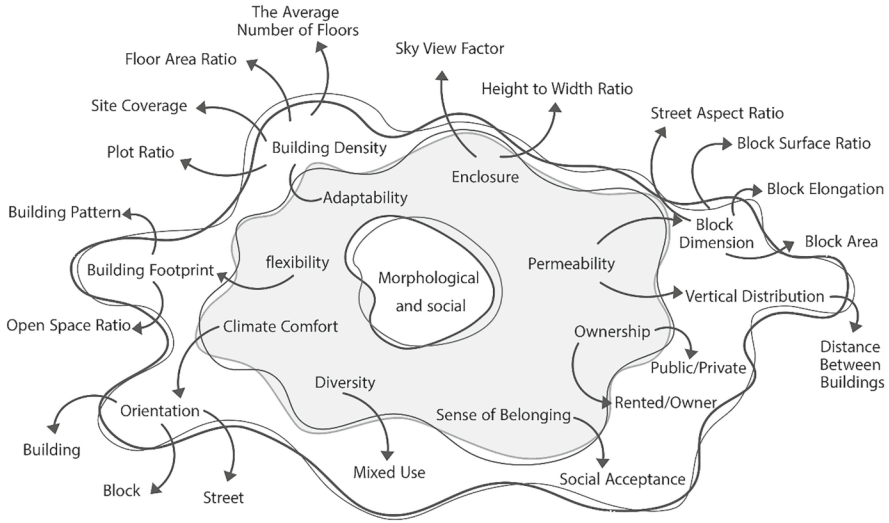


**Fig. 7.5** Concept of indicators with urban design qualities.

flow diagram illustrates how attributes such as building density, orientation, and ownership status are systematically associated with design qualities like permeability, flexibility, and climate comfort.

Fig. 7.6 synthesizes these insights, visually capturing the complex web of relationships between solar-optimized urban form parameters and the broader design qualities essential for resilient, socially cohesive neighborhoods. Together, these figures provide a comprehensive visualization of both the analytical framework and the integrative results underpinning successful solar energy integration at the community scale.

### 7.3 Discussion and Conclusions

This study examined the potential of the *Community Block* as a framework for achieving both solar energy optimization and social resilience at the neighborhood scale. By reframing the relationship between morphological parameters and social qualities, the research has emphasized how the design of urban form can transcend technical performance and become a catalyst for participatory, inclusive, and adaptive urban environments.

At the core of the Community Block model lies the understanding that spatial configuration and social structure are co-dependent. The arrangement of open spaces, streets, and building masses determines not only solar accessibility but also the patterns of social interaction and collective identity that emerge within a neighborhood. The findings highlight that when urban design processes explicitly

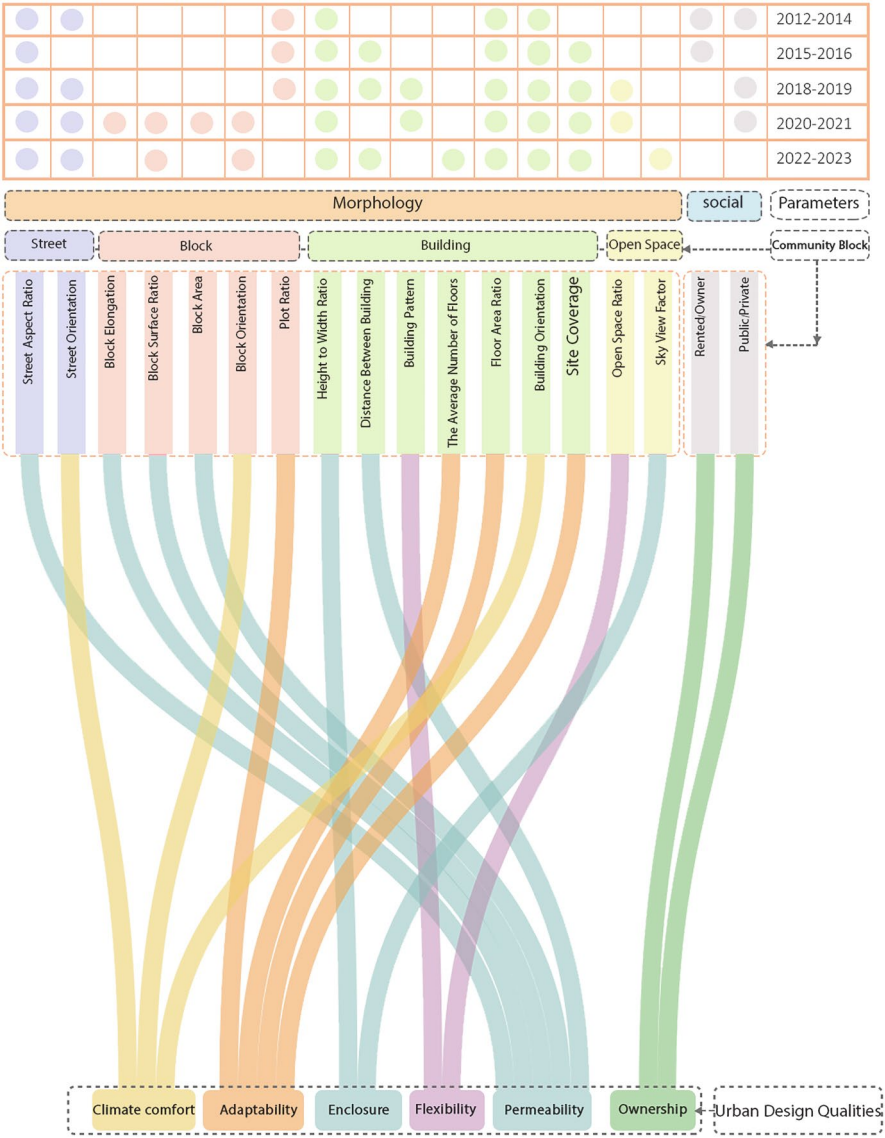


**Fig. 7.6** Relation of solar-optimized urban form parameters with urban design qualities.

integrate community participation—through co-design, shared open spaces, and mixed-use configurations—residents develop a stronger sense of belonging and responsibility toward their environment. This social cohesion, in turn, enhances the acceptance, operation, and maintenance of solar energy systems.

In contrast to conventional block typologies that treat environmental performance as an outcome of form alone, the Community Block advances a *socially*

*embedded* approach to energy transition. Here, renewable energy infrastructure becomes not merely a technological addition but a social process shaped by collaboration, learning, and everyday interaction. Open spaces function as collective platforms for these exchanges, fostering ecological literacy, civic participation, and behavioral change. The morphological features of permeability, adaptability, and enclosure—typically analyzed as quantitative design variables—are thus reinterpreted as mediators of social and ecological connectivity.

Such integration reinforces the notion that energy resilience cannot be achieved solely through top-down technological implementation. Instead, it depends on multi-scalar cooperation among designers, policymakers, and local communities. The Community Block, through its flexible and participatory structure, offers a spatial and institutional framework for this cooperation. It empowers residents to participate in decision-making processes, to co-own energy systems, and to collectively manage the maintenance and adaptation of shared infrastructures. The result is a form of *distributed resilience*, where communities act as both producers and stewards of sustainable energy.

This perspective aligns closely with the emerging paradigm of Transformative Growth, which seeks to move urban transformation beyond the binary of incremental ecological modernization and degrowth. Transformative Growth reframes urban prosperity as the capacity to thrive within ecological limits while fostering inclusivity, innovation, and collective agency. Within this paradigm, the Community Block represents a micro-scale embodiment of systemic change: it merges technical efficiency with social empowerment and ecological adaptation. By redefining productivity to encompass ecological, social, and technological dimensions, it illustrates how cities can grow qualitatively—enhancing life within planetary boundaries rather than expanding beyond them.

Moreover, the Community Block demonstrates that urban transformation is not limited to large-scale policy or infrastructural reform but can begin within the everyday spatial practices of neighborhoods. Small, community-driven interventions—solar retrofits, shared gardens, energy cooperatives—generate ripple effects that reshape local governance, public awareness, and spatial culture. These cumulative shifts exemplify the pragmatic side of Transformative Growth: change that is bottom-up, participatory, and context-sensitive, yet capable of producing structural impact.

In summary, the findings reaffirm that socially connected and solar-optimized neighborhoods are not parallel goals but mutually reinforcing ones. Technical parameters such as floor area ratio, aspect ratio, and site coverage determine solar exposure, but it is through the qualities of flexibility, belonging, and ownership that these parameters become socially sustainable. The Community Block framework thus bridges the divide between form and behavior, between morphology and meaning.

Ultimately, this study positions the solar-optimized Community Block as both a theoretical construct and a practical strategy for shaping resilient, low-carbon urban futures. It advances the idea that the success of renewable energy integration lies not in isolated technological efficiency but in *social design*: the creation of spaces

that invite participation, cooperation, and shared stewardship. Through this synthesis, the research contributes to the broader discourse on transformative urbanism, offering a model of growth that is environmentally restorative, socially inclusive, and deeply participatory.

### **7.3.1 Recommendations**

The outcomes of this research suggest that integrating social participation and morphological optimization can establish a foundation for urban energy transitions that are both resilient and equitable. To operationalize these insights, several recommendations are proposed across social, technical, and governance domains.

#### **7.3.1.1 Social Policies**

- **Enhance community participation:** Institutionalize participatory design processes at the neighborhood scale to involve residents in decisions regarding solar infrastructure placement, visual integration, and maintenance.
- **Strengthen social acceptance:** Promote awareness campaigns and peer-learning initiatives that demystify renewable technologies and highlight their social and environmental benefits.
- **Support collective ownership:** Facilitate community-based energy cooperatives or shared ownership models to ensure equitable access to solar energy, particularly for low- and middle-income households.
- **Cultivate a sense of belonging:** Design shared spaces that encourage daily social interaction, reinforcing local identity and long-term commitment to sustainable practices.

#### **7.3.1.2 Technical Policies**

- **Integrate solar optimization in design codes:** Embed morphological parameters—such as block orientation, aspect ratio, and open-space configuration—into urban design and building regulations to maximize solar performance.
- **Promote adaptive and flexible design:** Encourage modular and adaptable urban forms capable of integrating evolving energy technologies without major structural interventions.
- **Leverage open spaces as active infrastructures:** Utilize courtyards, rooftops, and community gardens for solar installations, pilot projects, and environmental education.

### 7.3.1.3 Governance Policies

- Encourage cross-sector collaboration: Foster partnerships among urban planners, engineers, social scientists, and local stakeholders to co-produce knowledge and practical strategies for solar-integrated neighborhoods.
- Institutionalize participatory governance: Create platforms that allow residents to continuously engage in monitoring, evaluation, and adaptive management of community energy systems.
- Embed transformative growth principles: Align urban energy policies with the broader paradigm of Transformative Growth by prioritizing qualitative improvements in ecological productivity, social inclusiveness, and technological innovation.

In conclusion, advancing solar-optimized, socially cohesive urban forms requires a multidimensional approach that aligns spatial design, technological innovation, and collective agency. The Community Block—through its integration of morphology, energy, and social participation—exemplifies a scalable model for Transformative Growth, offering cities a pathway toward resilient, low-carbon, and community-driven futures.

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