Modeling Metropolis: Clean Energy Guidelines for Neighborhood Design in Rapidly Urbanizing China

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Thesis Advisor: Dennis Frenchman
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Abstract

In China's current landscape the paradigm for urban development is the rapid creation of whole neighborhoods instead of the conventional piecemeal approach of creating individual buildings that gradually aggregate over time into neighborhoods. China's approach is complex and fast moving, and has resulted in the highly repetitive form of tower-in-park typology being applied throughout the country to develop new neighborhoods. This development strategy creates living environments that require households to adopt patterns of daily living that consume excessive resources and needlessly contribute to climate degradation by relying on mechanically controlled interior climates in neighborhoods requiring excessive dependence upon automobiles.

This situation presents compelling opportunities for planners and designers to create a more energy efficient city form. What is required is an effective method of accurately predicting, during the design process, patterns of neighborhood energy consumption. This thesis presents guidelines for doing this. When partnered with the Energy Proforma© the guidelines can help make possible rapid yet highly energy efficient urban design and development at the neighborhood scale.

Development of these guidelines drew upon the research of the Making the Clean Energy City in China Research Group led by Dennis Frenchman and Christopher Zegras. Other resources include literature describing previous approaches to neighborhood scale designs and guidelines, and an examination of current and emerging practices in the field of urban design and development. Finally, student projects are incorporated into the thesis and interwoven with the guidelines to illustrate the forms that potential developments might take.

0.0
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1.0 MODELING METROPOLIS

Introduction

"If we are to adapt to the historically unprecedented changes in thinking and practice, new design concepts and methods must be created."

~ Thom Mayne, Combinatory Urbanism 2011

The urban landscape of China is being radically transformed by changing standards of living, rapid urban development, and widespread adoption of more energy intensive, high consumption life styles. While numerous studies have examined energy consumption and efficiency at the metropolitan and building scales, few have focused on the neighborhood scale. The Chinese refer to this scale as "superblocks": the neighborhoods, commercial districts, and real estate projects that form the basic building blocks of urban growth. Typically taking on a tower-in-block typology, this government mandated form has removed residents from environments that promoted community development and diversity of use and has put restrictions on family composition and adaptation. The absence of mixed uses and accessible activities has increased dependence on personal automotive transportation and diminished opportunities for walking and, consequently, for communal interactions.

The repetitive form, single use development of "super blocks" may convey an image of modernity and order, but "if the sameness of use is shown candidly for what it is - sameness - it looks monotonous. Superficially this monotony might be thought of as a sort of order, however dull. But esthetically it unfortunately also carries with it a deep disorder: the disorder of conveying no

1.0a Sunshine 100 - a typical tower-in-park development in Jinan © George X. Lin direction" (Jacobs,1961). The current unrestrained continuation in China of tower sprawl in a field of formless city constitutes not only an esthetic disorder, but a dangerous compromise to the country's ability to provide for the future health and welfare of its population.

The current development designs used in China are largely incompatible with the climate for which they are intended, and their implementation requires excessive and unsustainable expenditures of energy for basic living needs. The adverse consequences of continually building this high-consumption city form is what led to the creation of the Making the Clean Energy City in China Research Team. The Team's extensive investigations into fundamental relationships between neighborhood scale designs and energy consumption led to discoveries that have resulted in the creation of a series of evidence-based Clean Energy Guidelines for designers, policy makers, and developers. According to Ben-Joseph in The Code of the City (188) "standards we have to work with should only be used as a baseline and not as a device to prevent excellence from being created." It is precisely the creation of excellence that the Research Team intends to result from the use of its Clean Energy Guidelines. The Guidelines are intended to foster creative solutions to the challenges posed by the necessity of designing and building more energy efficient and, at the same time, more livable urban environments. Used in tandem with the Team's Energy Proforma (described below) the Clean Energy Guidelines allow designers and developers to rapidly design neighborhoods that consume less energy per household.

The following chapter introduces the research background, scope, questions, methodology and product of this thesis.

1.1 Research Background

Under the guidance of Professors Dennis Frenchman and Chris Zegras, the Making the 'Clean Energy City' in China Research Team created the base and context for this thesis. The Team developed the Energy Proforma© tool for measuring and testing the energy consumption of a cluster design ("cluster" is defined as a 200m x 200m section of neighborhood. The Energy Proforma© is a web-based, open-source tool developed as a support to the decision making process of planning. Designers input a simplified model of the neighborhood design, assigning to forms a series of attributes (derived from earlier empirical analysis establishing values to critical variables and coefficients) that serve to better define potential energy consumption, production (in the form of renewables) and patterns of use. The Energy Proforma© is then "run" on the design and evaluates the physical qualities of the forms with the embodied attributes. The output evaluation provides projected measures for embodied energy (imbued in materials and construction), operational energy (including heating, cooling, lighting/power, and conveying), renewable energy (what is produced onsite to offset energy expenditures), and transportation energy (expended to move from and around the site). The output also includes energy consumption per household within the tested development, the development capacity, and common area expenditures. The Energy Proforma© tool provides an opportunity to derive conclusions from the data output and on the basis of critical relationships within the design, to further iterate and test until the design of an optimal prototype is produced.

In cooperation with Tsinghua University in Beijing, the Research Team conducted two studios to create neighborhood designs. During the summers of 2010 and 2012, the students researched existing neighborhoods within the city of Jinan, and then designed their own prototype neighborhoods for the project site of Jinan West – a new development situated around a new high-speed rail station. Each of these neighborhood designs contained a cluster component tested by the Energy Proforma© tool to discover the most vital physical relationships within the neighborhood form that result in significant reductions in energy consumption. Continuing this research at MIT, the Research Team continued its statistical analyses, resulting in further refinements to the Energy Proforma© tool. It is this work, and the author's participation in the 2012 studio, that form the categories and rules for the guidelines proposed in this thesis.

1.2 Research Scope

Urban designers have long attempted to introduce prescriptions and "toolkits" to insure the quality design of cities. Primarily considered a method of protecting public well-being, the applications reflect changing values that underlie the efforts to regulate the form of a cities. A greater responsibility for protecting the environment has emerged in the 21st century as a planning value. As an example, mindful redevelopment to mitigate climate change has been introduced in a variety of ways, including the promulgation of municipal energy standards, third-party rating systems, and individual cities' visions for "greening" their urban spaces and practices.
This thesis reflects on three frameworks developed to guide urban development: Clarence Perry's Neighbourhood Unit, Christopher Alexander's Pattern Language, and the College for New Urbanists' Urban Transect and Form Based code. Each framework was introduced as a new approach to creating urban form and each resulted in successes and failures to varying degrees since their introduction.

This thesis also examines two recent attempts by cities to incorporate sustainable practices into development and resident behavior: "Chicago: Adding Green to Urban Design: A City for Us and Future Generations" and "Guide to Copenhagen 2025." The practical value of each of these approaches to urban development is tested by being coupled with the Energy Proforma© tool, in which sustainable practices are embedded rather than merely inserted or overlaid.

Recognizing the capabilities of the Energy Proforma and the metrics it displays, this thesis articulates the qualitative "lessons" indicated and supported by the work of the Research Team. These "lessons" form the basis for the Clean Energy Guidelines contained in Chapter 4 of this thesis.

1.3 Research Questions

The way neighborhoods are designed and the resulting arrangements of buildings influences the daily habits and behaviors of residents and, consequently, their consumption of energy. Design arrangements also impact building systems life-cycles and operations. The work of the Research Team has produced data, designs, and methods critical to understanding how to design neighborhood forms that consume less energy. One of the major contributions of this thesis is to use these discoveries to create Clean Energy Guidelines that can be used in companion with the Energy Proforma tool.

The creation of these qualitative Guidelines was a response to two key questions:

1. What is the relationship between the physical design characteristics of neighborhoods and the energy they consume and produce?

2. How can knowledge of these features be translated into a systematic approach that will enable designers and policy-makers to make decisions that result in more energy efficient neighborhoods?

This thesis uses research data to determine what best combination of best practices will produce low-energy neighborhood configurations. This approach entails a bundled approach to design and development practice: the dual deployment of the Energy Proforma© tool, and the Clean Energy Design Guidelines (authored in this thesis).

1.4 Methodology

The data for the research is found in the substantial library of work produced by the Research Team and the Summer Studios. Rather than including these materials in their entirety, each guideline and each section of the Clean Energy Guidelines has examples from the research that were key in its formulation and demonstrate the form-energy feature being highlighted.

The author's studio design experience and her the use of the Energy Proforma© led to an understanding of the methods of collecting and analyzing the data. Evaluated by both professors and students, the sampling of ten designs and resulting energy outputs contained common design attributes that equated to lower energy consumption, and therefore deemed necessary for inclusion.

1.5 Key Product

"The patterns can never be 'designed' or 'built' in one fell swoop – but patient piecemeal growth, designed in such a way that every individual act is always helping to create or generate these larger global patterns, will, slowly and surely, over the years, make a community that has these global patterns in it." (Alexander, 1977, 03) This is rarely the norm in the Chinese landscape where the design and construction of complete neighborhood segments is determined by centralized authority. While efficiency at this scale is important, the final result would have a more organic feel by drawing upon the lessons and form perpetuated by the long-standing vernacular of a given area (as seen in the Urban Taxonomy). The Clean Energy Prototypes inform six common practices of urban arrangement that can result in better urban form.

The Clean Energy Guidelines create a structured path toward clean energy design. Organized in descending scale, the guidelines suggest avenues of design investigation that will lead to better energy use. To preserve the option for universal application, few of the guidelines include specific metrics. Once the Energy Proforma© tool is calibrated to locational settings, the outputs indicate measures that achieve improvements. The original research and testing was based in Jinan, Shandong Province, China, but soon the project will be used globally. Within the structure of each guideline, the first research question is about the relationship of neighborhood physical design to energy consumption and is answered in the Energy and Implications section that explains and quantifies the connections between energy and urban form with metric samples taken from the research evidence.

1.6 Thesis structure

This thesis is organized as follows:

Chapter 2 expands the introduction of the Making the Clean Energy City in China Research Team's methodology and findings, beginning with the Jinan neighborhood survey that produced the Urban Taxonomy and the Clean Energy Prototypes. It shifts into the use of the Energy Proforma© and its web interface and outputs.

Chapter 3 creates a context of urban form guidelines for city-making. Included is an examination of different approaches for optimized configurations, how these have stood up over time, if value shifts have rendered them obsolete, and whether each approach is holistic and includes elements such as energy measures. Each approach has an important foundational concept that informs its formulation and application and consequently, important lessons can be learned from its successes and failures.

Chapter 4 Chapter 4 contains the Clean Energy Guidelines meant to be used by designers and developers to guide them in the design process. By following the critical initial steps they will find that their designs will begin at higher levels of energy efficiency. The Guidelines are intended to be used in conjunction with the Energy Proforma© tool. These guideline is represented qualitatively, but displays the metrics of a sample project that incorporates the approach and produces results in keeping with the goal of lower energy consumption. The Guidelines are organized overall in a descending scale (regional to urban to building to unit). Each begins with the impact summary of each step, the guideline, a graphic sample (pulled from the collected data for the project, the energy impacts with sample outputs, and the long term implications.

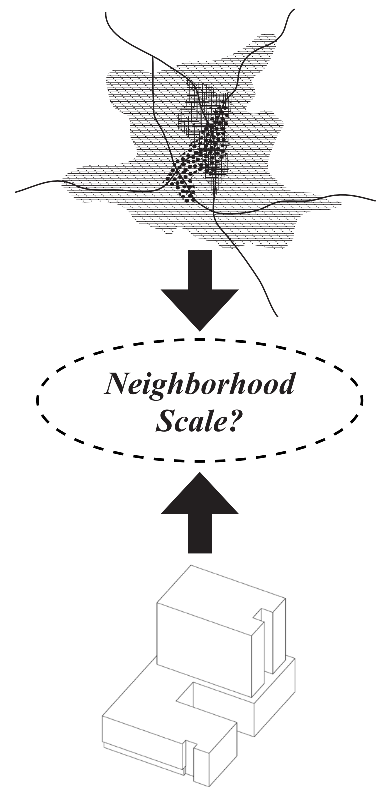
Chapter 5 concludes the thesis by with a discussion of the future direction of making clean energy cities one neighborhood at a time. It is a fundamental DNA, specifying the essential relationships between form and practice which can begin to signal meaningful steps to take for efficient neighborhood design. This information is distilled into qualitative urban design guidelines with quantitative measures that can be utilized by a design and development team to expedite the integration of energy saving measures in a context of fast-paced design phases without sacrifice energy saving measures in favor of a swift product completion. If followed, the qualitative guidelines promote the design of Clean Energy neighborhoods and cities that are critical in this age of diminishing natural resources.

2.0 NEIGHBORHOOD DESIGN

Making the 'Clean Energy City' in China

The design of buildings has been the subject of the sustainable development movement for many years. Research and innovation has resulted in new approaches to building materials, integrated and generated energy systems, controlled and responsive façades, and resource and waste reuse. The urban scale has been addressed with efforts to provide alternative transport options, such as bike- and car-share programs, better and more accessible mass transit, and the introduction of sprawl controls such as urban growth boundaries. While these are all positive steps toward the long range goal of effectively addressing climate change, the building and urban scales of such interventions lie on different ends of the spectrum, as was discovered and established by the Making the 'Clean Energy City' in China research. A critical element that has been missing is the neighborhood scale: how the design of collections of buildings, streets, and open spaces, determines how energy is consumed. The formation of the Making the 'Clean Energy City' in China research group was prompted by the need to investigate this and related issues.

The current practice as mandated by Chinese urban development policy is a system of vast land-clearance, parcel assembly, and single-developer neighborhood construction. The dominant form being built upon this new landscape is the highly-replicable tower-in-park – a city fabric defined by "two symbiotic instruments of Megalopolitan development – the freestanding high-rise and the serpentine freeway. The former has finally come into its own as the prime device for realizing the increased land value brought into being by the latter" (Frampton, 1983, 16). Typically housing



2.0a Scalar relationships of current energy design © author

2.0b Tower-in-park condition which typifies Chinese urban development © Christopher Rhie

in China what was in the 1990s and 2000s an expanding middle and upper-income population, this highly-replicable form was swiftly implemented to also accommodate the urban migration of formerly rural households. Operating under the misconception that more households would be living within this typology, the practice was codified.

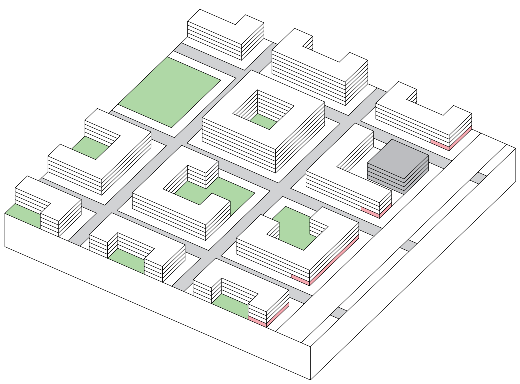
The majority of the models operate as gated communities that are distant from the existing central business district. This establishes an ever-dependent relationship with automobiles, accentuated by a public realm dominated by parking surfaces and structural entries. Sparsely distributed, single-use structures fill the parcel and these are networked with interior roads. The spacing between the towers, enforced by day-lighting laws, created shaded gaps of planted green space that the isolated residents rarely utilize. The residential high-rise towers lack alternate uses within and residents must then drive for services and employment. The buildings are controlled climate, homogenous structures lacking in diversity of units to serve a varied population. These inefficient neighborhood forms consume high amounts of operational and transportational energy due to the combinatory nature of living elements and practices. Given the rising demand for housing and development in this region, and all over the world as urban populations continue to grow, a more conscious way of developing neighborhoods and cities must be designed and implemented to alleviate the already dire pressures placed upon natural resources to mitigate the effects of climate change.

2.1 Urban Taxonomy through Traditional Neighborhood Survey

The research group began with a method of analysis by which a survey of vernacular urban forms were studied. This practice, employed by designers such as Alvar Aalto and termed by Kenneth Frampton as "critical regionalism", looks to how sensitivities of climate, light, topography, and tectonics are observed and understood in application (Frampton, 1983, 27). Once the vital characteristics are isolated and observed to establish a system of best practice, the concepts are able to be imbued into new types of design process and urban form.

In conjunction with this regional survey, the group received unprecedented access to data documented the energy consumptions and living patterns of 600 Chinese housholds. Through extensive analysis and regressions, the group was able to better understand the influences in daily life that led to types and quanitites of consumption. This information was then able to be extrapolated into the base data for the Energy Proforma© site and the documentation of the city prototypes.

After an exhaustive process of researching the neighborhoods of Jinan, the critically extant characteristics of each area allowed them to be classified into six basic clean energy neighborhood prototypes. These are evident in many combinatory applications, but the variety is distilled into an essential set. An Urban Taxonomy was generated by the research team that cataloged the case studies under each of the prototypes, and subsequent global samples.



2.1c Small perimeter block axon and Proforma outputs
© Making the Clean Energy City in China

Small Perimeter Blocks:

• If properly oriented, the cluster allows sun to penetrate to all units, retains heat in the winter, and can mitigate the effects of wind in cold climates. Energy is conserved by moderation of the microclimate and the reduced need for elevators in low rise structures. It also allows for individual front doors on the perimeter and semiprivate space inside the block, a highly livable arrangement.

• The collection of small blocks creates a highly permeable (accessible), pedestrian dominated environment that can easily accommodate a mix of shops, services, and schools where convenient and feasible. This reduces the need for a car, which may still access any unit through shared streets, although parking would ideally be located at the periphery of the neighborhood.

• Low rise allows for lighter weight construction and reduced embodied energy.

• Large roof surfaces provide ample space for PV and solar hot water (and the court yields space for geothermal wells, if desired.

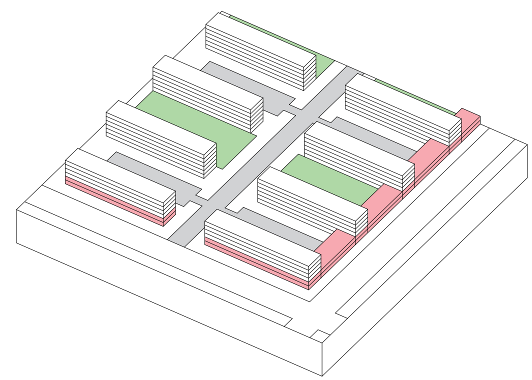
Walk Up Slab Enclaves:

- These forms are typical in many clean energy projects because, when aligned east-west with proper shading devices, they can maximize solar gain in the winter and reduce it in the summer, lowering heat and cooling energy demands. In China, units are typically arranged off common stairwells serving 3-4 units per landing with no elevator. (Elsewhere units are accessed off single-loaded corridors.) This efficient plan enables cross ventilation in each unit, reducing demands for cooling, and minimizes energy use in common space and elevators.

- Shops, restaurants and services on surrounding streets are accessible on foot from within the enclave. Larger scale enclaves should be well connected to surrounding public streets to enable direct access (as opposed to a single gated entry, which increases travel distances and energy use by cars).

- Low rise allows for lighter weight construction and efficient floor plates with minimal common space reduces embodied energy.

- Sloped roof surfaces can provide ideally oriented space for PV and solar hot water, however, the amount of roof surface per unit is less than the small perimeter block, and becomes even lower as the height of the slabs increases.



2.1b Walk up slab enclave axon and Proforma outputs
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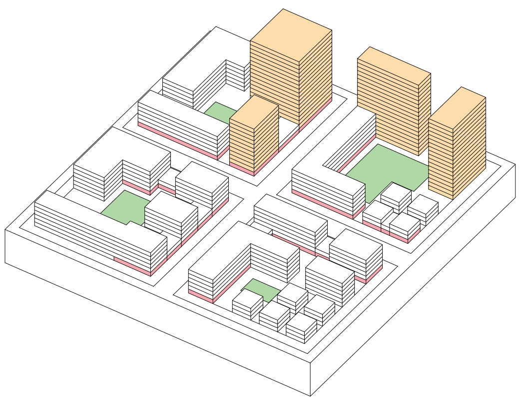


3.1d Urban grid axon and Proforma outputs
© Making the Clean Energy City in China

Urban Grid:

• This prototype is less able to take advantage of energy savings to be found by integrating high and low rise building systems because there is no regular pattern of form. Of course, individual structures may be oriented and designed to take advantage of passive solar heat gain and loss, however the overall potential to save energy is less than would be found in a more integrated system. The major energy savings of this prototype emerge from its ability to achieve relatively high densities within a very accessible, livable environment.

• As with the perimeter block prototype, city streets surrounding the blocks maximize opportunities for shops, restaurants, services, schools and parking structures to be integrated in the fabric, all conveniently accessible because of the grid. Animated public streets encourage walking and use of the public realm, reduces use of autos, the time people spend in their apartments, and energy consumption. The densities that may be achieved by this prototype makes mass transit more feasible.

• Taller structures enabled by this prototype require heavier construction, more steel and therefore have more embodied energy.

• As with passive measures, the Mixed Grid has less potential for incorporating renewable energy systems than a more organized form, notwithstanding individual opportunities on a building by building basis.

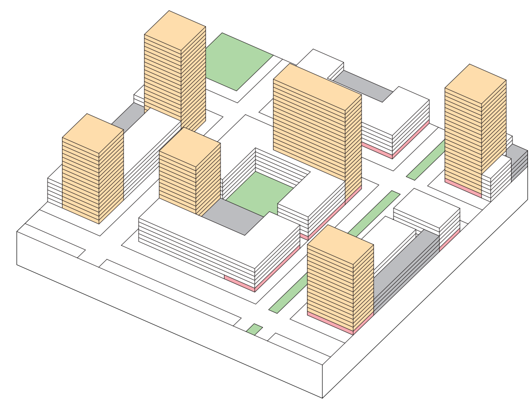
High Density Perimeter Blocks:

• If the clusters are properly oriented, and taller elements carefully located, sunlight to units may be maximized, and wind minimized, during winter months, reducing heat demands. During the summer, taller elements may shade the units and court spaces below, reducing cooling demands. Furthermore, by integrating the energy systems of high and low rise structures, chimneys or vertical spaces within taller elements can provide natural ventilation for the entire block, and recover and re-circulate heat in cooler months.

• Conventionally scaled (2 lanes with parking) city streets surrounding the blocks maximize opportunities for shops, restaurants, services, schools and parking structures to be integrated in the fabric, all conveniently accessible because of the grid. Animated public streets encourage walking and use of the public realm, tends to reduce auto usage, the time spent by people in their apartments, and energy consumption.

• Taller structures require heavier construction, more steel and therefore have more embodied energy. Lower structures may be of lighter construction, yielding moderate embodied overall.

• The roofs of low rise elements provide good locations for photovoltaics and solar hot water. Taller structures are less efficient solar collectors, due to small roof areas, however, depending on height they could offer sites for wind power. Court spaces provide locations for geothermal wells.



3.1e High density perimeter block axon and Pro-forma outputs
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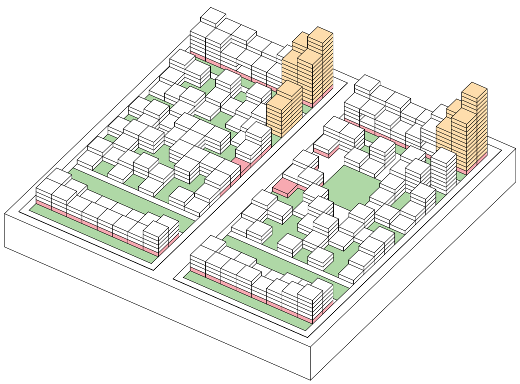


2.1f Urban sponge axon and Proforma outputs
© Making the Clean Energy City in China

Urban Sponge:

• Traditional variations of the Urban Sponge cluster type are organized around spaces and courtyards of various sizes which allow sunlight to enter but mitigate the microclimate, protecting from cold winds in the winter and providing shade and natural ventilation in the summer. These benefits extend into three dimensions including even high rise structures with upper level "court" spaces that provide daylight or shade as appropriate, natural ventilation, and places for cooling vegetation, saving energy in surrounding units on all sides. Taller elements may naturally ventilate and recapture heat from lower elements as with the High Density Perimeter Block prototype.

• The Urban Sponge is a pedestrian environment, where cars and parking structures are relegated to the periphery of the blocks. However, vehicular access to service and vertical circulation must be maintained on the ground level. This saves energy by reducing car travel and elevator use to the degree that mixed uses - schools, services, even shops and restaurants - can be located on routes of movement at or above ground level.

• Embodied energy consumed per unit would depend upon density and height. Taller structures enabled by this prototype require heavier construction, more steel and therefore have more embodied energy.

• The sensitivity to design can be given to the location of photovoltaic and solar heating elements, which maximize energy capture.

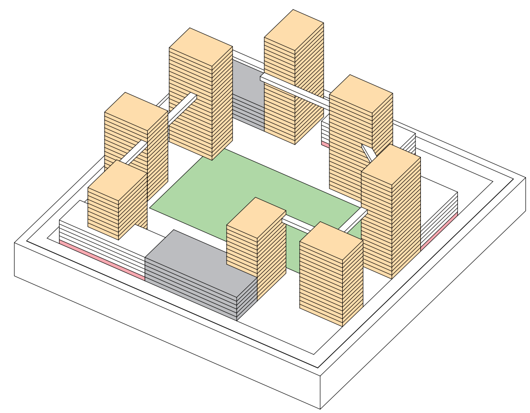
Tower Networks:

- To maximize solar gain, and beneficial shade, towers need to be carefully located to not interfere with each other or activities on the ground. This will inevitably be more difficult than high-low schemes given the number of towers and suggests that office and hotel uses, which require less direct sunlight, be concentrated more in the northern sections of a district or on the lower levels of the towers.

- Connecting upper levels provides the opportunity to establish a secondary public realm of shops, services, educational, and social activities in the air, and convenient access between living and working -- between apartment and office buildings. This makes the most sense where the density is sufficient to also support activity on the ground. The two realms can be then effectively linked. This networked, mixed use environment can reduce the need for vertical trips and car trips on the ground, saving energy.

- Embodied energy consumed per unit would depend upon density and height. Taller structures enabled by this prototype require heavier construction, more steel and therefore have more embodied energy.

- This predominantly high-rise cluster provides less roof space than alternatives and therefore has less potential for photovoltaic or solar hot water generation. Depending on height and spacing, the towers do offer opportunities for wind power generation. By using towers to achieve density, more ground space can be made available for geothermal wells, if appropriate.



2.1g Tower networks axon and Proforma outputs
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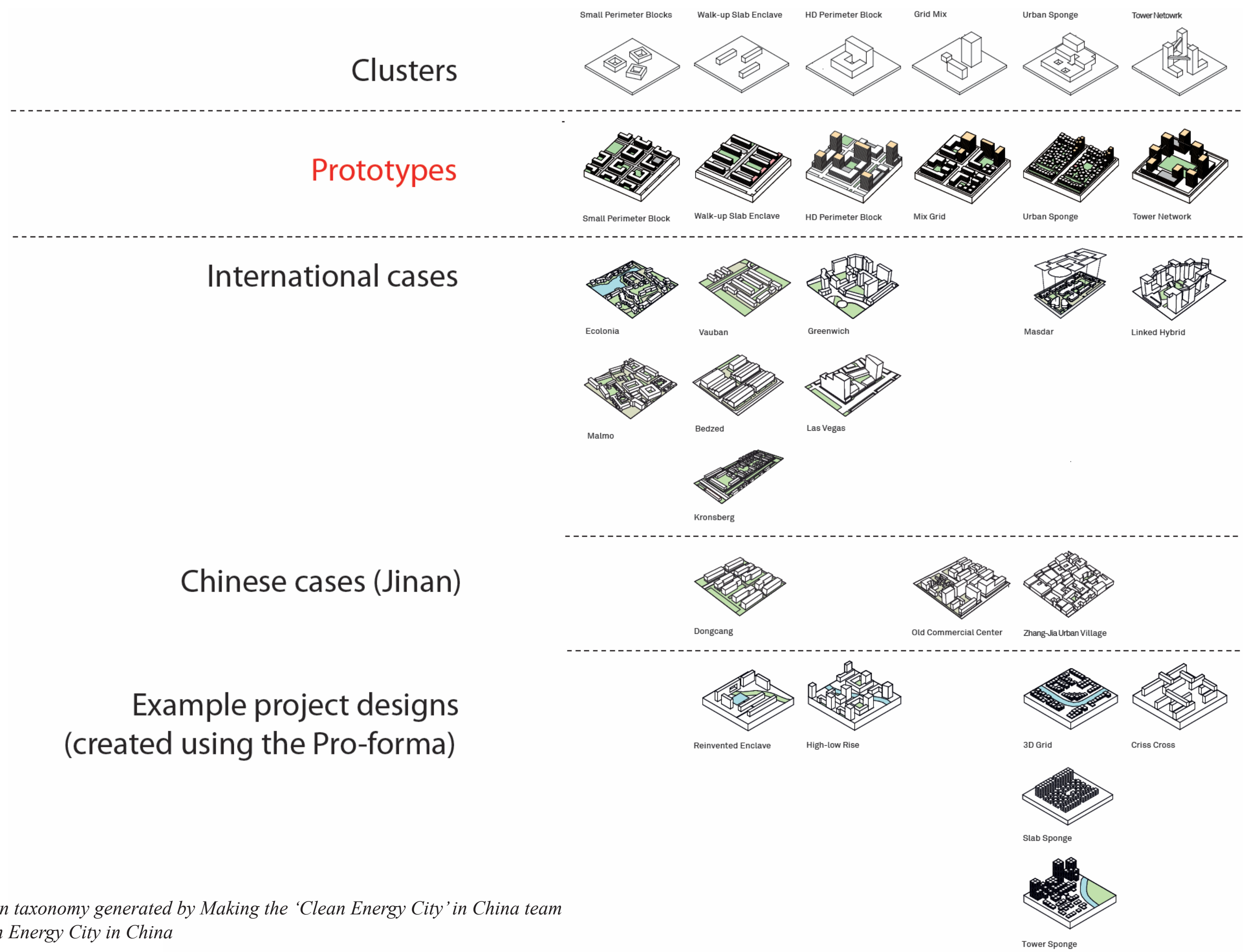


2.1h Complete urban taxonomy generated by Making the 'Clean Energy City' in China team
© Making the Clean Energy City in China

Prototypical models alone were not sufficient to create better clean energy designs. While making some of the connections visible, the researchers began to apply sophisticated multivariate regression models and statistical analysis to construct an assessment tool that accurately reflects the building and living patterns of neighborhood design.

2.1i Sunshine 100 - a typical tower-in-park community in Jinan, and a study site for the research team © George X. Lin

2.2 Energy Proforma©: An Iterative Tool for Clean Energy Neighborhood Design

Upon the realization that urban form is a major factor in determining the energy consumption of a given neighborhood development, the notion of having a method for quantifying it and identifying the critical relationships influencing energy consumption generated the creation of what is now called the Energy Proforma©. Such tools had not been explored, and this particular tool was released as an accessible web-based interface for a wide audience. While energy modeling is common practice in the field of mechanical engineering, traditionally it was a simple calibrated calculation examining a single building based upon the ratio of glazing to solid façade, the material components of both applications, and the effectiveness and operational energy of power and HVAC loads. This provides numerical analysis for satisfying municipal energy codes, ASHRAE standards, and LEED requisite requirements, but is flawed for numerous reasons. It fails to capture the ramifications of many other aspects of buildings and development that researchers have attempted to define and account for in a comprehensive manner. This became the mission of the Energy Proforma© development team.

What has been lacking is an effective and universal procedural system for measuring the performance of a given development. This was the first step taken by the development team, under the guidance of Professors Dennis Frenchman and Christopher Zegras. It was accomplished by forming collective considerations and classifications, using defined and consistent sources of data, and establishing an output unit that allows for direct comparison. Once these are created, a common measure output for such projects can be compared and studied from a variety of contexts and uses. By seeking to create a new approach to guiding an iterative design process, the first step was establishing new specific classifications of energy consumption that will lead to a more inclusive measure. The complex interactions that were identified early became organized into four fields:

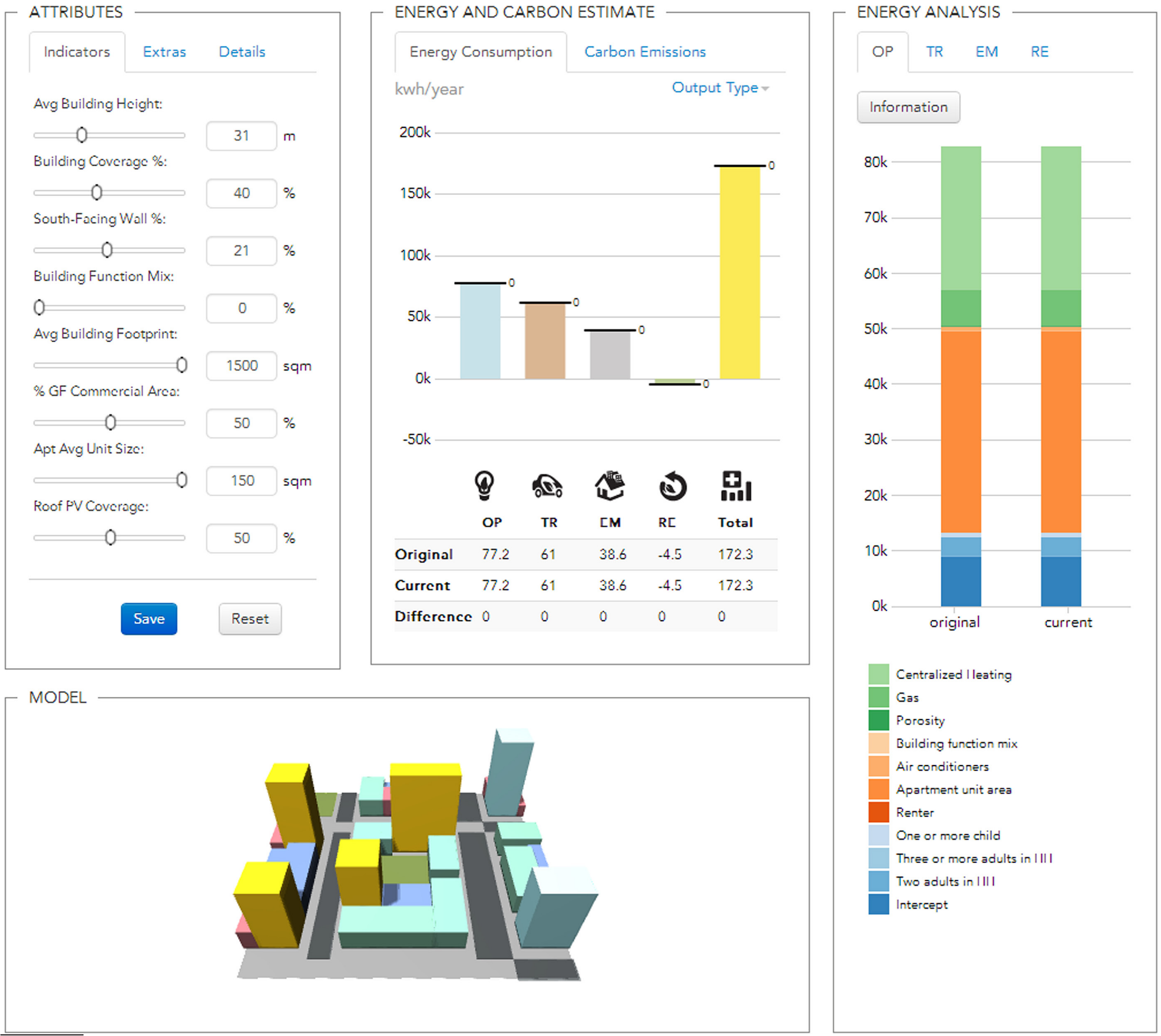
- lifecycle process of building construction, from the energy expended in the sourcing, production, and transportation of given materials, the energy expended in the maintenance and replacement to continue occupancy, and finally the demolition of the sites and buildings;

- operations of the buildings energy systems, including the residential units, work spaces, and common areas;

- the frequency and distances travelled by residents depending upon the access to services, employment, activities, and uses around them with more energy being wasted by isolation;

- the integration of technologies capable of generating renewable clean energy and offsetting the operational consumption.

These categories became the definitions of the four main dimensions of the Energy Proforma© measures: Embodied, Operational, Transportational, and Renewable. All of these are combined to provide a more holistic image of the Total Energy Consumption of a given neighborhood design, or to borrow a term from financial proformas, the net present energy value of the project. While the Proforma© disseminates the outputs into four distinct categories, there are several variables that overlap and have intrinsic effects upon the overall design realm: building orientation, ground- and upper-level circulation, block distribution, configuration of form and uses (vertically and horizontally), and the resulting human movement. The resulting system became the basis for a practical tool that can be used in an iterative process and provide real-time feedback for formal and programmatic decisions made during the design phase that can affect the relative energy performance of a development.



2.2a A sample output of the Energy Proforma©

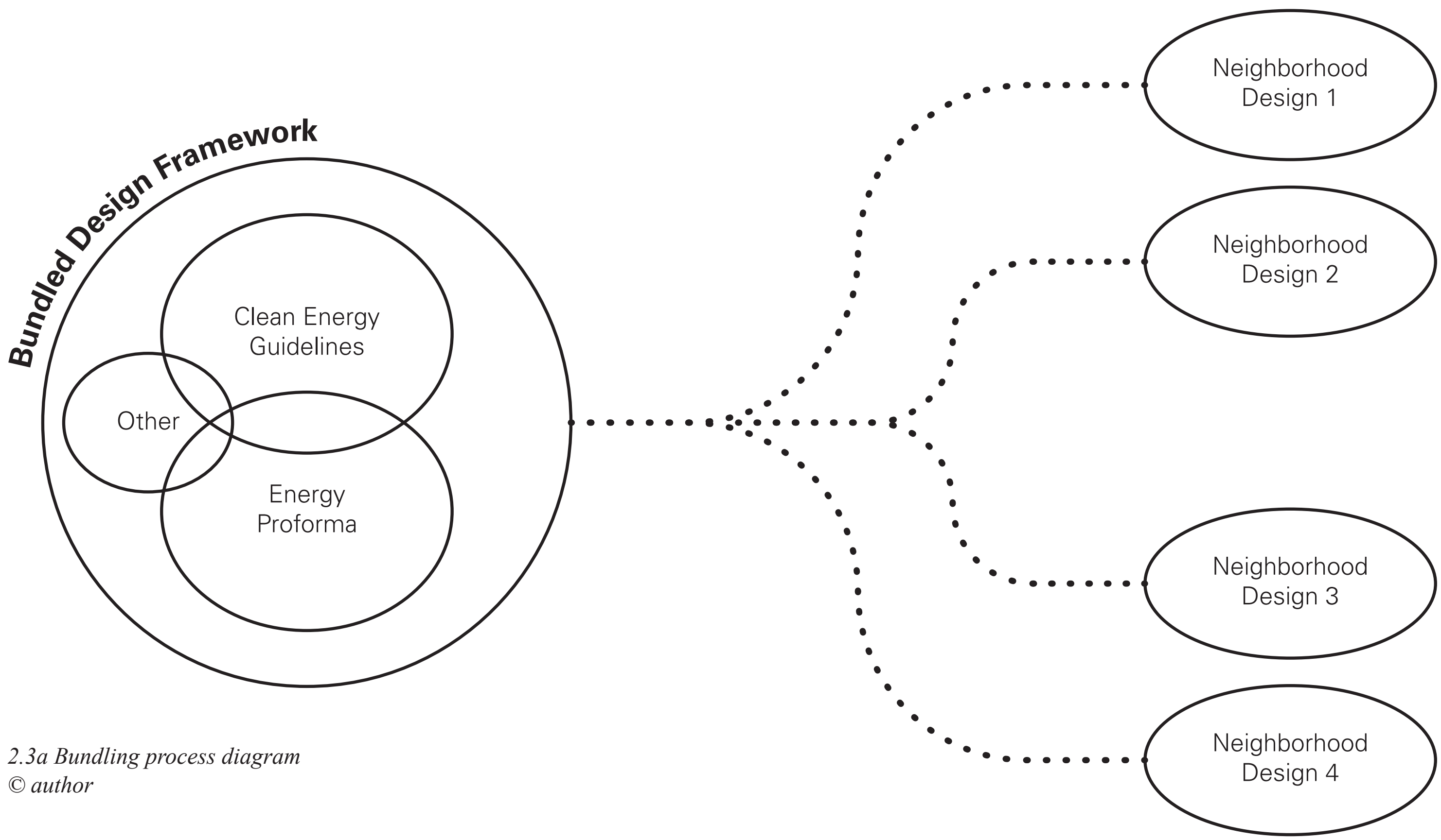
To begin the process of using the tool, the Energy Proforma© is calibrated to specific location, climate, and socio-economic factors. Next is the input of the series of attributes that define all of the individual components of the physical model. These attributes can include details such as the number of floors that are commercial, the percentage of glazing and photovoltaic coverage, the amount of open space, frequency of road networks, or physical adjacencies. Once these attributes are applied to the forms, the models and variables can be processed by the Energy Proforma©. The output then informs a designer of what the current categorical performance measures are reporting. This output level is interactive and the user is able to adjust certain inputs to immediately realize some of the ramifications of particular decisions. Design decisions are not prescribed or idealized, which leaves a unique decision-making process to the designer with opportunity for innovative outcomes.

The strength of this system is a method that is complete, integrating all of the factors affecting the energy performance of a project over its life cycle (construction, operation, and demolition) and combining them to the single, proportional energy output of the project. This iterative process encourages an understanding of the more complex connections held within the form-energy system of a particular urban design. This establishes an effective method for both research and practice. On the research side, a series of "cluster" models (the predetermined size of 200 meters by 200 meters) can be rapidly designed and tested under controlled situations to generate a collection of comparable results. It is also transparent, so the data, assumptions, causal elements, and their interactions can be followed for future replication when required. When applied to practice, the designer has a swift system of continuous output on the predicted energy performance of a neighborhood design. As it is tested through the traditional work phases (Conceptual stages through Design Development), the user is able to understand fundamental relationships and trade-offs necessary to achieve lower-energy design.

3.3 Bundling Practice and Policy for Better Energy

The research group currently has a team dedicated to understanding multilevel policy and how it can best be affected to better incorporate comprehensive energy considerations. Policy goals for urban development can be established to work in tandem with advanced tools such as the Energy Proforma©. To first accomplish such foundational changes, a deeper understanding of the necessity for a comprehensive method for better urban design must include an overall reduction in energy consumption. Potential reforms aimed at neighborhood development policy, building upon this research on energy-efficient urban patterns in Chinese cities, include energy performance standards, land lease and parcelization reforms, property and operational taxation, carbon credit trading, and a transparency/disclosure program.

Any path to successful reform requires establishing a common protocol for evaluating total energy consumption at the neighborhood scale. When coupled with the Energy Proforma and the subsequent Clean Energy Neighborhood Urban Design Guidelines (see Chapter 4.0), deeper level policy changes can assist in a realization of lower relative energy consumption of real estate development schemes across four dimensions of energy use: operational, transportation, embodied, and renewable energy generation.



2.3a Bundling process diagram
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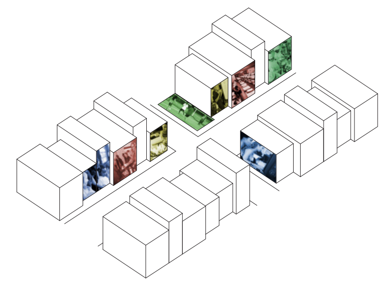
3.0 NEW ORDERING

Ordering the Built Environment in Urban Design

Frederick Law Olmsted Jr., and in turn many professionals in the planning field, felt there was a vital necessity to regulate the role of the developer in the interest of the city (Ben-Joseph, 2005, 100). Rather than allowing an urban landscape to be manipulated at the hands of "ignorance and greed on the part of landowners and builders" (Olmsted, 1916, 3), the process should be clearly guided and enforced to protect the public interest while maintaining measures for inventiveness and ingenuity.

The practice of controls and guidelines for the development of urban form has been present and considered in a variety of approaches within the planning field. Over time, the systems of values that cause the priorities of practice to rise to the fore may adjust: the ability for a child to negotiate a safe urban realm established a framework for the Neighbourhood Unit, the balanced and systematic application of aesthetics by a universal user prompted the creation of the Pattern Language, and the desire to depart from a damaging Euclidean separation provoked the New Urbanists to devise the Urban Transect. All three offer insight to the past successes and failures of prior frameworks for neighborhood-scale formal guidelines. Also researched are the two prominent solutions for sustainable design, BREEAM and LEED ND, and finally two progressive urban comprehensive plans.

Urban planners and designers are continually confined and influenced by the obligations of public and private actors with a multiplicity of agendas and expectations. The specific approaches, devised by planning professionals and experts to create a neutral framework

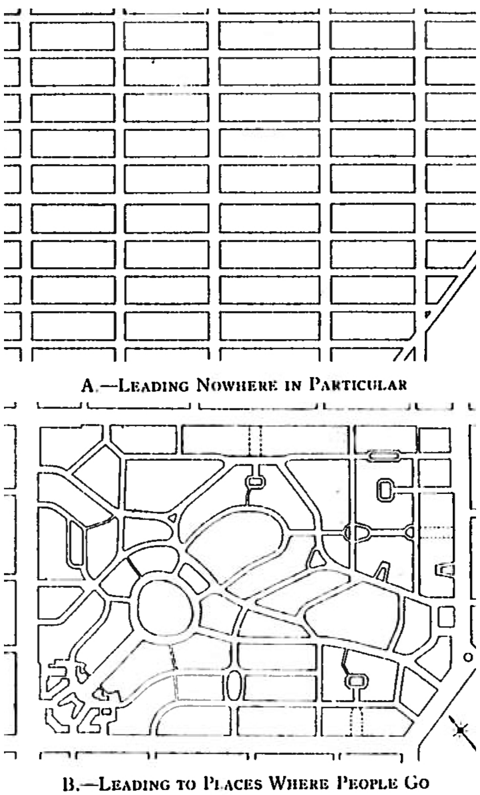


2.0 A representation of new neighborhood form © author

of urban design in which they can shape the built environment, are examined in the following section.

Current precedents, such as the examples profiled in this chapter, have limitations posed by the the design of the approach, whether the framework only accounts for form or energy, rather than recognizing and embracing the more complex relationship of form-energy and allowing a designer to exploit the full extent of a neighboehood design potential.

3.1 Neighborhood Unit: Walkability Measures as Design



3.1a Perry's view of conventional and neighborhood street systems

An early pioneer in providing a documented framework for the ordering of urban form, Clarence Perry released the Neighbourhood Unit as a sensible method of community-centric neighborhood planning where civic assets are distributed in an accessible and equitable manner. The primary prescriptive goal of the configuration was to create a prototypical system of design application that could be both replicable and customized with fixed controls embedded within the implementation process. This scheme of arrangement is to create neighborhoods that promote "family-life communities" rather carrying the intention of being a detailed plan (Perry, 1929, 34). The purpose for defining this neighborhood as a unit is to imply the distinction of being an entity unto itself while still acting as part of a whole. A series of assumptions are made in advance, which many would find antiquated from a planning perspective, e.g. the occupants of the unit would work outside of the area and the area itself would not contain centralized functions but be a mixed use, horizontally distributed neighborhood. Perry envisioned a sequential process of development from the ground-up at a time when new neighborhoods on open land were common and space constraints were not the concern they are today.

The urban design proposal of the Neighbourhood Unit is based upon six requirements (Perry, 1929, 34):

1. Size – A residential unit development should provide housing for that population for which one elementary school is ordinarily required, its actual area depending upon population density.

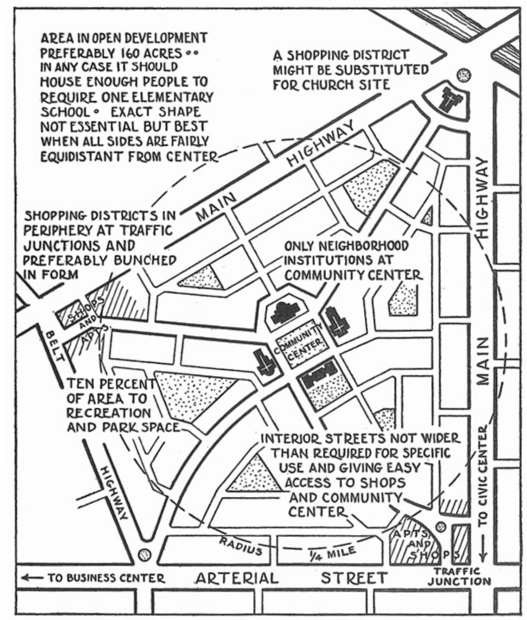
2. Boundaries – The unit should be bounded on all sides by arterial streets, sufficiently wide to facilitate its by-passing by all through traffic.

3. Open Spaces – A system of small parks and recreation spaces, planned to meet the needs of the particular neighborhood, should be provided.

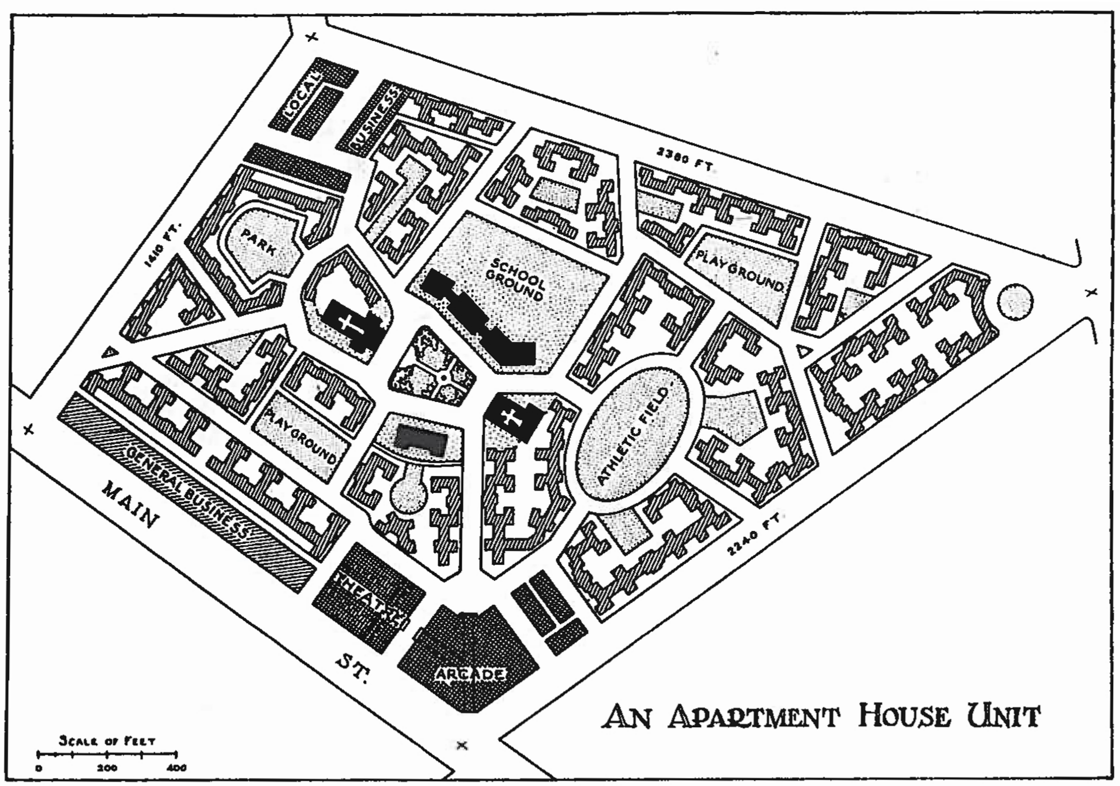
4. Institution Sites – Sites for the school and other institutions having service spheres coinciding with the limits of the unit should be suitably grouped about a central point, or common.

5. Local Shops – One or more shopping districts, adequate for the population to be served, should be laid out in the circumference on the unit, preferably at traffic junctions and adjacent to similar districts of adjoining neighborhoods.

6. Internal Street System – The unit should be provided with a special street system, each highway being proportioned to its probably traffic load, and the street net as a whole being designed to facilitate circulation within the unit and to discourage its use by through traffic.



3.1b Perry's Neighbourhood Unit principles



3.1c Plan of Clarence Perry's Apartment House Unit: "A method of endowing a multiple-family district with interesting window vistas, greater street safety, more liberal open spaces and a neighborhood character

TABLE III.—DISTRIBUTION OF AREA IN FIG. 12

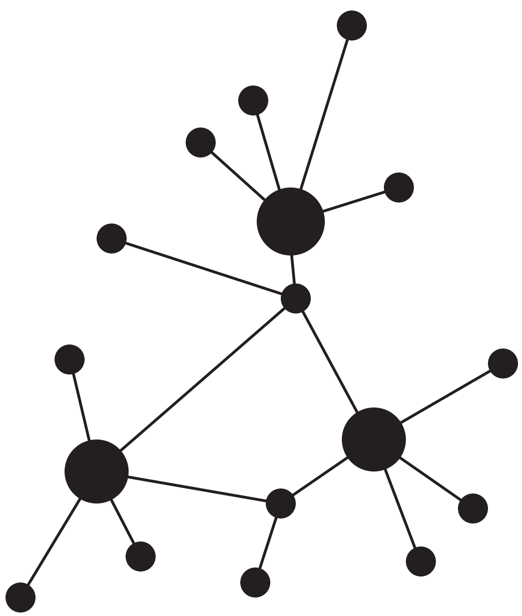
Total area of unit	75.7 acres	100 per cent
Apartment buildings	12.0	15.9
Apartment yards	21.3	28.0
Parks and playgrounds	10.4	13.8
Streets	25.3	33.4
Local business	4.9	6.5
General business	1.8	2.4

2.1d Accompanying metrics

These principles were derived from a series of ideals that Perry believed vital to a comprehensively considered plan. He then established a series of metrics, first calibrated to "Low-Cost Suburban Development" to understand the capacity and distribution of various attributes of the neighborhood, such as the number of residents to support a school (Perry, 1929, 37). The school was intended to be the most centrally located, walkable entity in order to ensure that a child's walk to school was safe, only about one-quarter mile. Boundary arterials meant only smaller, interior streets were crossed. The boundaries of the perimeter roads serve to confine the interior space into a distinguished "place" with the suggested width of such streets being 160 feet, and width of the remaining bounding streets slightly smaller at 120 feet (Perry, 1929, 37). "Smaller" interior streets are then 40 to 50 feet wide which Perry deemed appropriate for the density and needs of a single-family residential neighborhood, designed to fit the character of use rather than encouraging through-traffic. Those networks would be subject to a "functional disposition" by which they are employing a "tree-like design for the street system…branches, covering all sections of the unit, facilitate easy access to the school, to the main street stem, and to the business district" (Perry, 1929, 39). The value of open space and recreation was recognized with the recommendation of providing 10% of the land area given to parks.

The plan faced significant criticism in years and decades to follow. The most infamous came from Reginald Isaacs who characterized the neighborhood unit as a mechanism for subdivision and financial gain for mortgage lenders that reinforced what he considered the FHA's agenda of utilizing the unit system "as instrumentation for segregation of ethnic and economic groups…termed inharmonious" (Isaacs, 1948, 19). Rather than being a form for containing, Isaacs saw boundaries as a method of exclusion, lacking the egalitarian permeability of a democratic design. In time the contained property of the Neighbourhood Unit can be seen in the features of a gated community (even without the physical gate) where communities are contained and isolated rather than part of a larger whole. Originally purported to meet the fundamental needs of family life, Perry's Neighbourhood Unit lacked the ability to be a viable guide for urban design when compact development and enhanced walkability became common priorities, but the only measure of a rational system was the population of a given development.

3.2 Pattern Language: Structuring Design

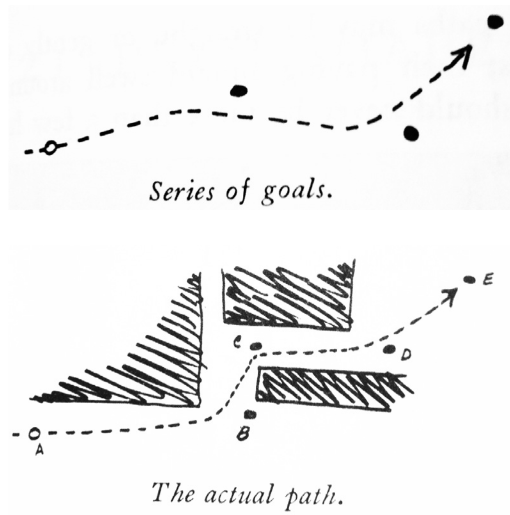


3.2a Rhizome structure diagram of Pattern Language process © author

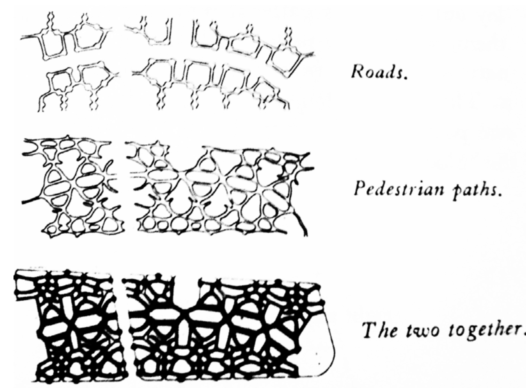
Pattern Language, established by Christopher Alexander and his team at the Center for Environmental Structure, was devised as a structured yet universally accessible approach to ordering urban form based upon the isolation of fundamental and extant patterns. Alexander's intention was that even a layperson is capable of employing successful and objectively "good" design practices through the utilization of a clearly mapped approach. As Alexander states, there are "two essential purposes behind this format. First, to present each pattern connected to other patterns, so that you grasp the collection of all the 253 patterns as a whole, as a language, within which you can create an infinite variety of combinations. Second, to present the problem and solution of each pattern in such a way that you can judge it for yourself, and modify it, without losing the essence that is central to it" (1977, xi).

Through a method of design guidelines, a user is able to understand an emergent language which will signal the presence of a pattern that will lead to the coherent inclusion of a new layer of design patterns. The method of application is similar to a mathematical generative grammar which is simply a series of rules that will predict (or lead/guide) a particular combination by creating a set of problems and documented solutions. Similar to a mathematical or quantitative approach, "each pattern may be looked upon as a hypothesis like one of the hypotheses of science. In this sense, each pattern represents our current best guess as to what arrangement of the physical environment will work to solve the problem presented." (Alexander, 1977, xv).

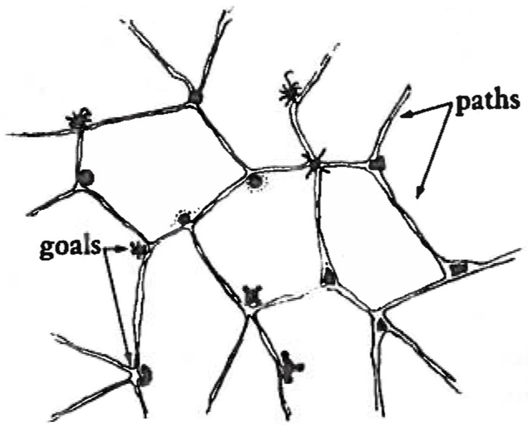
When all these patterns are taken together, a particular "language" will emerge, but the makers of this system declare there is an infinite series of outcomes. Theoretically, when taken in a combinatory practice, "no pattern is an isolated entity. Each pattern can exist in the world, only to the extent that is supported by other patterns: the larger patterns in which it is embedded, the patterns of the same size that surround it, and the smaller patterns which are embedded in it." (Alexander, 1977, xiii). The guidelines are introduced by its authors as an established method for reliably distilling good systems and criteria that will make for a good design. In this case, good is represented by the multiscalar mixture of repetition and compositional uniquity. Because of the potential number of combinations and outcomes and the individual ingenuity of the designer, rarely would uniformity



3.1b The gradual building of goals and paths in spaces



3.1c Pattern language process of "growing" path networks in street distributions



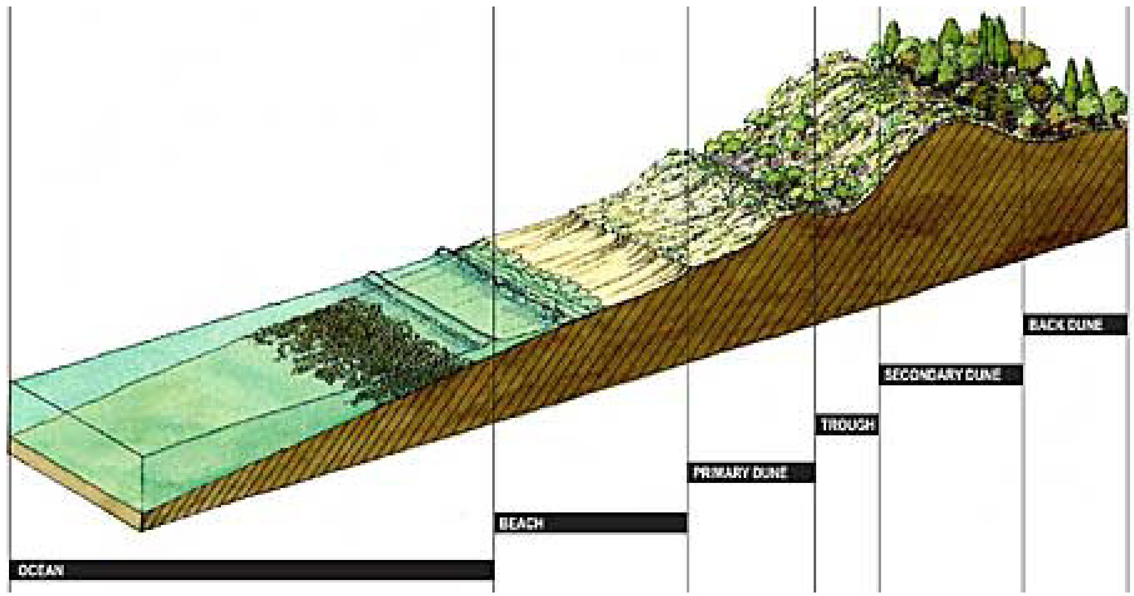
3.1d Pattern language network of paths and goals; goals should be limited to a 10 minute walk apart

result, in spite of the finite palette contents. Instead, the result is "a pattern language" with "the structure of a network…there is no one sequence which perfectly captures it" (Alexander, 1977, xviii). Like the rhizomatic structure of a tree the path travelled within a network can be configured in an endless number of ways.

The concept of thinking in terms of patterns, whether identifying those that are emergent or applied through a system, has readily been embraced in a variety of fields from software and interface design to pedagogical techniques in linguistics and speech structure. One of the successes was isolating the importance of the pattern concept and its ability to multiply and divide space and systems and a variety of scales. Potential downfalls include its subjective application by the non-professional, and the immeasurable results of a project. The design is a progression over time, as the "patterns can never be 'designed' or 'built' in one fell swoop – but patient piecemeal growth, designed in such a way that every individual act is always helping to create or generate these larger global patterns, will, slowly and surely, over the years, make a community that has these global patterns in it." (Alexander, 1977, 03). While this is an application to be embraced in the smaller building realm, or even in a collective method across neighbors, this is not capable of being exercised in large developments where centralized development relies upon the rapidity and affordability of a streamlined construction process. This approach offers a necessary flexibility and option of form that can enhance form-energy benefits, outweighing the convenience of replicated forms, such as the towers in China.

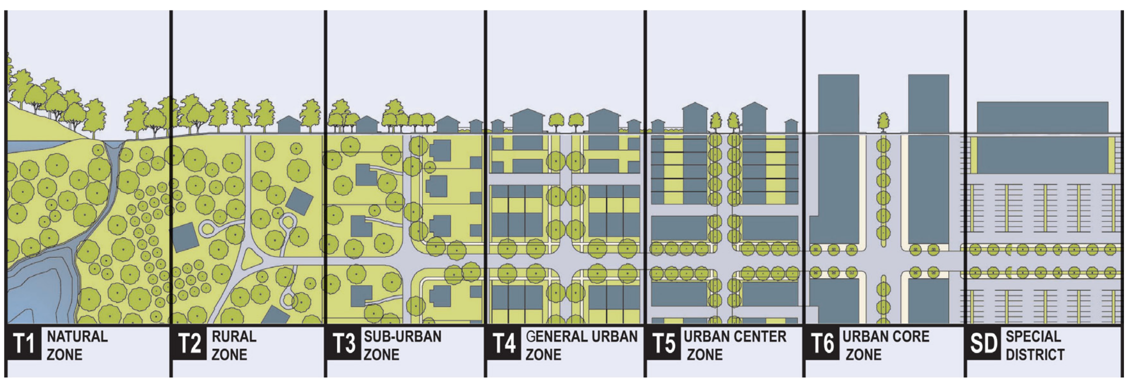
3.3 Urban Transect & Form Based Code: Ordering Intensities

Following years of use separation encouraged by regulations embodying Euclidean zoning, the Urban Transect was devised as a prescriptive tool for urban planning by DuanyPlater-Zyberk and the College for New Urbanists. Initially inspired by the Ecological Transect to spatially organize and establish order for the given contents of an ecosystem, the view shifted to the human ecosystem (Bohl, Plater-Zyberk, 2000). The Transect was created as an attempt to establish a new normative theory for contemporary development. By assembling a lexicon of form and features, then assigning a place or characteristic for such as condition, the concept becomes a system for assembling an urban milieu possessing the universality that comes with ease of application, but also with an innate sense of place and uniquity that come with community engagement.



3.3a Ecologocal transect serving as a base for the Urban Transect (source: http://www.transect.org/)

Rather than ordering what already is there, the opportunity is presented to establish a desired organization and to build toward it using a common language that creates the framework for a new zoning system (SmartCode). Utilizing common urban modules within a system of shared knowledge and resources, a way is provided for the community to evolve gradually toward its defined vision. "Even though the Transect is called a 'model,' the fundamental importance of the Transect is its flexibility for communities to create immersive, sustainable human habitats" (Neely, 2006). By utilizing building form and typology, rather than more traditional zoning methods (which led to the separation of uses and the isolation of sprawl), the new paradigm is to create blended forms and uses at a human scale through a collaborative process of multidisciplinary experts and public participation. Rather than approaching development in an overly incremental fashion, the imagining of the complete environment allows for the creation of a development strategy and regulations that are compatible with the actions and expectations of citizens and developers (Neely, 2006).

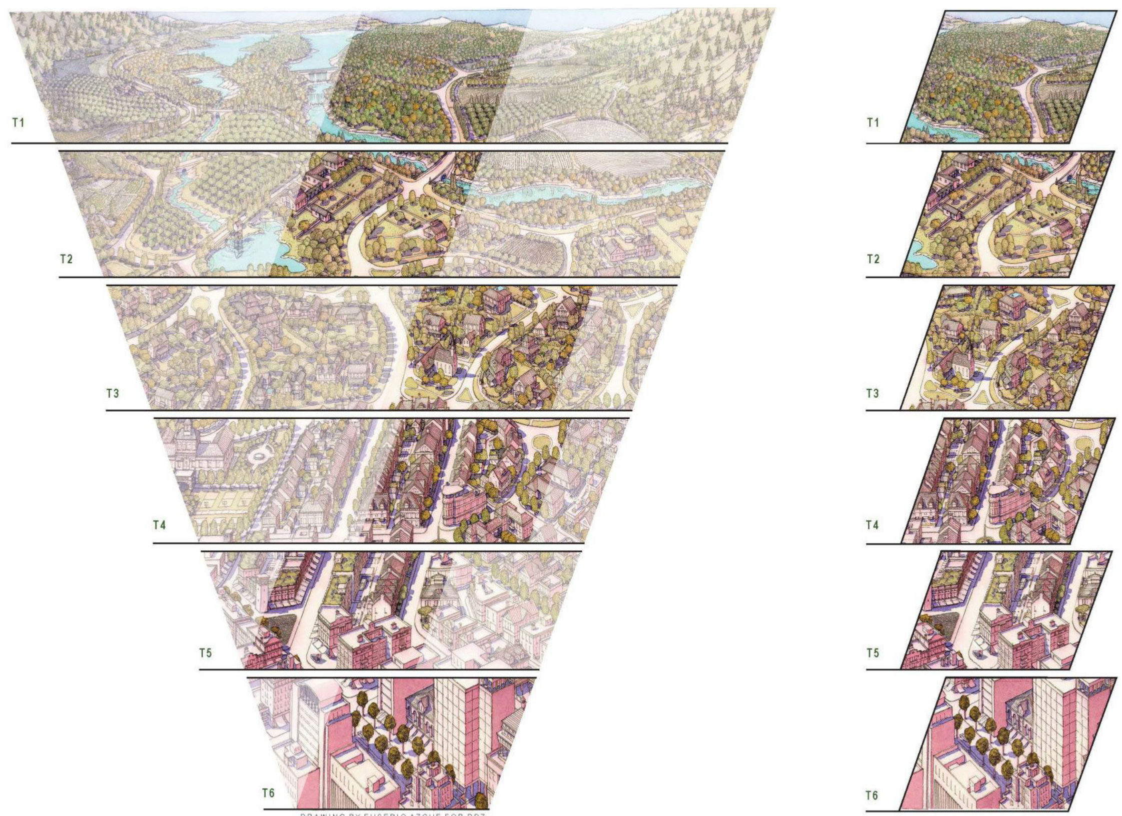


3.3b T-zones of the Urban Transect (source: http://www.transect.org/)

The Transect has "orders" of built environment that transition from rural to urban and has been divided into Transect-zones (T-zones) that step down in levels of intensity while defining the general development intent with respect to the other zones. The basic zones are:

- T-1 Rural Preserve
- T-2 Rural Reserve
- T-3 Sub-Urban
- T-4 General Urban
- T-5 Urban Center
- T-6 Urban Core

The T-zones vary, not only in levels of development intensity measured through ratio and typology, but also in intensity of natural and social components. The T-zones could be considered graded habitats that possess particular attributes and qualities specific to their character and intensity, but intended to be flexible and adaptive based upon the nature of each specific area. The zones are meant to be structurally balanced based upon what are termed walksheds (pedestrian paths derived from the watershed methodology) and planners can "assemble environments into one continuous system [that] promotes sustainable, coherent urban pattern composed of human environments" (Talen, 2002). There is a place for preservation in this model, but the designations must first be established to complement the order. With the emphasis on walkability, there is a closer link between transportation and



3.3c Existing prototype diagram - urban wedge (source: http://www.transect.org/)

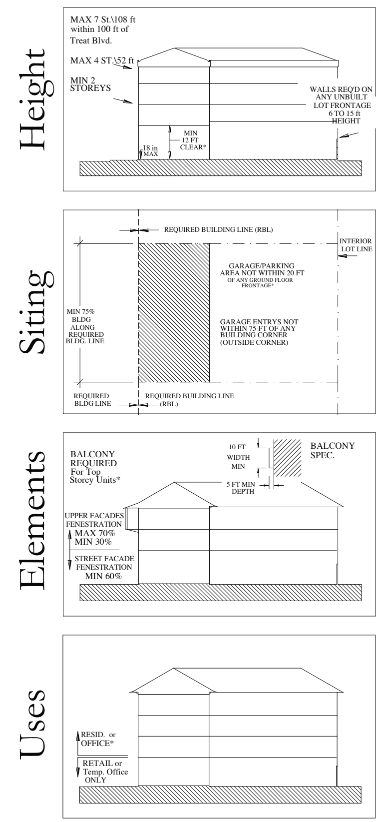
use with the application of methodologies similar to transit oriented design/development.

The application methodology begins with the process of analysis. Once the focus area has been identified by local planners and officials, the area is then evaluated for calibration and comparison to existing transect prototypes for direction (Center for Applied Transect Studies, n.d.). This process is accompanied by an in depth environmental assessment referred to as the Quadrat and Dissect in nature which is composed of a spatially sectional and surface study. An evaluation of the existing human habitats is then conducted which emphasizes the identification and location of zones of value by citizens and planners.

A point to be emphasized is the importance of the Transect as only the first step in the process. The Center for Applied Transect Studies (CATS) created the model and framework to be partnered with a Form Based Code (FBC). The Form-Based Codes Institute defines the framework as "a method of regulating development to achieve specific urban form, with a lesser focus in land use, through city or county regulations" (Form-Based Codes Institute, 2010). The concept of the Form Based Code is the alteration of the urban realm through form rather than land use to generate a more integrated space that harkens to the successful traditional urban patterns of scholars such as Jane Jacobs. The land use based codes tend toward a separation of uses that is neither necessary nor encouraged, and is seen as a factor that helps to perpetuate sprawl. In contrast to land use based codes, the Urban Transect approach prescribes the parameters for the physical environment with the emphasis placed on the quality of the public area to produce "pedestrian-friendly, context sensitive, design-driven, and implementable development outcomes thus enhancing a community's identity and long-term sustainability" (Mercier, 2008). By following a community-driven vision for the form of the city, there is greater ease in following the integrated procedure of plans, codes, and policies.

The method of calibrating or formulating the FBC occurs as civic participation involving planners, policy-makers, professional facilitators, consultants, and community members participate in an extensive public charette process to reveal mutual community priorities and place-specific constraints or issues. All Public engagements must be inclusive and, to the extent possible, motivated by a shared desire to provide unbiased and unabused service to the community. Dissemination of information for the public is fundamental to continued application and support and is only accomplished by producing all related documents in plain language and making them readily available. This helps to demystify what has been a traditionally obtuse process. Over time it can result in opportunities for the perpetuation and self-preservation of what is good and successful for the entire community.

The end result of this process is condensed into a shared concept or community vision. One could conceive of the FBC as merely, for better or worse, a codified version of this vision. Once the community commitment has been made, the base code is then calibrated to the place. This occurs through local planners and related players identifying areas of import, and possibly the assignment of zonal values for following the transect or a related model. Production of the required materials follows in the form of regulating plans, public space standards, building form standards, administration outlines and assignments, and definitions {graphic}. Additional items can sometimes include: architectural, landscape, signage, environmental resource, and annotation standards. This can then translate into a direction for a compatible city form, while still following the axiom "Form follows Function" (Mehta, 2006) with an emphasis on diversity, legibility, adaptability, continuity, quality, accessibility, and character – all elements that contribute to making places for people (Place-Making).



3.3d FMB envelop standards for storefronts (source: http://www.formbasedcodes.org/)

Derived Lessons

**Neighbourhood Unit:
Walkability Measures as Design**

- Focused on neighborhood scale of development & arrangement
- Human space as dictate
- Static metrics forced approach to become obsolute
- Inflexible & non-responsive to reflect shifting values

**Pattern Language:
Structuring Design**

- Non-hierarchical system to create cohesive combinations
- Formally infinite
- Universally accessible
- Clear path of application

**Urban Transect:
Ordering Intensities**

- Engaged Process learned from prototypes
- Context sensitive with prescriptive solutions
- Incompatible with municipal regulations & codes
- Restrictive formal guidance

3.4 BREEAM and LEED ND: Categorical Sustainable Frameworks

While the previous frameworks have looked specifically to the development of urban form through a series of measures and dictates, they were not conceived with the intention of considering sustainability and energy. There are several aspects of best practice that the methods embrace that have inherent positive effects, such as walkable neighborhoods that shift transportation away from cars, but the concept of energy and resource conservation is not a focus. This changed in the 1990s with the introduction of several "green building" frameworks that created systems for assessing and rating buildings by using impact and success scores. These frameworks reflected and added impetus to a growing industry awareness of the importance of sustainable building practices.

The United Kingdom (UK) Green Building Council established the first national environmental assessment system called Building Research Establishment Environmental Assessment Method (BREEAM). Introduced in 1990, it began as an energy assessment system for office buildings. Subsequent versions quickly embraced other typologies, such as industrial and retail. BREEAM requires the assessment process to be performed by independent, licensed assessors trained to provide accurate validation and certification issuance (Parker, 2009). This system dominated the "green building" landscape in the UK and through Europe, eventually spreading to areas such as the Gulf countries. Eventually a larger scale version emerged, BREEAM Communities, focusing on the whole community scale of planning and design to generate livable and viable places for residence and commerce.

In 1993 the US Green Building Council released a similar system known as Leadership in Energy and Environmental Design (LEED) of which there are now several versions differing by application. The LEED evaluation systems have typically consisted of a categorical credit accumulation measured for grading (certified, bronze, silver, gold, and platinum). It played a pivotal role in the landscape of US development. Prior to LEED, US industry frequently "shunned environmentally-friendly materials or energy-efficient systems for the high initial cost and 'pseudo-science'" [but over time] legitimized/mainstreamed Green Design as a business investment" (Quirk, 2012). LEED for Neighborhood Development (ND) is a system that emerged from the need to consider a development scale larger than the single building.

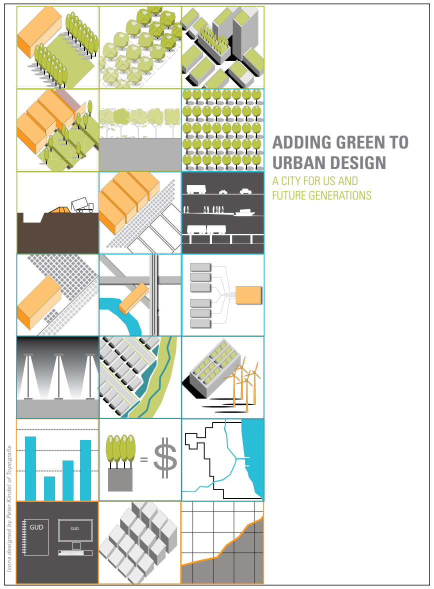
Benefits of these rating systems include reliable measures based upon "research back standards that [provide]…credibility" (Quirk, 2012) and perceived ease of use. Both systems operate by applying a categorical rating system that assigns credits according to the extent to which a metric threshold is satisfied. As more are credits achieved, a project receives higher recognition. The thresholds are quantitatively based, and in the case of both BREEAM and LEED, the rating system can be adapted to prevailing climatic conditions.

Although they have an empirical basis, BREEAM and LEED both rely upon isolated rating systems that do not consider the specific context or purpose of the development (Quirk, 2012). While there is award given to developing brownfield and for choosing locations close to other developments, neither model is sufficiently programmed to discern with greater specificity ideal locales. This can result in a somewhat superficial satisfaction of some metrics, resulting in arguably inaccurate ratings. Another drawback is that BREEAM and LEED are not "smart." As design processes move forward there is not a capacity for measuring the dynamics between metrics. Metrics must be met to achieve the receipt of a credit, but opportunities cannot be exploited for obtaining feedback during design about how projected performance on one set of metrics will affect performance on other metrics. Both BREEAM and LEED require ongoing attention to building performance after construction by means of post-construction appraisals, but feedback at this stage is too late to impact the design process.

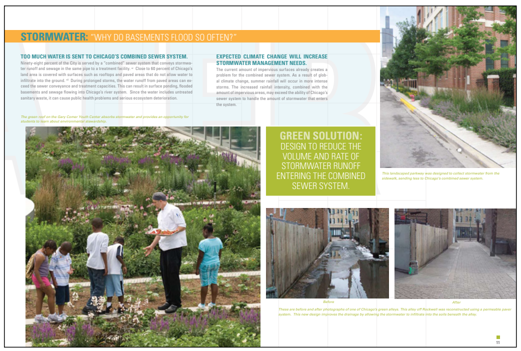
These rating systems were created in an attempt to develop a "broad-spectrum, holistic approach to being Green" (Quirk, 2012). Some of the greatest successes of BREEAM and LEED are due to the positive impacts on public relations and financial return that certification can provide. Competition between the two systems has been positive: when one is more effective, the other adjusts to improve, thus creating a type of "dynamic tension between the two competing systems" (Parker, 2009). However, the downside to both remains the lack of true, real-time measures at the design level able to provide feedback necessary to optimize the production and operations of a new development.

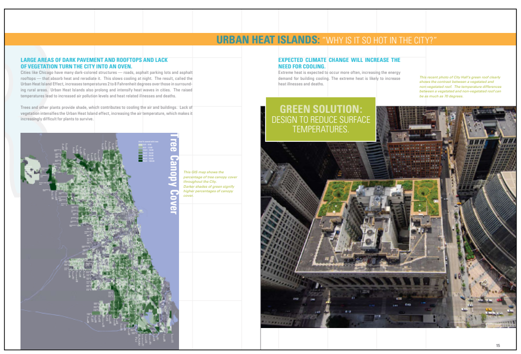
3.5 Greening City Plans

As long as the built realm is part of a system of exchange, whether as a system of capitalism in the interest of globalization or the expansion of ideologies, there will be situations of conflicting and compromising sensibilities at the point of intersection between the practice of urban design and the practice of real estate development. According to Thom Mayne, the notion of shaping cities through comprehensive plan-making as a means of controlling their growth is "increasingly ineffective simply because future developments cannot, in the present volatile societal dynamics, be accurately predicted" (Mayne, 2011, 09). Given this pessimism in the capacity of the urban planner and designer, does this render the comprehensive plan ineffective, or more significantly, obsolete? It may instead usher in the need for a reconfigured approach to the city plan. Rather than the excessively zoned designations of the past, cities are introducing new approaches in an attempt to base city-making on best-practices. "The complex interplay of human and natural forces shaping cities today and into the future demands that architecture give form to urban forces active beyond traditional building and property lines, and also that large-scale planning assume more flexible and adaptive spatial structures that are capable of accommodating the unpredictable…new design concepts and methods must be created," (Mayne, 2011, 09) but with this notion of dexterity there must also be a systemic framework to ensure excellence in the built environment.



3.5a Chicago's Adding Green to Urban Design: A City for Us and Future Generations





3.5b Plan excerpts addressing heat islands

As municipalities are poised to enter a future of space-constrained development, dwindling resources, and increasing urban population growth, several cities have been issuing sustainability-based plans. Two such plans are the "Guide to Copenhagen 2025" and the "Chicago: Adding Green to Urban Design: A City for Us and Future Generations." It is worthwhile to briefly examine these documents as examples of the kind of planning one might expect from two cities with reputations for being progressive and forward thinking as they seek to cope with the challenges of making themselves sustainable and livable places for the 21st century.

The Chicago plan was adopted by the city in November 2008, with Mayor Daly stating that it "builds upon the notion that densely developed cities… are the most environmentally responsible form of human settlement" (Daly, 2008, 03), and that through the continuation of compact development and living, natural resources will be more efficiently used by urban dwellers. The plan is intended to promote strategies for better design and to potentially position Chicago on the national stage as a leader in sustainable urban practices that address issues relating to water, air, and land.

One of the methods of implementation is the treatment of exposed urban "surfaces" – building facades, roofs, streets, yards, open spaces, parking lots, driveways, sidewalks, and alleys. Traditional values are reiterated in the first chapter, such as the benefits of urban density, and also point to the government's role in supplying controls that ensure sustainable urban development. The second chapter presents the goal and objectives of the plan:

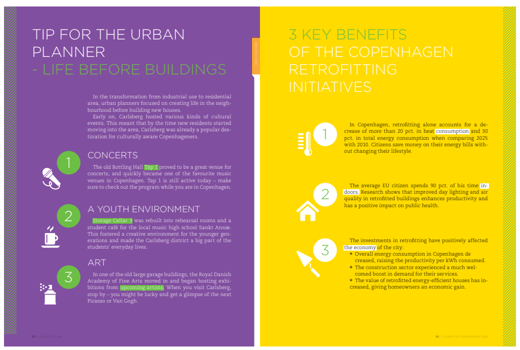
Plan Goal:
Maintain and improve Chicago's urban design to optimize its environmental benefits for current and future generations.

Plan Objectives:

- Water – Capture and use precipitation and encourage water conservation.
- Air – Improve air quality.
- Land – Preserve and expand the quality and function of vegetated surfaces.
- Quality of Life – Improve safety and public health and engage people in the outdoor environment.

Chapter three is made up of the "21 Key Actions" that are divided between Approach and Action, Integration, Innovation, and Assessment. The plan does not provide any formal guidance for the creation of the built city environment, but instead gives advisory direction to the city and the Plan Commission on how to regulate and review urban design and development projects. There are also points regarding the distribution of public finance and investment for the city's built spaces. The only evident measures reflect on past practice, e.g. green roofs already constructed. There are no concrete metrics established within the categories, or even a normative basis for comparison. While it makes early mention of, and continually returns to, the conservation of the natural resources, there is no mention of energy consumption according to urban form. Ultimately the plan's most prominent contents, beyond the gesture of "green" commitment, are the

3.5c Guide to Copenhagen 2025

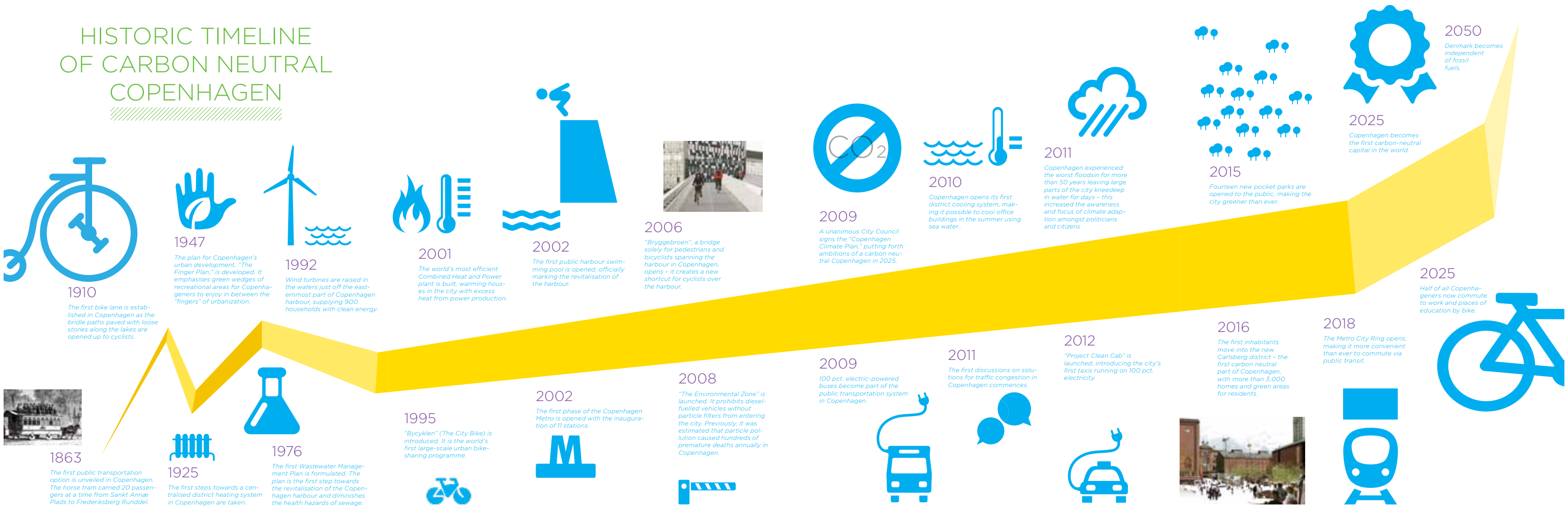


3.5d Plan excerpts addressing culture and retrofit priorities

suggestions for application and a rather vague implementation timeline for bureaucratic training and adoption.

In contrast to the entirely internal efforts of Chicago, the Guide to Copenhagen 2025 enlisted the assistance of an outside consultant, Sustainia, in the development of their plan for taking the city into the future. The Guide's intention is to establish an achievable scenario for a carbon-neutral city by the target year of 2025. Told through a narrative of the future citizen engaged in activities of their daily lives, the visualization of the sustainable city in the Guide is intended to stimulate interest and motivation to support change. A graphically dynamic and lively composition, the Guide took the approach of adopting a guidebook medium as an accessible tool for every citizen to understand the designs and measures required to help the city reach its goal. Developing the plan was a multidisciplinary effort with contributions from Microsoft, GE, BIG Architects, Knoll, and IKEA. Interspersed throughout are "mantras" that are simply rephrased principles such as "all citizens should live within a 5-10 minute walk to green areas."

The Guide lacks the standard linear format typically used to help readers understand how a plan will be implemented. Instead, data and qualitative guides are interspersed throughout the narratives and cityscapes. Under a title "This City is Made for Walking," one finds the statement, "It takes five minutes to walk four hundred metres. Installing conveniences such as shopping and public transport within this distance promotes walking and cycling" (Hansen, 2012, 14). It is significant and should be acknowledged that the Guide



3.5e Plan excerpt of a timeline for carbon neutrality is a collective effort of a broad cross-section of city residents and was not simply left to technocrats and designers. However, the Guide lacks practicality. Subtle data is buried in qualitative claims instead of being included in direct and specific forms that professionals can extract and employ in a meaningful manner. That there is currently no companion guide for practice is a significant drawback to this approach.

As promotional pieces that can encourage resident involvement, provide general information, generate enthusiasm for, and confidence in, the city administration, these documents seem to work well. Modeled on the travel brochure, both are effective examples of advertising (an important takeaway) that combine helpful information about sustainability, with past, present and future projects that have and will changed how the city expends energy and provides more opportunities for residents to enjoy a "greener" life style.

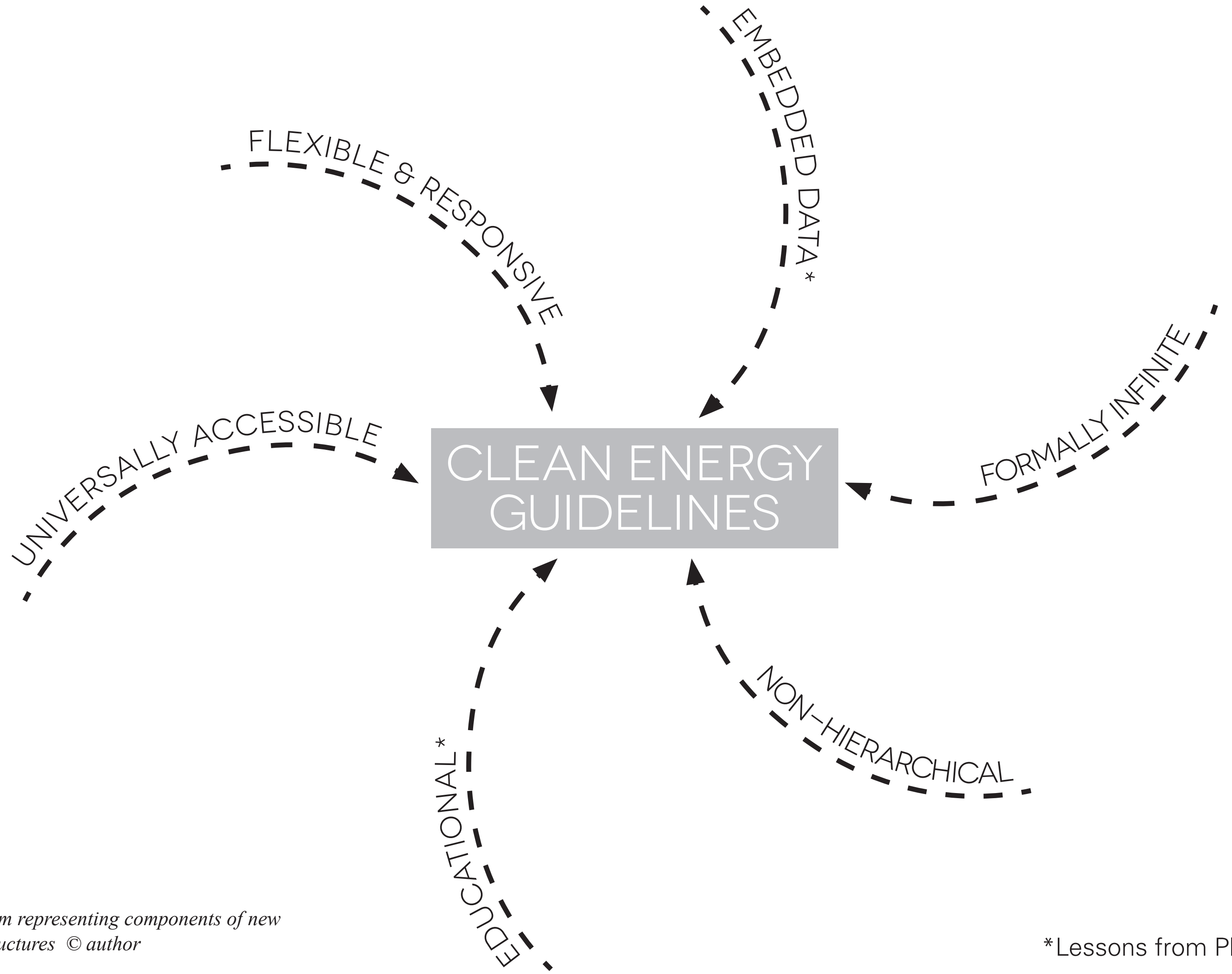
Perhaps because the plans, especially Chicago's, primarily focus on changing the energy consumption of individual structures and infrastructures (already existing or planned for the future) their methodology seems neither intended nor capable of providing a more comprehensive focus. Much of the method of creating sustainability seems to involve piecemeal efforts at altering, adding and overlaying. It seems to be intended primarily for the building scale, not the neighborhood, with no apparent method of measuring energy consumption of, an existing or planned neighborhood as a whole system. This approach is of very limited use for making new neighborhoods from the ground up and for planning changes to elements of existing neighborhoods in situations where it is important to know how the planned change impacts the neighborhood as a whole.

In contrast, because energy conserving principles are embedded into the Energy Proforma© and the Clean Energy Guidelines, they provide a way of measuring how different individual entities in a neighborhood work both individually and together to achieve more comprehensive goals of sustainability. It is this level of design that begins to reveal the most basic form-energy relationships that are capable of making a substantial difference and improvement in neighborhood design for the future. Mitigating climate change must be a result of deeper impacts from the DNA of a city, the most elementary levels of urban construction that embodies the principcals from the inside-out, rather than a mere address of sufacing and superficial networks which is merely triage.

3.6 New Ordering: A New Way to Form

The above approaches to urban planning and development, though different from each other, all function as frameworks for a more or less fluid planning process. Ultimately, the codes and partnered systems strive for a similar result: a variegated, compact, walkable, and sustainable form which is commonly accepted to be conducive to the development and sustainability of community vitality. But are any of the key variables in these approaches able to be defined, quantified, and measured? Measurements taken of key variables provide the empirical evidence needed to evaluate successful application of an approach and its ultimate practicality. Without evidence, degrees of success or failure cannot be determined, and planning remains a repetition of what is "professionally deemed good practice" rather than a process proven to produce good neighborhood design.

When compared across case studies of applications, the product can be varied in typology, scale, and use. This comes from the malleability of the codes, regulators, and users. Certainly the Pattern Language and Urban Transect strive to avoid an over-formulaic approach to prevent homogeneity and/or failure (Kohr, 2004, XX), and to establish significant patterns of activities and layers of meaning necessary for a cohesive sense of place. The continuing struggle to establish a normative and navigable approach to planning will cause the results of these approaches to exist in a state of limbo between the predictable or formulaic and the haphazard and incoherent. Regulations will continue to be over-relied upon and "continue to exert influence and shape the built form of the global landscape" (Ben-Joseph, 2005, xx), and the continued subjectivity of applications without quantifiable accountability measures will remain a serious shortcoming.



3.6a A diagram representing components of new guidelines structures © author

*Lessons from Plans

4.0 CLEAN ENERGY GUIDELINES

Application and Practice

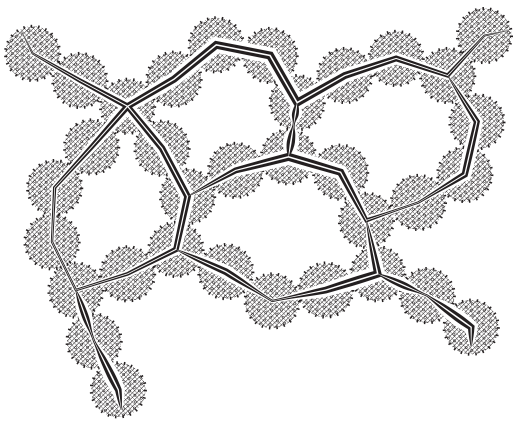
The guidelines are intended to be used in conjunction with the Energy Proforma©, which is where they depart from more traditional applications of design guidelines and formal codes. In this case the guidelines do exactly what is implied in the name: they guide. By beginning with an informed view on the energy consumption of given forms within the urban taxonomy, the designer is able to begin the design process with formal clues that improve energy consumption. The critical difference between earlier and more conventional guidelines and the Clean Energy Guidelines is that because of the Energy Proforma©, after following an initial recommendation, the designer can dimension and determine the implications of each design decision. The initial design endeavor can systematically consider and implement each guideline while testing iterations with the Proforma©.

These guidelines and directives are qualitative and quantitative derivations that comprise the 3 years of global research by the Making the ‘Clean Energy City’ in China group at MIT. By applying the design characteristics and lessons on best practice herein, the preliminary stages of design will begin to formulate an urban neighborhood that makes efficient use of energy on a city-scale. Topics for guideline content include elements such as: height, orientation, porosity, road networks, unit sizes, parking, transportation access, and construction type, among others. When taken together, the composition of form and relationships such elements have to one another, the characteristics that affect energy consumption can be adjusted. The guidelines are written from perspectives of empirical research, best practice, and on-going investigation that all contribute to a more flexible type of development approach, where the goal is not to meet a fixed or arbitrary minimum standard but to optimize performance through the continual adjustment across an array of variables which has the potential to reach a higher overall energy performance standard than could have been planned.

Note: Unless noted otherwise, the materials and images used for this section are created by the Making the Clean Energy City research group and the Beijing Urban Design Studio, 2012.

section 0.0
GENERAL PRINCIPLES

0.1 Modal Shifts from Automobile Ownership



4-0.1 Diagram of walkable nodes within a connected framework © author

The use of cars and other personal motor vehicles that burn fossil fuels is a major contributor to the degradation of the environment and climate change. Providing for the needs of pedestrians, bicyclists, and mass transit users will help reduce use of such personal vehicles. Through an effectively planned public realm, urban design can help lower greenhouse gas emissions that are affecting and accelerating climate change. One of the critical components is pedestrian networks safely connected to alternative transportation such as bicycles and mass transit.

By moving away from autocentric city form, new urban design methods will help to create a thriving neighborhood that is achieving levels of success in energy, economy, and social well-being. Current models feature streets that are spatially dominated by faster moving zones dedicated to cars. This practice is encouraged by designated spaces for people that are spaced beyond a recommended five minute walking distance, and is poorly connected to mass transit, which makes driving a personal vehicle the most attractive and convenient. Existing urban zones can be retrofitted over time, with the right-of-ways becoming reclaimed as public space for bicycles, pedestrians, and recreation.

Building up a multitude of car-free zones will create a comprehensive urban network that has shifted from a fossil-dependent system. Interconnected multimodal systems, as well as capitalizing upon new technologies for mobility-on-demand to close extant gaps within the system, can aid in a long-term resolve and commitment to make urban areas primarily car-free for daily life and activities.

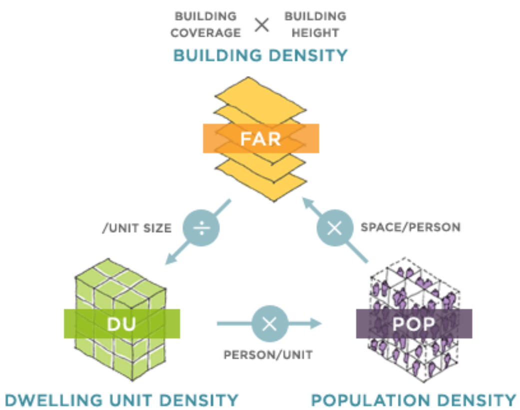
0.2 Priority for Pedestrians

One of the most effective methods of moving people away from personal vehicle use is to create links of pedestrian patterns that are pleasant to experience while possessing an ease of use. The paths of pedestrians is where community interactions can take place, and where people can engage in activities such as vending, taking respite in seating, or seeking an exterior dining experience. Well-ordered and protected spaces that are capable of promoting such happenings will draw people out of interior spaces (where energy is frequently being spent on interior comfort). Protection can come in the form of thermal comfort (shade from the sun), weather and elemental shielding (canopies for rain), and personal security (well-lighted areas). This can also happen in the buffering between less desirable zones, such as landscaping or parked cars protecting the sidewalks from the street traffic, or vehicular access points set away from public open spaces.

Urban spaces can engage the interest of pedestrians through effective transitions between public and private realms by creating a permeability with street-level spaces within buildings to exterior spaces. Complementing this with livelier street edges will attract commercial and recreational visitors and extends the neighborhoods hours of use. The more lively and populated the space is, the safer the pedestrian landscape will be. The design of the public realm that first considers the movement and activities of people will encourage people to spend more time walking and congregating in public spaces (see 3.4 Pedestrian Paths for design strategies).

4-0.2 Pedestrian zone
© Andrew Turco

0.3 Developing Neighborhoods with Higher Target Densities



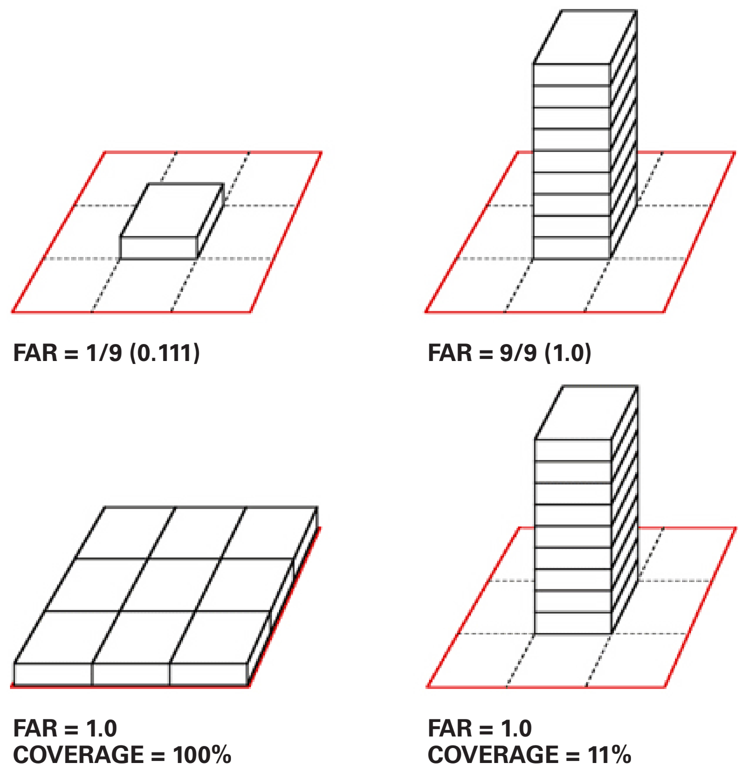
4-0.3a Three measures of density (source: http://densityatlas.org/)

When developing clean energy cities, creating urban spaces at higher densities can prevent the practice of sprawl and greenfield development while making lively neighborhoods. This is accomplished through compact, mixed use development where a diverse population can live and work while also finding a multiplicity of features to suit their needs. Such compact living practices will increase the likelihood of people travelling to destinations via walking or mass transit, and contribute to the reduction in personal automotive reliance. There is also a reduction in the expanses of infrastructure and strain on services to communities when the smaller distances between destinations are maintained through dense development.

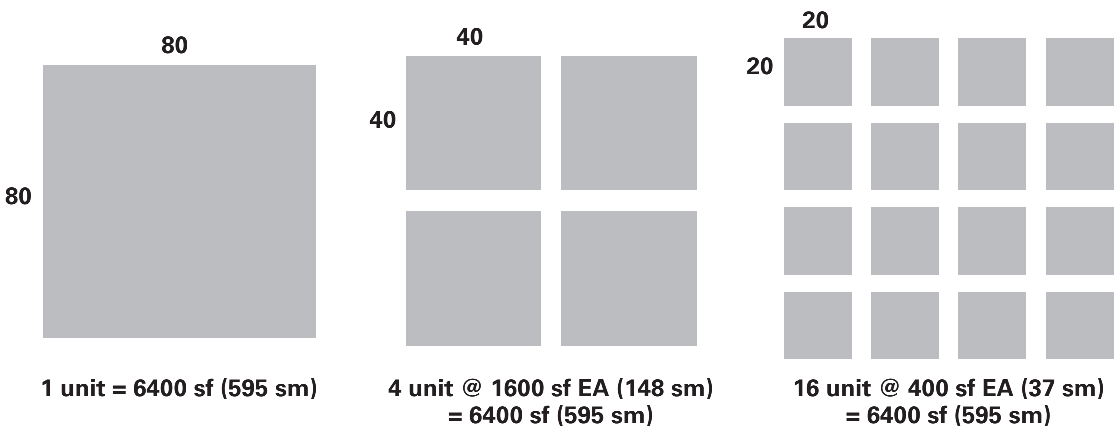
Additional methods to aid in densification can be the practice of retrofitting existing structures (conversion to residential or mixed use and adding space or units by increasing structure height) or urban infill (building on vacant or small lots adjacent to existing structures to prevent outward, or sprawl, development). Establishing an urban growth boundary is a regulatory tool that can aid in maintaining an ongoing contribution to the increase of urban density. With the majority of the world's population now living in urban centers, the compact nature must be retained for long term sustainability. Developing at a high density is essential for a more efficient use of energy and land resources over time. There are three critical metric when evaluating density: building density, dwelling unit density, and population density.

This section was developed with aid from the Desnity Atlas
http://densityatlas.org/

Urban density can be represented by **Floor Area Ratio (FAR)**. FAR is a ratio measure calculated by dividing the total building area by the site area. It is a commonly used control in regulatory practice to dictate the intensity of development but does not give a complete picture of density. Building coverage looks at the portion of the total ground area of the site covered by the building. When this measure is combined with FAR, it begins to convey a three-dimensional sense of the development types, such as point tower high-rise development which can have a high FAR and low building coverage percentage, or large plate low-rise which can have the same FAR but a high building coverage measure.



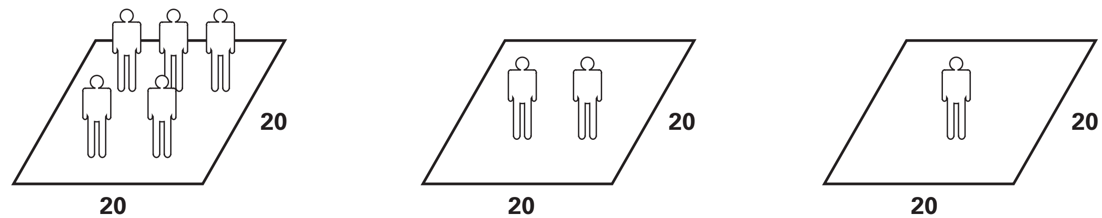
4-0.3b Diagrams of FAR and building coverage (source: http://densityatlas.org/)



4-0.3c Diagram of dwelling unit density (source: http://densityatlas.org/)

Dwelling unit density (also seen as DU/area) looks at the number of households per unit of area (in this case square kilometer) and is part of the Energy Proforma© model input/outputs. The area of the units themselves is not part of the quantification, and the additional layer of information is required to better understand the density at hand, but typically an increase in dwelling units will result in an increase in density. This will also give a more descriptive sense of the marketability of a development by understanding the real estate options and viability of rental or sales in a given area. The dwelling unit density will also give a better sense of the services that can be supported by the target area, such as schools, public utilities, or grocery stores.

Population density rounds out the three metrics by representing the number of people in a specified area. This is not the same as dwelling unit density, as this considers the total area of a given development and how many square meters are given to an individual in living units, public spaces, and commercial uses. Neither measure alone is complete. They must be used together to make the outputs meaningful. This measure can better inform the infrastructural needs of a given community, whether provided by the municipality or by private development.



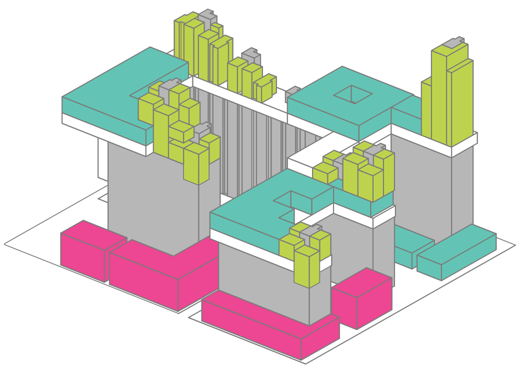
5 people in 400 (36.5 sm) = 80 sf (7.3 sm)/person

2 people in 400 (36.5 sm) = 200 sf (18.25 sm)/person

1 people in 400 (36.5 sm) = 400 sf (36.5 sm)/person

4-0.3c Diagram of population density (source: http://densityatlas.org/)

0.4 Retrofitting Existing Structures



4-0.4a A retrofit proposal for an existing tower-in-park development. New proposal includes ground level structures for mixed use (pink), upper level connections (white), duplex units (blue), and stacked micro-units (green). This proposal also includes an energy retrofit of the facades and hvac systems.

Retrofit can be an effective strategy towards making a clean energy city and attaining a level of carbon neutrality. Outdated stock and poorly constructed architecture provides the chance to update and modify structures to carry them into the future. By reusing existing structures, there can be a realized reduction in the embodied energy of the materials expended upon construction.

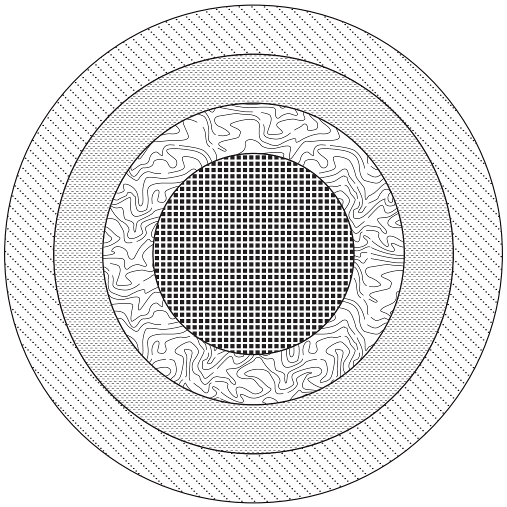
The ubiquitous presence of the tower-in-park typology can be better served in the long term by embracing and enabling a better vision for neighborhood living. Ground level additions can fill in the large voids of the base plane which is currently dominated by surface parking and unused open space. The new forms can house commercial uses, as well as direct-entry units, to help activate this level (see section 3.1 Ground Level Uses for further guidance on programmatic and infill types). New streets can be inserted through the superblock to increase the distribution network and further support the activation of the ground level (see section 2.1 Block Size / Street Distribution for guidance on street placement and block sizes, then section 2.2 on Street Design). The upper levels of the buildings can be retrofitted through the addition of structures for new housing types, connected levels, and programmatic functions. The design should include energy upgrades to the façade through the incorporation of generative technologies (photovoltaic systems on roof and façade surfaces), and passive energy systems for example operable louvers to mitigate solar gain and decrease dependence upon unit cooling systems such as air-conditioning or green roofs to diminish the heat island effect and increase insulative properties of the building.

The effects of these retrofitting measures have not been quantified by the current version of the Energy Proforma©, but the sample project has a documented performance that is improved upon from the tower-in-park base case (see the Energy Proforma© section for future areas of advancement).

4-0.4b Above is a tower-in-park retrofit section showing the integrated sustainability and energy strategies to enhance the livability of the tower structures, including partial erosion of the facade, stack effect with vertical natural ventilation, cooling pools in the courtyards, geo-thermal wells, and in-unit cross ventilation.

section 1.0
DEVELOPMENT SITES

1.1 Proximity to Central Business Districts or Existing Neighborhoods



4-1.1a Classic monocrentric city model demonstrating the outward growth of a city which increases developmental and transportational impacts. © author

Appropriate site selection is essential for the success of creating a sustainable community and the main impacts are felt in three areas:

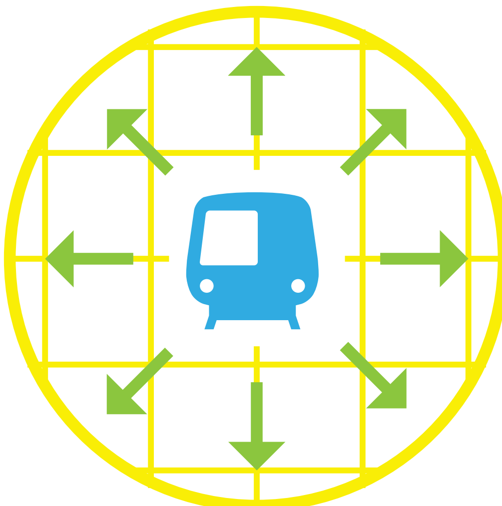
1. **Preservation of greenfield and existing urban fabrics**
2. **Transportation**
3. **Economic development**

Guideline: New neighborhood development should occur on a previously developed site in close proximity to an existing Central Business District (CBD). Treatment of an existing site should first employ efforts of infill development and retrofitting of existing buildings and infrastructure.

Energy Impact Compact city development is first achieved through responsible site selection. Sprawl has a multitude of negative environmental effects; therefore, whenever possible, it is preferable for a development to utilize land that has already been developed such as a remediated brownfield or an existing neighborhood site. Brownfield can be properties that are blighted, contaminated, functionally obsolete (such as transfer stations or outdated infrastructure), or formerly industrial sites. Through applied remediation, the landscape can be cleaned and recovered to suitability for human use and habitation. Often these sites have preliminary infrastructure serving them which can be utilized by the new development.

Another approach for preventing sprawl is urban infill which promotes the building of structures among existing development. Infill will retain the compact nature of a city and increase the density of a site. This practice can avert unnecessary clearing of more vernacular urban village form and displacement of rural or peripheral populations.

Reuse and adaptation of existing space prevents undue travel distance for residents to places of employment and services. This also protects agrarian land that can be preserved for agricultural cultivation. This then decreases the travel distances of goods to cities for consumption, thus reducing the fossil fuels expended on the transportation of those goods.



4-1.1b Compact development can be well-served by modes of mass transit

4-1.1c "Tower sprawl" (Frenchman, 2012) necessitates vast highways and long commutes (source: http://southeastasianews.org/chinese_ghost_cities.html)

Implications The current practice by the Chinese central government is to secure and aggregate numerous large parcels of land for new development which are then built up by a single developer. Necessary infrastructure is frequently included. Often these new developments occur on agriculture land or newly cleared rural or peripheral villages, displacing the inhabitants. What is built is remote from existing development, resulting in longer travel distances for residents on new, longer infrastructure to employment, and any new businesses are constructed in isolation. Proximity to the CBD or existing neighborhood developments will decrease these travel distances to employment, housing, services, activities, and amenities, and can partially capitalize upon existing infrastructural routes. There are better chances of economic development for new businesses when established in areas that are already commercially viable with people treating the area as a destination of use. The adjacency to existing businesses attracts foot traffic already reducing or eliminating the need to launch a new commercial node.

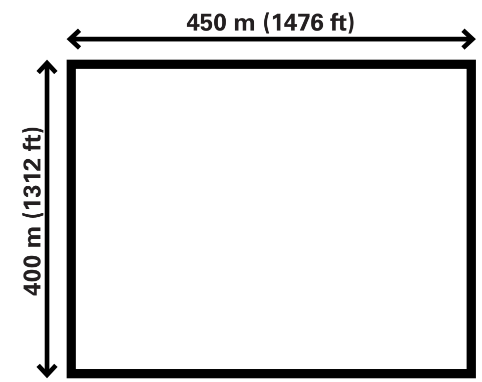
As manufacturing and industrial functions become cleaner, they are being folded into urban program and functions. This means they have forms and locations that better correspond with the compact fabric of the city, in contrast to current common practice of sprawling on greenfield adjacent to expansive infrastructure. The already existing connectivity between these nodes of concentrated development will present opportunities for creating interconnected, multi-nodal networks of transportation for residents.

section 2.0
SITE PLANNING

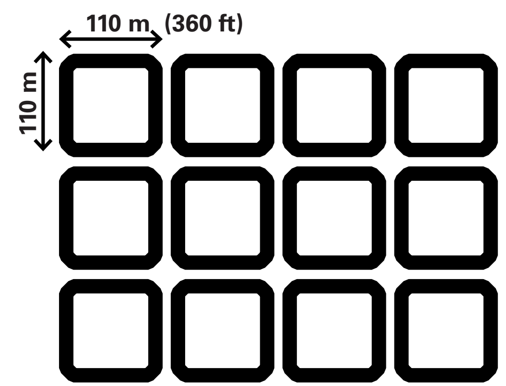
2.1 Block Size / Street Distribution

A frequent distribution of streets will create a smaller block size over the gridded design area. The small block sizes allow for more opportunities for pedestrian access to perimeter buildings and will reduce the need for frequent vehicular trips by neighborhood residents.

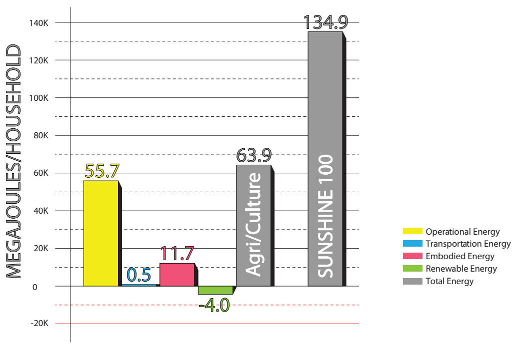
Guideline: Typical urban block sizes should be no smaller than 60 meters (approximately 200 feet) and should not exceed 120 meters (262 feet) measured from the centerline of the street. These overall dimensions allow for the required sizes of all types of programmatic uses to be well developed while allowing for the frequent distribution of streets through the grid. The smaller blocks create walkable environments favorable to pedestrians and can reduce the necessity to drive by containing a diversity of uses and destinations.



4-2.1a Block dristribution of a Jinan superblock



4-2.1b Block distribution of Barcelona, Spain



4-2.1d Energy consumption output for a gridded site (80m x 80m)

Energy Impact The traditional superblock is the propagated typology one encounters in Chinese urban development. While it was initially viewed as an efficient approach to developing several properties with a single entry point, the forgotten element was the human realm. The large block size will be host to large buildings set back from the right-of-way and a walkable route. The ground level experience lacks a diversity of places, uses, and destinations and is instead populated by parking lots and car access routes around islands of housing. A resident is required to drive to alternate uses and amenities. This driving increases transportation costs because, in addition to triggering the necessity for driving, the larger block sizes and limited path options for a motorist cause trips to be longer. The average trip length in this development type is shorter due to the centralized nature of programmatic uses, that makes longer trips necessary for the majority of consumptions (food, shopping, education, etc.).

By making the blocks smaller, there is greater opportunity for edge development to the right-of-way along principal paths of movement. A variety of commercial and civic uses are able to occupy the ground level thus making these places accessible to residents without relying upon a vehicular mode of transportation. An assortment of paths is then offered due to the numerous street options dividing the land masses and allows for fluidity across a unified system. Finally, the frequent street distribution allows for a simpler navigation pattern by drivers visiting a given place. By being able to more easily correct misdirection, less time is spent attempting to correctly locate and navigate.

Implications The current practice by the Chinese central government is to secure and aggregate numerous large parcels of land for new development which are then built up by a single developer. Necessary infrastructure is frequently included. Often these new developments occur on agriculture land or newly cleared rural or peripheral villages, displacing the inhabitants. What is built is remote from existing development, resulting in longer travel distances for residents on new, longer infrastructure to employment, and any new businesses are constructed in isolation. Proximity to the CBD or existing neighborhood developments will decrease these travel distances to employment, housing, services, activities, and amenities, and can partially capitalize upon existing infrastructural routes. There are better chances of economic development for new businesses when established in areas that are already commercially viable with people treating the area as a destination of use. The adjacency to existing businesses attracts foot traffic already reducing or eliminating the need to launch a new commercial node.

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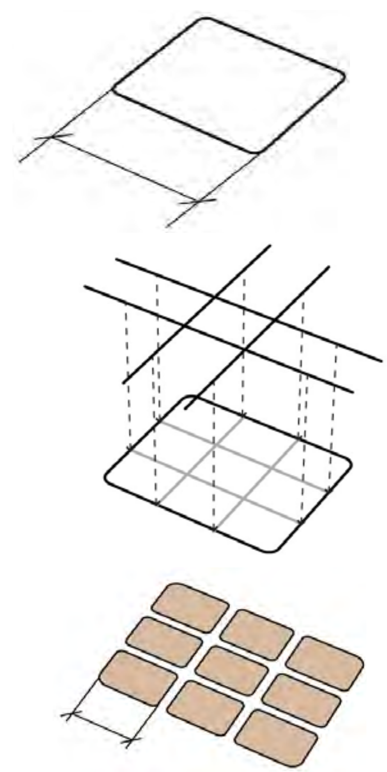
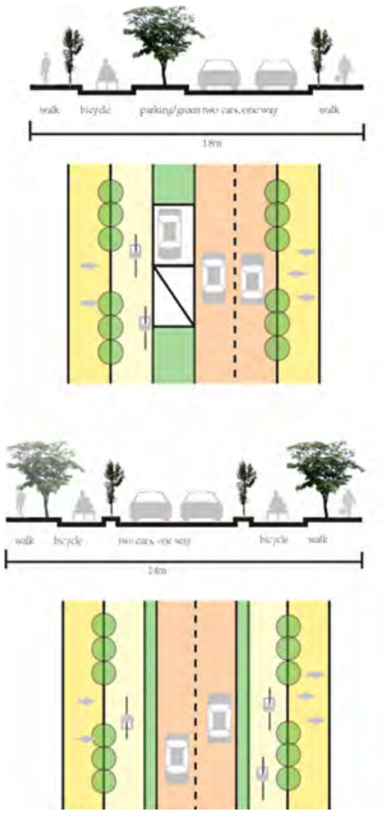


4-2.1f Subdivision of an urban block / street distribution

2.2 Street Design

Streets communicate the quality of the public setting of a given neighborhood and should accommodate multiple users among a larger network. Such streets require a balanced design with respect to the number of lanes given to vehicular traffic, alternative transport, bicycles, and pedestrians. Proper furnishings further enhance the experience of the public realm.

Guideline: Streets widths should be confined to the minimum depth required to maintain suitable flows and operational needs while maintaining conditions that are favorable for the non-vehicular uses. Alternative transportation should be accommodated by providing clear paths of access or crossing for pedestrians, as well as areas of refuge, for modal changes to occur. Passengers embarking or disembarking on MRT or BRT should be protected from regular traffic flows. Street trees should be evenly planted, with species selection capable of growing into large, shady canopies, and stormwater management strategies incorporating green infrastructure should be integrated with street grading and drainage patterns.



4-2.2a Sample street sections

Energy Impact Calmed street conditions and the creation of commuting zones for pedestrian and bicycles result in a series of benefits: reduced car traffic flows, decreased neighborhood transportational energy outputs, and smaller road coverage areas. This reduces the heat-island and climate effects of a neighborhood. Finally, green infrastructures filtrate contaminated run-off on site and reduce the need for complex water treatment.

Implications There is a paradigm shift being experienced the world over with the public realm design changing from enhancing the experience of the individual automobile to the communally-minded user of alternate transport methods. Street design is a pivotal part of the fundamental shift in values and practices to create better places for people and to mitigate effects that road design and car travel have had on climate change. Comprehensive neighborhood planning and design must include the design of better streets with a diverse range of users laying claim to space and movement. In addition to approaches such as 2.3 Perimeter Development, 3.1 Ground Level Uses, and 3.3 Open Spaces, there are a variety of lively uses and places for residents to access over shorter distances, minimizing reliance upon personal vehicle trips. Well-considered streets can become part of a lively network of open spaces and public uses, and even have the capacity to change use when well combined within the network. The periodic surrender of street space for alternate uses presents opportunity for pedestrians to recover the streets as a place for human uses.

2.3 Perimeter Development

4-2.3a Cluster diagram depicting Productive City mixed use perimeter development

The "Perimeter block" typology is important to proliferate as a neighborhood form. A consistently built-up form along the perimeter of the streets will provide opportunities and destinations for pedestrians and increases the liveliness of the ground plane. Additionally, the buildings create central interior courtyards and open spaces for communal or private use and permits allocation to amenities, solar access, and natural ventilation.

Guideline: Development should be concentrated around the perimeter of the block, along the right-of-way, and the buildings should be suitable to a mixture of uses with emphasis on commercial and civic uses.

Energy Impact Single or a variety of buildings should be clustered at the perimeter of the blocks. These developments should contain the most public of uses, such as retail/commercial and civic functions, to maintain a lively and active street level. There is a possibility for front doors to be on the perimeter, especially larger building entrances, shops and services, and establish semi-private spaces within the block. With the shops and services located along the principal paths of movement for pedestrians, there is a simple accessibility of mixed uses and destinations. The visibility of such functions from the vehicular lanes will encourage drivers to park and depart their vehicles to engage in the lively environment.

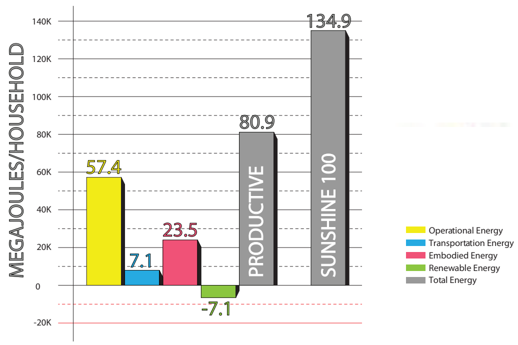
The two areas where energy savings are most realized are:

1. A mixed use environment providing high accessibility and walkability

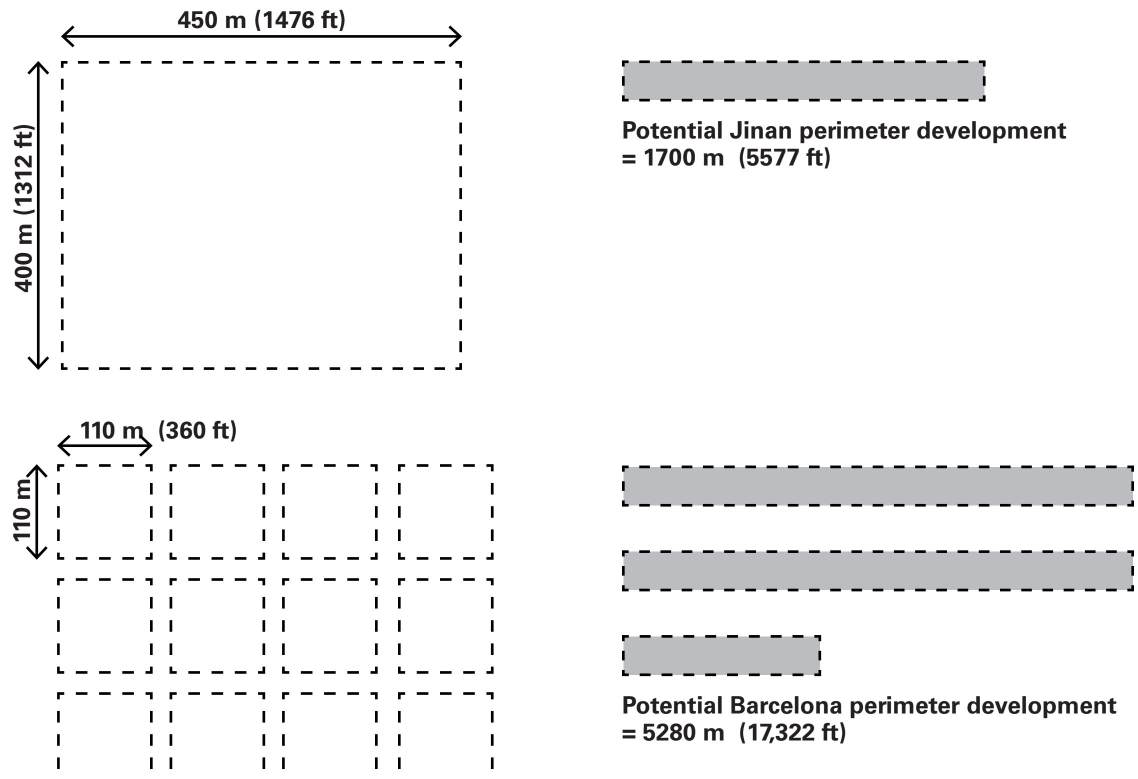
2. A per household reduction in automotive use and trips

3. An internal void that presents greater opportunity for passive energy exchange

The perimeter development is conducive to mixed use development which provides amenities and services within a walkable neighborhood. The multiple uses will create destinations and stimulate trips for residential households. Development along the right-of-way means many of the spaces are accessed by pedestrians. This will reduce the need for travel by car, reducing the overall number of automotive trips per household. The internal courtyard space will allow day lighting for the interior spaces. By creating the internal "void" space, there is an improved chance of capturing airflow for cross-ventilation, thus reducing the need for mechanical air movement and the energy expended by the equipment. Finally, the central space can have a protective quality by retaining heat in the winter and mitigate the negative effects of wind in cold climates. Attention should be paid to capturing/blocking prevailing seasonal winds for cooling and warming (see 5.2 Building Orientation).



4-2.3b Energy consumption output for Productive City with perimeter development



4-2.3c Perimeters and linear measures

Implications The perimeter development guideline makes the public, pedestrian realm a richer setting while also maximizing the mixed use development potential of a given block. The development of the perimeter with commercial and civic uses concentrated on neighborhood goods and services will maintain a livable and human scale to the milieu. This fashion of development is frequently found in destination neighborhoods and is typical in cities throughout the world, such as the urban grid patterns built in the 1920s around Jinan, or the newer development of Bo01 in Malmo, Sweden. The level of diversity found in these urban forms are in turn able to host a wide array of uses and activities within the morphology. A smaller density or intensity application can accommodate neighborhood level retail and services, creating a walkable system that is similar to Clarence Perry's "Neighborhood Unit" (cite). The higher density and intensity version can become a more central urban block with larger retail tenants or more prominent civic functions accessed from nearby blocks by walking (with a pleasant journey via a lively ground-level) or by alternate transport to promote long-term deferment from automotive reliance.

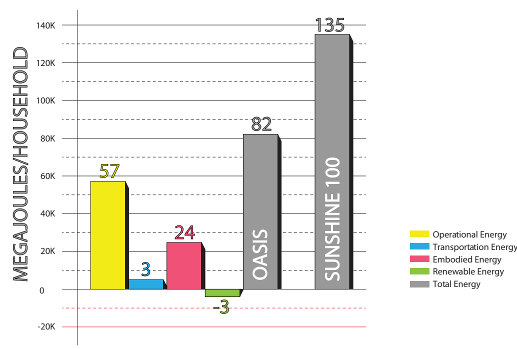
section 3.0
PUBLIC REALM DESIGN
3.1 Ground Level Uses

4-3.1a Mixed use ground levels create active places for pedestrians
© Matthew Bunza

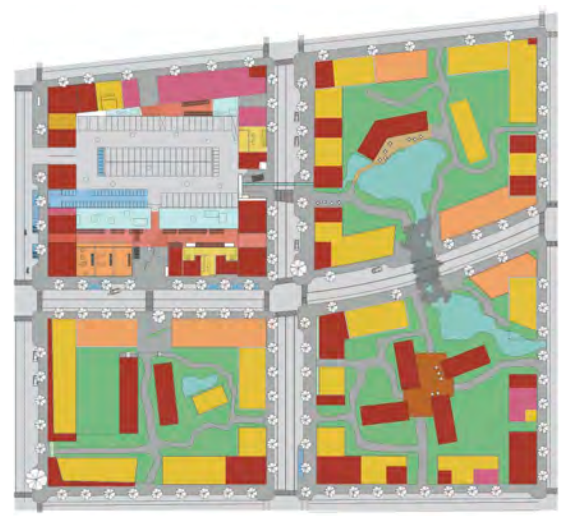
An assortment of uses distributed throughout the ground level creates livable places with amenities and services. The activities generated by mixed use at the ground level establish an accessible social space, and fosters a continual, daily liveliness, and multiple opportunities for employment and economic development.

Guideline: Mixed uses should occur within the ground level of buildings along main right-of-ways. The allowable uses are commercial; (e.g., retail, food and beverage), offices with active storefronts, workshops and collaborative spaces, social and community service organizations, civic organizations, government offices, and recreational or open spaces. Less retail-dominant streets should be stimulated by ground level live/work units. Street level uses should stimulate and reinforce an active environment, vary in dimension (size, width, and depth), hours of operation (to maintain longer hours of neighborhood activity), and create and enhance existing pedestrian links, and social prospects. Where appropriate, wide pedestrian spaces should be created for retail or for restaurants to "spill-out" into a plaza or sidewalk for greater outdoor activity. The permeability of the building base will increase the number of spaces that can be accommodated, creating multiple points of entry, open or transparent facades, display spaces, and street-front open spaces for additional furniture and landscaping.

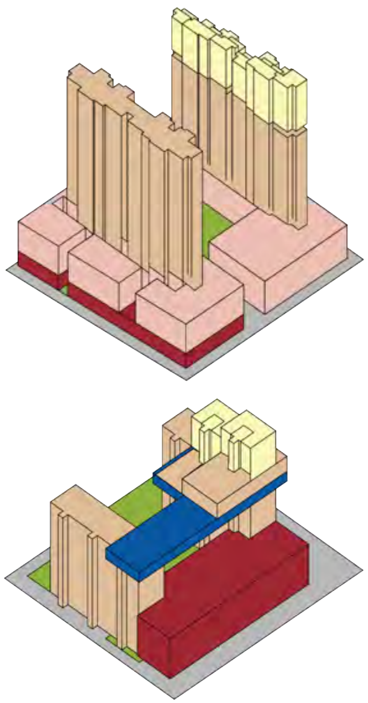
Energy Impact Active ground level uses, such as neighborhood retail and services, reduces transportational and operational energy for the neighborhood design. A place that is conducive to walking where pedestrians can secure services and satisfy daily needs reduces the reliance upon automobiles for personal consumption, which in turn reduces the transportational energy expended by a household. A variety of uses present in a neighborhood creates variations in operational energy consumption, enabling members of a household to walk to other activities in the neighborhood, and minimizes the operational energy consumption in the home. The staggering of operations can better for distribute loads placed upon renewable and generative energy sources, such as solar or wind.



4-3.1b Energy consumption output for New Springs - a neighborhood with active ground level uses



4-3.1c A cluster ground level plan with mixed uses throughout, especially along public right-of-ways



4-3.1d Ground levels uses are represented in two diagrams: left shows commercial and live/work unts as active ground level uses; right shows commercial on a main right-of-way and residential walk up on residential streets

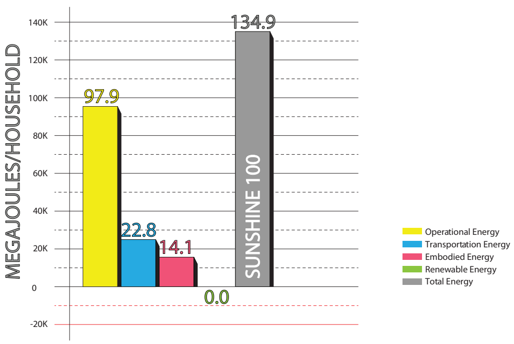
Implications Diverse mixed use ground levels result in streets becoming centers for activity, and engaging the interest of pedestrians while bridging the public and private realms. The increase in people utilizing the streetscape increases the level of safety and desirability of such places as viable destinations. Street level spaces should be designed to suit a variety of programs to engage the interests of the pedestrians in a neighborhood, and the increased foot traffic such measures generate results in greater economic development opportunities for the area. The transparency and permeability of the ground level also engages pedestrians in interior activities. The more variation pedestrians experience, the more they discover points of interaction within the public realm. Furnishings, street art, and landscape features, and other street amenities enliven streets by providing pedestrian points of interests and purposes for congregation. Among these diverse uses lie locations of employment and commerce which reduces commutes for residents. Close residential proximity to places of employment increases the likelihood of residents walking to work rather than driving, further reducing the transportational energy consumption of a neighborhood.

3.2 Parking

Traditionally, zoning requirements create overserved parking and results in the single occupancy vehicle being the frequently preferred form of transport. The design of denser neighborhood development with enhanced accessibility and mobility to destinations results in the reduction of parking provisions. Parking begins to take on different patterns of use, configuration, and materials and reduces negative impacts on climate of excessive and inefficient automobile use.

Guideline: Measures should be taken to reduce the negative impacts of parking in several ways: the reduction of required parking stalls, the reduction of impervious surfacing, and the implementation of programs that reduce the use of automobiles. The areas where better parking design will have an impact are:

1. ***Improved parking location and points of access:*** *Points of access for parking should not impede the public right-of-way and hinder pedestrian flow and safety. Nor should it create large gaps in perimeter development. Surface parking should be located off secondary vehicular paths with safe connections to destinations.*
2. ***Lower parking ratios:*** *In a neighborhood served by public transit, parking ratios should be reduced or eliminated to lessen the number of parking spaces in a neighborhood.*
3. ***Parking types (structured vs. surface):*** *In a denser development, non-coverage should be given to open space functions rather than parking. In less dense locations, parking should not be structured, but rather delegated to surface spaces. This provides potential for gradual infill and continual reduction over time in neighborhood parking provisions.*
4. ***Shared spaces and functions:*** *Less space is dedicated to parking when, for example, spaces for residential use are vacated in the morning and replaced with office. When parking spaces are not used, they can host recreational functions.*
5. ***Managed parking programs:*** *Parking areas accommodate more automobiles per square meter when parking structures and lots are managed and denser configurations, such as tandem parking, are used.*
6. ***Pervious materials for surface parking:*** *The use of porous or penetrable materials allows vegetation to grow through the surface and makes possible storm water management through on-site infiltration.*
7. ***Employer incentive or assistance for public transport:*** *Subsidizing part or all the cost of public transportation reduces the economic disincentive to take public transportation.*
8. ***Employer-provided shuttle services:*** *Shuttle services that conveniently connect car-share or transit locations to the location of employment increases the number of employees using public transit.*
9. ***Priority parking to non-single-occupancy-vehicles:*** *Increasing the convenience factor for car-shares over single-occupancy-vehicles incentivizes car-pooling.*



4-3.2a Energy consumption output for Dikou with only occassional street parking

Energy Impact The overall reduction of parking reduces automobile use. While some automobile use will remain, new neighborhoods should strive to be car-limited. Reductions in the required parking result in corresponding reductions in dedicated parking space. As a result, structured parking areas which consume high embodied energy in construction and operational energy through lighting and mechanical control will be reduced, and the surface parking areas needed can be constructed of materials that will reduce heat-island effect and increase the amount of on-site storm water infiltration. The use of alternate materials decreases the use of asphalt, which contains petroleum, and standard concrete, which contains aluminum and chloride. An overall shift away from automobile use will see a neighborhood reduction in transportational energy.

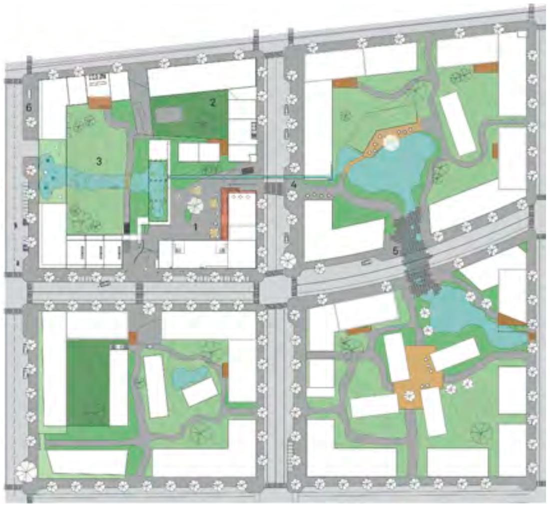
Implications Planners, building owners, and policy makers have the ability to use parking as a means of shifting to clean energy neighborhood design. The implementation of the above strategies results in a reduction in single-occupancy-vehicle use, and over time in an overall reduction in dependence on automobiles.

3.3 Open Space

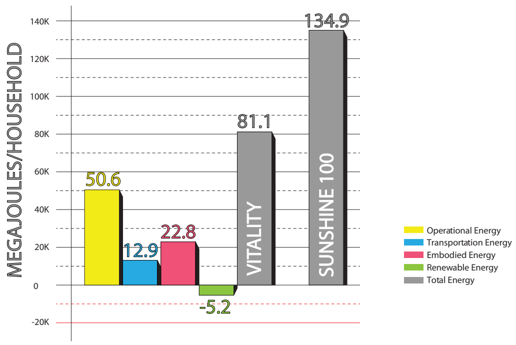
The provision of open space promotes the creation or designation of landscapes within the urban environment. These spaces can be designed or flexible, but should be responsive to the needs of the users while serving the function of integrating nature and health into the urban fabric.

Guideline: Open spaces, such as parks or plazas, should host a variety of uses and activities while being flexible in design. Good open spaces should consider one or more of these characteristics and purposes:

1. ***Use natural/green textures and pervious hard surfaces.***
2. ***Link open spaces with pedestrian networks.***
3. ***Incorporate a multifunctional green infrastructure (for purposes such as stormwater management).***
4. ***Include spaces that are both programmed spaces (playgrounds and furnished amenities for outdoor living) and unprogrammed (for flexible uses by season or time of day/week).***
5. ***Designate recreational and active space to encourage health and provide relief from the urban environment.***
6. ***Exhibit a variety of spaces and uses to foster dynamic community interactions.***
7. ***Preserve nature within the urban development.***



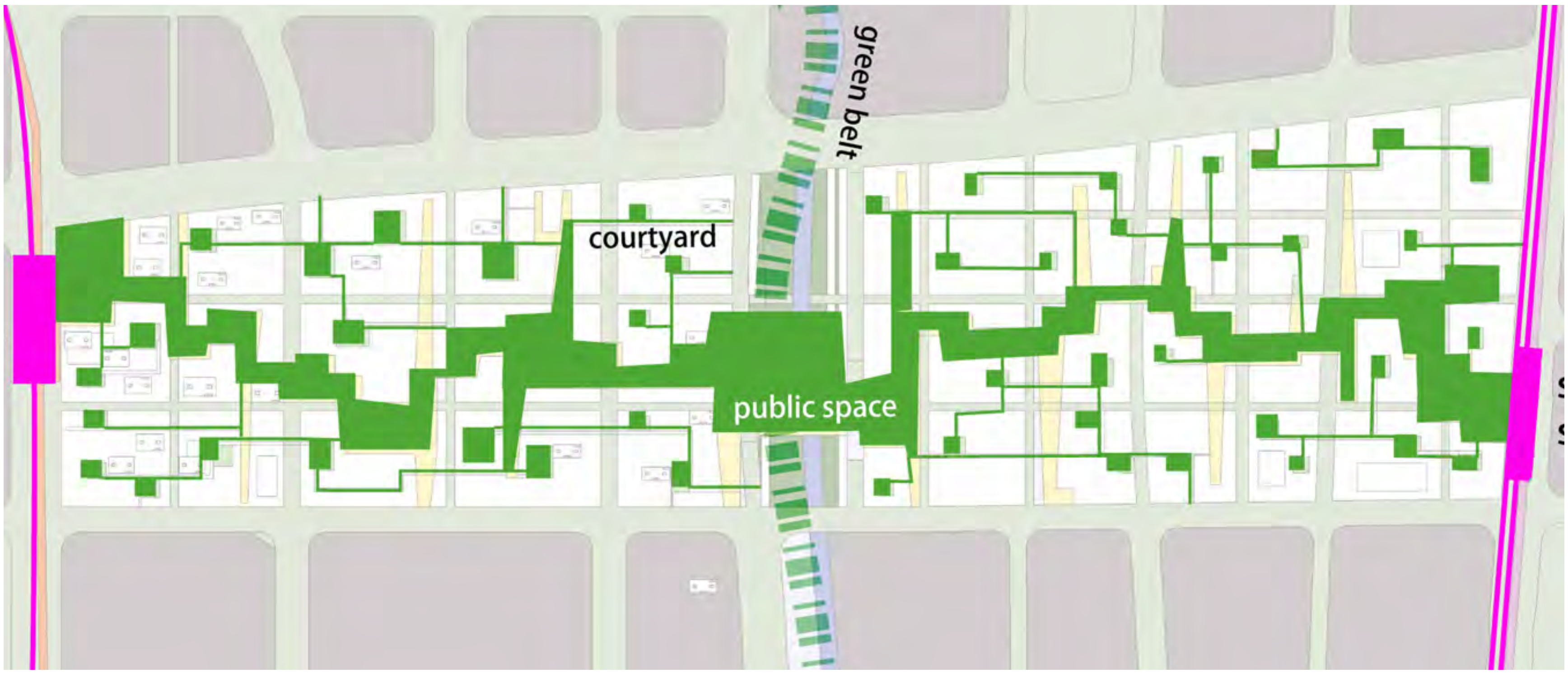
4-3.3a A cluster site plan with a network of open space typologies



4-3.3b Energy consumption output for Greenway with networked green spaces

Energy Impact The provision of open space within an urban neighborhood is vital. Vegetation cover reduces heat island effect and mitigates long-term climate change. By creating accessible, walking places for people to visit their neighbors, household members are not always indoors and consuming operational energy or driving to a destination and using transportational energy. Open spaces create variations in the urban zones of a city, defining places as public, semi-public, and private, which increases the types of accessible neighborhood destinations for people to visit and serves to connect places in ways convenient for pedestrians.

On sites with partial building coverage, non-building areas can be designates for open space. Such spaces can remain open or become developed for urban infill. Public open spaces should be integrated with cycling and walking paths to make such alternate transport modes more attractive. Open spaces can accommodate systems of green infrastructure, such as bioswales, for storm water collection and management. They can also become areas where wildlife, such as birds, have habitats within the city and can host ecological processes which promote biodiversity within the urban fabric. Finally, open spaces can utilized for cultivation. Urban agriculture can provide opportunities for exterior activities and nutrition, and the food consumed has not incurred the transportational energy required for transfer.



4-3.3c Networked open space moving between public, semi-public, and private realms

Implications Open space has innumerable ecological and social benefits within a community. Given the constraints created by urban densification, there must be a long-term, concerted effort towards preservation of open space. Urban nature has the "green lung" effect upon a city neighborhood, by filtering the air through biological processes while having little or no impact on resources (excepting occasional maintenance). Offering habitat for animals to live in the city is vital to the ongoing survival of plant species in need of pollination (through birds and insects). The natural environment also contains prospects for green infrastructure that is well integrated with recreational elements, and can serve larger areas of the neighborhood through a tributary system (such as storm water management networks). These spaces can also reduce climatological influences such as heat-island effect.

Well maintained open spaces positively influence real estate values of surrounding properties. Research has demonstrated that access to green space alleviates depression and can contribute to a reduction in endemic issues related to public health. Sites for personal cultivation, such as community gardens, can be places of rewarding interactions and enjoyable activities, and can provide nutritional supplements to families experiencing difficulties obtaining sufficient quantities of healthy foods. Well-designed open spaces should measures for universal access as a democratic approach to experience and use. Parks and plazas provide the opportunity for people and nature to coexist, and this should not be exclusionary. The better the design of a place, the more potential users it will have, thereby diminishing the need to give valuable space over to nearly redundant uses. Diversity of place also promotes better community and is a distinctive neighborhood asset.

As larger percentages of the global population become urban dwellers, people tend to live greater distances from significant allotments of nature. The dispersal of green and open spaces in a city will provide sites for recreation, methods of mitigating climate change, and preserve pockets of urban nature.

4-3.2d Urban park with open space and recreation (source: http://www.djc.com/stories/)

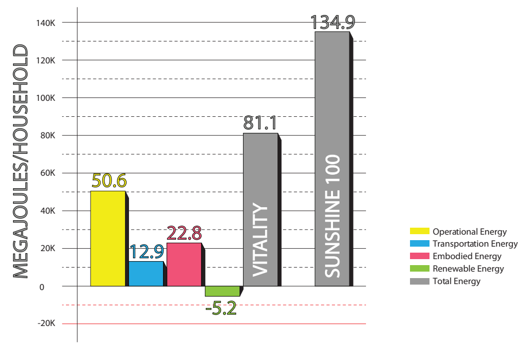
3.4 Pedestrian Paths

Pedestrian circulation should be protected and emphasized through contiguous systems of weather/climate protection and spaces of activity and security. Once a desirable and well-designed route for walking is made available, many residents and visitors will opt to walk rather than drive.

Guideline: A linked system of overhead weather and solar protection should be created through the integration of a variety of applications. Evenly spaced street trees with wide canopies provide protection from summer solar gain or winter winds and precipitation. Building canopies that extend over the pedestrian right-of-way create places of refuge from the elements while maintaining an engaged relationship with the public realm. Public and commercial uses allow opportunities for pedestrians to enter or pass through buildings, continuing the protective aspect. Coordination in the planning of such elements with adjacent sites prevents substantial gaps in coverage. The scale of the design of elements should be commensurate with the projection of the climatological elements the pedestrian is sheltered from. Proper human-scale, downward illumination will ensure the safety of the spaces that are linked by the protective elements through primary and secondary access ways.

The following variety of design elements can be linked into continual, safe passage for pedestrians:

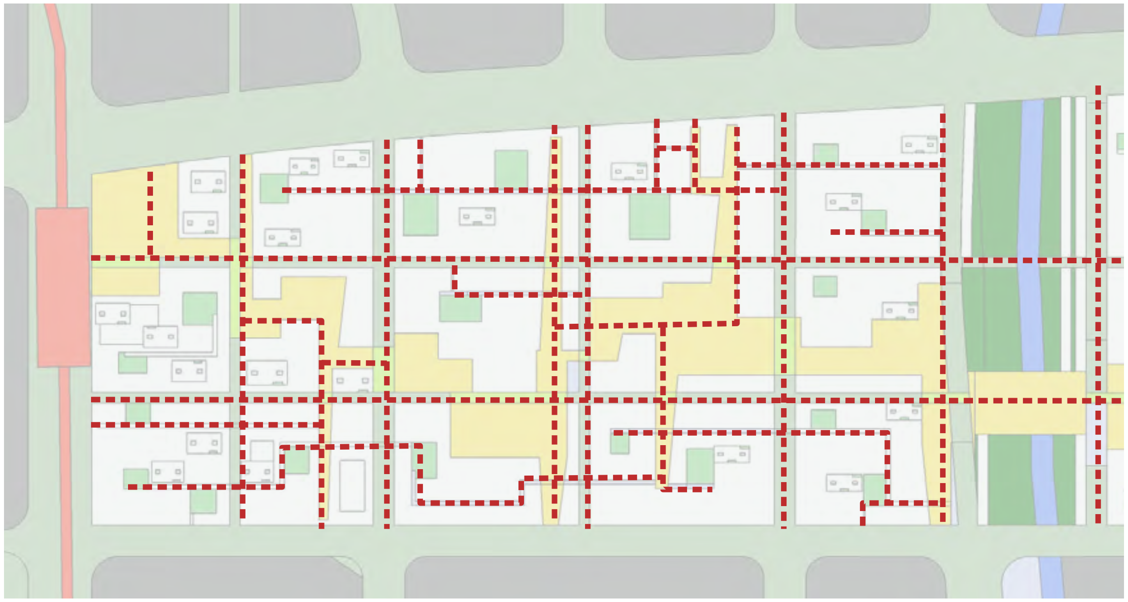
- ***Trees and landscape furnishings;***
- ***Canopies and structural overhangs;***
- ***Street lighting at the human scale (not just street lighting for automobiles);***
- ***Active, staggered-hour uses to generate lively spaces (spaces do not deactivate after business hours);***
- ***Assortments of primary and secondary access ways;***
- ***Through-block connections when interior spaces contain public amenities or connect disparate public spaces.***



4-3.3a Energy consumption output for Greenway with contiguous pedestrian passage

Energy Impact As covered in General Principles, pedestrian movement requires minimal amounts of energy, therefore elements found in the urban landscape should also serve to create a better path. The numbers of people traversing sites by foot will increase when the environment is comfortable for pedestrians. This results in a modal shift away from automotive transit use which lowers transportation energy consumption for the neighborhood. When people shift to the outside environment, they are reducing the operational energy of the interior spaces by no longer using them.

Implications Climatological and personal comfort has the potential for increasing the utilization of pedestrian routes. The long-term economic sustainability of a neighborhood will be increased with the rate of incidental walk-ins. By making pedestrian routes safe, desirable, and sheltered from outdoor elements there is a better opportunity for a modal shift to occur with a corresponding reduction in automotive transportation, and movement toward achieving the greater goal of a car-free neighborhood.



4-3.4b Pedestrian site circulation goes along right-of-ways as well as through sites and buildings

section 4.0
TRANSPORTATION SYSTEMS

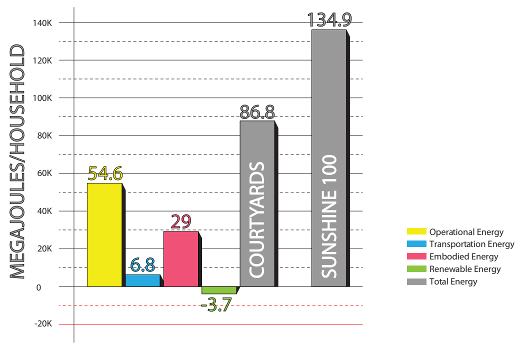
4.1 Multi-modal Networks / Linkages

As dense development increases, comprehensive measures must be taken to ensure a greater mode share of public transportation. This can only be accomplished through a well-linked multi-modal system that operates as part of a larger mobility framework. Modes of transport demonstrate a high degree of variation and are not simply interchangeable, but a good system can be designed to suit specific users in their space and needs.

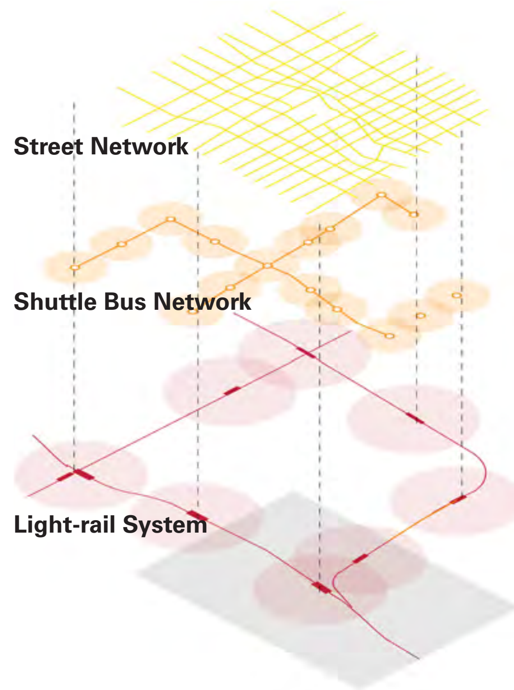
Guideline: Establish a sensible hierarchy of mobility networks embracing a multi-modal strategy with strong, coordinated linkage points to connect modes and promote fluid transfers between regional, urban, and neighborhood scales of mobility. Well-designed systems should coordinate hub and transfer locations that are connected by safe, accessible walking paths. Transport frequency and times should be coordinated to allow for optimized speed in service. Stream-lined systems for payment, such as universal fare cards, should be provided across the systems.

A hierarchical system should cover all scales of the city, from the regional to the neighborhood. One example of a hierarchical system is a high-speed rail system that serves a region. The station has a light-rail system that connects the districts of the city, especially the central business districts. From a centralized location within each district, there are electric shuttles in a dedicated lane making stops through each neighborhood that are no more than a 5 minute walk apart. At this final level, stops can feature sustainable personal mode options, such as bike- or car-shares and suitable walking environments. This creates a safe and fluid journey for commute or recreation.

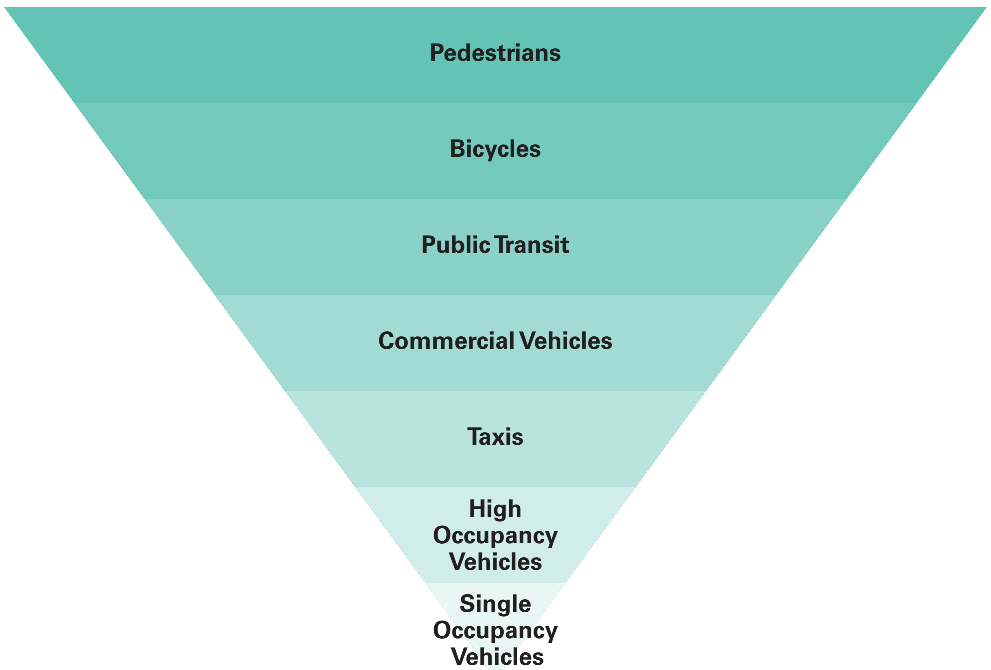
Energy Impact Significant benefits are realized through the implementation and concerted use of a well-serving multi-modal transportation network. The less often residents rely upon automobiles, for transportation; the less transportational energy is used, resulting in reductions in the contributions that the use of fossil fuels make to the greenhouse effect. Reducing the physical space dedicated to automobile storage reduces the embodied energy of the construction materials and processes, and the operational energy used to maintain the spaces through lighting and mechanical systems.



4-4.1a Energy consumption output for Remix which creates a hierarchical multi-modal system



4-4.1b Partial multi-modal overlay



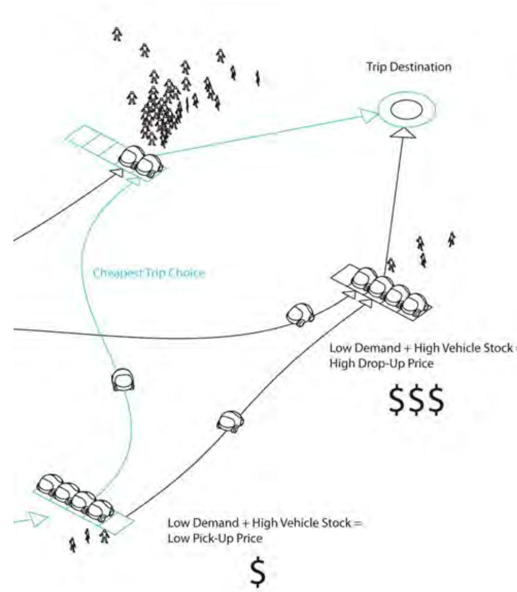
4-4.1c Multi-modal hierarchy - prioritized from the top to the bottom

Implications A well-coordinated, multi-modal transit network can provide a variety of transportation options and a rapid method of movement for residents. Currently automobiles are deemed a more "convenient" option for many commuters, due to low costs incurred in time and fuel. By applying comprehensive measures, including 2.2 Street Design and 3.2 Parking, personal automotive transport can be de-incentivized at many points of the journey to create a more effective modal shift. As transportation systems become better, the dependence upon automobiles decreases. This achieves a significant reduction of CO_2 emissions, embodied energy of automobiles and roads, and mitigates heat island effect.

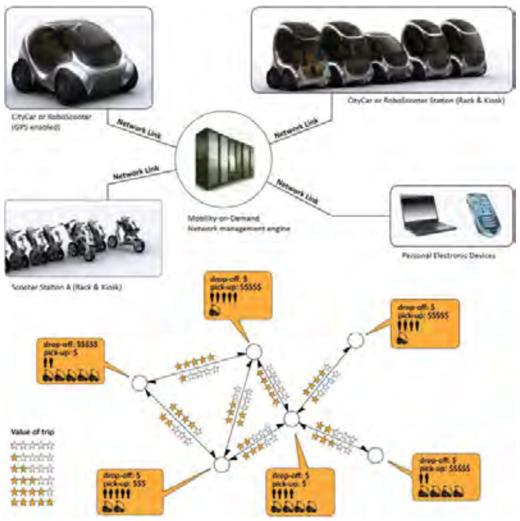
4.2 Smart Mobility & On-Demand Systems

Smart mobility and On-Demand mobility models make the neighborhood scale a more navigable place via alternate transport options. The design should be based on suitable tools, utilizing the compactness of development with an adjustable mobility system. This increases the efficiency of a network while answering to local needs of a multi-modal framework.

Guideline: Integrate communication technologies to build a more responsive transportation network. In the neighborhood scale, shuttle systems with short routes and high frequency will better tie into a larger system. A continuous run during peak times can mitigate congestion, and a tapering during off-peak can remain effective. To accomplish this, immediate demand can be sent from a station or mobile devise to trigger the activation of a given route. This mobility on-demand will create an effective network for addressing compact scales within a larger, hierarchical framework.



4-4.2a Smart mobility vehicle sharing (source: MIT Medialab)



4-4.2b On-demand mobility (source: MIT Medialab)

Energy Impact Smart mobility and On-Demand mobility models represent a level of control and convenience in mass transportation that has traditionally been absent. Making more efficient use of technologies, commute times can be made shorter as part of a more efficient system. The modal shift will reduce neighborhood transportational energy consumption.

Implications The more fluid and efficient a mobility system becomes, the less a resident is motivated to opt for the “convenience” of an automobile for transportation. The Smart Mobility and On-Demand systems are able to close the gaps in an integrated, multi-modal framework. Through multidisciplinary planning, such alternative transportation methods will become the dominant method of urban movement.

4.2 Smart Mobility & On-Demand Systems

A nuanced understanding of the different but complementary natures of mobility and accessibility are required to create a better functioning, more comprehensive network that decreases automotive dependence and successfully shifts drivers away from single-occupancy vehicle use.

Mobility: Moving people and goods from place-to-place, such as home-to-employment.
Accessibility: The ability for people to reach goods and destinations to satisfy their needs.

In order for a successful neighborhood to function, these characteristic must both function in the positive, where mobility will increase access to possible destinations, and access to goods can create more efficient points for mobility.

Guideline: Comprehensive development planning should embrace a multi-disciplinary approach. Transportation systems should be designed in conjunction with neighborhoods to increase the positive covariance of mobility and accessibility.

Energy Impact Transportational energy can be reduced when multi-modal options are utilized more than automobile transport. To achieve this, the systems must be optimized to develop efficient mobility with expansive accessibility.

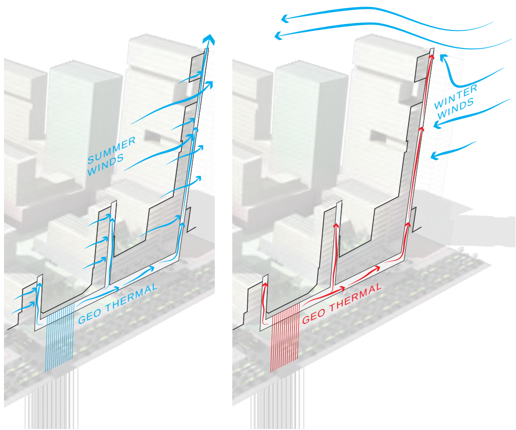
Implications There is a history of these two transportation elements not being mutually satisfied by the same measure. Highways may have a high measure of mobility with many people being moved around, but a low level of accessibility as it prevents people from accessing services or consumptive goods due to long travel distance, physical barriers (lateral crossing), and the economic factors required for long-distance automobile travel. In the long-term, when these two factors are considered in tandem, multi-modal systems will better serve the urban population and reduce transportational energy consumption.

4-4.3a On-demand mobility

section 5.0
BUILDING FORMS

5.1 Orientation & Staggering of Structures (Site Porosity)

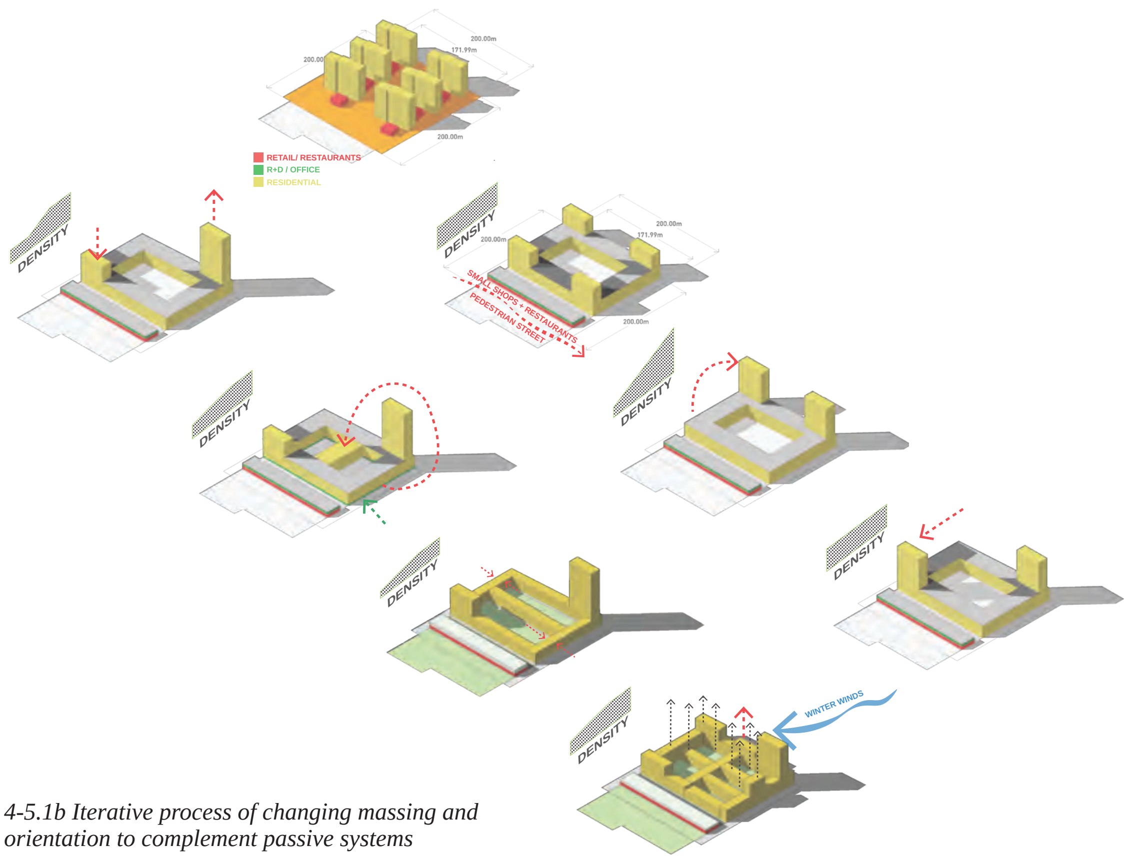
Buildings that are positioned to better capitalize upon passive energy reduces the operational energy of the neighborhood. Solar gain can be used as a passive heating solution to reduce the amount of energy required for heating. Prevailing winds can be captured for natural cross ventilation to reduce the energy expended for cooling interior spaces.



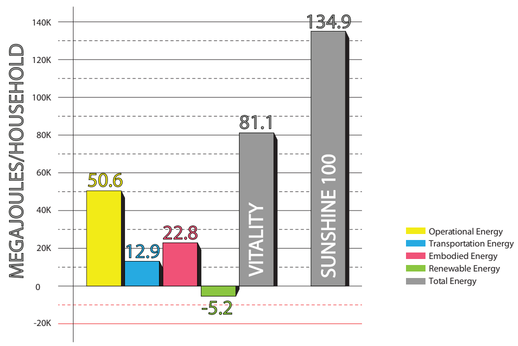
4-5.1a Building positions are open to summer winds and closed to winder winds

Guideline: When planning building placement on a site, consider solar patterns and seasonal prevailing winds. Buildings should be staggered to prevent casting shadows on another building that prevents it from being capable of passive heating through solar gain. The buildings should consider maximizing sun exposure for the interior spaces to reduce the amount of energy consumed for heating. Optimum building positioning can utilize prevailing winds for natural ventilation and cooling. Natural cross ventilation requires an exchange of interior air with exterior air, requiring windows and interior spaces to accommodate the free flow of air.

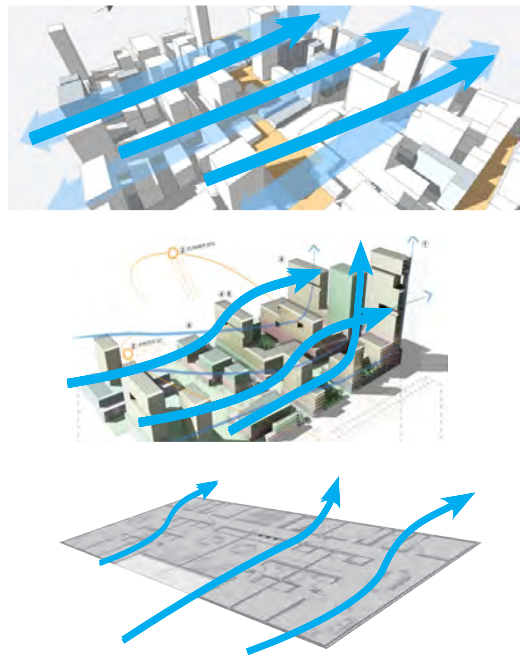
Energy Impact Operational energy is the energy that is expended upon the heating, cooling, lighting, and general operation of a building during its life, and is typically the most significant stage of energy consumption. Capturing natural systems without mechanical production significantly reduces energy consumption, and passive energy systems are entirely clean and free. This guideline, combined with subsequent measures, can provide and maintain thermal comfort to building occupants.



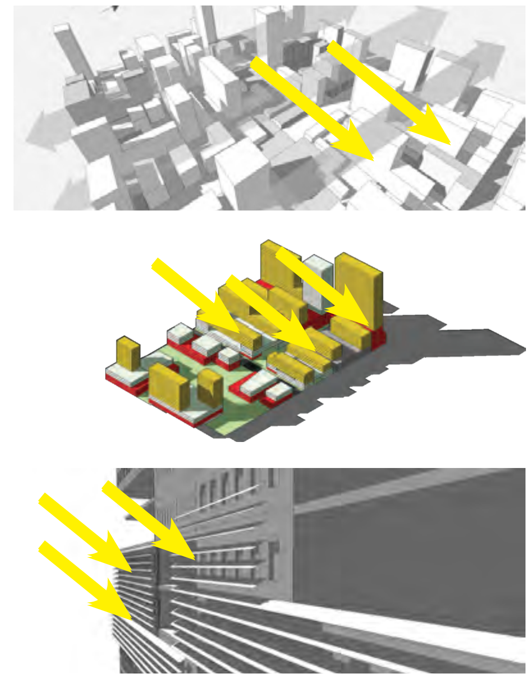
4-5.1b Iterative process of changing massing and orientation to complement passive systems



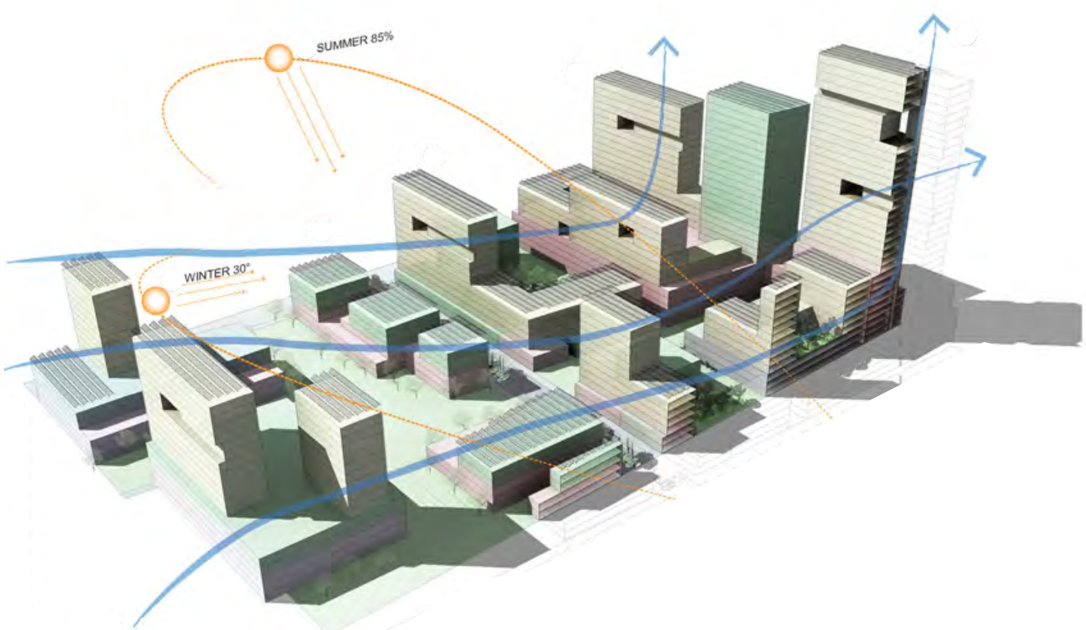
4-5.1c Energy consumption output for Greenway with staggered form



4-5.1d Winds across the project are mapped to capture natural ventilation



4-5.1e Sun is studied on the site to optimize solar gain and shading



4-5.1f Resulting cluster example from Greenway

Implications The reduction of operational and total energy consumption increases a neighborhood's independence from grid-supplied electricity. In many regions, the grid-power is sourced from fossil fuels (coal for example), with negative environmental and climatological impacts from the fossil fuel production process and a corresponding increase in green-house gases. Decreases in energy consumption equal decreases in the negative impacts of fossil fuel production.

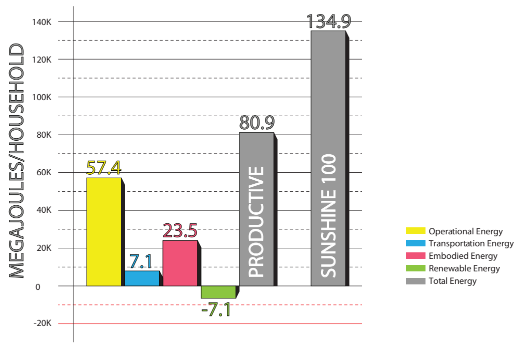
5.2 Height Variation & Articulated Form

Variation in building height can positively affect the number of households or types of program contained on a site. Articulation of form presents opportunities to create a diversity of spatial experiences, formal interests, and opportunities to realize energy benefits. This can manifest in several ways, from setbacks in the façade to vertical stepping in the structure.

4-5.2a Layered, articulated neighborhood roofscape of Dikou urban village © author

Guideline: Buildings should be composed of articulated, layered forms for optimal energy consumption. This can be achieved through a variety of approaches:

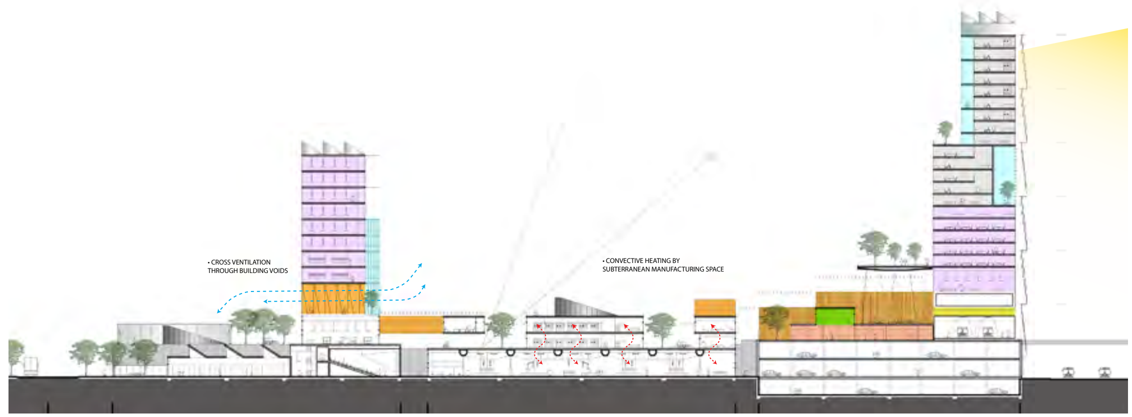
1. Towers combined with podium levels to accommodate more households but maintain active ground levels or support vertical mixed use.
2. Stepping the structure to create greater area for amenity space and/or green roof surfacing.
3. Mid-building setbacks to create amenity space and shading opportunities to reduce solar gain and mechanical cooling loads.
4. Structural overhangs to increase façade shading and reduce solar gain.



4-5.2b Energy consumption output for Productive City with varying heights and articulation

Energy Impact Complexity of form is evident is many samples of energy-efficient neighborhood patterns. This approach will avoid a single extrusion, such as the tower-in-park model, by designing towers engaged with lower-level structures. Lower structures can be less energy-intensive to construct and operate, especially when an elevator is not required. Articulation creates a reduction in operational energy consumption through passive systems cooling. The shade projected onto exterior spaces keeps the surfaces and occupants cool and shades interior spaces maintain to maintain lower energy loads. By providing additional surface for green roof with a variety of heights, there is a reduction in heat island effect, as well as providing space for urban agriculture and cultivation on site. The articulation in the building will reduce transportational energy by creating on site amenity spaces and spatial opportunities for diverse programmatic uses. Interior and exterior spaces can be passively cooled by providing shade through the use of set-backs, overhangs, and structural canopies

Implications Heavily articulated urban form of varying heights is commonly found in the vernacular urban sampling where a gradual layering of structures over time are built to accommodate efficiently distributed interior life and needs, and to create a diversity of space and use. While new neighborhoods are not incrementally developed, over time there are inherent features within habits of daily life that can be embraced and simulated in new forms, such as building setbacks serving as amenity space. Occupying buildings that have diverse types of spaces at varying heights on the interior and exterior creates more desirable active places for communal congregation within smaller sites, creating a more compact city form.



4-5.2c Section through a block of the Productive City

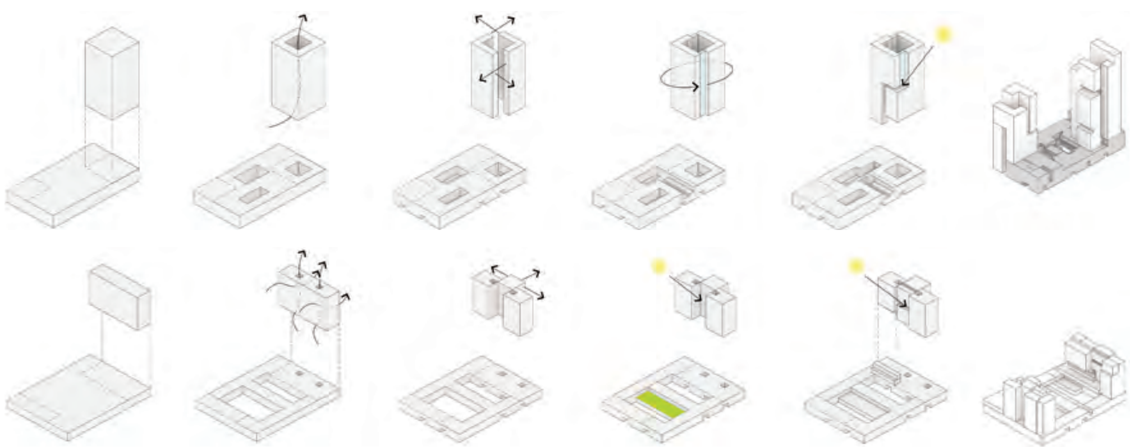
5.3 Porous forms

4-5.3a Commercial cluster from High Density Gardens depicting porous towers and podiums for enhanced ventilation

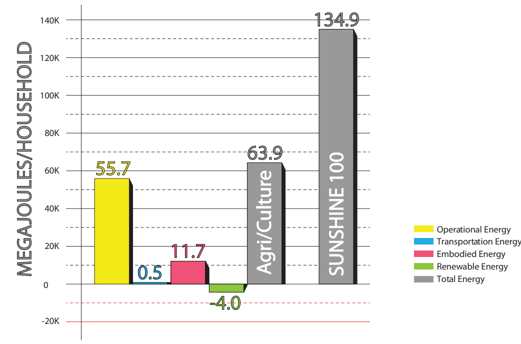
Forms with continuous openings through the building can generate a chimney or stack effect for increased natural ventilation and give more interior spaces access to fresh air, thus reducing the operational energy spent on mechanical air exchange and cooling.

Guideline: Creating a porous, sponge-like form generates air movement, (stack effect), which draws fresh air into the interior spaces of a building, and creates movement and air access for interior spaces. Openings should carry through the building vertically, drawing cool air from the ground level, supplying fresh air and cooling through the chase, and expelling warm air from the top of the openings.

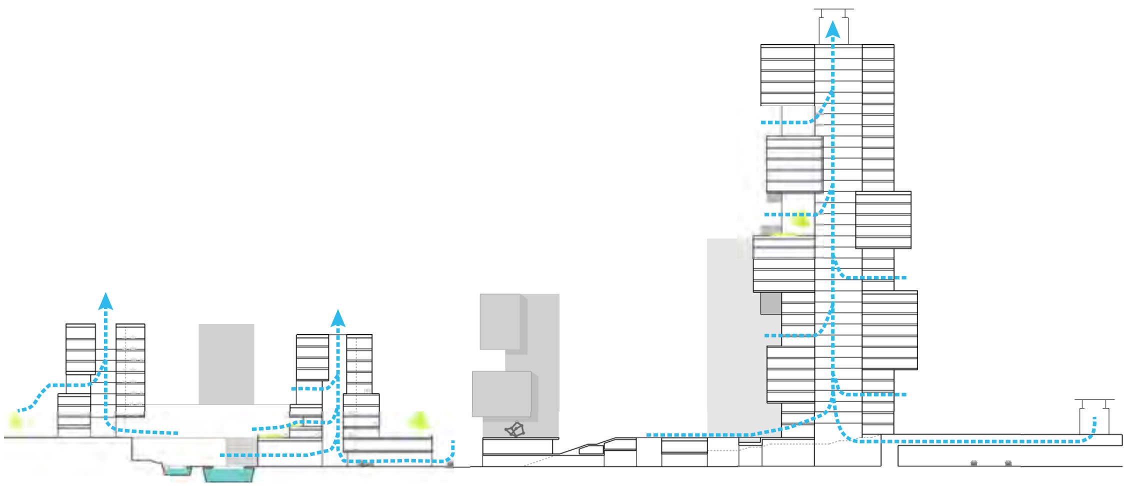
Energy Impact Stack effect is driven by the difference in temperatures and air densities between two spaces. By keeping open cavities within buildings and having the entry and exit points occur in different types of environments (ground level vs. roof), a free flow of air can take place. Warm air will naturally rise in these spaces, and it will create a reduction in air pressure in the base and lower levels which will then draw in cooler air from the exterior "pore" and a natural movement of the air from cool to warm will occur. Once this movement has begun, the channel of air can be mildly diverted to provide fresh, cooler air to units which will reduce the need for mechanical cooling and will reduce the building's operational energy.



4-5.3b Examples of porous tower form from High Density Garden



4-5.3c Energy consumption output for High Density Garden with a highly porous form



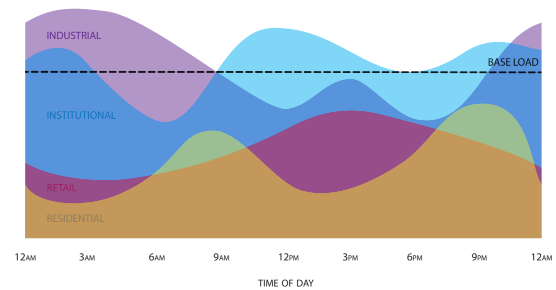
4-5.3d Energy consumption output for High Density Garden with a highly porous form

Implications By properly harnessing the thermodynamic characteristics of a vertical structure with chases and porous openings, the need for mechanical cooling can be reduced. Once this application is combined with other passive strategies such as cross ventilation (stack effect can be combined with this) and passive shading, the need for any structural cooling through the use of operational energy can be eliminated. The stack effect also serves to deliver fresh air to interior spaces that may otherwise not receive fresh air without the assistance of ducting and mechanical air exchange, requiring operational energy consumption.

section 6.0
BUILDING ORGANIZATION

6.1 Building Programs

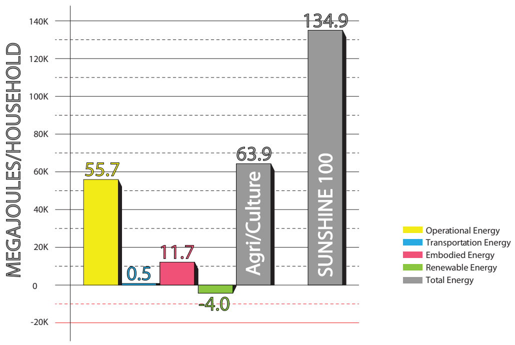
Buildings no longer need to be comprised of a single use, and the more programs one contains, the more activities and diverse populations it can sustain. Vertical mixed uses can be accomplished by better organized internal systems, which enable diverse offerings within each structure, creating a well-served neighborhood.



4-6.1a Mixed uses will distribute peak energy loads throughout a district

Guideline: Mixed use development should be practiced throughout neighborhood planning and design in both horizontal and vertical configurations. Examples of mixed use development include any combination of:

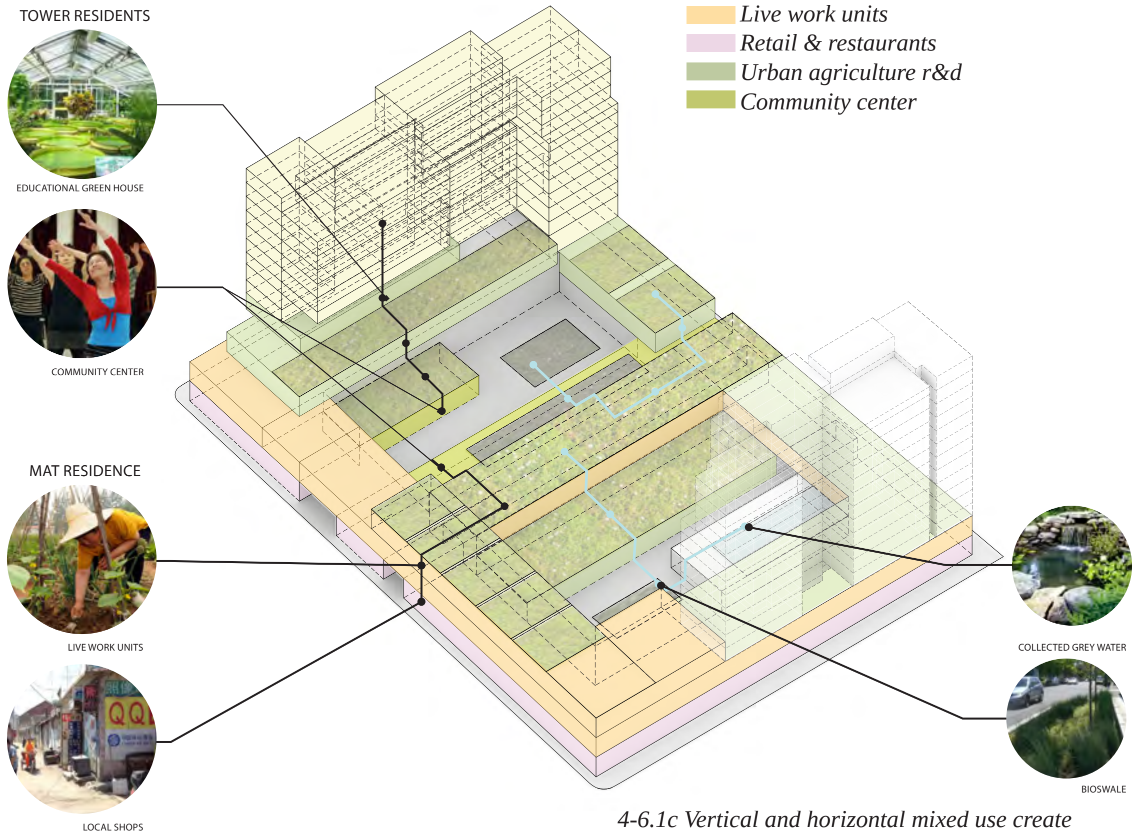
- *Residential (micro-units, flats, duplexes, townhomes, live/work);*
- *Commercial (retail, services, office, r&d);*
- *Civic (schools, government, community, cultural);*
- *Production (shared/collaborative spaces, clean industry);*
- *Multiuse spaces;*
- *Open space and recreation;*
- *Parking.*



4-6.1b Energy consumption output for High Density Garden and its mixed use development type

Energy Impact Combinations of uses will typically create a lively, 24-hour setting, and can bring people closer to their daily necessities and activities. The availability of comprehensive services and uses on-site means there are immediately accessible options for the daily-life patterns of neighborhood residents. The most significant area where energy reduction will be realized is in transportational consumption with reduced travel distances between housing, workplace, commercial, and other destinations reducing overall transportational energy consumption by creating a proximity and ground level condition that is walkable. This produces variation in building density and coverage, creates more compact development, and staggers the hours of energy consumption on a site. The varied peak uses in energy consumption is in turn better for the gradual consumption of renewable energies. The combinatory nature of uses will create a variation of form, thus necessitating an articulated or varied form (see 5.2 Height Variation & Articulated Form).

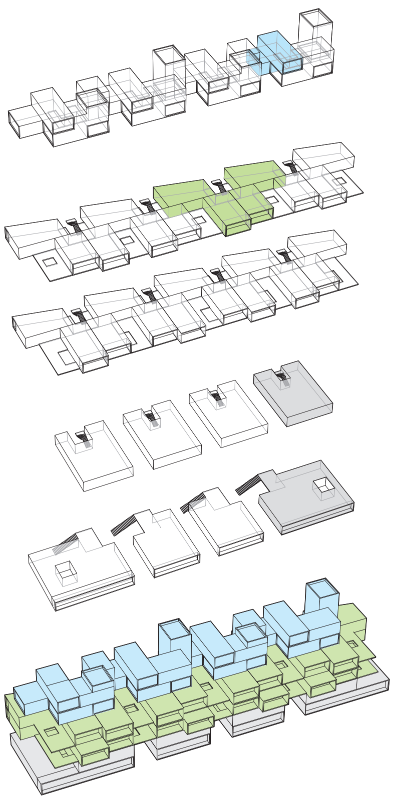
Implications Mixed use development opens the door to a variety of programming and design solutions for a given neighborhood. Historically, thriving neighborhoods in urban settings have typically had a mixed use composition where residents are able to walk to work, seek services, and partake in recreational or community activities. Higher density, urban development creates opportunities for this to again become a normative practice and for household reliance upon automobiles to fulfill daily needs to decrease. Over time this can begin to recontain urban growth and ensure compact cities full of lively, diverse, active neighborhoods.



4-6.1c Vertical and horizontal mixed use create variation and activity

6.2 Variation in Unit Sizes

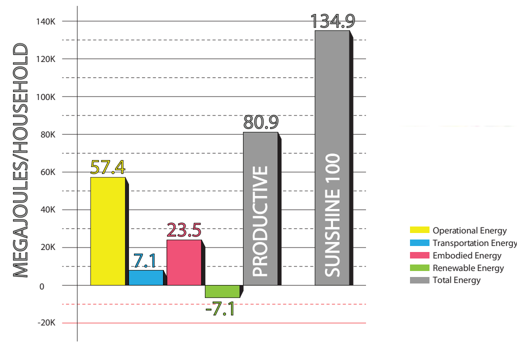
Housing units should not be homogenous, but should be designed to serve a diverse demographic. This can prevent households from being overserved with space they need to heat or cool and represents an inefficient use of materials.



4-6.2a A variety of unit types allow for diversity among residents

Guideline: New structures and neighborhoods should host a variety of unit sizes. Households are capable of being mobile within a given neighborhood, which maintains continued engagements with the community while they are able to move into units that are appropriate to their spatial needs. Rather than a homogenous supply, new developments should look to provide micro-units for single occupancy, small units for double occupancy, and several sizes for family units to accommodate different size families and structures. If feasible, units should be physically responsive to the needs of the occupants by being flexible/variable in nature. The provision of accessible amenity spaces will also keep the provided area per person at a lower number as they require less interior space for activities.

Energy Impact Households residing in more unit area than they need results in an over-consumption of energy. The operational energy used through the mechanical heating and cooling of the space as well as delivery power will exceed the amount needed for sufficient thermal comfort in an appropriately sized space. Under- or un-used spaces are composed of materials that required embodied energy for their production, transportation, and installation which is ultimately wasted in such a situation.



4-6.2c Energy consumption output for Productive City and its diverse housing types

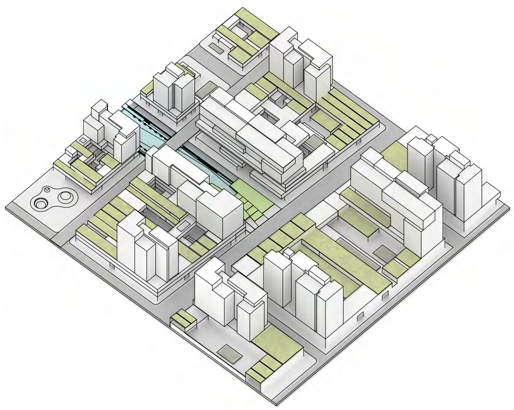
4-6.2a Unit configurations can suit tenants to prevent wasted space and resources

Implications Diversity of housing stock within a neighborhood provides residents opportunities to change units as their family circumstances change, without having to leave the community and forego relationships and amenities they become engaged with. This keeps communities intact longer and improves liveliness and security. This also creates situations where households are consuming allocations of space more consistent with their needs rather than being overserved by the square meters they occupy. Excessive area results in larger than needed volumes being heated, cooled, and lit. This uses unnecessary operational energy, whereas right-sized spaces use only the amount of energy residents activities require. And with amenities located close to the housing, less general living space in the unit is required, further reducing interior space needed per person.

Due to a varied and walkable exterior environment within neighborhoods, less area needs to be dedicated to each occupant per unit. These smaller sizes permit a more efficient use of space. In time, flexible or variable units make this dedicated area per person even smaller, resulting in additional embodied and operational energy conservation. With fewer building materials dedicated to construction, embodied energy used in the transportation of materials from source and production sites, operational energy spent during manufacturing, energy used during construction and the operational energy needed to thermally serve the space, all are reduced.

section 7.0
BUILDING MATERIALS

7.1 Green roofs and walls



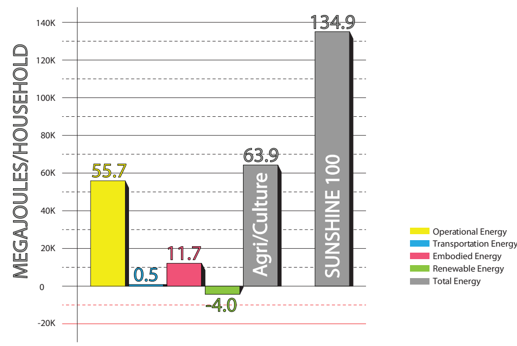
4-7.1a Extensive green roofs cover the buildings and create opportunities for urban agriculture

4-7.1b Green roofs connect buildings and amenities in Shanghai
(source: http://farm1.static.flickr.com /27/41572708_81e861cc23.jpg?v=0)

Vegetated surfaces are an established system for mitigating urban heat islands.

Guideline: Horizontal and low-slope roof surfaces should be covered with extensive or intensive green roof systems. Facades can be built up with intensive systems or deciduous façades that respond to seasonal changes.

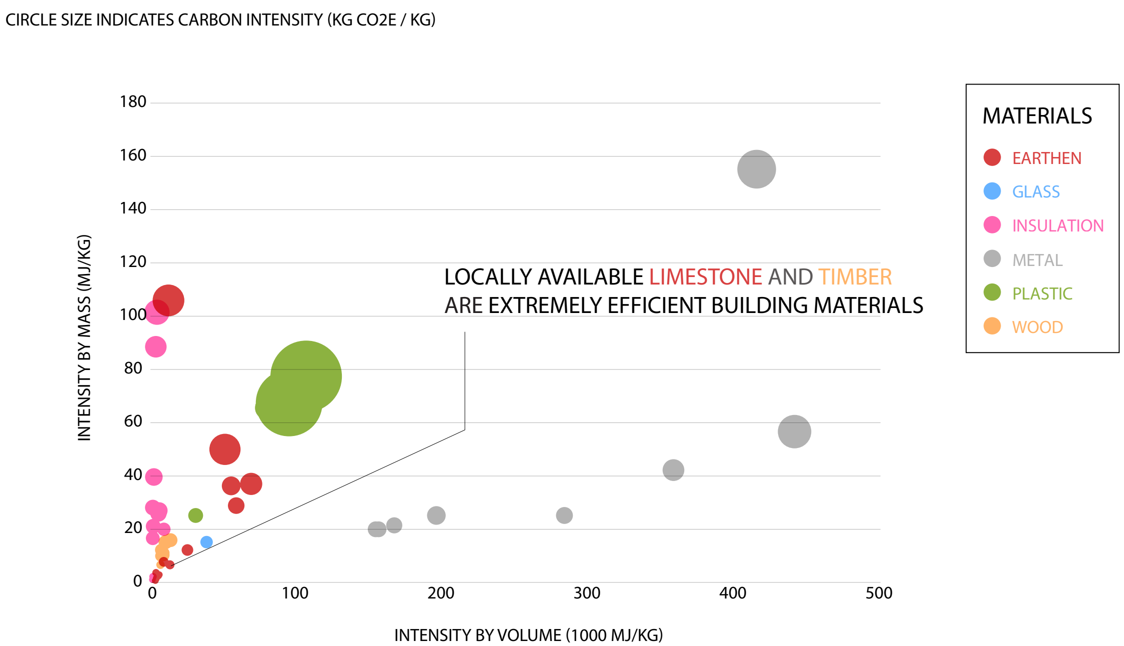
Energy Impact Green roofs offer a variety of energy benefits. Due to the insulating qualities of the green layer, it reduces energy costs and consumption on heating and cooling by maintaining a regular interior temperature and reducing operational energy. Vegetative surfaces reduce the heat island effect, mitigating the effects of urban climate change. Plants reduce the air pollution and CO2 emissions and have a filtering effect on city air. Plants and the planting medium capture rainwater and enhance water quality. The process of evapotranspiration cools the surface below, providing an additional cooling effect to the already shaded roof surface. Finally, vegetation creates natural habitats and ecosystems with urban areas.



4-7.2c Energy consumption output for High Density Garden and its mixed use development type

Implications A more extensive application of green roofs and surfaces throughout urban spaces will reduce micro-climates in neighborhoods and in turn reduce the heat island effect in urban areas. Urban air quality dramatically improves as green roofs become more expansive, acting as lungs within the city. Intensive green roof systems are deep enough to be used as sites for urban agriculture and, therefore, urban biodiversity. Given that green roofs can be installed on a wide range of building types, symbiotic relationship can become established between building programs. Roof top agriculture can supply produce to restaurants, support research and development, and provide educational opportunities for adults and children.

7.2 Locally-sourced and manufactured materials



4-7.2a Embodied energy savings are derived from using locally-sourced materials, with the usage of concrete and steel minimized as much as possible.

By producing large amounts of CO2 before and throughout the life of the neighborhood forms, current methods of manufacturing, sourcing and transporting have become unsustainable and need to change to less energy intensive methods.

Development projects should source local materials and/or materials with high recycled and low-impact content.

Energy Impact The materials currently used in the construction of a neighborhood are transported from manufacturing sites all over the world. This distance incurs high levels of transportational energy in addition to the energy intensive material production/preparation processes. For example, the energy intensive processes involved in mining, smelting, manufacture of aluminum panels, and their transportation results in high levels of embodied energy.

Concrete is a ubiquitous building material, and frequent application makes it responsible for high global CO2 emissions. Simple measures can be made to lessen its impact, such as using recycled content for aggregate, and removing the toxic additives. Once demolished, concrete can be reduced to smaller sizes and be reused, either as aggregate in new concrete or as fill in new building elements, such as gabion blocks. While the embodied energy will always remain high for concrete, it can be reduced through these methods. Additional composite materials made by natural materials, such as wool bricks or natural polymers, frequently prove to be stronger than their traditional counterparts and reduce the embodied energy of the materials.

Locally-sourced materials reduce transportation distances. Low-impact production processes reduce the energy spent on manufacturing. Natural and recycled materials reduce impacts on natural resources. Taken together, local sourcing, low impact production, and the use of recycled and natural materials results in significantly lower embodied energy required for neighborhood development.

Implications There is a long tradition of low-impact settlements when looking to vernacular developments for clues. One of the lessons to be taken from vernacular development is that construction from locally sourced materials creates low-impact settlements. In addition to becoming an investment in the local economies of a region, the reduction of harmful impacts helps mitigate the long-term effects of climate change.

5.0 CONCLUSION & FUTURE DIRECTION

5.1 Role of Guidelines in Neighborhood Development

The bundled approach of using the Energy Proforma© together with the Clean Energy Guidelines will aid designers and developers in creating more livable neighborhoods that require less embodied, operational, and transportation energy, and that maximize opportunities to produce renewable energy. While the language of the guidelines is mostly qualitative, each guideline is supported by design samples which demonstrate an improved form-energy relationship. Coupled with metrics produced by Energy Proforma© outputs, the results give planners clear ideas of the consequences of their proposals.

A caveat: As professionals become increasingly adept at using the Energy Proforma© tool and the Clean Energy Guidelines, they "must make certain that standards do not result in mediocrity in urban form or in the public realm. They must realize that good urban design is not a result of standards and regulations derived from mathematical formulas, but rather from experience gained from use" (Ben-Joseph, 2005, 187). When bundled, the Energy Proforma© and the Clean Energy Guidelines give its users a method that, with each iteration, utilizes metrics *and* the experiences and lessons learned from past applications.

The primary contribution of this thesis is the creation of the Clean Energy Guidelines to be used with the Energy Proforma© to promote a better way to develop cities in neighborhood increments in the face of increasing climate change and shrinking natural resources.

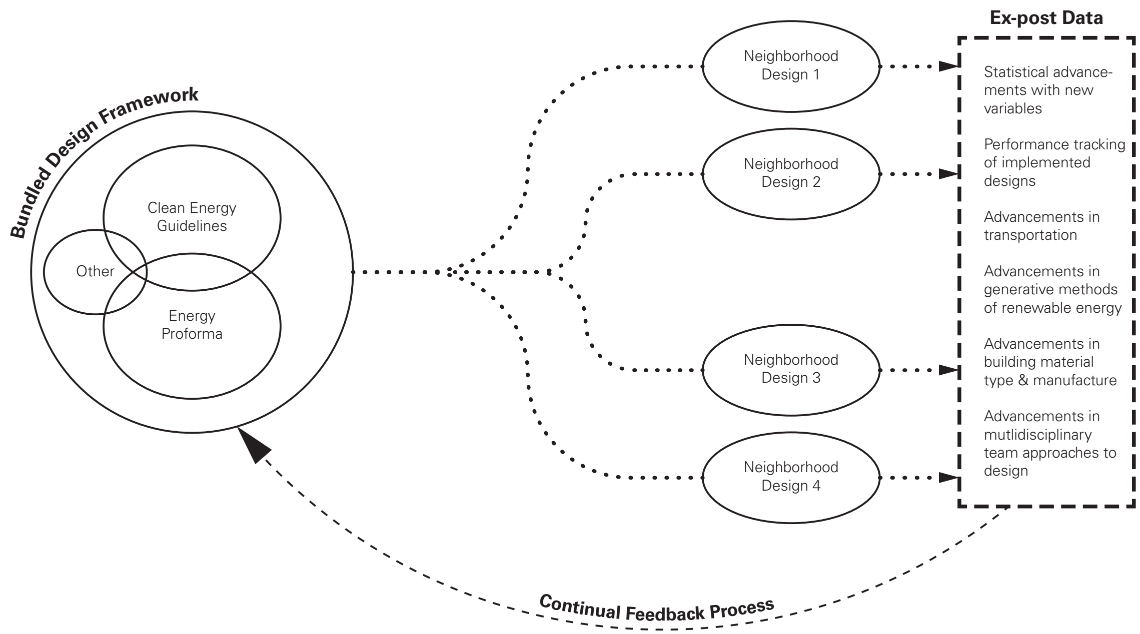
This thesis also significantly contributes to the on-going research and of work of the Making the 'Clean Energy City' in China Research Group to help reshape energy policy in China.

5.2 Implications and Next Steps

The implications for this project are substantial, and can have a positive impact at many levels of global development. Existing Chinese policy and practice have perpetuated a form which has no derivation from climate, geography or tradition. It has been a modern exercise that has been proven to be a failure in addressing issues of energy consumption, community development, and is inimical to many of the traditional ways of Chinese life (CITE!!). Innovative urban planning and design in China has become an economic and environmental necessity. Elevating standards of living for the world's largest population in the fourth largest country, is a daunting challenge faced by the Chinese government. The Energy Proforma and the Clean Energy Guidelines can make a real contribution to this effort. By adopting a new approach to urbanization, there will be an opportunity to create a new generative growth pattern based in smarter, livable design, methods of design and construction that are site specific, and policy standards that ensure the process is viable from the beginning.

These Guidelines, along with continuous feedback and improvement, have the potential to influence development policy at a time when the current standards have created an unsustainable, ubiquitous pattern that has served to accelerate the exhaustion of natural resources, erode community interactions at the ground-level, and both alienate and isolate citizens. (CITE!!!).

The Guidelines are intended to remain flexible and to evolve over time. This flexibility allows variables such as finer grain sustainable design features, e.g. water collection and management systems, wind production, strategic building orientations, to be integrated into the Guidelines. As the Guidelines themselves become more practiced, they will expand to accommodate the new knowledge and practices that will elicit a better result. The idea is that by keeping the Guidelines a living product, they exist "in a state of flux and adjustment – on the one hand with a view to preventing newly discovered abuses, and on the other hand with a view to opening a wider opportunity of individual discretion at points where the law is found to be unwisely restrictive" (Olmsted, 1916, XXX). Only with a responsive framework can the neighborhood designs adapt and improve over time. The Guidelines provide precisely the kind of responsive framework capable of producing an infinite number of results and, integrated into a feedback process, continues to evolve into improved versions of itself.



5.2 Process and feedback loop

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REFERENCES

"Access to Destinations - About Accessibility." 2013. Accessed May 4. http://www.cts.umn.edu/access-study/about/index.html.

Alexander, Christopher, Sara Ishikawa, and Murray Silverstein. 1977. A Pattern Language: Towns, Buildings, Construction. Oxford University Press.

Al-Homoud, Mohammad Saad. 2001. "Computer-Aided Building Energy Analysis Techniques." Building and Environment, Volume 36, No. 4, 421-433.

Allaire, J. 1960. "Neighborhood Boundaries". Information 141. Planning Advisory Service. Chicago, Illinois: American Society of Planning Officials. http://www.planning.org/pas/at60/pdf/report141.pdf.

Ben-Joseph, Eran. 2005. The Code of the City: Standards and the Hidden Language of Place Making. The MIT Press.

Ben-Joseph, Eran. 2012. ReThinking a Lot: The Design and Culture of Parking. 1st ed., 1st Ptg. The MIT Press.

Berg, Nate. 2013. "A Guide to Copenhagen From the Future" The Atlantic Cities. Accessed May 2. http://www.theatlanticcities.com/design/2012/06/guide-copenhagen-future/2209/.

Berliner, Nancy. 2003. Yin Yu Tang: The Architecture and Daily Life of a Chinese House. Hardcover with Jacket. Tuttle Publishing.

Bernthal, John E., Nicholas W. Bankson, and Peter Flipsen. 1988. Articulation and Phonological Disorders. Vol. 27. Prentice Hall. http://www.lavoisier.fr/livre/notice.asp?id=O3OWA2AKL6OOWE.

Black, Elissa. 2008. "Green Neighborhood Standards from a Planning Perspective: The LEED for Neighborhood Development (LEED-ND)." Focus: Journal of the City and Regional Planning Department 5 (1): 11.

Bourbia, F. and F. Boucheriba. 2010. "Impact of Street Design on Urban Microclimate for Semi-Arid Climate (Constantine)." Renewable Energy, Volume 35, No. 2, 343-347.

"BREEAM: What Is BREEAM?" 2013. Accessed July 19. http://www.breeam.org/about.jsp?id=66.

Broto, Carles. 2008. Urban Apartment Blocks. Links International, Ceg.

Burry, Jane, and Mark Burry. 2012. The New Mathematics of Architecture. 1st ed. Thames & Hudson.

Carbonell, Jordi. 2009. "The Olympic Village: Ten Years on Barcelona: The Legacy of the Games 1992-2002." Accessed On 6.

http://ceo.uab.cat/2010/docs/wp087_eng.pdf.

"Center for Applied Transect Studies." n.d. http://transect.org/transect.html.

City of Chicago,. 2008. "Adding Green to Urban Design: A City for Us and Future Generations". Comprehensive Plan. Chicago, Illinois: Chicago Plan Commission. http://www.cityofchicago.org/dam/city/depts/zlup/Sustainable_Development/Publications/Green_Urban_Design/GUD_booklet.pdf.

Condon, Patrick M. and Duncan Caves, and Nicole Miller. 2009. "Urban Planning Tools for Climate Change Mitigation." Policy Focus Report. Lincoln Institute of Land Policy, Volume 8.

Crawford, J. H. 2002. Carfree Cities. International Books.

Crawford, J. H. 2009. Carfree Design Manual. International Books.

Farr Associates. 2008. "An Expert Review on the Strength of the Data in Support of Proposed Community Design Standards in LEED for Neighborhood Development." http://www.cnu.org/sites/www.cnu.org/files/CDC-LEED-ND_Report.pdf.

"Form-Based Codes Institute." 2010. http://www.formbasedcodes.org/.

Foster, Hal, ed. 2002. The Anti-Aesthetic: Essays on Postmodern Culture. New Press, The.

Frampton, Kenneth. 1983. "Towards a Critical Regionalism: Six Points for an Architecture of Resistance", in The Anti-Aesthetic: Essays on Postmodern Culture. edited by Hal Foster, Bay Press, Port Townsen.

Frenchman, Dennis, and P. Christopher Zegras. 2012. "Making the Clean Energy City in China: Year 2 Report". Cambridge, Massachusetts: Massachusets Institute of Technology, Center for Advanced Urbanism. http://energyproforma.scripts.mit.edu/documents/MIT_Clean_Energy_City_Year_2_Report_web.pdf.

Gaubatz, Piper. 1998. "Mosques and Markets: Traditional Urban Form on China's Northwestern Frontiers." Traditional Dwellings and Settlements Review, Volume 9, No. 2, 7-21.

Golany, Gideon. 1992. Design & Thermal Performance: Below-Ground Dwellings in China. University Of Delaware.

Golany, Gideon S. 1992. Chinese Earth-Sheltered Dwellings: Indigenous Lessons for Modern Urban Design. University of Hawaii Press.

Isaacs, Reginald R. 1948. "The Neighborhood Theory: An Analysis of Its Adequacy." Journal of the American Institute of Planners 14 (2) (June 30): 15–23. doi:10.1080/01944364808978605.

Jacobs, Allan B. 1995. Great Streets. The MIT Press.

Jacobs, Jane. 1961. The Death and Life of Great American Cities. Random House.

Jao, James C., and with Janet Adams Strong Ph.D. 2012. Straight Talk About China's Urbanization. FIrst. Xinhua Publishing House.

Kikegawa, Yukihiro, Yutaka Genchi, Hiroaki Kondo, and Keisuke Hanaki. 2006. "Impacts of City-block Scale Countermeasures Against Urban Heat-island Phenomena Upon a Builing's Energy Consumption for Air-Conditioning." Applied Energy, Volume 83, No. 6, 649-668.

Layzer, Judith A. 2010. "What Works and Why? Evaluating the Effectiveness of Cities' Sustainability Initiatives." Prepared for the American Political Science Association Meeting, Washington, D.C. September.

LeGates, Richard, and Frederic Stout, ed. 1998. Early Urban Planning: 1870-1940. 2nd ed. Routledge.

Litman, Todd. 2011. "Introduction to Multi-Modal Transportation Planning." Victoria Transport Policy Institute 15. http://www.vtpi.org/multimodal_planning.pdf.

Lloyd, Scott, and Katrina Stoll, ed. 2011. Infrastructure as Architecture. Jovis.

Lorch, Richard. 2003. Buildings, Culture and Environment: Informing Local and Global Practices. Edited by Raymond J. Cole. 1st ed. Wiley-Blackwell.

Lynch, Kevin. 1960. The Image of the City. The MIT Press.

Lynch, Kevin. 1984. Good City Form. The MIT Press.

Maas, Winy, and John Thackara. 2010. Green Dream: How Future Cities Can Outsmart Nature. Edited by Ulf Hackauf and Pirjo Haikola. NAi Publishers.

Mayne, Thom. 2011. Combinatory Urbanism: The Complex Behavior of Collective Form. 1ST ed. Stray Dog Cafe.

Nolen, John. 2012. City Planning; a Series of Papers Presenting the Essential Elements of a City Pla, 1869-1937, n. Ulan Press.

"NRDC: LEED for Neighborhood Development." 2013. Accessed July 20. http://www.nrdc.org/cities/smartgrowth/leed.asp.

Parker, James. 2009. "BREEAM or LEED - Strengths and Weaknesses of the Two Main Environmental Assessment Methods." February. http://www.bsria.co.uk/news/article/breeam-or-leed/.

Qijun, Wang, and Jia Xianfeng. 2002. Traditional Chinese Residences. Translated by Zhang Shaoning. Foreign Languages Pr.

Quirk, Vanessa. 2012. "Where Is LEED Leading Us?…And Should We Follow?" Archdaily.com. April. http://www.archdaily.com/227934/where-is-leed-leading-us-and-should-we-follow/.

Raimi, Matt, Aaron Welch, and Kaid Benfield. 2011. "A Citizen's Guide to LEED for Neighborhood Development: How to Tell If Development Is Smart and Green." https://www.nrdc.org/cities/smartgrowth/files/citizens_guide_LEED-ND.pdf.

Perry, Clarence. 1929. "The Neighborhood Unit," Monograph One. Vol. 7 Regional Survey of New York and Its Environs: Neighborhood and Community Planning. New York: New York Regional Plan.

Roseland, Mark. 1997. "Dimensions of the eco-city." Cities, Volume 14, No. 4, 197-202.

Rowe, Peter G. 1999. “Housing Density, Type, and Urban Life in Contemporary China.” Harvard Design Magazine, Volume 8. Summer, 40-45.

Rudofsky, Bernard. 1987a. Architecture Without Architects: A Short Introduction to Non-Pedigreed Architecture. Reprint. University of New Mexico Press.

Schylberg, Katarina. 2004. “An Indicator System for Caofidian Eco-city.” China Academic Journal Electronic Publishing House. www.cnki.net

Staley, Sam, and Adrian Moore. 2008. Mobility First: A New Vision for Transportation in a Globally Competitive Twenty-first Century. First Edition. Rowman & Littlefield Publishers.

Sustainia, Jakob Hansen, Solvej Christiansen, Meik Wiking, and Morten Jastrup. 2013. “Guide to Copenhagen 2025.” Accessed March 25. http://www.sustainia.me/wp-content/uploads/2012/06/CPH-2025.pdf.

Tang, Wenfang, and William L. Parish. 2000. Chinese Urban Life Under Reform: The Changing Social Contract. Cambridge University Press.

Tsu, Frances Ya-sing. 1987. Landscape Design in Chinese Gardens. McGraw-Hill Book Company, New York.

Yates, A. P. 2003. Sustainable Buildings: Benefits for Occupiers, Designers, Investors, Developers and Constructors. IHS BRE Press.

Wang, Qijun. 1993. Traditional Residential Architecture of China. Sanlian Publishing Co, Hong Kong.

Wang, Ya Ping and Alan Murie. 1996. “The Process of Commercialisation Urban Housing in China.” Urban Studies. Volume 33, No. 6, 971-989.

Wright, Arthur F. 1977. “The Cosmology of the Chinese City,” in The City in Late Imperial China, G. William Skinner, ed. Stanford University Press, Palo Alto.

Zhang, Yan and Ke Fang. 2003. “Politics of housing redevelopment in China: The rise and fall of the Ju’er Hutong project in inner-city Beijing.” Journal of Housing and the Built Environment. Volume 18, 75-87.