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Energy Sector Management Assistance Program

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# Planning Energy Efficient and Livable Cities

Energy Efficient Cities

MAYORAL GUIDANCE NOTE #6





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## EXECUTIVE SUMMARY

The world's urban population is expected to increase by about 2.7 billion by 2050. Virtually all of the increased population will be in developing countries, leading to massive needs for new and improved housing and urban infrastructures (UNDESA 2012). The planning and design of these new developments will reshape or create new urban landscapes with significant implications for energy consumption, infrastructure costs, as well as the livability and social and economic resilience of cities.

Studies of cities around the world indicate that a city's livability and its level of energy use are closely linked to its physical form, namely the spatial distribution and dimensions of buildings, streets, and parks, as well as the spatial coordination of residences, jobs, social services, and environmental amenities. The most energy efficient and livable cities often demonstrate the following characteristics:

- 1 | Built-up areas are compact and the densities of buildings, residents, and jobs are strategically distributed along transit corridors and matched with social and environmental services and amenities;
- 2 | Street networks are dense and interconnected and display a variety of sizes and functions that consider the needs of all users, particularly pedestrians, cyclists, and transit users;
- 3 | Public transport modalities correspond to population and job densities and the stops are accessible by walking;
- 4 | Social services and environmental amenities, such as schools, hospitals, parks, and green spaces, are designed to maximize accessibility by walking;
- 5 | Urban blocks are small sized and buildings are aligned along streets to create various street fronts and vibrant sidewalks;
- 6 | Multi-functional (or mixed) uses are ingrained in neighborhoods, blocks, and even individual buildings;
- 7 | Streets are places for people and promote walking; and
- 8 | Design and layout of buildings and streets are adapted to local climatic conditions.

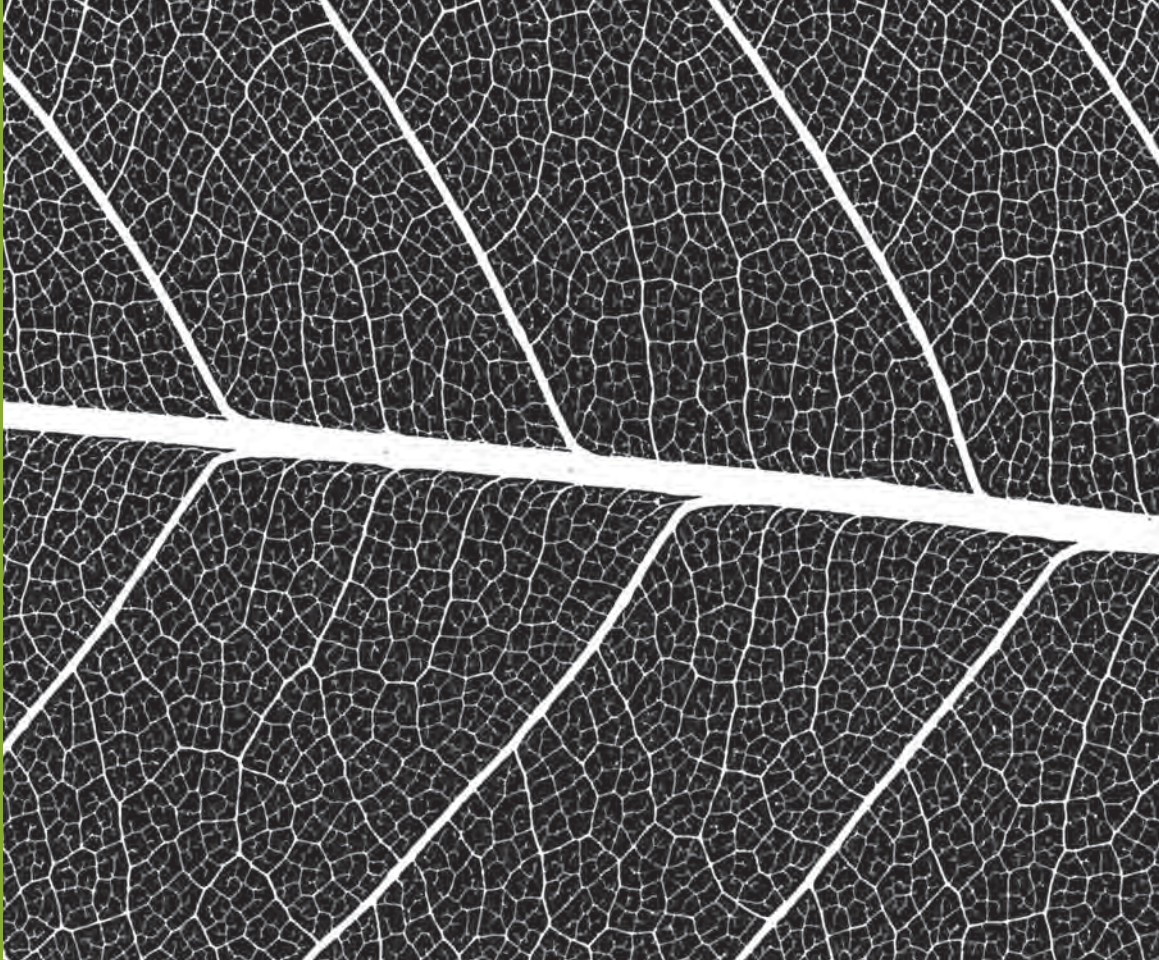
Achieving a high level of energy efficiency and livability generally requires deliberate and consistent urban planning policies promoting such convergence, persistent city leadership efforts spanning decades, capable local institutions, and broad-based citizen support. Such is the case of Curitiba, Brazil, proving that improvement and transformation in livability and energy efficiency can be attained in a developing country city with limited budgetary resources.

City governments have great leverage in shaping the physical form and the socio-economic fabric of cities as they are often responsible for preparing and implementing urban development plans, and enacting and/or enforcing laws and regulations to guide urban land use. However, it is important to ensure that decisions related to urban development are made in a participatory, collaborative, and transparent process, in close coordination with various horizontal and vertical government units, as well as the cooperation of various stakeholders, including developers and citizens.

This guidance note advises city leaders in urbanizing developing countries on how to shape their cities for greater livability and energy efficiency through urban planning

policies, zoning regulations, and design standards and guidelines. The principal strategies, reflecting the above key characteristics, include the following:

- 1 | Build compact and well-connected urban areas with dense network of streets and paths;
- 2 | Prioritize walking, cycling, and public transportation for access to jobs, social services, and environmental amenities;
- 3 | Foster transit-oriented developments and mixed-use neighborhoods; and
- 4 | Optimize designs of buildings and neighborhoods to suit local climatic conditions.



## SPATIAL PLANNING, URBAN FORM, AND ENERGY EFFICIENT CITIES

Cities hold the key to an energy efficient and livable future. Unlocking that potential requires the refashioning of urban spatial development, not on the premise of automobiles, but on the principle of human-scale solutions, such as maximizing accessibility to jobs, shops, social services, and environmental amenities by walking, cycling, and public transportation. Urban spatial development has very strong ‘lock-in’ effects: once urban forms are defined, as cities grow, it is very costly to retrofit.<sup>1</sup> As will be explained in the following sections, urban form greatly impacts the energy use, infrastructure cost, and the social and economic resilience of a city.

### DYNAMICS OF URBAN FORM

The transformation of urban forms is influenced primarily by political economy, transportation technologies, land markets, and urban development policies.

- **Political economy** refers to the dynamics and interactions of the diverse actors and rules involved in urban development decision-making processes, which affect land use patterns (e.g., conversion of rural land vs. densification of existing urban built-up areas).
- **Transportation technologies** are a key driver of urban transformation. The urban extension of a city is directly correlated to the average distance that can be travelled

in one hour (Wortmann 1985). Thus, the improvement of traffic speed may encourage urban sprawl. New technologies and infrastructures for transport may dramatically change the spatial distribution of land use, densities, and activities within the city.

- **Land value** drives the rate of conversion of rural land into urban land. The improvement of transport technologies and infrastructures makes cheaper rural land accessible. Hence, it allows its conversion into urban land and increases the area available for urbanization. Without land value control, market forces naturally drive cities towards urban sprawl.
- **Urban development policies** are responsible for land use, the size of blocks and plot subdivision, the structure and hierarchy of the road networks and street patterns, and the spatial distribution of social services and environmental amenities. Growth management issues such as urban sprawl, growth patterns, and phasing of developments heavily influence urban form. One of the main policy tools for urban planning is the control of the Floor Area Ratio (FAR)—ratio of the floor area over the building footprint area. FAR regulations have a big impact on the distribution of built densities and land prices.

## URBAN FORM GREATLY AFFECTS ENERGY USE

Urban energy use is affected mainly by: (i) the spatial dimension of urban areas; (ii) the coordination of resident and job densities; (iii) the accessibility of jobs, services, and amenities by walking, cycling, and public transportation; and (iv) the extent to which the built environment adapts to local climate conditions. The first three factors directly affect demand for motorized transportation while the last factor affects the operational energy demand of buildings.

### Spatial Dimension

The structure and distribution of land use, the form, sizing, and scaling of urban plots, and the sizing and scaling of street networks have a strong impact on energy efficiency. Optimizing these aspects of urban form can reduce energy needs by a factor of two to four (Salat and Bourdic 2011; 2013). Energy efficient urban forms, as shown in many historic city centers around the world, display a fine-tuned balance of street sizes and functions: a few very large streets, a medium number of medium-size streets, and a large number of narrow streets that promote walking. In Paris, 60 percent of the streets (the historical street network) are less than 12 meters wide and accommodate low speed traffic (Bourdic and Salat 2012). A high density of narrow streets with close intersections and continuous sidewalks creates a lively, safe, and walkable urban landscape. Walking distances tend to be shorter and the system of close intersections enables pedestrians to change direction easily, a factor that promotes convenience. It enables and encourages non-motorized travel behaviors such as walking and cycling for daily short trips.

On a wider scale, larger streets allow connecting distant parts of the city using motorized transportation modes. These wide axial lines, however, are not highways only reserved for automobiles. They are urban boulevards that accommodate various modes of transit (cars, public transport, cycling, and walking), green corridors, shops, and cultural activities. Their large and vibrant sidewalks can easily be crossed by foot. Tightly connected and integrated with the narrow streets network, they ensure the continuity of public space—an essential feature for walkability. An example would be La Rambla in Barcelona, which is a large route connecting different districts and is, at the same time, a bustling place of intense social life and a promenade for pedestrians. A key challenge is to design large routes within the urban area not as arterial roads or freeways with limited access, but as urban boulevards well-connected with the public domain of the streets, squares, and gardens. Figure 1 is an example of redesigning urban freeways for urban livability.



Figure 1 | Transformation of Seoul's Cheong Gye Cheon from an Elevated Freeway to an Urban Greenway



Source | Jun 2000.

Conversely, oversizing of street grids in greenfield urban developments is common in fast urbanizing countries. In China, for instance, the regulatory sizing of the grid prescribes a main road every 500 meters and an even bigger road every kilometer. This very wide grid leads to an oversizing of urban blocks while the network of human-scale, walkable, middle, and narrow streets is missing. This prevents walking and other non-motorized transport modes and locks cities into car-dependent paths (Box 1).

**Compact cities require less energy to move people and goods around.** Urban sprawl, made possible by automobiles, makes driving a necessity and is responsible for high energy needs for transportation (Rickwood, Glazebrook, and Searle 2008). Urban

### Box 1 | The Absence of Connectivity and Fine Grain in Chinese Urban Developments

The following pictures illustrate the size of blocks and impacts on connectivity of a series of cities in Europe, Japan, and China. It shows the absence of connectivity and the increase of average distances between intersections in recent urban developments in China.

	Turi, Estonia	Barcelona, Spain	Paris, France	Ginza, Tokyo	Pudong in Shanghai, China	Towers North in Beijing, China
Intersections per km <sup>2</sup>	152	103	133	211	17	14
Distance between intersections (m)	80	130	150	43	280	400

Source | Authors.

sprawl combines low density and fragmentation of the urban area, increases the average travel distances for daily trips, and hinders a shift toward less energy-intensive transportation modes (transit, walking, and cycling; see Box 2 and Figure 2). For example, urban expansion in China in the last 15 years has been characterized by relatively low density development through excessive conversion of rural land (Figure 3), due to overreliance on land lease for municipal finance.



## Resident and Job Densities

**Strategic distribution of resident and job densities<sup>2</sup> along transit corridors encourages the use of public transportation and reduces dependency on automobiles for commuting to work.** Density must take into account local specificities, notably those concerning hydrography, climate, and topography.<sup>3</sup> What matters most for energy efficient urban form is the strategic and coordinated distribution of densities across different parts of a metropolitan area. For example, good practices of transit-oriented development tend to apply a wide variation of densities in different areas, taking social and economic features into consideration. They allow for higher density development around transit lines and stations to capitalize on location premium.

Floor to area ratio (FAR) is often used as a proxy for population and job densities. But high FAR is not reached simply through vertical elevation of buildings though, but with large building footprints instead (Table 1). Medium-rise urban fabrics (7 to 10 floors high) with a high building footprint ratio often have a higher built density than high-rise buildings with a low building footprint. Built density is higher in traditional European urban fabrics composed

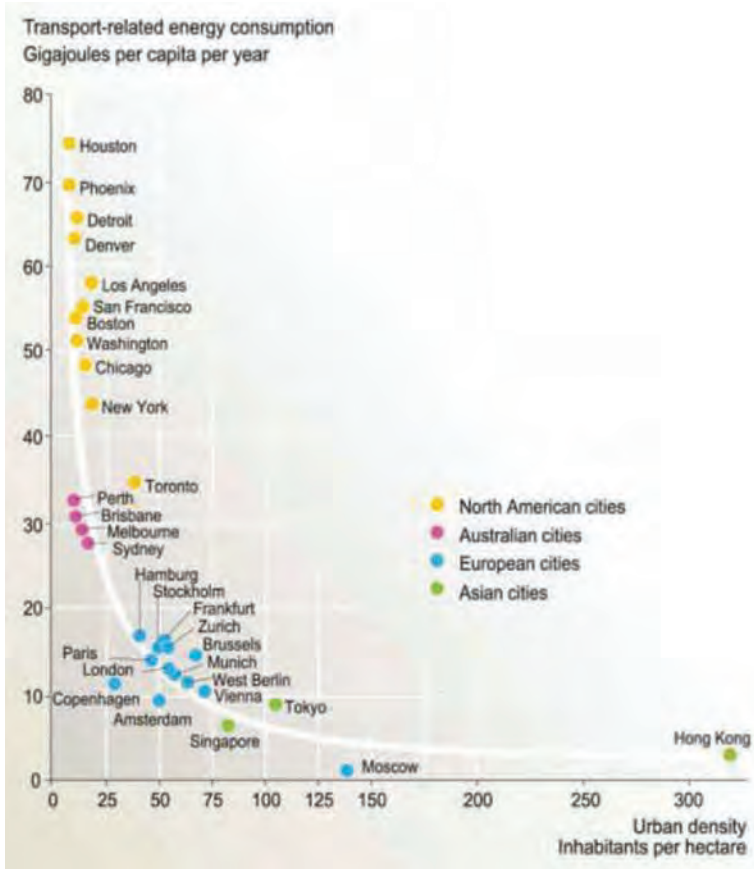
### Box 2 | Sprawl vs. Compact Cities

An often cited example of urban sprawl is Atlanta, GA (US), which has a similar population as Barcelona but occupies an urban area that is 26 times as large.

	Sprawling City	Compact City
		
Location	Atlanta	Barcelona
Urban Population (million inhabitants)	2.5	2.8
Urban Area (km <sup>2</sup> )	4,280	162
Urban Density (pph)	6	173
Energy Consumption Per Capita for Private Transportation (MJoules)	80	9

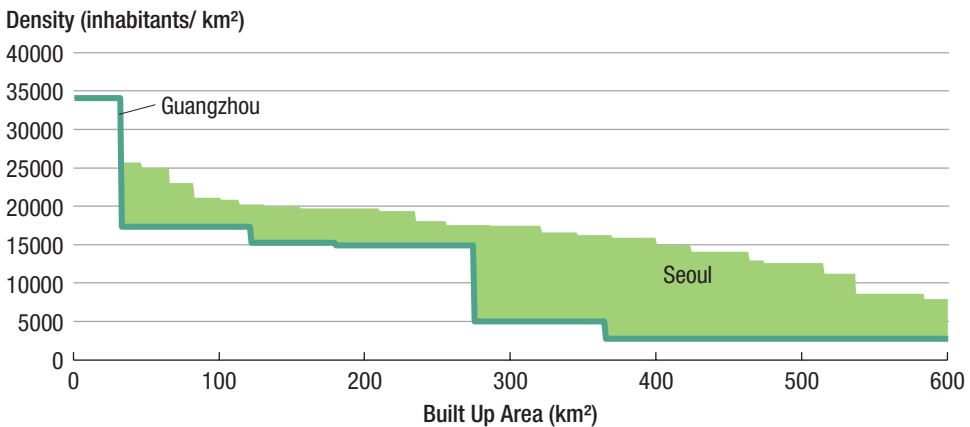
Source | Bertaud and Poole 2007.

Figure 2 | Urban Density and Transport-related Energy Consumption in Selected Cities



Source | Kirby 2008; Newman and Kenworthy 1989.




Figure 3 | Guangzhou Could Accommodate 4.2 Million More People, If It Had Seoul's Density Profile



Note | The green area indicates the potential for redensification in the densest 600 km<sup>2</sup> of Guangzhou.

Source | Salat 2011.

Table 1 | Comparison of Urban Density for Three Typical Urban Fabrics (800 m<sup>2</sup>)

	Low Rise Suburban Area (villas)	Medium Rise Continuous Small Block Area	High Rise Large Blocks Area
			
Location	Shanghai	Paris	Shanghai Lianyang
Building Footprint (%)	17%	55%	12%
Average Number of Floors	2	7	31
Gross FAR	0.4	3.8	3.7

Source | Salat 2011.

of medium-rise buildings (5 to 7 floors) with a high building footprint (50 to 60 percent of the ground) and compact continuous urban street blocks with internal courtyards than in many recent modern high-rise developments with low building footprints (less than 15 percent of the ground). An urban fabric with a low building footprint (10 percent) must have six times taller buildings on average (42 floors) to reach the same built density as an urban fabric of seven-floors high with a building footprint of 60 percent.

### Accessible Density





**Accessible density is a major driver of citywide energy efficiency as it significantly influences travel behaviors.** Put simply, where services and amenities are easily accessible (i.e., less than 10 minutes by walking) and walking is safe and comfortable, people tend to forgo driving. If urban design were to combine walking accessibility with reliable public transport services, the need to drive within cities would be drastically reduced.

The sizing and the scaling of urban services amenities should be finely tuned. Achieving this balance depends upon an optimal distribution of large-, medium-, and small-scale urban amenities. For example, a balanced urban fabric has a few large hospitals, shops, and parks, and a large number of small-scale clinics, small shops, and pocket parks. This high density distribution of small-scale amenities in the urban fabric ensures that daily urban amenities are close and accessible for every citizen.

### Designing for Local Climate

**Adapting designs and layouts of buildings and streets to fit local climatic conditions reduces energy use for space conditioning.** Streets and buildings need to be designed and configured to support day-lighting, ventilation, and passive cooling or heating. In a dense urban environment, clusters of buildings, urban blocks, and urban textures are the right scales to design energy efficient built environments (Table 2).

Table 2 | Energy Consumption for Space Heating in Three Urban Textures (1,200 m<sup>2</sup>)

Urban Setting, in European Temperate Climate	Continuous Texture, with Small Blocks	Large Blocks	Towers, 110 m High
			
Heating needs (kWh/ (m <sup>2</sup> .yr) with average U-value=0.87 W/(m <sup>2</sup> .K))	39	50	102

Note | Heating needs is defined as kWh per m<sup>2</sup> floor area per year. 110 m high towers need 2.5 times more energy for heating than a 21 m high continuous fabric of urban blocks.

Source | Salat, 2011.

The bulk of the next phase of urbanization will take place in the hot and humid climates of developing countries. However, there is a substantial lack of knowledge in passive design optimizing techniques, natural ventilation, and the cooling of the urban built environment. Most of the research in passive buildings has been carried out for cold and temperate climates (Europe and North America). This lack of knowledge and know-how jeopardizes the emergence of passive urban forms adapted to local climates.

### URBAN FORM HAS A DIRECT IMPACT ON INFRASTRUCTURE COSTS AND INVESTMENTS

Cities with higher density tend to have lower per capita infrastructure length, indicating potentially smaller life cycle cost per capita (Müller et al. 2013). Water network length per capita, wastewater network length per capita, and road length per capita are inversely correlated with urban density (Figure 4).

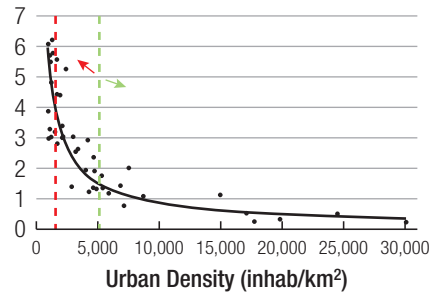
### URBAN FORM HAS A STRONG IMPACT ON SOCIAL AND ECONOMIC RESILIENCE

Social infrastructures density and land use influence urban resilience: areas with dense and diverse social and commercial services are more resilient to unexpected social and economic events (Box 3).

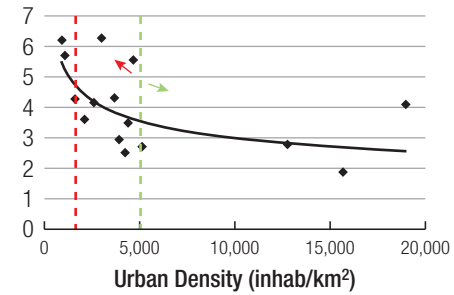
Diversified small block urban areas are more adaptive to economic changes than large block mono-functional urban areas (Box 4).

Figure 4 | Densification Increases Efficiency and Lowers Carbon Emissions and Infrastructure Costs

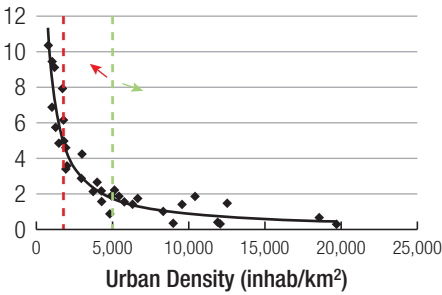
**Carbon Emissions for Transport (tCO<sub>2</sub>/cap)**



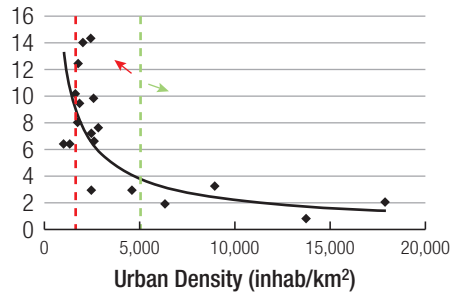
**Water Network (m/cap)**



**Road Network (m/cap)**



**Waste Water Network (m/cap)**



*Note* | Impact of urban density on carbon emissions for transport and infrastructures: road, water, and wastewater network lengths (various cities in developing and developed countries). The business-as-usual urbanization scenario corresponds to the red arrow and would lead growing cities toward automobile dependency and high energy consumption per capita for transport, as well as higher infrastructure costs per capita. The green dotted line represents the current situation in Chinese cities, with an average density around 5,000 people/km<sup>2</sup>. The red dotted line corresponds to the average gross density of new urban developments in China, with a density below 2,500 people/km<sup>2</sup>. Moving in the direction of the green arrow would promote sustainability.

*Source* | Salat and Bourdic 2013; Müller et al. 2013.

### Box 3 | Social Infrastructure and Urban Resilience

In Chicago, a heatwave in July 1995 had opposite effects in two adjacent communities comparable from a socioeconomic point of view. Forty-one per 100,000 people died in the first community; only 4 per 100,000 people died in the second. Klinenberg (2004) argues that this difference was due to the differing levels of social infrastructure of the two neighborhoods. The former had many empty lots, little street life, few shops or markets, and a great deal of violent crime which made many people afraid to leave their homes. The latter, by contrast, was bustling with commercial activity on busy streets. Only a few lots were empty and local churches offered a variety of social activities for seniors.

*Source* | Authors.

#### **Box 4 | Land Use Flexibility in Manhattan, NY**

Manhattan has a fine-grain urban fabric, consisting of small street blocks with buildings aligned on the street side. This urban design feature has made Manhattan's buildings highly adaptive and flexible. According to economic circumstances, floor areas are easily changed from industrial to commercial, from offices to housing, etc. This high flexibility provides Manhattan with a very high resilience in times of change. This is to be compared with large mono-functional urban blocks such as slabs or towers that are less flexible in use.

*Source | Salat 2011.*





# WAYS TO PROMOTE ENERGY EFFICIENT URBAN FORMS

To develop energy efficient urban forms, stakeholders must integrate spatial planning and all essential urban infrastructures policies from the metropolitan level down to the neighborhood scale. Decision-making for urban planning could benefit from comparisons with international benchmarks of best practices. Implementing these key principles will foster sustainable urban growth:

## IMPLEMENT COMPACT URBAN GROWTH POLICIES AND REGULATIONS

Urban development should seek a compact footprint through preservation of open space, reuse and infill of existing areas, and dense expansion of new growth. A variety of regulatory and incentive-based tools that promote compact urban growth are available and include:

- Right of ways for roads, transit corridors, drainage and water supply, etc., as well as strategic green space, agriculture land, and other environmental assets carefully designated, protected, and enforced;
- Establishment of a redevelopment authority to convert brownfields and distressed urban districts and guide densification of existing areas, with the power to underwrite the cost of land development through such value capture mechanisms as tax-increment financing, increase of FAR, and assistance with land assemblage/acquisition through eminent domain powers (Box 5);
- Land consolidation and readjustment schemes to assemble land and finance local infrastructure improvements;
- Process-related tools, such as streamlining development reviews and fast-tracking projects permits;
- Urban planning and street design guidelines<sup>4</sup> that illustrate how to incorporate energy efficiency and livability principles; and
- Travel demand management such as regulating parking and imposing road-use charges to limit the use of vehicles.

Some of these implementation tools often require the passage of enabling legislation by higher levels of government before introduction by local authorities (Suzuki 2013).

## DEVELOP DENSE AND INTERCONNECTED NETWORKS OF STREETS

The street network should include a variety of street types based on adjacent land uses and street characteristics. A balanced street network should include:

- A human-scale, highly walkable, dense, fine-grain, and connected network of streets that makes walking access, and not speed of travel, a priority
- A network of wider streets that rapidly connects distant parts of the city and neighboring jurisdictions, while making good use of public transportation systems (i.e., tramway, BRT)

## Box 5 | FAR Increase, Revenues Extraction, and Value Capture in India

Extra revenues may be generated through development fees, up to 40 to 50 percent of the property prices. In Mumbai, an increase in FAR from 1.3 to 4 in key places would provide local authorities 45,000 to 55,000 Rupees per m<sup>2</sup> to be reinvested into urban infrastructures.

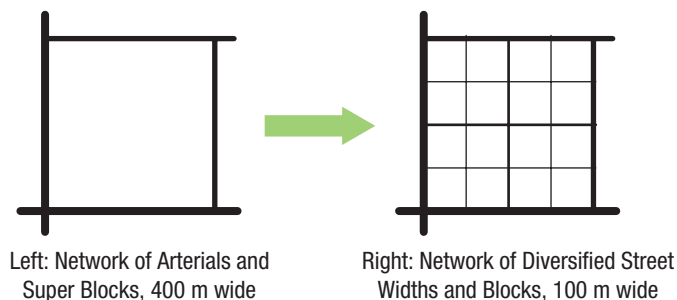
Source | McKinsey Institute 2010.

- Permeable blocks with an average block length limit of 150 m in new developments and public paths created through existing superblocks (Figure 5)
- Networks of bicycle lanes and pedestrian paths
- Secure bike parking in buildings, on streets, and at transit stations
- Auto-free streets and greenways to encourage non-motorized travel

## INTEGRATE SPATIAL, TRANSPORTATION, AND INFRASTRUCTURE PLANS

Integrating urban infrastructures with the built environment has been increasingly recognized as a means of enhancing cities' economic competitiveness, improving environment and energy efficiency, and increasing social equity. Public transport hubs benefit from capturing the peaks of urban density, services, and amenities. An appropriate matching of urban density and infrastructures is fundamental if urban density is not to overwhelm infrastructure and result in congestion. Guided by a long-term vision that emphasizes transit-oriented development principles, Curitiba, Brazil, strategically built new developments along its Bus Rapid Transit (BRT) corridors, and today the city has lower greenhouse gas emission levels, less traffic congestion, and more livable urban spaces compared with other similar Brazilian cities. By contrast, Bogota, Colombia, and Ahmedabad, India, focus their BRT planning on mobility and—with the existence of restricted regulations and the absence of pro-active planning—urban growth patterns have been largely shaped by market forces. Both cities have missed an opportunity to align urban development with transit capacity (Suzuki 2013; see Boxes 6 and 7).

Figure 5 | Comparison of Street Networks

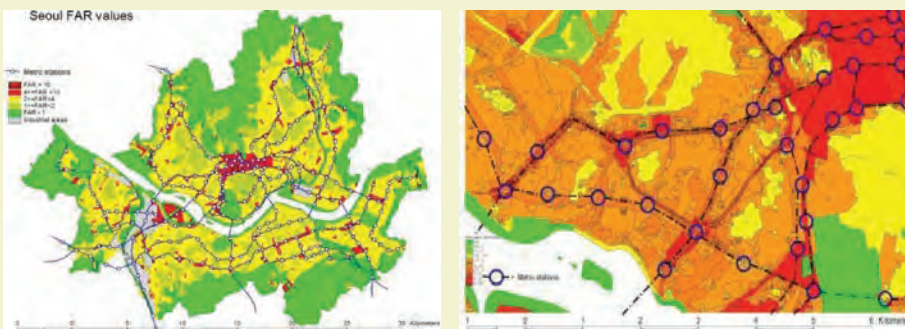


Source | Authors.

## Box 6 | Seoul FAR Strategy: Differentiation and Higher Densities around Metro Nodes

Seoul's spatial structure is compact (the city's expansion is restricted by hills and by the border to the north), and polycentric, with a large central business district (CBD) but many important subcenters. A grid-like metro system links the various sub-centers and the CBD. The FAR in Seoul is linked to the location of metro stations and to the network of main streets:

- 10 in part of the CBD, 8 in the rest of the CBD and sub-centers
- 0.5 to 4 in residential areas
- FAR are higher in areas around main metro nodes



Source | Bertaud and UNEP 2008.

## ENSURE ACCESSIBLE GREEN SPACES

Green spaces are an essential feature of energy efficient and livable cities. However, many urban policies concerning green spaces in emerging countries' cities boil down to a predetermined percentage of green space. What really matters is access and proximity of green spaces with diversified social activities instead of proportion only (see Box 8).

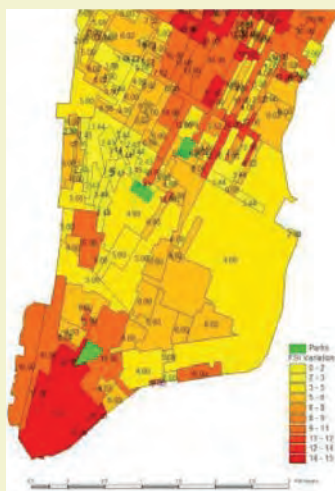
## DEVELOP SMALL BLOCKS WITH DIVERSIFIED USES

Except for rare and justified situations (i.e., large infrastructures, key urban amenities), cities should avoid the super block approach to land division. Rather, cities should further develop the fine grain of small urban blocks (i.e., 1 ha) by dividing a block into a few dozen urban plots with diversified uses. Buildings with public uses and shops should line the ground floor of most street fronts within easy walking distance of housing and jobs. The human-scale fine mesh of narrow streets creates an urban fabric that is mostly constituted of small urban blocks, normally less than 120 m wide. The alignment of buildings along streets, also called perimeter development, creates various street fronts and engaging sidewalks that promote walking (Box 9).

Examples of good urban planning come from 19th century Europe and modern day Manhattan. Statutory urban planning in 19th century European cities made alignment of buildings along streets mandatory and prescribed regulations for continuous building heights, including the architectural detailing of façades to maintain the rhythm and character of the

## Box 7 | FAR and Urban Infrastructure in Manhattan and Mumbai

Manhattan's density zones are typically small and vary with street width, infrastructure capacity, and land use (commercial office districts have higher FAR than residential ones). In contrast, Mumbai's density zones are large, uniform across the city, and generally low. Local urban planners justify such low densities for not overwhelming infrastructure. Rather than increasing densities, new urban developments have been pushed out to new towns and suburban industrial estates. But this strategy ignores the opportunity to increase FAR to finance better and higher capacity infrastructures (World Bank 2013a).



Left: South-side of Manhattan



Right: Mumbai

Source | World Bank 2013b.

street front. Setbacks were limited. In Manhattan, plot subdivision schemes differentiated between plot sizes, fostering commercial development along the North-South avenues and residential development along the East-West streets within the same urban blocks.

Setback rules are mostly inherited from the modernist period in Western countries. Their intention is to avoid the alignment of buildings on the street, following a doctrine of the street being a conveyor for traffic only and not a place for people. The large setbacks have since been called into question and are often reassessed in Western countries. They should be reassessed in developing countries as well, as their impact on urban land use is often negative (Box 10).

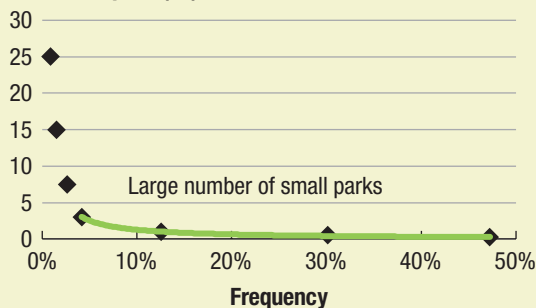
Authorities should consider:

- Prescribing FAR and building heights according to street width; and
- Adding a conforming line ratio in the regulatory framework. The conforming line imposes a minimal proportion of buildings to be aligned on a street front. The conforming line ratio can be modulated according to the type of building (i.e., more than 60 percent for residential buildings, more than 70 percent for commercial and office buildings; see Figure 6 and Box 11).

## Box 8 | Green Space Distribution: Comparing Paris and Beijing

The spatial distribution of green spaces in Paris results from policies and regulations that have ensured that every citizen lives less than 400 m from a public park, square, or garden. This target has been reached whereas green spaces only represent 5 percent of the urban area. There are a few large parks that allow a wide range of activities for residents, and a large number of very successful pocket parks for daily family activities and intergenerational mix (300 green spaces less than ½ ha). This long tail distribution of parks follows a Pareto distribution (Schattner, Bourdic, and Salat 2012), which is an important tool for optimization in economy and urban planning. As a comparison, green spaces in Beijing represent 30 percent of the urban area. Most of the green spaces are very big parks, and the long tail of small parks is lacking. As a result, residents live more than 3 km away from public parks on average.

### Size of the park (ha)



Left: Long tail distribution of parks in Paris, with the long tail of small parks in green.

Right: Numerous small parks in Paris ensure 5 minute walk accessibility to parks (red) to 80% of the people.

Source | Schattner, Bourdic, and Salat 2012.

## Box 9 | Typical Block Sizes across Europe, US, and Asia

The average size of urban blocks varies significantly across cities. The typical urban block size in Japanese cities (e.g., Tokyo or Kyoto) is 50 m in width. It is between 70 and 100 m in European historical cores such as Vienna or Paris. It is 100 to 120 m in nineteenth-century planned cities such as Washington D.C., New York, or Barcelona. This is the appropriate scale for a walkable, active, and livable urban space. In suburban residential sprawled areas, as well as in many recent high-rise urban developments, the size of an urban block is 200 to 300 m, sometimes up to 500 m. This oversizing of blocks discourages walking and generates car dependency.

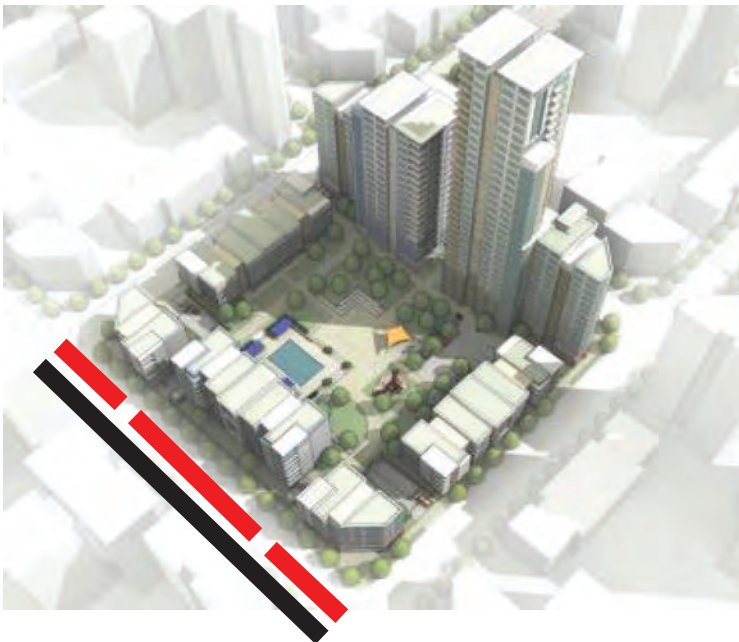
Source | Authors.

### Box 10 | Setback Rules in China

The setback regulations in China are variable. In extreme cases, the built front is set back 100 to 150 m from an already oversized road width. This results in distances 300 to 450 m between buildings on opposite sides of the road. This type of road, with high-speed traffic, cannot be crossed on foot. It is not designed on a human scale for pedestrians. Too large setbacks prevent reducing the size of the urban block: if the urban block was smaller than 400 m, after deduction of the setbacks, there would be very little land left for the building footprint.

*Source | Authors.*

Figure 6 | A Conforming Line Ratio Promotes Development along the Street



In this example, 80% of the buildings (red line) are aligned on the street (black line).

*Source | Energy Foundation 2012.*

### Box 11 | Alignment on the Street, FAR, and Street Width in Paris

In Paris, the *Plan local d'urbanisme* prescribes building heights according to street width and the districts. The height of the façade is comprised between  $W+2$  m and  $W+3$  m with  $W$  equalling the street width. The height of the building under eaves must be comprised between  $W+6$  m and  $W+8$  m. A maximal height is also given according to the district: 25 m in central districts and 31 m in peripheral districts. Alignment on the street is compulsory.

*Source | Authors.*

## ESTABLISH MIXED-USE DEVELOPMENTS

Functional mixed-use planning should be applied from the district scale down to the building scale. An engaging district or neighborhood rests upon a balanced mix of housing buildings, office buildings, shops, and urban amenities. Compared to mono-functional districts and neighborhoods, mixed-use developments reduce the demand for motorized travel, shorten average travel distances both for commuting and personal trips, and promote walking and other non-motorized travel. At the block and building scale, mixed use consists of developing small-scale business spaces for offices, workshops, and studios on the ground floor of apartment blocks and home-working premises. This option increases an area's vitality and makes the urban environment more attractive (North Shore City 2005; see Figure 7).

A successful mixed-use development has:

- A fine grain texture of plot subdivisions, buildings, and groups of buildings that have adaptive qualities and may accommodate changes of functions (i.e., be easily changed from offices to housing and *vice versa*)
- A continuous landscaped public space inside and outside the block system that does not lock landscaping into privatized blocks
- A parcel code for mixed-use control to be included in the regulations that imposes the ratio of office, commercial, and residential floors down to the building scale

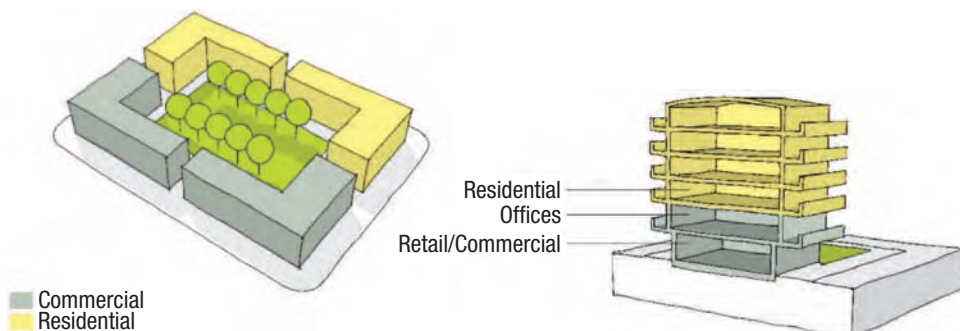
## DESIGN STREETS FOR PEOPLE, NOT FOR CARS

Good urban forms have a safe, connected, dense, and continuous pedestrian network. The quality of a street is enhanced by sidewalks or footpaths, traffic calming measures, proper lighting, and outdoor activities such as cafés, shops, and restaurants (City of Melbourne et al. 2004). This is facilitated by the development of the block along the streets and by limiting building setbacks.

Good street design should incorporate these guidelines (Energy Foundation et al. 2012):

- Streets and other public space, such as roadways, sidewalks, bicycle lanes, intersections, and uses along the curb, should be designed to balance the needs of all users, including pedestrians and bicyclists.

Figure 7 | Mixed Use on the Block and Building Scale



Source | North Shore City 2005.

- Public space of streets should be continuous with unlimited access to all types of streets, and include space for various activities such as public squares and rest areas.
- Buildings with public uses and shops should front the sidewalk and residential developments should have multiple access points to encourage sidewalk activity, visibility, and safety.
- The distance between buildings and the sidewalk should be limited.
- Traffic speeds should be limited on local streets.
- Streets should have traffic-calming features to help enforce speed limits.
- Street crossings should be shortened and pedestrian safety and convenience emphasized.

## MAXIMIZE THE POTENTIAL OF BIOCLIMATIC DESIGNS

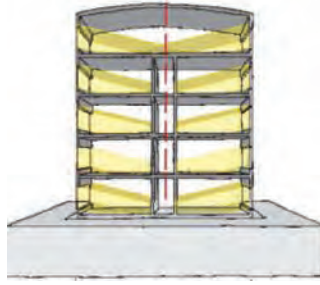
Bioclimatic design discovers and enhances the natural potential of a site, including solar light and heat, wind, and temperature changes. Bioclimatic urban design should be based on small block compositions adapted to local climate with shallow buildings and intermediate spaces to ensure natural ventilation and natural lighting, as well as solar heat gains in winter in cold climates.

Since most future urbanization will take place in subtropical climates, control of heat gains is the starting point for energy efficiency. Measures to control heat transfers between a building's interior and the environment include:

- Designing with the different vernacular types of urban fabric that have developed locally
- Establishing cooling as the dominant condition to be taken into account for energy efficiency
- Cooling intermediary spaces between indoors and outdoors by passive techniques so that these spaces can serve as buffer zones and comfortable semi-outdoor spaces for different activities
- Ensuring that building designs are permeable, combining open plans and sections for cross-ventilation, stack-ventilation, or both
- Adapting the depth, form, and orientation of buildings to local climate requirements and incorporating passive strategies such as natural thermal solar gains, passive lighting, and passive cooling and ventilation (some studies recommend building depths of 10 to 14 m to use the full bioclimatic potential; see Figure 8)
- Planning dense built-up areas while allowing a high level of sun penetration on the façades and in the cores of buildings using innovative techniques such as climatic envelopes (DeKay 2012, 619–630; see Figure 9)
- Shaping tall buildings in relationship to other buildings and to the wind to create favorable street and open-space microclimates.

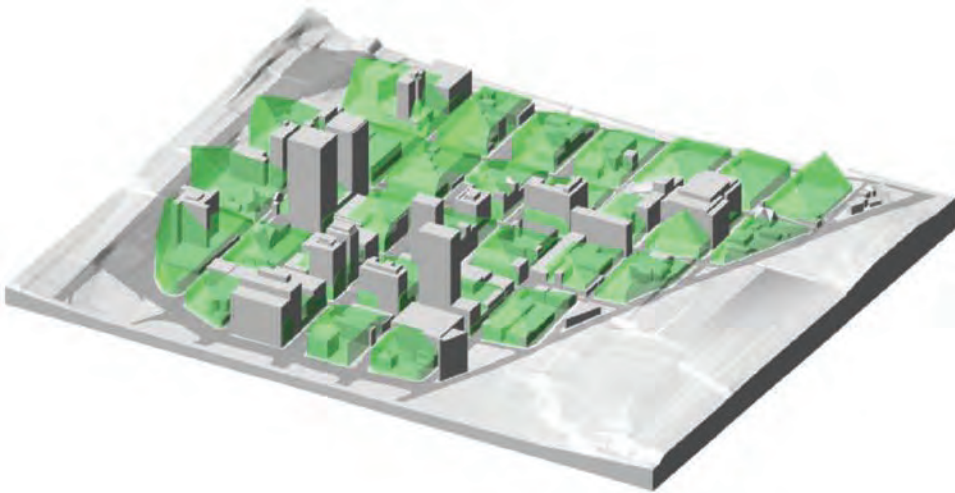


Figure 8 | Buildings 10–14 m Deep Offer Optimal Bioclimatism



Source | North Shore City 2005.

Figure 9 | Example of Bioclimate Retrofit



Composite climatic envelopes in Chattanooga, USA, overlaid on existing building volumes, view from southeast and section looking north.

Source | DeKay 2012.

## CONCLUSIONS

This note advises city leaders on how to manage the growth and transformation of urban forms toward an energy efficient and livable path through supportive planning policies, zoning regulations, and design guidelines.

As examples in this note show, there are proven economic, social, and environmental co-benefits of energy efficient and livable urban forms. Achieving these outcomes requires concerted efforts by city, regional, and national governments in setting a forward-looking strategic vision, creating an enabling institutional and regulatory framework, exploiting the right mix of regulatory and incentive based tools, and pursuing sustainable infrastructure financing. City governments have great leverage in shaping the physical form of cities as they are often responsible for preparing and implementing urban plans, and enacting and/or enforcing laws and regulations to guide urban land development. However, it

is important to ensure that decisions related to urban development are made through a participatory, collaborative, and transparent process, with close coordination between various horizontal and vertical government units, as well as collaboration with various stakeholders, including developers and citizens.

The impact of good spatial planning is enduring, and is achievable for many of the developing cities adapting from international experiences. The example from Curitiba, Brazil, a widely recognized sustainable city, shows that consistent efforts led by strong leadership, capable institutions, and innovative approaches have generated tremendous results with very limited budgetary resources (Box 12).

### **Box 12 | Curitiba, Brazil: A Sustainable City**

The city of Curitiba, Brazil, successfully achieved a sustainable urban form through transit-oriented development. Curitiba first outlined its Master Plan in 1965, aiming to limit the growth of the city center and encourage commercial and service sector development along transportation arteries. The Master Plan also included strategies for economic development and local community self-sufficiency with livable city spaces. The city is public transport oriented and its BRT system carries 50 times more passengers than it did 20 years ago. Additionally, Curitiba's gasoline use per capita is 30 percent below that of 8 comparable Brazilian cities. It also has lower greenhouse gas emission levels, less traffic congestion, and more livable urban spaces. Particularly noteworthy is that Curitiba adopted an incremental approach to development, whereby the city procured the basic rights of way for critical transport infrastructure systems, but developed the infrastructure when demand justified supply.

*Source | Suzuki et al. 2009.*

## ENDNOTES

- <sup>1</sup> Urban form refers to the spatial extension, physical layout, and design of a metropolitan area, city, or town.
- <sup>2</sup> Floor area ratio is often used as a proxy for population and jobs densities.
- <sup>3</sup> Hydrography is fundamental in delta regions, such as Hanoi in Vietnam. Most of the pre-existing lakes have been filled through the urbanization process; maintaining them is necessary to prevent flooding. These lakes could have participated in the natural cooling of the city. Climate and topography are crucial in cities like Mexico City, where the basin traps air pollution during heat waves. Density thresholds have to be moderated, taking into account these characteristics.
- <sup>4</sup> Examples of specific guidance for creating livable streets and urban environments through plans and regulations can be found at: [www.bostoncompletestreets.org](http://www.bostoncompletestreets.org) or [www.nyc.gov/html/planyc2030/html/theplan/the-plan.shtml](http://www.nyc.gov/html/planyc2030/html/theplan/the-plan.shtml).

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## ACRONYMS AND ABBREVIATIONS

BRT	Bus rapid transit
CBD	Central business district
FAR	Floor Area Ratio
ha	hectare
km	kilometer
US / USA	United States of America

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- 3 | *Improving Energy Efficiency in Buildings*, by Feng Liu
- 4 | *Toward Sustainable and Energy Efficient Urban Transport*, by Om Prakash Agarwal
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