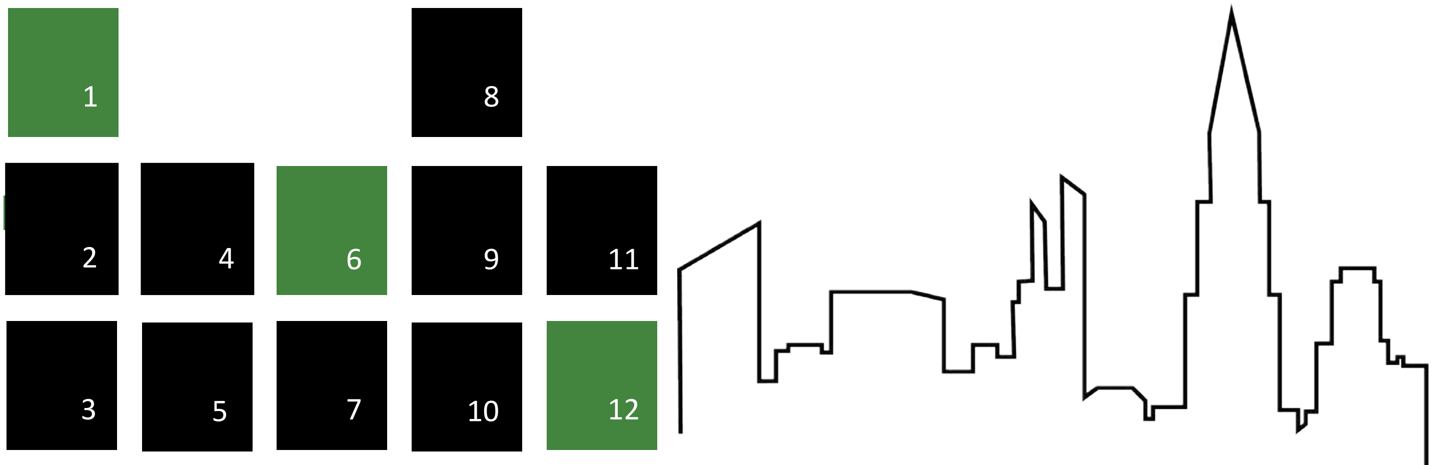

12 GREEN GUIDELINES

CDBC’S GREEN AND SMART URBAN DEVELOPMENT GUIDELINES

OCTOBER 2015
DRAFT FOR COMMENT

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Our mission is to assist in China's transition to a sustainable energy future by promoting energy efficiency and renewable energy. We support policy research, standard development, capacity building, and best practices dissemination in the eight sectors of buildings, electric utilities, environmental management, industry, low-carbon development, renewable energy, sustainable cities and transportation.

12 GREEN GUIDELINES
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FOREWORD

At the United Nations General Assembly session in September 2015, President Xi Jinping committed China to being a global leader in tackling climate change. Green, low-carbon, and smart new-type urban development will play an important role in alleviating climate change. This development strategy has also been the core objective of China Development Bank Capital's (CDBC) efforts towards new-type urbanization in the past few years.

As urban development practices have evolved, we profoundly feel that the ideals behind green and smart development have already become common belief. Everyone wants to realize these ideals, but there is still the question of how it can be done. Not only are there no successful case studies in China, there are few internationally, and many of these experiences have been limited and dispersed in scope. We need to integrate existing domestic and international experience with the conditions of China's new-type urban development to create a comprehensive and working model. Only then can we rapidly expand this model and achieve significant progress.

Hence, two years ago, CDBC's International Advisory Group for Green and Smart Urbanization began work on *CDBC's Green and Smart Urban Development Guidelines* with the intent to create a benchmark for green and smart urban development to be used in China and internationally. In these two years, we have gathered input from over a hundred urban planners, mayors, developers, experts, and other industry players. We also surveyed international best practices in the context of China's unique economic, environmental, and social conditions. With this foundation, we created the *12 Green Guidelines* and the *Six Smart Guidelines*. We were careful not to create a long list of desirable options, but instead focused on the most critical and foundational design elements of green, smart, livable, and economically successful urban development. The design elements featured in the *Green and Smart Urban Development Guidelines* are already in practice in a number of cities in both developed and developing countries. A well-designed city can reduce congestion, improve air quality, reduce noise pollution, and decrease energy use. It can create enjoyable spaces for everyone, from children to the elderly, and increases options for daily life. It makes neighborhoods more attractive and livable, and creates cities with more vitality and economic prosperity.

These guidelines include two case studies, one on the Pearl District and Brewery Blocks in Portland, Oregon and the other on Hammarby Sjöstad in Stockholm, Sweden. These two cases show that our guidelines can achieve both economic and environmental benefits. The case studies detail the process to success, including the regulatory, financing, and technical mechanisms that were part of each urban area's development strategy.

12 GREEN GUIDELINES

The *12 Green Guidelines* fall into three key categories: urban form, transportation, and energy and resources. These guidelines are measurable and practical, and they concisely describe the foundations of sustainable urban development:

Urban Form: Urban Growth Boundary, Transit-Oriented Development, Mixed-Use, Small Blocks, Public Green Space
Transportation: Non-motorized Transit, Public Transit, Car Control
Energy and Resources: Green Buildings, Renewable and Distributed Energy, Waste Management, Water Efficiency

SIX SMART GUIDELINES

The *Six Smart Guidelines* are designed to optimize the *12 Green Guidelines.* "Smart" provides for more optimal ways to achieve green results. When done in addition to the *12 Green Guidelines*, smart technologies can capture additional economic, environmental, and social benefits. The *Smart Guidelines* fall into six key categories:

Smart Telecommunications
Smart Mobility
Smart Energy Management
Smart Governance
Smart Public Services
Smart Safety

The *Six Smart Guidelines* emphasize the importance data analysis and optimization. We focus on case studies with returns on investment to demonstrate the application of these smart technologies.

As our time and experience is limited, this edition of *CDBC's Green and Smart Urban Development Guidelines* is still in development. Particularly as global green and smart practices evolve, these guidelines will need to be added to and improved on. CDBC is an important player in China's urbanization, and we hope to collaborate with other players in China and internationally to put these guidelines into practice and advance, for the long-term, the sustainable urban development of China. Moreover, we hope that Chinese and international partners will continue to introduce us to global best practices and potential collaborators. We hope to expand the perspective of Chinese urban developers and involve world-class international developers in China's urbanization process to create opportunities and achieve mutual benefits.

Zuo Kun
Vice-President, China Development Bank Capital
October 2015

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THE 12 GREEN GUIDELINES

URBAN FORM

1. URBAN GROWTH BOUNDARY

Every city should establish an enforced urban growth boundary (UGB). The UGB should be set based upon a rigorous analysis of ecological sensitivities, environmental capacity, and the efficiency and productivities of various land uses. The boundary can expand beyond the existing urban footprint only if there are no suitable infill locations as indicated by an intensity of urban land use of at least 10,000 residents per square kilometer.

URBAN FORM

2. TRANSIT-ORIENTED DEVELOPMENT

Cities should be built around their public transit systems. The area within 500-800 meters of major transit stations, such as the metro or bus rapid transit (BRT), or within 500 meters of nearest bus or transit stops (in case BRT or Metro is not available) should have FAR at least 50% higher than the average of the district. For big cities, at least 70% of residents should live in TOD areas characterized by convenient mass transit service. Great accessibility (pleasant walking amenities to transit system within a 500-meter radius) must also be offered.

URBAN FORM

3. MIXED USE

All residential units should be close to at least six kinds of amenities within 500-meter radius of building entrance (amenities include schools, post offices, banks, retails, clinics, activity centers, restaurants, etc.). The job-resident ratio (the number of people employed divided by the number of residents) should be between 0.5 and 0.7 over every commuting district, which should have a spatial area that is no more than 15 km2. Normally, these commuting districts are bounded by physical barriers for pedestrians.

URBAN FORM

4. SMALL BLOCKS

Blocks should be less than or equal to 2 hectares and 70% of the blocks should comply with this standard. Exceptions made for industrial areas.

URBAN FORM

5. PUBLIC GREEN SPACE

Publicly accessible and usable green space should comprise 20-40% of the construction areas (residential area should be at the higher end of this range). All residences should have accessible public space within 500 meters.

TRANSPORTATION

6. NON-MOTORIZED TRANSIT

There should be dedicated and connected walking paths of at least 10 km in length per square kilometer, and dedicated and connected biking paths of least 10 km in length per square kilometer in urban areas.

After a review of over a dozen of the most important indicator systems, we found that a simple but high-quality recipe with quantitative benchmarks for urban development does not currently exist. These 12 Guidelines will be the guiding principles for the Green & Smart Urban Development Guidelines. They are the most important aspects to ensure that a city is happy, healthy, and prosperous.

TRANSPORTATION

7. PUBLIC TRANSIT

All new developments must be within a 500-meter radius of a bus or rapid transit station. For the city as a whole, at least 90% of developments should be within 800-meter radius of a public transit station.

TRANSPORTATION

8. CAR CONTROL

Every city should have a strategy to cap car use. Where high-quality transit exists, there should be limits on parking.

ENERGY & RESOURCES

9. GREEN BUILDINGS

At least 70% of buildings should be MOHURD One-Star, 20-40% of buildings should be MOHURD Two-Star, and 5-15% of buildings should be MOHURD Three-Star within any development.

ENERGY & RESOURCES

10. RENEWABLE AND DISTRICT ENERGY

Every project should analyze the potential for district energy, such as combined heat and power (CHP), waste to energy, and waste heat re-use. There should be 5-15% local renewable energy generation for residential areas and 2-5% for commercial areas.

ENERGY & RESOURCES

11. WASTE MANAGEMENT

All buildings should have waste classification facilities. All household waste must be sorted and collection of hazardous waste must be prioritized. At least 30-50% of waste should be composted and 35-50% recycled or re-used.

ENERGY & RESOURCES

12. WATER EFFICIENCY

All buildings must have 100% adoption of cost-effective water saving appliances, and green spaces surrounding buildings must adopt low water-use plants. All water consumption should be metered and at least 20-30% of water supply must be recycled from either wastewater or rainwater.

INTRODUCTION

A SMARTER URBAN PARADIGM

What makes a city great? These guidelines show that there are a few key characteristics that make the difference. Building attractive public spaces, investing in low-carbon technologies, properly mixing uses, and offering a rich variety of mobility options will deliver a world-class city. Getting these core features wrong will condemn a city to traffic, pollution, and a lower quality of life.

These guidelines can help mayors, urban investors, and developers build prosperous and sustainable cities. These guidelines are aimed at the planning stage, where the greatest opportunities lie.

PURPOSE

Many of China's biggest challenges–pollution, congestion, livability, and climate change—can be alleviated with better urban planning. These strategies also yield impressive economic benefits. According to the World Bank, a reform scenario that involves "green and smart" strategies would only cost the Chinese government 6.8% of GDP, as opposed to the baseline scenario that would cost 8.6% of GDP.

The hallmarks of a green and smart city include cleaner air, less congestion, greater efficiency, and the intelligent use of technology to optimize complex urban systems. The same strategies can make a city more people-friendly, livable, and attractive. Research shows that green and smart cities offer a better quality of life and produce a more innovative, dynamic economy. For developers, green projects offer opportunities to distinguish their brand and earn higher profits.

These guidelines lay out a dozen key guidelines for achieving these goals. They are a departure from some current trends in China, but the guidelines are proven internationally and in many Chinese developments.

These guidelines should be used by municipal governments and developers at the very beginning stages of selecting and designing urban projects. They are comprehensive in that they cover the major aspects of urban development at the neighborhood or district level, including urban form, transportation, buildings, energy, waste, and water.

THE GUIDELINES

In the process of developing these guidelines, we reviewed more than a dozen other benchmark and indicator systems to determine what already exists, what contains loopholes, and what is missing. Our conclusion: a simple but high-quality recipe with quantitative benchmarks for urban development does not currently exist.

Our 12 Guidelines for Green and Smart Urban Development aim to cover all of the critical aspects of urban development and fall into three categories: urban form, transportation, and energy and resources. The goal of our work is ambitious: we hope mayors, urban planners, and developers will consider these the “default,” that is, these should become the new normal practice. We understand there might be circumstances in which one or more of these guidelines may need to be altered, but such circumstances must be justified and explained.

For each of our 12 Green Guidelines, we use three principles as criteria for inclusion:

1） BENEFICIAL: This is the most important principle: there must be direct economic, environmental, and social benefits compared to business-as-usual practices.

2） MEASURABLE: The second principle is that the indicator must be quantitatively defined and be measurable. This allows one to easily discern whether a project meets the indicator, and reduces the threat of “greenwashing” and gaming the system.

3） PRACTICAL: Third, we look at existing standards and projects in China to determine feasibility. The benchmarks are ambitious but feasible. We trust that China’s impressive speed of learning means that this approach can become the new normal.

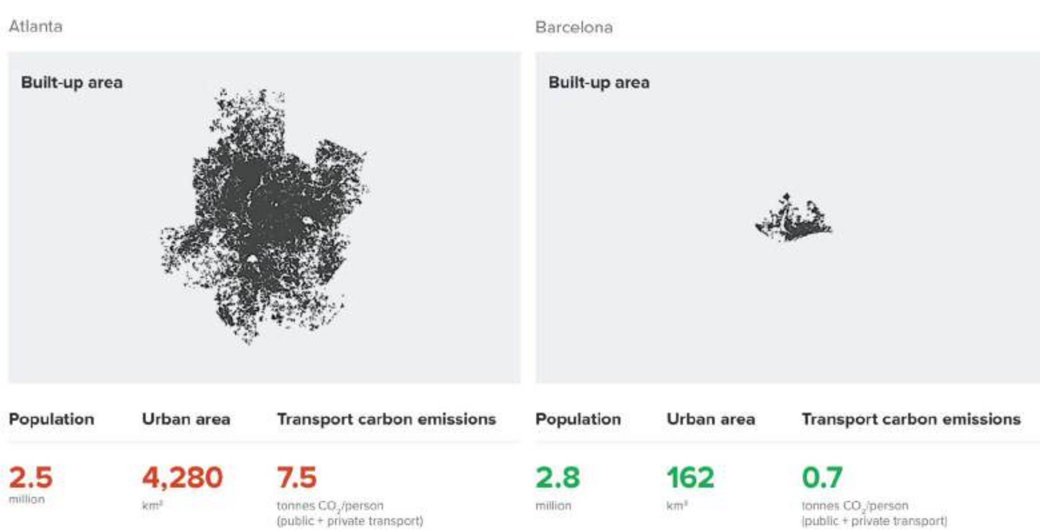
In this document, we define each quantified guideline with a rationale, explain the key economic, environmental, and social benefits, provide a brief case study, and also list the key best practices for optimal implementation.

1 URBAN GROWTH BOUNDARY

Every city should establish an enforced urban growth boundary (UGB). The UGB should be set based upon a rigorous analysis of ecological sensitivities, environmental capacity, and the efficiency and productivities of various land uses. The boundary can expand beyond the existing urban footprint only if there are no suitable infill locations as indicated by an intensity of urban land use of at least 10,000 residents per square kilometer.

RATIONALE

UGB's are a tool to achieve compact development, which helps to create the enabling conditions for shorter commutes, and greater use of transit, walking, and biking. UGBs prevent sprawl, protect agricultural land, reduce traffic problems, and decrease air pollution. Compact development increases the efficiency of public infrastructure. This strategy can also increase the value of the built environment. Housing cost increases can also be offset by reduced transportation costs.



Urban sprawl is a serious issue in Atlanta – leading to higher carbon emissions per capita. Atlanta's sprawl and lack of comprehensive transit coverage mean that most of its residents depend on their cars for most of their transportation needs. In contrast, Barcelona contains the same population but has 1/10 of the carbon emissions (Source: The New Climate Economy).

This photo shows an edge of Portland's urban growth boundary along the Clackamas River.

BENEFITS

ECONOMIC

AVOIDS THE HIDDEN COSTS OF SPRAWL: Low-density development patterns cost the U.S. economy $1 trillion annually due to lost productivity and worsened health, especially from increased rates of obesity (Litman 2015).

REDUCED INFRASTRUCTURE COSTS: By concentrating development, governments can more efficiently provide public infrastructure (Burchell 2000). In contrast, sprawl means lower rates of utilization and higher per capita costs.

IMPROVED LAND-USE EFFICIENCY: Compact growth increases property values (Phillip and Goodstein 2000). It also increases the productivity of urban land use as measured in economic output per square kilometer.

LOWER TRANSPORTATION COSTS. While higher property values are good for developers and property owners, higher housing costs do impose challenges for homeowners. With proper transportation policies, compact development can improve overall affordability as measured by housing plus transportation costs (Center for Neighborhood Technology 2010).

ENVIRONMENTAL

PROTECTS NATURAL RESOURCES: Development in and adjacent to developed areas that already have the needed infrastructure that can help prevent sprawl, which will protect natural resources such as wetlands, streams, coastlines, and critical habitat (U.S. EPA 2013)

REDUCES CAR DEPENDENCE AND TRANSPORTATION ENERGY DEMAND: By 2030, urban growth boundaries and other improved urban design features, such as those recommended in these guidelines, can reduce national demand for transportation fuel by 21% (He et al. 2013). For new towns, the potential is greater, with at least 50% savings possible.

CLEANER AIR: Reduced transportation demand in vehicle kilometers traveled has a commensurate reduction in air pollution.

SOCIAL

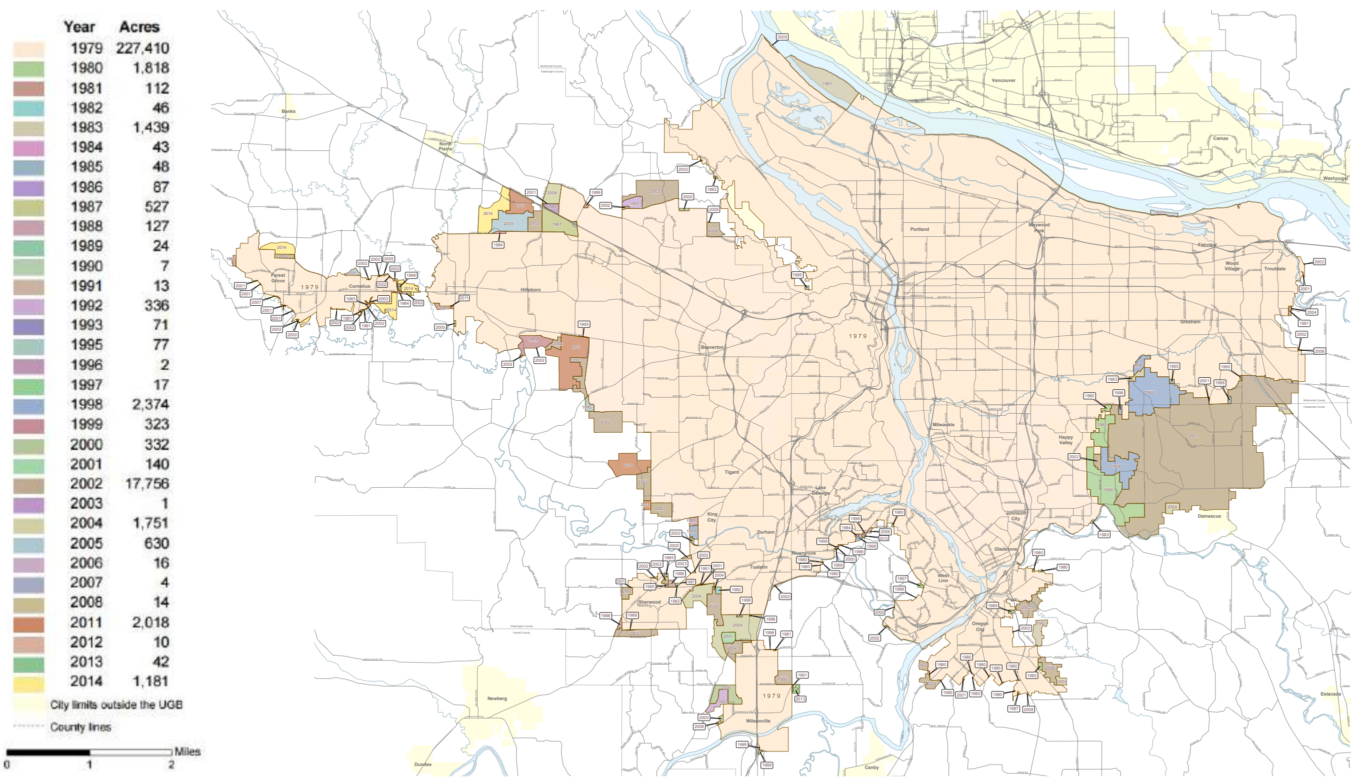
COMMUNITY COHESION: Compact development helps bring people together while sprawl isolates individuals.

MORE EQUITABLE ACCESS TO SERVICES AND JOBS: Compactness not only reduces the distances that must be travelled, but the resulting density supports a great supply and diversity of local goods and services (Kaido and Kwon 2008).

INCLUSIVE ACCESS TO MOBILITY: Lower transportation costs can ease the burden on lower income groups (Haas et al. 2006).

IN PRACTICE: PORTLAND, OREGON

Every city in Oregon must have a UGB. In the largest city, Portland, city authorities consider changes to their UGB every six years based on 20-year forecasts of population and employment and the ecological capacity of land within the existing UGB. Most expansions are small and under 20 acres. The figure below shows the boundary's evolution over time. The initial UGB is shown in the light peach color. Portland has accommodated expected population increases through policy and zoning changes within the existing area. The authorities look to increase the allowed Floor Area Ratios (FAR) of buildings and to increase public transport capacity. If the urban growth report indicates that the existing UGB provides sufficient capacity to accommodate the growth that is forecast over the next 20 years, no UGB expansion is needed. If, after these land efficiency measures are taken, there remains a need for additional capacity, the UGB can be expanded. Newly urbanized land is chosen from among priority areas, defined by their alternate value as agricultural land or protected natural areas, based on an ecological assessment. It should be noted that this is a policy across the state of Oregon, which helps to avoid competition among cities.



History of Urban Growth Boundary in Portland. The numbers to the side show the evolution of the urban growth boundary in Portland over time. (Source: Oregon Metro)

BEST PRACTICES

- **USE A MAP TO CLEARLY ILLUSTRATE THE BOUNDARY:** Portland's UGB offers a good example of how to use a map as a tool to both illustrate and enforce the boundary.

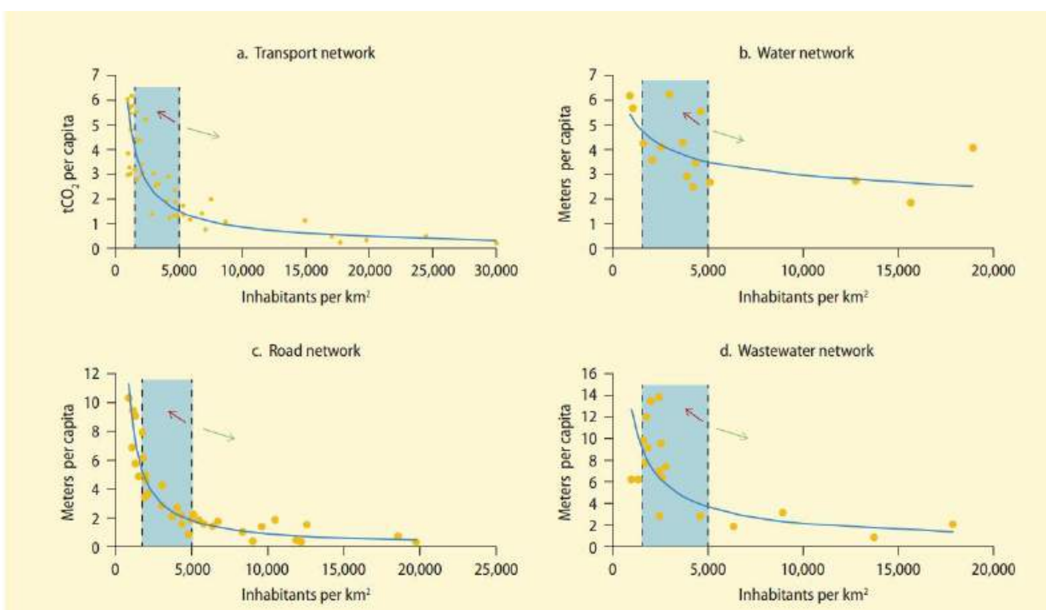
- **ESTABLISH AN ENFORCEMENT MECHANISM:**The local government should establish a strict enforcement mechanism to prevent greenfield development.

- **CREATE INCENTIVES FOR INFILL AND RE-DEVELOPMENT:** The local government should establish incentives for brownfield development through high-density standards, inclusionary zoning, and other smart planning policies.

- **UNDERTAKE AN ECOLOGICAL ASSESSMENT:** The city should identify the most valuable land for agriculture and the most precious ecological, historical, and cultural areas that deserve protection.

- **UPDATE THE BOUNDARY BASED ON ECONOMIC CONDITIONS:** The local government should update the UGB periodically to account for population growth and economic changes, always seeking infill opportunities first. Investment in technical capacity is crucial.

- **ACTIVELY MANAGE COSTS OF COMPACT DEVELOPMENT:** Actively manage the potential costs of more compact development. For example, this can be done by increasing the supply of housing within the boundary that is located near high quality transit.



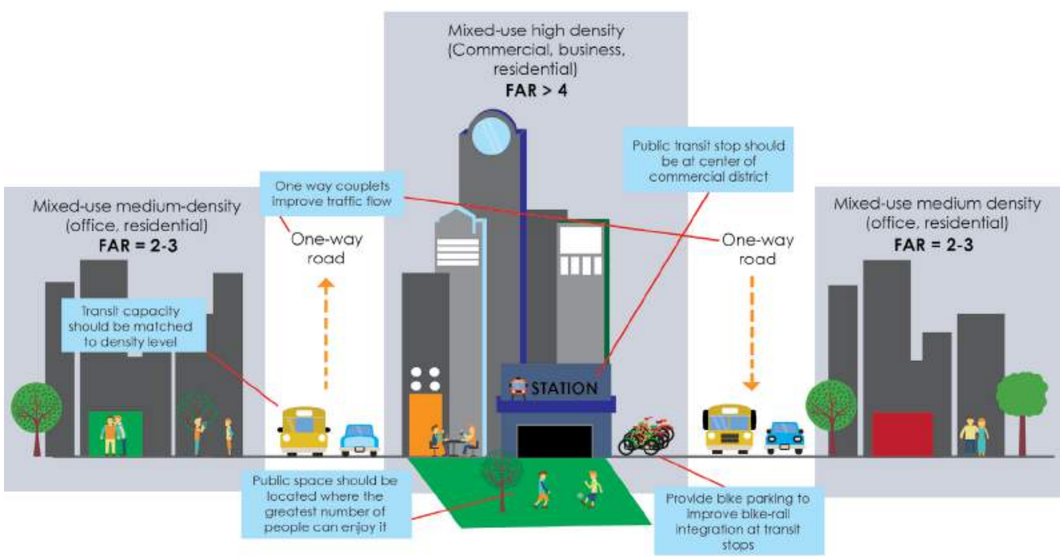
Impact of urban density on carbon emissions, and length of water pipes, roads, and wastewater pipes needed for infrastructure (Source: World Bank).

2 TRANSIT-ORIENTED DEVELOPMENT

Cities should be built around their public transit systems. The area within 500-800 meters of major transit stations, such as the metro or bus rapid transit (BRT), or within 500 meters of major bus corridors (in case BRT or Metro is not available) should have a floor area ratio (FAR) that is at least 50% higher than the average of the district. For big cities, at least 70% of residents should live in TOD districts characterized by convenient mass transit service. Great accessibility (pleasant walking amenities to transit system within 500-meter radius) must also be offered.

RATIONALE

Public transit must be the preferred travel mode for longer distance trips. Increasing the density of people working and living around transit stations is one of the best ways to make public transit more convenient and successful. China's cities are already suffering from traffic congestion problems, which contribute to air pollution. More cars will only decrease mobility by increasing congestion and traffic. Mixing uses (the third benchmark) makes cars less desirable by increasing the availability of goods and services nearby, but some trips will inevitably exceed a comfortable walking or biking range.



This graphic shows the logic behind transit-oriented density. Density should be matched with transit capacity. Public transit stops must be placed in the most convenient locations so that the greatest number of people can access them. The FAR should be highest close to the highest capacity transit stops (Source: Energy Innovation).

Hammarby's transit spine goes through the main areas of the district so that every residence is within walking distance from a transit stop. Density is also concentrated alone the transit lines. The transit spine's ability to link all residences to a major transit source exemplifies transit-oriented development (Source: ITDP).

BENEFITS

ECONOMIC

ESSENTIAL TO SUCCESSFUL MOBILITY: The ability for people and goods to move around is a fundamental requirement for economic growth. TOD is an essential strategy for managing growth efficiently in terms of land, energy, and public funds (Calthorpe and Associates 2012).

TRANSIT ACCESS SPURS PRIVATE INVESTMENT: 67% of major transit investments in North America were followed by investments in new buildings that exceeded the cost of the transit upgrade (ITDP 2014).

BETTER RETURNS ON TRANSIT INVESTMENT: Allocating density around transit stops will increase ridership, thus leading to better return on transit investment (Fehr and Peers 2004).

MORE FLOOR SPACE FOR DEVELOPERS TO SELL: The redesign of Yongxin in Chenggong, Kunming according to TOD principles increased the amount of floor area space by 50% (Energy Foundation and Calthorpe Associates 2011).

ENVIRONMENTAL

DECREASES CARBON EMISSIONS: Residents of transit-oriented developments are two to five times more likely to use public transit than others who live in the same region (U.S. EPA 2013). Transit oriented development also produces less emissions than traditional suburban development (U.S. EPA).

LAND CONSERVATION: Transit-oriented development can re-direct population growth to economically vibrant areas with good transit connections, which conserves land and natural resources (Freemark 2011).

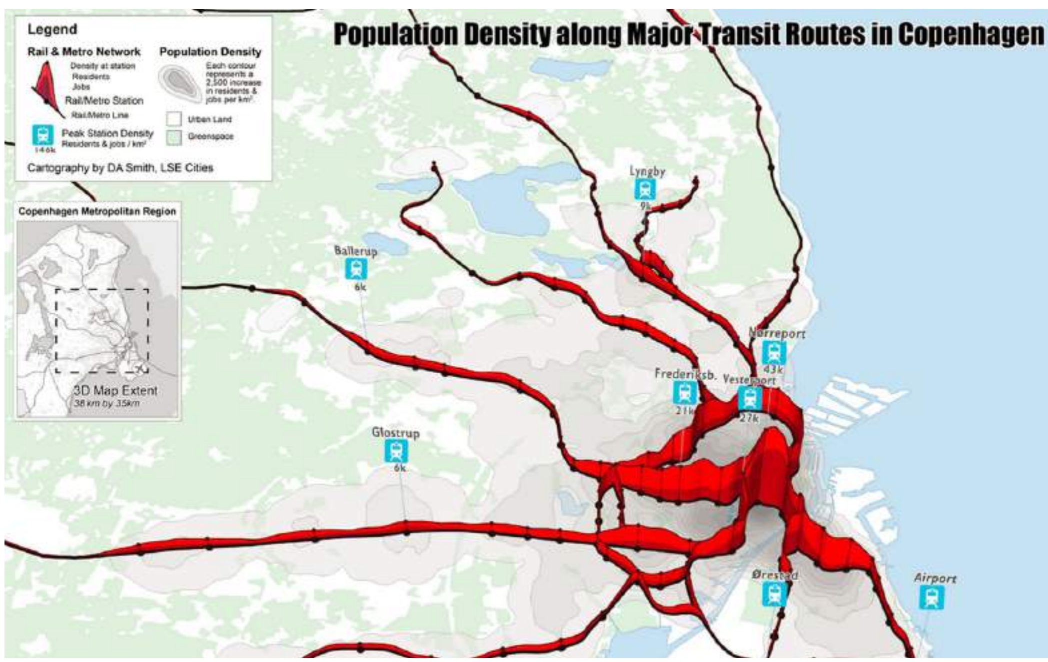
SOCIAL

INCREASES ACCESS TO MOBILITY FOR DISADVANTAGED GROUPS: Increasing building density and allowing for more population and job density increases the effectiveness of public transport as well as equitable transit access for the entire community.

BUILDS SOCIAL TIES: Compared to car travel, public transit is a shared experience. Public transit can help to build social ties and community.

IN PRACTICE: COPENHAGEN

The graphic below illustrates Copenhagen's successful creation of Transit-Oriented Development. The height of the red bars show the combined resident and job density and are superimposed on top of the transit network. There is the greatest density at transit hubs and secondarily along transit lines. Copenhagen's achievements in this area are the result of a regoinal plan that goes back to the year 1947. The plan clusters development around regional rail lines and includes green space buffers between them. Copenhagen has also seamlessly linked transit, biking and walking facilities. One-third of Copenhagen's suburban rail-users access stations by bicycle. Jan Gehl's pioneering leadership in prioritizing pedestrian space started in 1962 with the clearing of cars from the Strøget, today still one of the longest pedestrian streets in Europe. In the 1990s, a series of bold steps were taken to refocus new development in transit oriented ways. Rail growth was built in advance of demand to steer growth along desired transit corridors. In this way, Copenhagen was able to help developers identify which areas to prioritize in development. Copenhagen's transit-oriented development strategy has paid off. For example, sprawling Houston spends about 14% of its GDP on transport, while Copenhagen only spends 4% of GDP on transport.



The figure above shows how density in Copenhagen is matched with transit capacity (Source: LSE Cities).

BEST PRACTICES

- MATCH DENSITY TO TRANSIT CAPACITY: Allow for and encourage the greatest density at the highest transit capacity stations, such as where two rapid transit lines cross.

- CHOOSE AREAS WITH DEVELOPMENT POTENTIAL: Infill and redevelopment areas are usually prime targets for transit-oriented development since they are often located closer to the city center or close to existing residential areas.

- INCREASE WALKABILITY AROUND TRANSIT STATIONS: Make walking safe and enjoyable. A tried-and-tested way of making this happen is through mixed-use buildings lining key pedestrian routes – providing shops, restaurants and other conveniences to transit-users. The high footfall around transit stations enables retail to succeed.

- CREATE A SENSE OF PLACE: The district should have its own identity, through either historic buildings, rich public places, or a unique commercial area.

The BRT stops in Guangzhou optimize the riding experience. Stations are comfortable, safe, and provide real-time transit information (Source: ITDP).

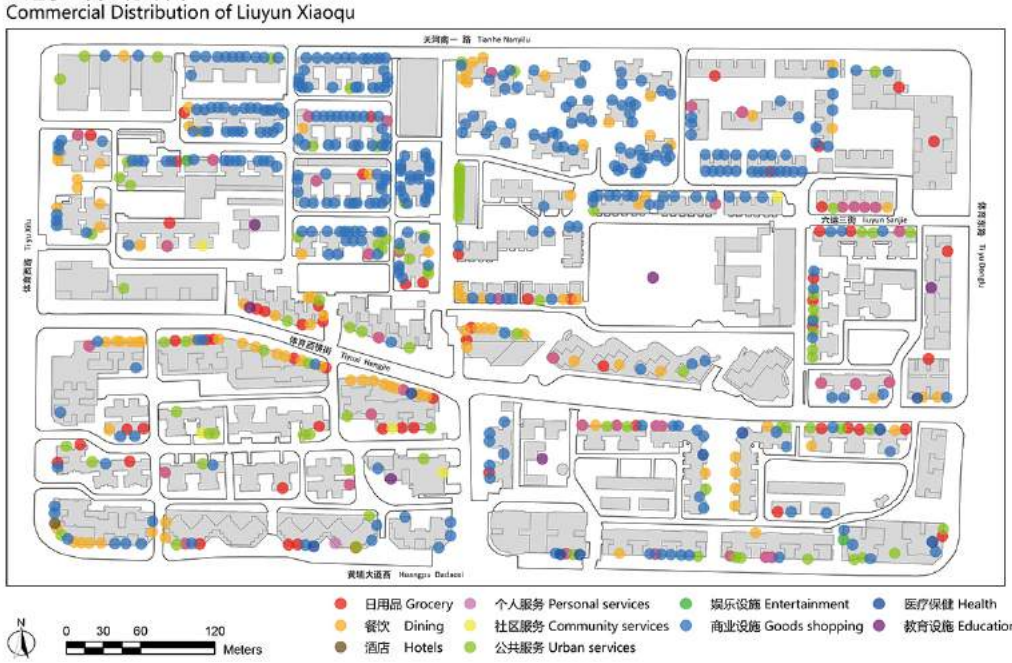
3 MIXED-USE

All residential units should be close to at least six kinds of amenities within 500-meter radius of their residential building entrance (amenities include schools, post offices, banks, retails, clinics, activity centers, restaurants, etc.). The job-resident ratio (the number of people employed divided by the number of residents) should be between 0.5 and 0.7 over every commuting district, which should have a spatial area that is no more than 15 km^2. Normally, these commuting districts are bounded by physical barriers for pedestrians.

RATIONALE

Current Chinese planning standards require a certain amount of each amenity per capita in cities, but does not specify where the uses are to be located with respect to housing. Mixed-use – the intermingling of residential, commercial, and residential uses – guarantees access to amenities that are close to where people live. Requiring a certain level of mixed-use in each area allows residents to access important amenities without travelling far distances, decreasing car use and improving quality of life. This is especially important for developments with elderly or children, as it is more difficult for them to travel further distances independently, especially areas with wide roads dominated by cars.

六运小区商业分布图
Commercial Distribution of Liuyun Xiaoqu



Liuyun Xiaoqu is a walkable, mixed-use neighborhood in Guangzhou. Below, the variety of amenities and services provided within the neighborhood is shown. Liuyun Xiaoqu became mixed-use by simply allowing ground-floor residents to commercialize their homes (Source: ITDP).

BENEFITS

ECONOMIC

INCREASES IN PROPERTY VALUE: Property values increase from mixed-use neighborhoods (ITDP 2012).

SAVES HOUSEHOLDS MONEY: Households save money and time due the availability of locally accessible goods and services. This allows people to meet their needs with fewer long distance trips (Stantec 2009).

ENVIRONMENTAL

IMPROVES AIR QUALITY: Mixed-use promotes non-motorized transit which decreases energy use and related air emissions (Zhao 2014).

REDUCES CAR USE: Mixed-use neighborhoods are less likely to have car commuters since there is a better jobs-residents balance (Han and Greeb 2014).

OPTIMIZES ENERGY USE: Creates a more varied load demand profile, reducing peak load pressure, to create more cost-effective and reliable electricity demand conditions.

SOCIAL

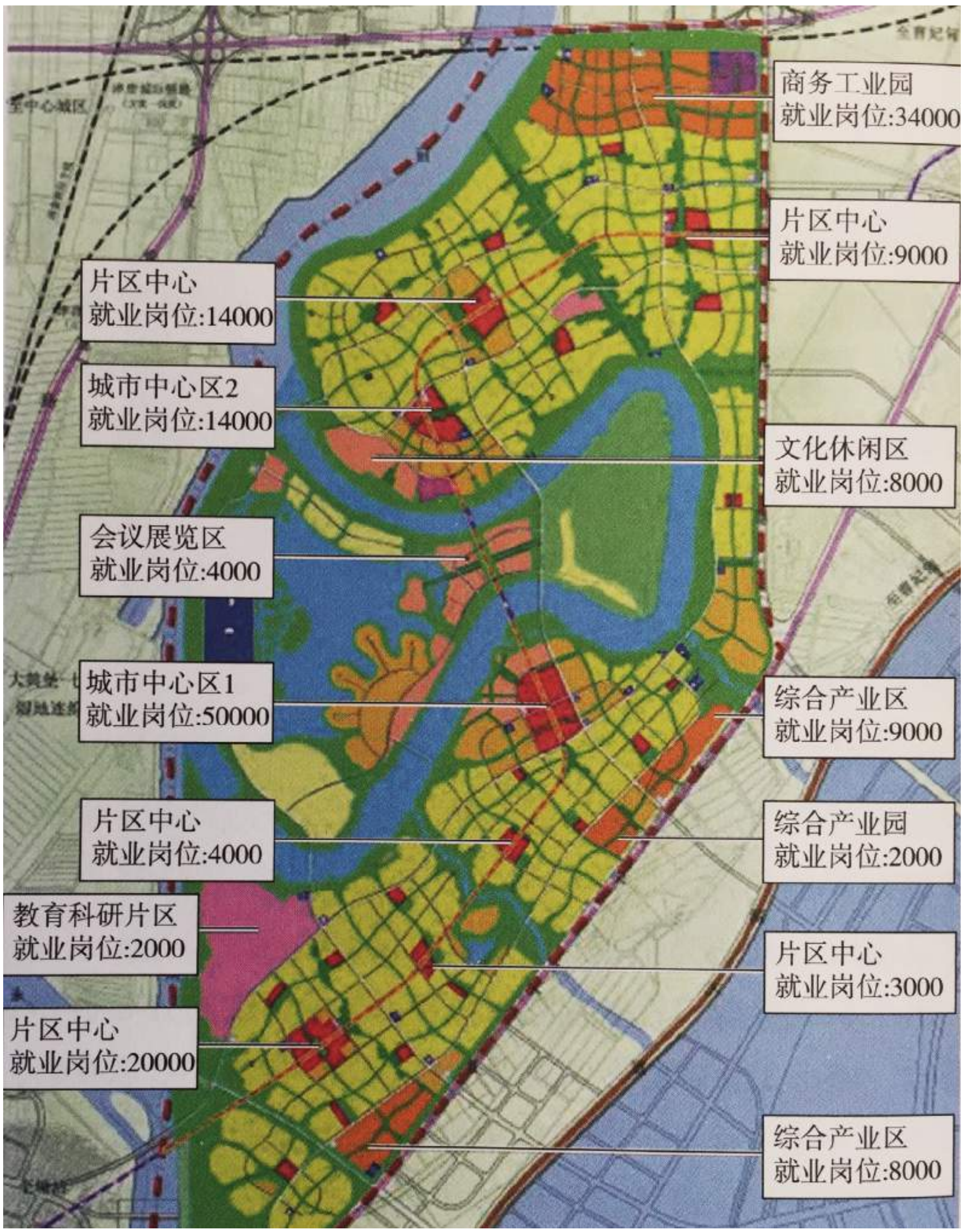
REDUCES LIKELIHOOD OF OBESITY: Increase in land-use mix reduces the likelihood of obesity (Frank et al. 2004).

INCREASES ACCESS TO AMENITIES: Increases accessibility of amenities for the elderly, children, and handicapped residents.

This photo shows first-floor commercial spaces in Liuyun Xiaoqu with residential spaces on the upper floors. The mixed-use space is made even better with great greenery, adequate sidewalks, and great car control.

IN PRACTICE: TIANJIN ECO-CITY

The Sino-Singapore Tianjin Eco-City is a transit-oriented mixed-use development. First, the Tianjin Eco-City will be based on a number of TOD-districts, each with its own district center. Second, each district will have a certain number of residential units and a number of jobs, with the job-housing ratio over each TOD district to be about 0.5 (shown in the figure below). Finally, for each residential district, the radius from the center to public green space and amenities is less than 800 meters, ensuring that residents are walking and biking distance to the most important amenities. Moreover, public transit is within 500 meters of 100% of residents. The figure on the next page shows the way that mixed-use planning units are used to create even larger mixed-use areas that will comprise the eco-city (Calthorpe at al. 2014).



Commuting districts in Tianjin Eco-city with job-housing ratio of 0.5.

BEST PRACTICES

- **PROVIDE FLEXIBLE, PERFORMANCE-BASED ZONING STANDARDS:** The local government should make sure that zoning ordinances allow for mixed-use and re-zone certain developments to have more mixed-use areas.

- **CREATE A GREAT WALKING EXPERIENCE:** For mixed-use to be successful, it is important to make pedestrians feel welcome and safe. Walkways that are car-free and allow pedestrians easy access between blocks and especially between adjacent sites can relieve traffic congestion and improve pedestrian experience. Extensive walking and biking paths can make direct connections easier on foot .

- **ENCOURAGE HUMAN-SCALED BUILDING FEATURES:** Require building entrances to be placed close to the street, ground floor windows, scaled signs and lighting, awnings, and other ways for the architecture to be more interactive with the pedestrian. The first floor of buildings should be open to the public as commercial or active spaces.

Mixed-use Neighborhoods in Tianjin Eco-city

Figure A

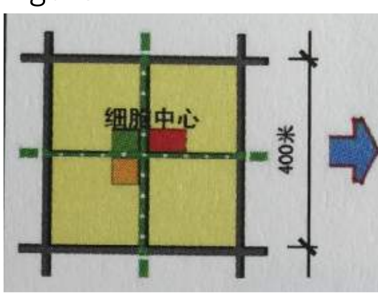


Figure B

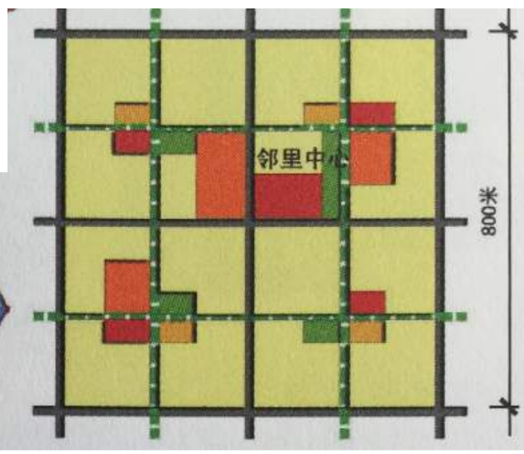


Figure C

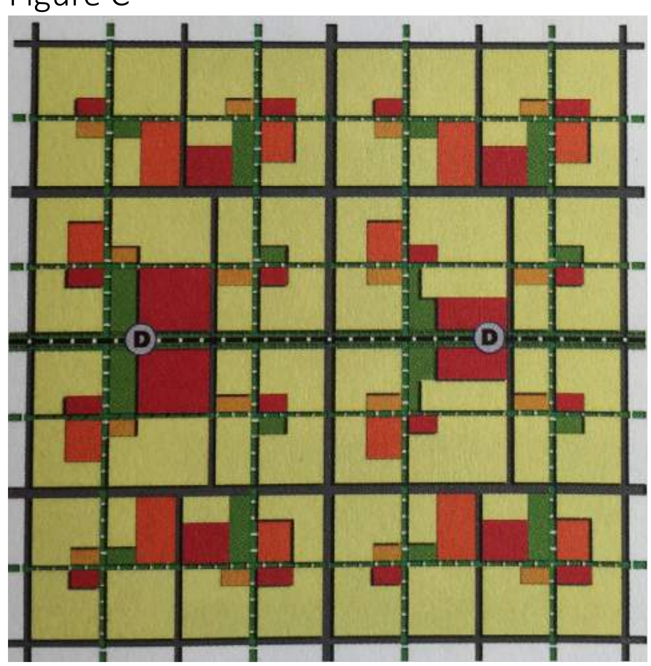


Figure A shows the smallest unit for residential areas that are 400 meters across, each of these becomes a larger area of 800 meters by 800 meters (Figure B), which combines to make Figure C. By ensuring that each 400 meter by 400 meter has a neighborhood center, the Tianjin Eco-City ensures walking distance access to all important amenities.

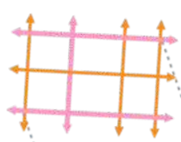
4 SMALL BLOCKS

Blocks should be less than or equal to 2 hectares and 70% of the blocks should comply with this standard. Exceptions made for industrial areas.

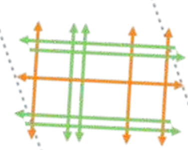
RATIONALE

Small blocks are the essential element of an effective urban transportation network. They create a dense mesh of narrower streets and paths that are more pedestrian-friendly. This shifts people away from cars, improving air quality. At the same time, they can help optimize the flow of traffic for remaining cars on the road. Small blocks also create variety of public spaces, architectures, and activities, thus increasing the vibrancy of the neighborhood. Superblocks have been dominant in China's planning paradigm due to the convenience it affords local governments when selling land. The large arterial streets that typify superblock development actually constrict flow compared to a denser network of smaller streets. With superblocks, all traffic is concentrated on a few main avenues. The net result is traffic congestion. Wide streets also create barriers to pedestrian movement, thus encouraging more people to drive.

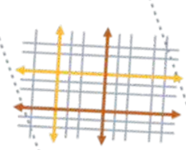
Engineering Small Blocks from Superblocks



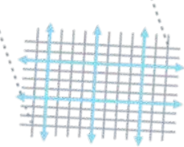
Superblocks with wide arterials before modification.



Replace major arterials with one-way street pairs and add transit to remaining arterials



Add car-free streets, some with dedicated transit lines;



Add narrow local streets with bike lanes and sidewalks.

This series of figures shows how a neighborhood with superblocks can be easily modified to have small, walkable blocks.

BENEFITS

ECONOMIC

SAVES COSTS ON INFRASTRUCTURE: Based on planning and development costs in China, there is a 31% reduction in roadway infrastructure costs due to savings from pavement, curbs, drainage, street lights, and trees for the city for dense urban networks in contrast to superblocks (ITDP 2014).

DECREASES ENERGY USE: Small blocks contribute to energy savings due to less travel demand by supporting more use of non-motorized travel modes (Energy Foundation 2011).

INCREASES RETAIL SPACE: Small blocks necessitate higher path density, which naturally means more sidewalk facing retail space for developers to sell (Interview with Chinese developer 2014).

DRAWS TALENT: Small blocks lay the foundation for interesting, vibrant places, which in turn will attract human talent (Florida 2014).

FLEXIBILITY IN LAND DEVELOPMENT FINANCE: Developments can be financed in smaller phases, meaning less capital must be raised at any given time (Interview with Chinese developer 2014).

ENVIRONMENTAL

REDUCTION IN ENERGY USED FOR TRAVEL: Superblock residents use more energy to satisfy their transportation needs compared to residents of other types of neighborhoods (Energy Foundation 2011) .

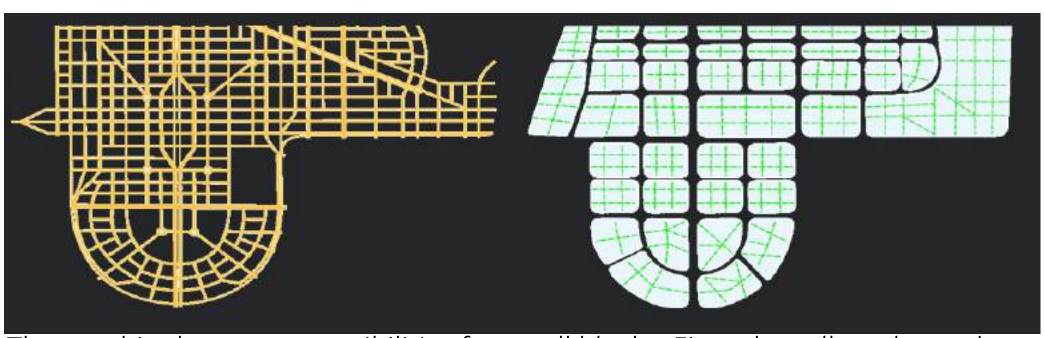
REDUCES CONGESTION: Small block urban network decreases traffic delays by 25% but making traffic flow more efficient (Energy Foundation and Calthorpe Associates 2011). Congestion and environmental damages have reduced Beijing's economic output by 7.5 percent to 15 percent (Creutzig and He 2009).

SOCIAL

INCREASES ACCESSIBILTY AND SAFETY: The elderly and children can more easily navigate areas with small blocks. Cities with small blocks are safer for drivers (Marshall and Garrick 2009).

INCREASES SAFETY: A dense street network with short and frequent pedestrian crossings would greatly enhance pedestrian safety and reduce jaywalking. A dense street network can also add resilience to the transportation system by providing many alternative routes for ambulances and fire trucks in emergencies (Center for Urban Transportation Research 2006).

ENHANCE SENSE OF COMMUNITY: Small residential blocks with more defined space shared by fewer residents create a suitable social scale where everyone knows each other, thus nurturing a sense of belonging for the community.



The graphic shows two possibilities for small blocks. First, the yellow shows dense networks of streets and paths. Second, the white and green shows an arterial-dominant street network that still provides pedestrian-bike access through the blocks by adding non-motorized transit paths (Source: ITDP).

IN PRACTICE: PEARL DISTRICT, PORTLAND

The Pearl District of Portland went through an extraordinary redevelopment in the mid--1990s after a series of plans culminating in the River District Urban Renewal Plan of 1998. The existing rail yard became a successful, walkable, mixed-use neighborhood that is built on small blocks.

In general, the development has blocks that are no more than 67 meters by 67 meters and 84% of these small blocks have complete sidewalks. Retail fronts on many of the block faces improves the walking experience of these small blocks, which makes walking more interesting, increases economic vitality, and creates local business opportunities.

Another key lesson from the Pearl District is the benefits gained from putting small blocks and one-way couplets together. One-way couplets allow roads to be more narrow, which improves the pedestrian's ability to cross roads while also improving traffic flow. Most of the local streets in this area also have a speed limit of less than 32 kph. Hence, the planning of the Pearl District is successful because they implemented small blocks along with narrow roads, good walking spaces, traffic calming, active frontage, and mixed-use.

The district has continued to grow economically. By 2006, 51% of the households in the River District Area (3,769 units), which is primarily comprised of the Pearl district, had a median family income in the 121st percentile or higher, as compared to 24% in 1999 (787 units) and 2% in 1994 (27 units).

Ground Floor Use

Dominant Building Use

These two graphics show the success of using small blocks combined with mixed-use in the Pearl District. The graphic to the left shows predominant ground floor use in the Pearl District while the grphic on the right shows predominant builiding use. The district allows ground floor uses to be more varied, which improves the livability of the district (Source: Portland Metro).

This photo shows great biking lanes, a one way street, and the prevalence of small blocks in the Pearl District. By combining all the key elements of urban form and transportation outlined in this report, the Pearl District is a vibrant and attractive place to live for all types of people (Source: Steven Vance / CC BY 2.0).

BEST PRACTICES

- USE ONE-WAY STREET COUPLETS: Instead of creating large, two-lane boulevards, building pairs of one-way streets allows for better traffic flow with less paved area. Couplets also eliminate left-turn problems.

- LIMIT STREET WIDTH: Local streets should be no more than 20 meters wide and larger streets should be no more than 45 meters wide.

- DECREASE SETBACKS: Set maximum setbacks instead of minimum setbacks. To make small blocks work optimally, it is crucial to reduce setbacks. Decreased setbacks promote the connection between the building and the public sphere as represented by the sidewalk. They also increase the building floor space that developers can sell.

- PROVIDE ACTIVE SETBACK AREAS: Introducing benches, outdoor cafes, kiosks, and other amenities ensures that small blocks are lively and enjoyable.

- RE-SHAPE AND UPGRADE EXISTING SUPERBLOCKS: For some infill or redevelopment projects, it is difficult to reconfigure the road network. However, developers can look to open up connections in existing built environments by adding biking and walking paths.

5 PUBLIC GREEN SPACE

Publicly accessible and usable green space should comprise 20-40% of the construction areas (residential areas should have bigger coverage). All residences should have accessible public space within 500 meters.

RATIONALE

Attractive public spaces can bring economic vitality to any city space. Oriol Bohigas, a famous Spanish urban planner, says that “public space is the city.” Great public spaces allow a diverse group of people to come together, create economic vibrancy, and increase surrounding property values. Public spaces can give neighborhoods identity and a sense of place, which is vital for creating community and improving quality of life. Without enough public green space, high levels of density can make urban areas feel crowded and uncomfortable.

Quality Criteria for Space Between Buildings

PROTECTION	*Protection against traffic and accidents - feeling safe* - Protections for pedestrians - Eliminating fear of traffic	*Protection against crime and violence - feeling secure* - Lively public realm - Eyes on the street - Good lighting	*Protection against unpleasant sensory experiences* - Wind, rain, snow - Cold/heat - Pollution, dust, noise
COMFORT	*Opportunities to walk* - Room for walking - No obstacles - Good surfaces - Accessibility for everyone - Interesting facades	*Opportunities to stand/stay* - Edge effect/attractive zones for standing/staying - Supports for standing	*Opportunities to sit* - Zones for sitting - Utilizing advantages: views, sun, people - Benches for resting
	Opportunities to see - Reasonable viewing distances - Unhindered sightliness - Interesting views - Lighting (when dark)	*Opportunities to talk and listen* - Low noise levels - Street furniture that provides “talkescapes”	*Opportunities for play and exercise* - Invitations for creativity, physical activity, exercise and play - By day and night, in summer and winter
DELIGHT	*Scale* - Buildings and spaces designed for the human scale	*Opportunites to enjoy the positive aspects of the climate* - Sun/shade - Heat/coolness - Breeze	*Positive sensory experiences* - Good design and detailing - Good materials - Fine views - Trees, plants, water

These improvements are key to a great public space (Source: Jan Gehl).

BENEFITS

ECONOMIC

IMPROVES HOUSING PRICES: In Beijing, having a view of green space and proximity to water bodies raised housing prices by 7.1% and 13.2%, respectively (Jim and Chen 2006).

IMPROVES COMMERCIAL REAL ESTATE VALUES: Green space improves economic vitality. Studies show that green spaces can increase the value of commercial office space and retail locations by 7% or more (Clements et al. 2013).

SAVES COSTS ON CONTROLLING RAINWATER RUNOFF: Public green space helps to absorb rainwater runoff, thereby reducing the need for more expensive engineering approaches to guarding against flood risk (Zhang et al. 2012).

ENVIRONMENTAL

DECREASES ENERGY USE IN HOT CLIMATES: Tree cover can provide shade to limit the need for air conditioning on hot days. In addition to the direct benefits of shading, green space helps reduce the urban heat island effect (Burden 2006).

INCREASES FLOOD RESISTANCE: Trees absorb storm runoff and reduce the risk of flooding and sewage overflows. In Beijing, public green spaces saved the government 1.38 billion RMB in rainwater control in 2009 (Zhang et al. 2012).

IMPROVES AIR QUALITY: Urban green space can absorb carbon emissions and reduce harmful particles in the air, such as PM10 (Sonuparlak 2011).

SOCIAL

IMPROVES PHYSICAL HEALTH: There are improved health effects on individuals near public green space compared to those near vacant lots. Greenery also promotes healthy birth weight and increases life expectancy (Richardson 2014).

IMPROVES MENTAL HEALTH: Green space has the benefit of reducing the risk of depression (Maas et al. 2006).

COMMUNITY COHESION: Well-designed green spaces near community facilities creates places where community members gather and interact, building social ties.

Example of a great public space in Copenhagen - great seating, ability to enjoy the sun, hide from the sun, have drinks, and access to nearby shopping and dining options (Source: La Citta Vita).

IN PRACTICE: THE HIGH LINE, NEW YORK CITY

The High Line is a 1.45-mile long park running through New York City's Meatpacking District and Chelsea neighborhoods that hosts 3 million visitors every year (Moss, 2012). The park is built on an elevated portion of an abandoned railroad and was constructed after the city had considered destroying it. Creating the park was less costly than razing the property. The city also used the greenery that had naturally invaded the tracks as inspiration. Since the park's revitalization, which cost $115 million, the surrounding area has seen $2 billion in private investments, the addition of 8,000 construction and 12,000 permanent jobs, and a doubling in apartment values near the park (McGeehan 2011).

The photos above show the use of public green space at the Highline in New York City. The park has directly increased apartment values, private investments, and construction in the area.

BEST PRACTICES

- MAKE ACCESSIBLE TO PUBLIC: Make public green space accessible from sidewalks and streets so they are welcoming to all types of people. It is also highly desirable that public open spaces be located adjacent to community facilities such as local shops, schools, and daycare so that they can be easily enjoyed by people as part of their daily routines.

- PROVIDE A VARIETY OF PUBLIC OPEN SPACES: A city needs public open spaces at different scales–smaller, more intimate neighborhood parks, as well as large open spaces that are good for community gatherings, such as concerts, festivals, and other events.

- CHOOSE LOW WATER-USE PLANTS THAT ARE WELL ADAPTED TO LOCAL CONDITIONS: Choose low-use water plants; certain types of vegetation can also provide clean air benefits and can be managed using natural, chemical-free pest management. Using native or regionally appropriate plants will minimize maintenance costs and benefit the local ecosystem.

- ENSURE THE SPACE IS CLEAN: Make sure the park is clean, use signs to discourage littering, and offer trash, composting, and recycling bins to minimize waste.

- MAINTAIN PLEASANT WALKING PATHS: Sustain maintenance to keep leaves, mud, or snow from building up on the paths. Place benches or resting areas along paths to improve the walking experience for both young and old.

- INTEGRATE NATURAL AND CULTURAL ATTRACTIONS: Integrating restaurants and cafes with the park experience can increase vibrancy as well as improve economic vitality. Other additions, such as gardens, sports fields, and tables for games, can also help parks build community and a sense of place.

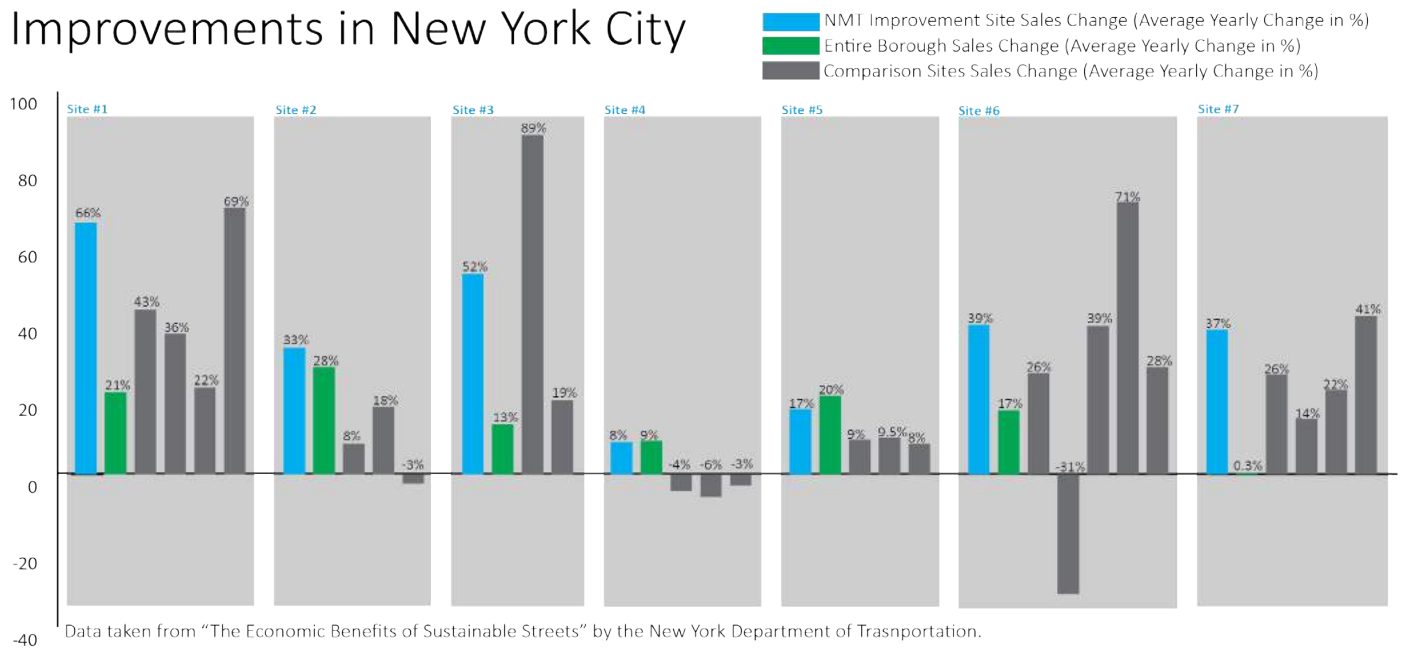
6 NON-MOTORIZED TRANSIT

There should be dedicated and connected walking paths of at least 10 km in length per square kilometer, and dedicated and connected biking paths of least 10 km in length per square kilometer in urban areas.

RATIONALE

At once ancient and modern, walking is at the core of high-quality neighborhoods all over the world. The most attractive cities in the world emphasize the pedestrian environment at a human scale. Biking also requires far less land and energy use than any other form of transportation–it produces no pollution while providing benefits for human health. Dense networks of walking and biking paths allow commutes to be shorter and more efficient, encouraging less car use and increasing healthy forms of commuting. Walkable and bikable neighborhoods are shown to be more happy, healthy, and innovative. Of the Theory of Relativity, Albert Einstein said, “I thought of that while riding my bicycle.”

Changes in Business Sales from Non-Motorized Transit (NMT) Improvements in New York City



Data taken from “The Economic Benefits of Sustainable Streets” by the New York Department of Trasnportation.

The chart above shows that in general, non-motorized transit improvements have improved business sales in New York City. Only a few of the comparison sites studied performed better than the NMT improvement sites (perhaps for other reasons such as new businesses moving in) and NMT improvement site businesses never had negative sales performance (Source: New York Department of Transportation).

BENEFITS

ECONOMIC

HIGHER PROPERTY VALUES: As has been shown in cities all over the world, there is a price premium in walkable neighborhoods (CEO's for Cities 2009).
HIGH RETURN ON INVESTMENT: Bike-share systems can produce many benefits–in New Zealand, the benefits were 10-25 times the cost (MacMillan 2012).
DECREASED GOVERNMENT COSTS: Governments avoid externalities from health, congestion, and pollution when there is less driving and more biking and walking (State of Green and Copenhagen Cleantech Cluster 2014).
RELIEVES CONGESTION: Improving the walking and biking experience is the best way to reduce car use. For example, Guangzhou's bike-share program prevents 14,000 car trips daily (ITDP 2013).
DECREASED TRANSPORT COSTS: There are substantial savings on fuel, maintenance, and parking costs with more walking and biking.

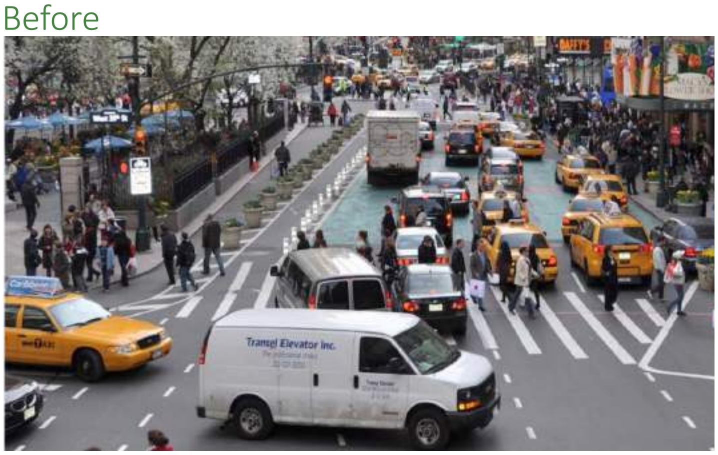
ENVIRONMENTAL

REDUCE CARBON EMISSIONS: Biking and walking produce no tailpipe emissions. In contrast, car traffic is an increasing source of carbon emissions in China.
IMPROVED AIR QUALITY: Motor vehicle emissions contribute significantly to PM2.5 levels and other damaging air pollutants. In Beijing, vehicle emissions accounts for about one-third or more of PM2.5 emissions (Weinmann 2014).

SOCIAL

IMPROVES PHYSICAL HEALTH: Walking contributes to heart health, and reduces the incidence of cancer (Hou and Ji 2004). By contrast, vehicle emissions contribute to illnesses such as asthma.
IMPROVED EQUALITY: As biking and walking are inherently less expensive transit modes, more citizens can afford the costs of biking or walking than driving.
DECREASED RISK OF INJURY: Adding more bike lanes can decrease accidents and injuries for everyone on the road, not just bicyclists.

Before



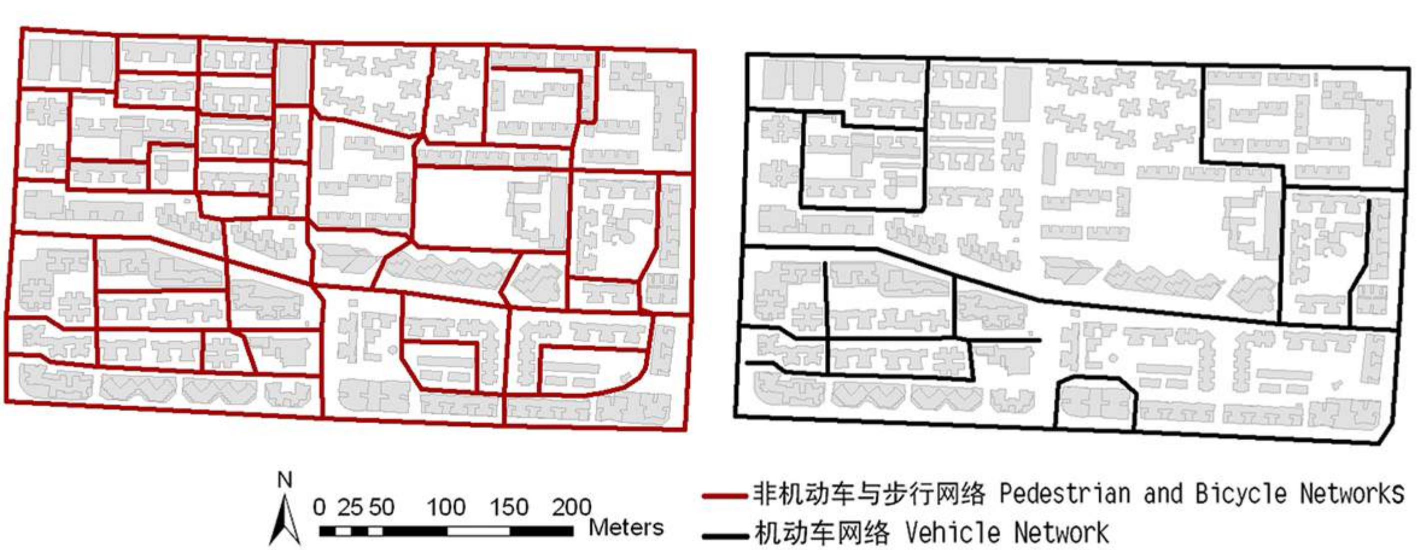
After

The above photos show the NYC Green Light for Midtown Project. Pedestrian injuries decreased, traffic flow improved, and a significant lower number of pedestrians are walking in the roadway as a result of this non-motorized transit improvement lead by Gehl Architects (Source: Gehl Architects).

The photo above shows a biking and walking path in Liuyun Xiaoqu. This neighborhood is less dependent on car use due to the well-crafted non-motorized transit paths (Source: ITDP).

IN PRACTICE: LIUYUN XIAOQU

Liuyun Xiaoqu is a revitalized community in Guangzhou. Liuyun Xiaoqu ranks fifth on a list of 50 transit-oriented projects compiled by the Institute for Transportation and Development Policy (ITDP). Liuyun Xiaoqu was awarded the highest rating of gold and ranked above similar districts in Germany, California, and Portland. Liuyun Xiaoqu was built before car use was mainstream in China and it has maintained high standards for car control. It also offers many car-free walking and biking paths. As a transit-oriented, car-controlled, mixed-use neighborhood, Liuyun Xiaoqu is walkable and people-friendly. The figure below shows the area's extensive pedestrian and bike paths and, for comparison, the less extensive road network for motor vehicles.



The paths above show how this neighborhood made travel by foot and bike much more convenient than travel by car. The biking and walking paths are more dense and comprehensive (Source: ITDP).

BEST PRACTICES

- **CREATE COMPLETE WALKING AND BIKING NETWORKS:** Non-motorized transit paths should form a complete network connecting to community amenities, parks, and local destinations so people could use them not only for recreation but also for other daily commuting needs.

- **ALLOW FOR EXCLUSIVE WALKING AND BIKING PATHS:** Unsafe biking and walking environments discourage non-motorized transit. For pedestrians, street crossings must be marked and secure. Biking paths should be protected from motor vehicle traffic, and a fair number of streets should disallow cars completely (though transit may be allowed on some).

- **BUILD WIDE PATHS:** Wide enough paths contribute not only to safety but also to pedestrian and cyclist comfort, another key to greater use. While the optimal width will vary, 2.5- 3 meters wide will be appropriate in many instances.

- **ENSURE VISUALLY ACTIVE FRONTAGE:** Walkability is enhanced when the pedestrian environment is inviting and interesting instead of walled-off. Visually active frontage occurs when there are windows, partially transparent walls, or accessible open space, such as a playground or park.

- **INVEST IN PEDESTRIAN ENVIRONMENT UPGRADES:** Trees, benches, and other inexpensive upgrades enhance the walking experience for pedestrians.

- **INTEGRATE BIKING AND WALKING PATHS WITH PUBLIC TRANSIT:** One of the hallmarks of a successful transit system is that residents can easily walk or bike to public transit stops, so biking and walking paths should feed into transit stops.

Before

After

The above photos show another non-motorized transit improvement in New York City. Adding bike lanes and using car space as public space can greatly improve the pedestrian environment and improve business value (Source: Gehl Architects).

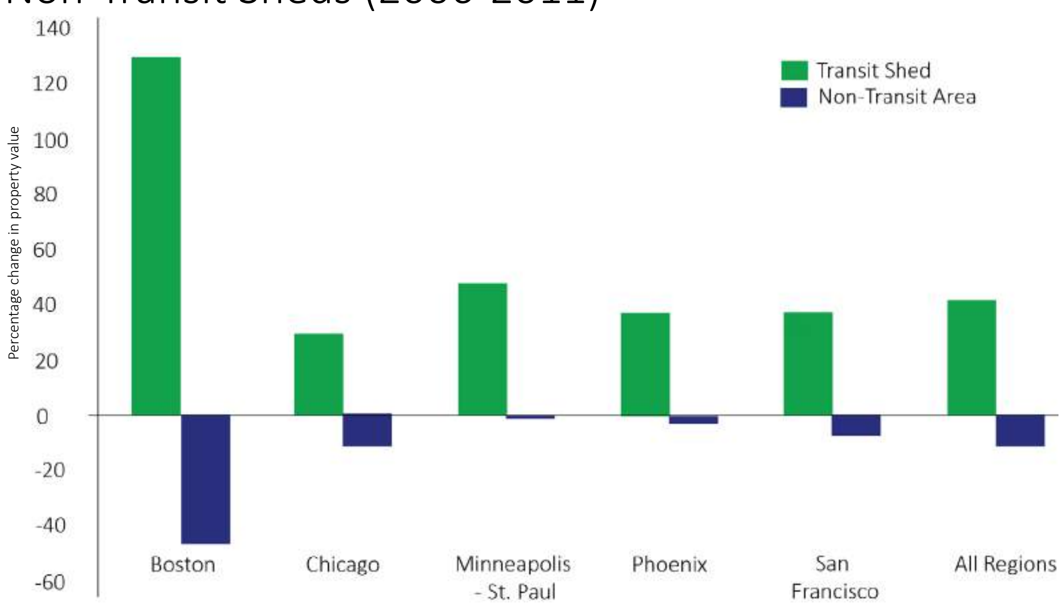
7 PUBLIC TRANSIT

All new developments must be within a 500-meter radius of a bus or mass transit station. For the city as a whole, at least 90% of developments should be within 800-meter radius of a public transit station.

RATIONALE

Making public transit accessible and a first-class option is one of the best ways to reduce car dependence. If public transit is a first-class option, people will often choose not to drive. Many of the greatest cities are known for their public transit systems–New York, London, Hong Kong, and Singapore are excellent examples. In these places, most commutes are by transit, not cars, even though large fractions of the population are affluent and can afford to drive. Public transit must be well integrated with biking and walking to solve the "last mile" question of how people will get to their final destination. Enrique Peñalosa, former mayor of Bogotá, points out "an advanced country is not one where the poor move about in cars, rather it's where even the rich use public transportation."

Percentage Change in Residential Sales Price Relative to Region during U.S. Recession for Transit and Non-Transit Sheds (2006-2011)



Residential properties located near public transit are the most economically resilient. The data above shows that residences near public transit never decreased in value during the Great Recession, whereas property values in non-transit shed areas did decrease in value.

BENEFITS

ECONOMIC

DECREASES COST OF CONGESTION: High-quality public transportation shifts commuters away from private vehicles, which reduces traffic congestion (American Public Transportation Association 2015).

HIGHER PROPERTY VALUES: Being located near transit increases real estate values. Proximity to public transit stops has led to price premiums of 11% in Hong Kong, 14% in Bogota, and an annual increase of 2.3% in Beijing (Deng and Nelson 2010; Ma et al. 2013).

DECREASES TRANSPORTATION COSTS: People living in cities with the best public transportation systems spend less of their household budgets on transportation. This contributes to the overall affordability of compact cities.

ENVIRONMENTAL

DECREASES CARBON EMISSIONS: Effective public transit systems decrease emissions. For example, transportation related emissions are 30% lower in the Hankou district (compact, good transit) than the Hanyang district (low road density, high proportion of car commuters) (Han and Greeb 2014).

IMPROVES AIR QUALITY: Public transit produces less CO_2, NO_x, and PM2.5 than car travel (Wang 2012; Chen 2012; Hughes 2011).

SOCIAL

INCREASES ACCESS TO MOBILITY FOR DISADVANTAGED GROUPS: High-quality public transit can improve transit times and accessibility of transportation for people of all ages and income groups (Gehl Architects and Energy Foundation 2014).

LOWERS CRASH RISK: Transit travel has about one-tenth the rate of crash deaths or injuries as car travel (Litman 2013).

It is important to integrate public transit with non-motorized transit, especially biking. This is a great way to solve the "last-mile problem" that commonly stumps transit planners. Good bike parking near transit stops allows users to easily access stops that might be slightly further away.

IN PRACTICE: GUANGZHOU BRT SYSTEM

Since its opening in February of 2010, the Guangzhou Bus Rapid Transit (GZ BRT) has served as a groundbreaking example of effective public transit in Asia. The BRT runs 22.5 kilometers along Zhongshan Avenue, one of Guangzhou's busiest roads, through several of the densest, most promising neighborhoods and includes safe, easy access by foot, bike, and metro.

The line has promoted development in the Tianhe and Huangpu Districts, two of Guangzhou's densest neighborhoods. There are plans for 329,000 square meters of new commercial real estate developments along the corridor, including the Donghaochong Canal Museum, and several large residential projects, such as Junjing Gardens, an apartment complex soon to house more than 50,000 residents. The surrounding property values experienced an increase of 30% in two years after the BRT began operation.

In its first year, the BRT also increased traffic speeds by 20% – time savings worth 158 million yuan ($24 million) valued at average wages– and improved riders' self-reported satisfaction with transit, safety, and the city. The project reduced the projected CO_2 emissions over the next 10 years by 865,000 tons with significant reductions in local air pollutants. In this same period, the project is projected to produce a 131% return on investment using a broad measure of social costs and benefits.

Guangzhou's BRT system has dedicated lanes that makes riding BRT a first-class transit option due to its convenience (Source: ITDP).

BEST PRACTICES

- **TRANSIT MUST BE A FIRST-CLASS OPTION:** Transit vehicles must be clean and comfortable. Passengers must feel safe. Travel times should be as fast as possible. The goal should be for transit and non-motorized modes to be the fastest mode of travel for most trips.

- **CONSIDER BOTH BRT AND METRO:** Prioritize speed, quality, and convenience. A well-designed BRT system is an excellent, cost-effective option that can carry as many passengers as a metro system but at one-tenth the cost. In densely populated places where surface area is particularly scarce, a metro system may make sense.

- **COORDINATE TRANSIT SO IT IS EASY TO SWITCH MODES OR LINES:** Feeder buses should leave immediately after the BRT arrives. Bus lines should have easy links to the metro. Non-motorized transit must be integrated with all public transit options. Smart technologies can aid in real-time transit data and optimizing dispatch.

- **ENSURE CONVENIENT AND SAFE ENTRANCES TO TRANSIT STATIONS:** To encourage the greatest use of transit, attention must be given to walkability. Access to stops and the walkability of nearby areas are important elements for making public transit a first-class option.

- **EMPHASIZE THE BIKE CONNECTION TO MAJOR TRANSIT:** Bike and transit systems can work beautifully together, so planners should ensure there is bike parking around major transit stops and that bike lanes go directly to the transit stop.

- **BUILD A SMART TRANSIT CARD SYSTEM:** Allow users to have one card that they can charge through mobile, web, or kiosks that can be used across metro, BRT, buses, and bike-sharing programs.

Key Statistics on Public Transit System Types

	BUS RAPID TRANSIT	LIGHT RAIL	METRORAIL
RIGHTS-OF-WAY	Mixed: shared (at-grade); dedicated and exclusive lanes	Exclusive (elevated or barriers) or shared (at-grade)	Exclusive, grade-separated
RUNNING WAYS	Pavement; roadways	Steel track	Steel track
CONSTRUCTION TIME	1-2 years	2-3 years	4-10 years
MAXIMUM CAPACITY	160-270	170-280	240-320
MAXIMUM CAPACITY	12-30	75-150	120-150
LINE CAPACITY (passengers/direction/hour)	5000 - 45000	12000 - 27000	40000 - 72000
MAXIMUM SPEED (kph)	60-70	60-80	70-100
AVERAGE CAPITAL COSTS (2000 US$/km)	8.4	21.5	104.5
AVERAGE OPERATING COSTS (2000 US$ per vehicle revenue	2.94	7.58	5.30

BRT takes much less time to construct, has lower capital and operating costs, and can often hold the same number of people as light rail and metro rail (Source: Seoul Development Institute, 2005).

8 CAR CONTROL

Every city should have a strategy to cap car use. Where high-quality transit exists, there should be limits on parking.

RATIONALE

U.S. planning practices have traditionally prioritized automobiles. As a result, transportation emissions compose up to half of per capita carbon emissions for most urban dwellers, and cars have taken over the public sphere. Enormous sums are then devoted to paving the city and maintaining the streets. This has come at great economic, social, and environmental cost.

China's greater population and density mean that cars can never be at the center of an effective transportation system for the country: Even with just one-tenth of Chinese currently owning a car, the major cities already have serious pollution and traffic problems. Chinese cities have a chance to follow a more sustainable path, and create cities with high-quality public transit that are more walkable and bikable. Car control is an essential element of this strategy. It makes streets safer for children and the elderly, alleviates costly congestion and pollution, and rejuvenates street life.

Parklets are appearing all over major cities - by taking away a few parking spots, cities are creating pockets of space for people to enjoy the city. The parklet on the left is located in Vancouver, Canada and the photo on the right is located in San Francisco, California.

BENEFITS

ECONOMIC

REDUCES HEALTH COSTS: Beijing's vehicle use restrictions that prevent driving based on license plate numbers yield RMB 1.1 to 1.4 billion in health benefits each year (Viard and Fu 2011).

INCREASES GOVERNMENT REVENUE: By recognizing the costs cars impose, and ending the implicit public subsidy, an efficient source of government revenue is created that can be directed to increasing the affordability of public transit. Charging for parking spots can also provide jobs. A study of the Daoli neighborhood of Harbin found that putting meters in 7,500 unmetered parking spaces could generate RMB 29 million annually (Fjellstrom 2008). Congestion pricing, in use in London and Singapore, also provides a source of revenue.

REDUCES CONGESTION: Strict car control means fewer cars on the road and less congestion. Congestion costs Rio and Sao Paulo 8% of their GDP (Industry Federation of the State of Rio de Janeiro 2013). Car control strategies have been shown to be effective in reducing congestion internationally.

MAKES LAND MORE ATTRACTIVE TO DEVELOPERS: New York developers show a marked preference for less or no-parking requirements.

ENVIRONMENTAL

REDUCES POLLUTION: Driving restrictions in Beijing based on license plate numbers led to a 20% reduction in air pollution with every-other-day restrictions and 9% during one-day-per-week restrictions (Viard and Fu 2011).

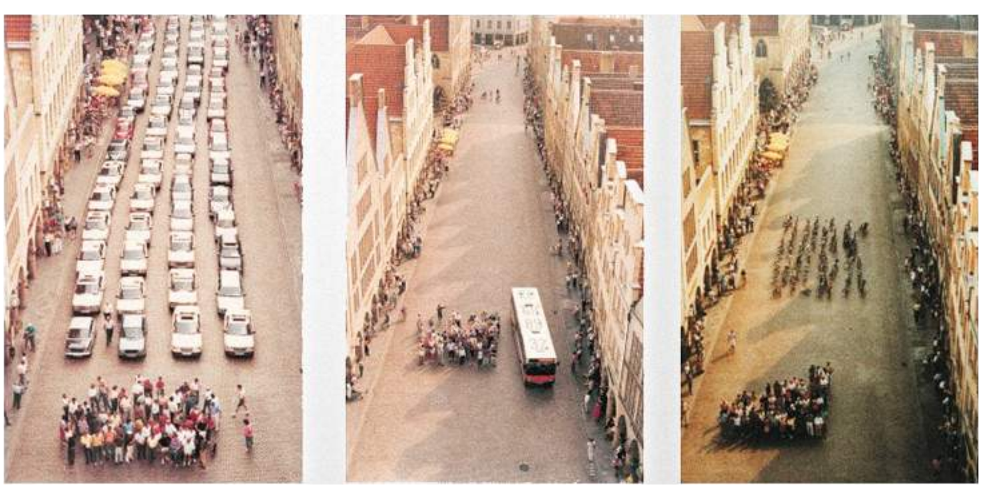
REDUCES CARBON EMISSIONS: Cities can reduce CO_2 emissions by optimizing traffic flow. Controlling the number of automobile licenses could achieve even greater savings (Zhou et al. 2012).

SOCIAL

REDUCES RISK OF OBESITY: Each additional hour spent in a car per day is associated with a 6% increase in the likelihood of obesity (Frank et al. 2004).

REDUCES RISK OF HEART ATTACK: Traffic exposure accounts for the highest percentage of heart attacks— more than 7%—due to a combination of the frustration of sitting in traffic and exposure to air pollutants (Baccarelli and Benjamin 2011).

INCREASES SAFETY: Vehicle accidents impose a significant burden, economically and physically, on individuals and the economy as a whole (Kusisto 2015).

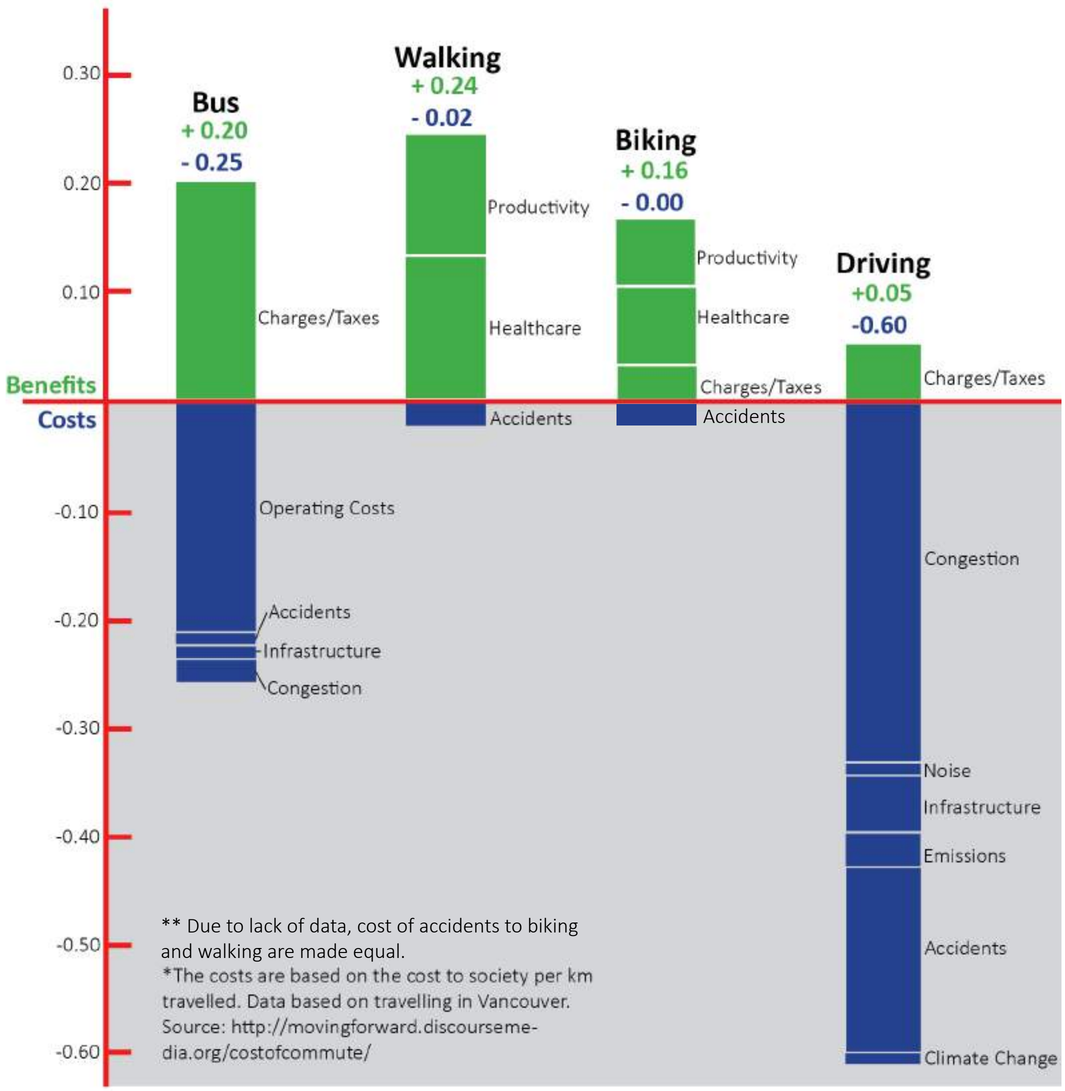


The graphic above shows the space that can be saved in cities if more space was given to public transit, people, or bikes.

IN PRACTICE: VAUBAN

The German city of Vauban makes car control a central element of its strategy to increase walking and biking. It costs up to $40,000 to purchase a parking spot and there is less than 0.5 car parking spaces per residential unit. Traffic speeds are limited to 30 km/hour. Vauban's residential areas are all located on car-free streets, where vehicles can drop-off or pick-up, but not park. These measures prompted more than half of the households moving to Vauban to sell their vehicles. Only 160 residents per 1,000 own cars. Private vehicle use makes up less than 20% of all trips, with the remaining 80% from non-motorized or public transit. In Vauban, 81% of residents from car-free households said they found that life without a car was either "easy" or "very easy."

The Social Cost of Various Transit Modes



The data above shows the true cost of driving compared to public transit and non-motorized transit modes. In total, the benefits of public transit, walking, and biking are higher and the costs are lower than driving.

BEST PRACTICES

- **CONSIDER CONGESTION PRICING AND OTHER TRAFFIC ALLEVIATION MEASURES:** Impose a charge for cars to enter the most congested areas, especially at peak hours, which can slash congestion. Lengthening red light times to enter the city during peak hours can also reduce car use and congestion.

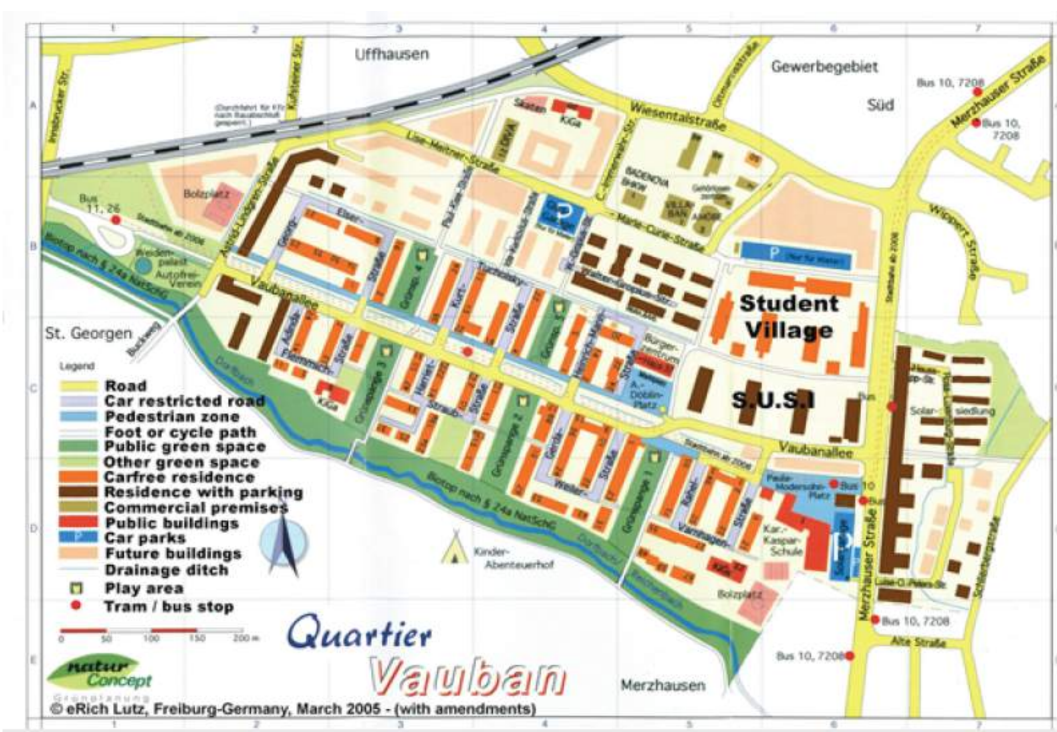
- **LIMIT CAR PERMITS:** Reduce the number of car purchases through auctions or lotteries. Beijing and Shanghai have set caps on the number of cars allowed to register, using a lottery and an auction, respectively.

- **DO NOT ALLOW FREE PARKING:** Parking must be directed away from areas with the highest number of people and businesses, and fees should be based on demand.

- **IMPOSE OFF-STREET PARKING MAXIMUMS:** This means that developers can provide as little parking as they consider necessary, which frees up space for development and pedestrians.

- **USE DEMAND-RESPONSIVE PRICING FOR PARKING:** Build meters and garages with pricing adjustments to make sure there is a minimum level of availability and parking spaces do not sit unused.

- **ELIMINATE SETBACK PARKING:** Parking in setbacks creates unpleasant walking environments and negatively affects the interaction between pedestrians and businesses. Physical barriers are often required to prevent parking in setbacks.



Vauban's car-free residences allow children to safely play on the streets. Convenient walking and biking paths combined with plenty of public green space make driving a second-class option for transportation in Vauban (Source: Rich Lutz).

9

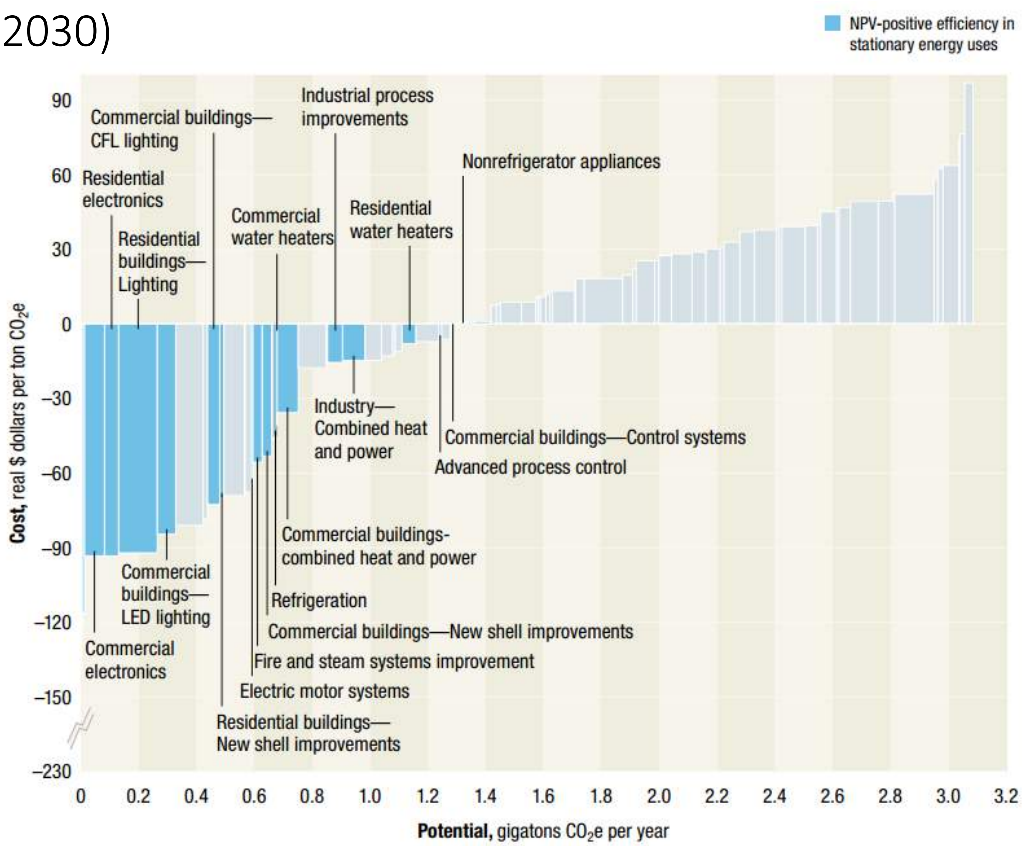
GREEN BUILDINGS

At least 70% of buildings should be MOHURD One-Star, 20-40% of buildings should be MOHURD Two-Star, and 5-15% of buildings should be MOHURD Three-Star within any development.

RATIONALE

Buildings account for about 25% of China's energy consumption and carbon emissions. In recent years, China has been adding 1.7 billion square meters of new building stock annually. These buildings will last for many years, and will be huge consumers of energy. Due to advancements in planning, materials, and supply chain efficiencies, green buildings now have almost negligible cost premiums compared to regular buildings, especially when integrated planning and cost-effective technologies are used. There is also potential in using green buildings to improve indoor air quality, thereby improving human health and building a better consumer case to encourage purchase of green buildings.

US Mid-range Greenhouse Gas Abatement Curve (2030)



The most cost-effective carbon emission options are found in the construction of green buildings. These data are for the U.S. but will broadly apply in China (Source: McKinsey and Co.).

BENEFITS

ECONOMIC

LOWER COSTS AND HIGHER PROPERTY VALUES: Operation costs of green buildings is 8-9% lower, the value of the building is 7.5% higher, and the total payback increases by 6.6% (The Climate Group 2011).

HIGHER LABOR PRODUCTIVITY: Green buildings mean healthier workers and improved productivity (World Green Building Council 2015).

ENVIRONMENTAL

IMPROVED INDOOR AIR QUALITY: Better building envelope and improved ventilation improves indoor air quality (World Green Building Council 2015).

LOWER ENERGY USE: One-Star buildings can save an average of 54.7% of all energy, Two-Star buildings save 57.4% of energy, and Three-Star buildings save 61.8% of energy compared to non-green buildings (Yip et al. 2013).

LOWER EMISSIONS: For example, average decreases in CO2 emissions are 3.2 kg/m2 for One-Star, 4.6 kg/m2 for Two-Star, and 6.1 kg/m2 for Three-Star (Yip et al. 2013).

DECREASED WATER USE: Green buildings can cut water use substantially (World Green Building Council 2015).

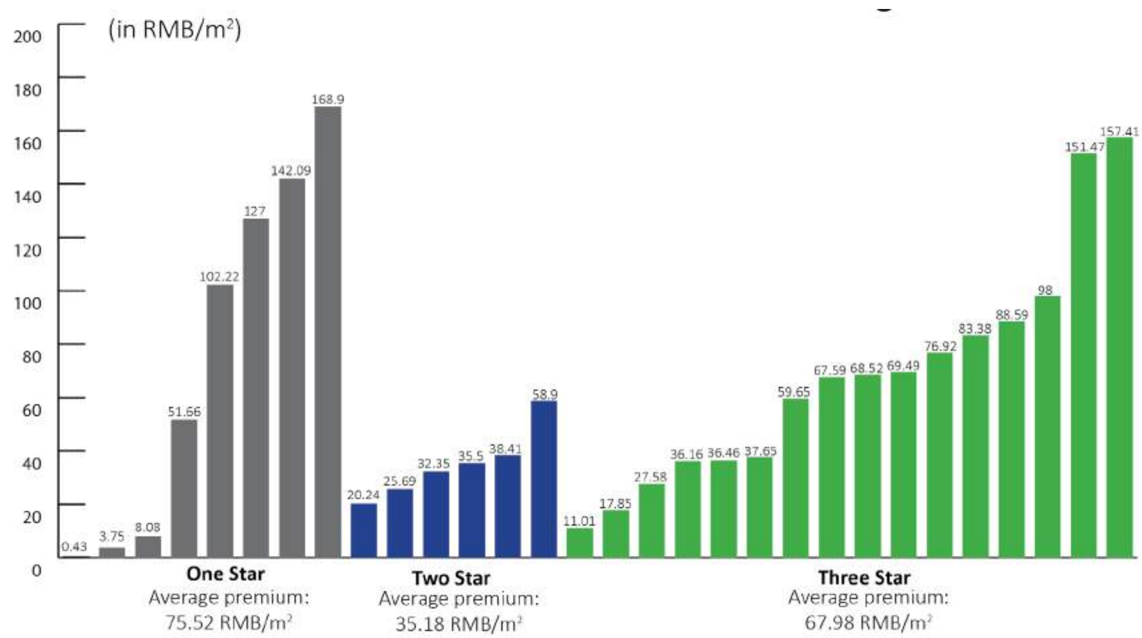
SOCIAL

HIGHER PRODUCTIVITY: In the U.S., one study shows that there would be a $200 billion gain in worker performance from better indoor air quality due to more green buildings (World Green Building Council 2015).

IMPROVED LEARNING ENVIRONMENT: Studies show that students who are exposed to more pollution score worse on tests and have lower overall performance (Baker and Bernstein 2012).

Good Planning Can Decrease Incremental Costs of Green Buildings in China

Sample Incremental Costs of 30 Residential Green Buildings in China



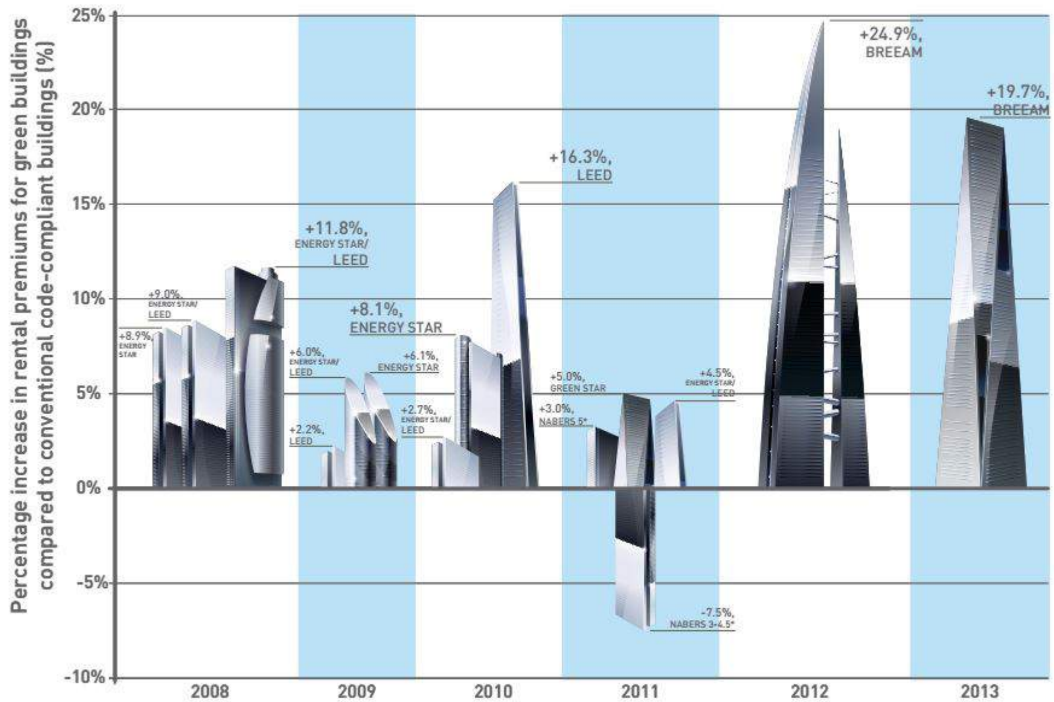
*From "The Study of Green Building Economics in China" by Stanley Yip, Li Hongjun, Song Ling, 2013.

Cost differences in green buildings in China are more due to planning optimization and technology selection rather than green building technologies just being more expensive on the whole (Source: Yip, Li, Song, 2013).

IN PRACTICE: RIVERHOUSE, NEW YORK CITY

The Riverhouse development is a high-rise residential development located in Manhattan's Battery Park City neighborhood. Riverhouse will achieve LEED Gold Certification and thereby save $200,000 each year in energy costs. Riverhouse's technologies, which include a central air system, tracking photovoltaics, triple-glazing on the curtain wall façade, efficient lights with sensors, and programmable thermostats, have contributed to 20% in energy savings compared to a base case. Riverhouse's measures will reduce its carbon emissions by 62,800 tons annually, but construction costs were only 5% higher than those of similar condominium buildings in New York City.

Rental Premium Increases for Green Buildings



In addition to energy saving benefits, green buildings also command higher rental prices as seen in this sample of green building projects internationally (Source: The Business Case for Green Buildings).

BEST PRACTICES

- CONSTRUCT HIGH-QUALITY BUILDING ENVELOPES: High quality building envelopes with the appropriate amount of insulation and high-performance glazing cut heating and cooling loads. Low-emissivity windows are also an important feature: they stabilize temperatures by increasing the thermal efficiency.

- USE ADVANCED HVAC EQUIPMENT AND CONTROLS: New technologies heat and cool exactly when and where needed, at minimum energy use.

- MINIMIZE CONSTRUCTION WASTE: Pre-fabricated building materials improve building quality and longevity in many types of construction while also minimizing construction waste. Using recyclable materials or re-using materials can also help to minimize construction waste.

- REDUCE ENERGY CONSUMPTION IN EQUIPMENT AND FIXTURES: Highly efficient mechanical systems and efficient lighting are two ways to improve energy efficiency at low cost.

- USE GREEN SPACE AND VEGETATION: Features such as gardens and green walls provide much better experiences for users. Low water-use plants can also help improve air quality.

- INSTALL BIKE PARKING AND SHOWERING FACILITIES: Safe and secure bike parking coupled with good showering facilities can increase biking and make it more pleasant.

- ENSURE HIGH QUALITY PROPERTY MANAGEMENT THROUGH DATA COLLECTION: Good auditing, metering, and care of the property can ensure that the energy and water savings from a green building are captured.

The Riverhouse development project in Manhattan's Battery Park City.

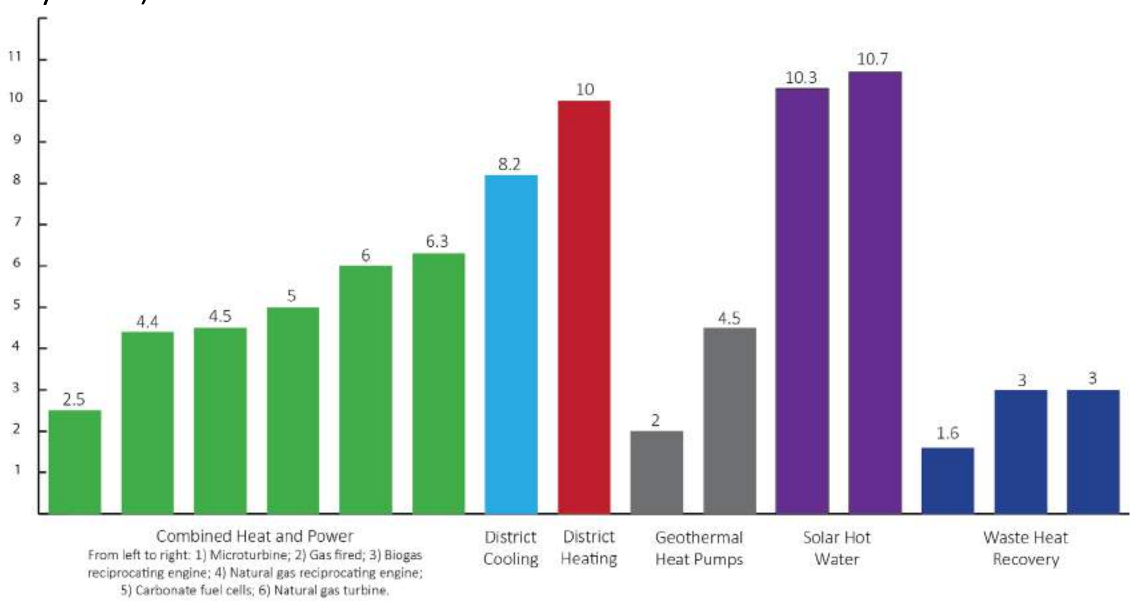
10 RENEWABLE AND DISTRICT ENERGY

Every project should analyze the potential for district energy, such as combined heat and power (CHP), waste to energy, and waste heat re-use. There should be 5-15% local renewable energy generation for residential areas and 2-5% for commercial areas.

RATIONALE

District energy can result in a 30-50 percent reduction in primary energy consumption. A good example is Denmark, which as seen a 20 percent reduction in CO_2 emissions from implementing district heating. In China, the benefits from district energy are already happening – in Anshan, 1 GW of waste heat is being captured from a nearby steel plant. Renewable energy is also falling rapidly in cost and increasing in efficiency – solar, wind, solar hot water, geothermal are all options that every project should consider to both recover technology investment costs and to improve overall energy efficiency. District energy projects are ideal for private-public partnerships that can both stimulate the local economy and provide the local government with a source of revenue, rather than energy payments going to outside firms or foreign markets.

Sample Payback Periods for Various District Energy Projects (in years)



This data reflects the payback periods for a number of district energy technology projects across the United States. Although there is variance in terms of local energy prices, payback periods show that the technologies are generally market viable.

BENEFITS

ECONOMIC

CREATES INCOME STREAM FROM WASTE: In the Anshan case study, capturing waste heat created a business model that created economic value for the city, district energy companies, and private companies (UNEP 2015).

POSITIVE LOCAL ECONOMIC SPILLOVERS: Cities can boost their economies by localizing energy production. In St. Paul, $12 million in energy expenses stayed in the local economy instead of having to pay out to fossil fuel importers (UNEP 2015).

CREATES LOCAL JOBS: In Oslo, Norway, district energy improvements led to the creation of 1,375 full-time jobs (UNEP 2015).

IMPROVES ENERGY EFFICENCY AND SECURITY: If connected to the central grid, distributed energy can reduce the peak load demand for the central grid and improve grid efficiency. Local energy generation can decrease the risk of energy security issues when centralized generation fails (UNEP 2015).

ENVIRONMENTAL

REDUCES GREENHOUSE GAS EMISSIONS: In Milan, a district energy program led to a reduction of 2.5 tons of particulate matter, 70,000 tons of CO_2, 50 tons of NO_x, and 25 tons of SO_2 in 2011 (UNEP 2015).

IMPROVES AIR QUALITY: By using CHP, waste heat, and renewable energy, cities can significantly improve air quality by replacing coal with these cleaner sources of energy (UNEP 2015).

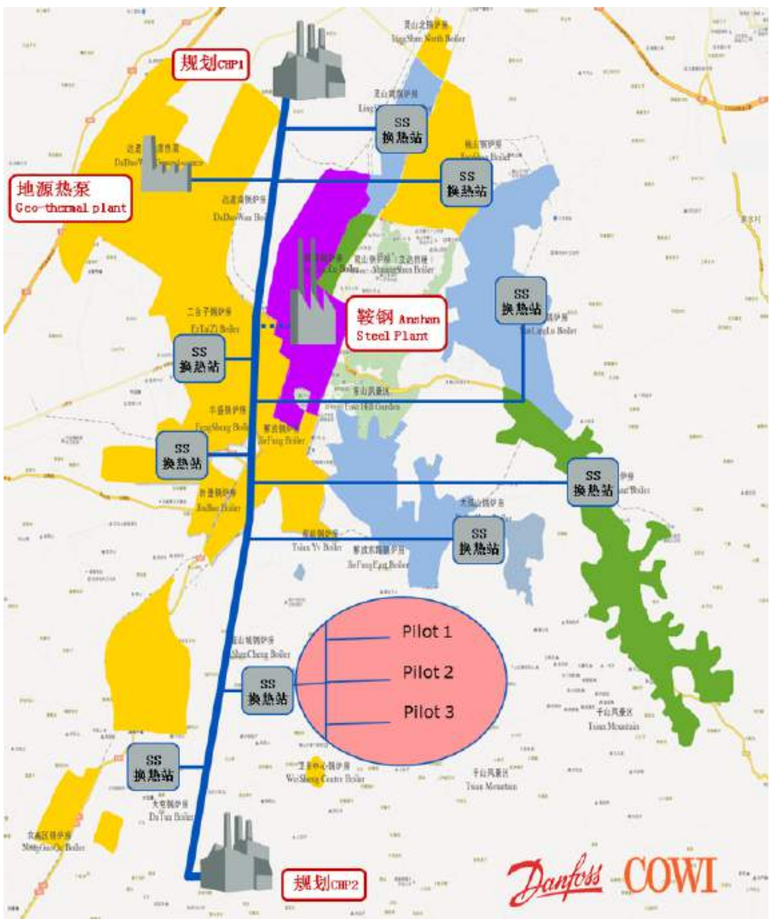
SOCIAL

IMPROVES SAFETY: Potentially dangerous equipment such as boilers, gas supply, etc. can be kept out of the building when using district energy systems. This improves the safety of building residents (UNEP 2015).

IMPROVED THERMAL COMFORT: For residents in certain climate zones in China, lack of district heating can mean inferior comfort quality for residents (UNEP 2015).

IN PRACTICE: ANGANG STEEL, ANSHAN

Near Anshan, the Angang Steel plant produces 1 GW of surplus heat and could soon meet 70% of the city's total heating needs. The local government is working with Danfoss and COWI, two Danish district energy companies, to create a new transmission line that will carry waste heat generated from the plant; this heat will then be converted to steam to turn a turbine. The transmission line plans to incorporate heat from two CHP plants and will allow for future connections with other heat sources. Angang Steel will receive a set tariff of RMB 0.11 per kWh. The project will be connected in stages, with the first stage heating 6.7 million m^2 and with the second stage heating 10 million m^2. The project will mean avoiding using 1.2 million tons of coal per year and the payback period is a mere 3 years. Anshan will also see improved air quality and lower greenhouse gas emissions.



This map shows the structure of the waste-to-energy project in Anshan. As a result of the waste heat from Angang Steel, 70% of the city's heating needs were met (Source: Danfoss).

BEST PRACTICES

- **USE INTEGRATED ENERGY PLANNING AND MAPPING:** Start with energy efficiency to reduce and smooth energy demand profiles and then use all cost-effective district energy and renewable energy options.

- **USE NET METERING POLICIES AND INCENTIVES FOR FEED-IN OF DISTRIBUTED GENERATION:** These can greatly affect the overall cost effectiveness of district energy technologies.

- **ENABLE GRID ACCESS FOR CHP AND OTHER DISTRICT ENERGY PROJECTS:** This is a precondition for net metering and the authorities should make this process simple and fast.

- **OPTIMIZE WITH MIXED-USE ZONING:** Having a more diverse set of energy users reduces variability in demand over time. This in turn lowers the unit costs related to district energy infrastructure per square meter of building. Establishing an anchor load is useful and can help to secure the initial build-up of a district energy system.

- **COMPACT LAND-USE IMPROVES DISTRICT ENERGY SYSTEMS:** The closer together the buildings are, the less piping is needed to connect them, which decreases costs and energy losses.

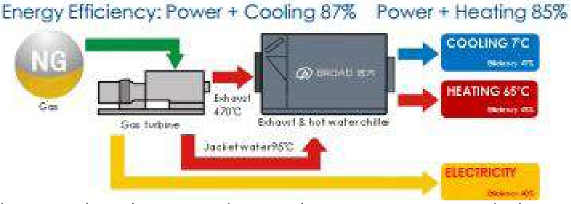
BROAD Exhaust and Hot Water Combined Cooling, Heat and Power (CCHP) System in Shanghai Hongqiao CBD

Hongqiao CBD is a large-scale integrated complex with urban functions

The largest power generation capacity of distributed energy system in China

- Power generator supplies electricity to buildings, BROAD chillers recycle exhaust & jacket water for cooling, no fuel input
- Cooling capacity 12,000kW
- Heating capacity 9,978kW
  8×Exhaust, hot water & direct fired chillers
  Cooling efficiency 106%
- Power generator capacity 12,000kW
  8 x Engines
  Power generation efficiency 40%
- Payback period 3.5 year
- Yearly energy saving 9,000 ton oil
- Yearly CO_2 cutting 27,000 ton
- Equivalent of planting 1,458,000 trees

Energy Efficiency: Power + Cooling 87% Power + Heating 85%



This shows a CCHP system in Shanghai CBD, the payback period is only 3.5 years and the efficiency for both cooling and heating is over 85% (Source: BROAD).

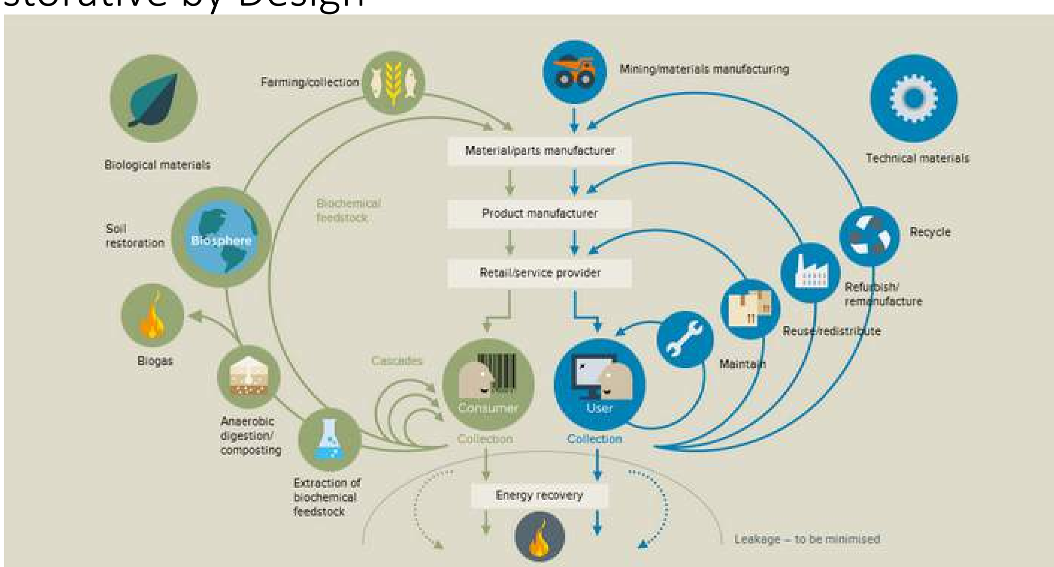
11 WASTE MANAGEMENT

All buildings should have waste classification facilities. All household waste must be sorted and collection of hazardous waste must be prioritized. At least 30-50% of waste should be composted and 35-50% recycled or re-used.

RATIONALE

China produces 254 million tons of garbage each year, which amounts to one-third of the world's garbage output. For example, in Beijing, waste quantity is growing at about 8% a year with statistics showing that only 4% is recycled. For waste management in China to be sustainable, a significant amount of waste must be diverted from landfills. Recycling and composting are simple strategies to reduce waste going into landfills. Building owners can sell recycling and composting to reduce costs of waste disposal. Local governments and developers can create sustainable recycling and composting systems that will lead to long-term benefits.

The Circular Economy: An Industrial System that is Restorative by Design



This graphic shows the idea model for waste - in which waste is recycled, composted, or recovered as energy in a closed-loop system.

BENEFITS

ECONOMIC

AVOIDS COST OF DISPOSAL AND CREATION OF NEW INCOME STREAMS: By recycling and composting, buildings can avoid the cost of disposal and instead make money from selling recyclable materials (New Jersey WasteWise Business Network 2013).

LOCAL JOB CREATION: Waste is an indicator of incomplete resource utilization. If 75% of waste in the Unted States were diverted from landfills, over 2.3 million jobs can be created (Tellus Institute 2015).

ENVIRONMENTAL

IMPROVES AIR QUALITY AND REDUCE GHG EMISSIONS: Food that is not properly composted turns into methane in landfills, which pollutes the air and has 21 times the global warming potential (per unit mass) of carbon. Alternatively, food waste should go through anaerobic digestion and be used to produce biogas or properly incinerated (Älgevik 2015).

REDUCES WASTE IN LANDFILLS: After the City and County of San Francisco rolled out its residential three-stream program (compostable, recyclable, and trash) to 130,000 single family and 20,000 buildings, waste going to the landfill was reduced by 24% (SF Environment 2015).

COMPOSTING ENRICHES SOILS: Compost can regenerate soils, suppress plant diseases and pests, reduce or eliminate the need for chemical fertilizers, and promote higher crop yields (U.S. EPA 2015).

IMPROVES ECOSYSTEM HEALTH: When not properly recycled or composted, waste can cause eutrophication from nitrogen equivalents, acidification from sulfur dioxide equivalents, and ecosystem toxicity from herbicides.

REDUCED GROUND AND SURFACE WATER POLLUTION: Storage and transport of solid waste can contaminate surface and ground waters.

SOCIAL

REDUCES SANITATION RISKS: Placing food scraps and organic waste in a closed, leak proof, and durable container and having it picked up can reduce the health risks of attracting rodents and insects.

IMPROVES HUMAN HEALTH AND HYGIENE: By diverting waste from landfills, composting and recycling can significantly reduce harmful emissions, smells, pests, and dust (Tellus Institute 2015).

IMPROVES AESTHETICS: Optimized waste management can reduce dumping at uncontrolled sites that detracts from an area's livability.

IN PRACTICE: SAN FRANCISCO, CALIFORNIA

By 2010, San Francisco was already diverting 77% of its trash from the landfill and the local Department of the Environment estimates that it could reach a 90% diversion rate by 2020. Through a public-private partnership with Recology, a local waste disposal company, San Francisco has residents pay based on the volume of trash disposed while Recology retains revenues from recycling and composting services. Recology provides the color-coded containers for residents and businesses. Since the ordinance passed, there has been a 50% increase in businesses using the service and a 300% increase in apartments using the service. This type of program can be adapted to the building, neighborhood, or city level.

Recology provides recycling, composting, and landfill bins to all residents in San Francisco. They also have education and awareness campaigns to increase rates of separation among residents. This kind of system might not be suitable for high-density areas. For those areas, the local government should be careful to not let waste bins obstruct walking and biking paths. For new developments, a waste vacuum system could also be a low-maintenance and cost-effective option.

BEST PRACTICES

- **MAKE SORTING WASTE EASY AND HAVE RELIABLE PICK-UP:** The city or a private contractor should provide free color-coded containers for residents and businesses. Habit formation is essential to locking in sustainable strategies. By offering a consistent and reliable pick-up schedule, residents and building owners can easily plan for it.

- **PRIORITIZE WASTE MINIMIZATION:** Re-use, recycling, and energy recovery should be considered next, with landfilling a last resort.

- **PLAN FOR WASTE STORAGE:** Depending on local conditions, waste pick-up times could vary and building operators must consider storage options for waste if there is a longer lag between pick-up times.

- **AVOID MIXING HAZARDOUS WASTE WITH OTHER TYPES:** Waste toxicity can be greatly reduced if special care is given to avoiding mixing hazardous waste, e-waste, and medical waste with other refuse.

- **USE INNOVATIVE TECHNICAL SOLUTIONS:** Technologies such as vacuum waste collection can substantially reduce or even eliminate the need for heavy trucks to access waste collection sites and the need for open storage of waste. Circular economy innovations can also incentivize users to generate less waste, and increase reuse, repair and recycling that can be applied on a local schedule.

This shows the order of operations when it comes to waste management - minimization, re-using, recycling, and recovering should all be considered before landfilling.

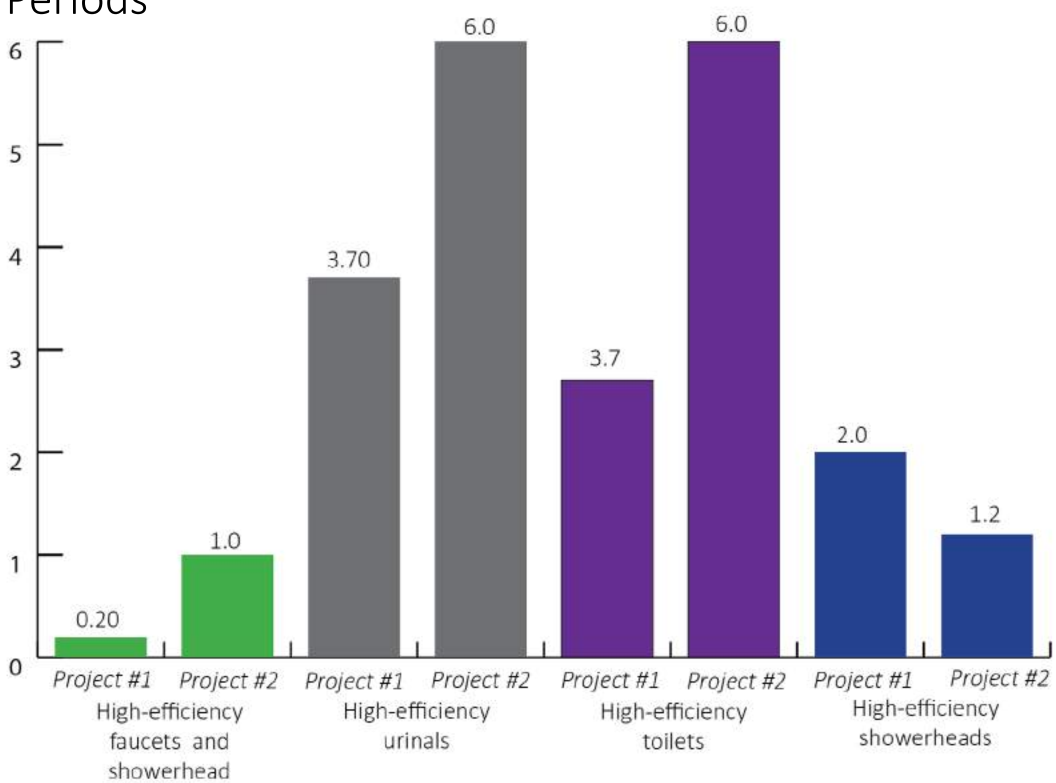
12 WATER EFFICIENCY

All buildings must have 100% adoption of water saving appliances, and green spaces surrounding buildings must adopt low water-use plants. All water consumption should be metered and at least 20-30% of water supply must be recycled from either wastewater or rainwater.

RATIONALE

China is suffering from water scarcity, especially in the northern regions. About 300 million Chinese lack access to safe drinking water. Water efficient fixtures, appliances, and plants can easily decrease water use. Water efficiency has significant energy benefits as well. Reducing water use also reduces the energy needed to heat, move, and treat it. Fixtures such as high-efficiency toilets and low-flow showers and faucets can make a big difference. For example, in California, switching from 2.8 gallon per flush toilets to 1.28 gallon flush toilets would save 260 million gallons of water per day.

Sample Water Efficiency Projects and their Payback Periods



Water efficiency technologies are cost-effective. These payback periods reflect water effeciency retrofits completed in various projects in the United States. It shows that these technologies are all market viable even when a diversity of technologies and local circumstances are accounted for.

BENEFITS

ECONOMIC

ELECTRICITY SAVINGS: Adopting water efficiency measures can also save money on electricity. In Guelph, Toronto, simple water efficiency measures are saving the small city of 120,000 more than $2,700 a week in water and wastewater electricity expenditures (Maas 2009).

LABOR AND EMPLOYMENT STIMULUS: Government investment in water efficiency technologies, such as high efficiency toilets in the U.S., can generate benefits that are 2.5-2.8 times the investment in terms of labor income, employment, and GDP growth (Baker et al. 2008).

REDUCES COST OF WASTEWATER TREATMENT: By reducing water use through efficient appliances, cities can save money on wastewater treatment costs.

REDUCES O&M COSTS FOR BUILDING MANAGERS: Efficient water appliances can reduce costs in terms of water, wastewater, and energy for heating. In a RAND study, investments in non-water-using urinals, high-efficiency toilets, and high-efficiency faucets yielded rates of return greater than 500% (Groves et al. 2007).

ENVIRONMENTAL

REDUCES HOUSEHOLD ENERGY USE: If households use efficient showers and faucets, they can reduce energy use and carbon emissions. Most water efficiency technologies like low water-use faucets and high efficiency toilets are cost-effective.

REDUCES GHG EMISSIONS: In California, urban water use accounts for 70% of the electricity associated with water supply and treatment. Utilizing more efficient water appliances can reduce the emissions associated with this electricity use.

SOCIAL

IMPROVES WATER SECURITY: Just like China, California is confronting water scarcity issues. California's strategy for urban water efficiency is based on benefits such as the ability to stretch existing water supplies and the ability to provide water for surface or groundwater storage in wet years (California Department of Water Resources 2015).

HELPS WATER DISTRESSED COMMUNITIES: For Chinese cities with acute water scarcity issues, smart and strategic planning in terms of water appliances for urban buildings can help ensure the water supply meets demand.

IN PRACTICE: RAND BUILDING

The RAND Corporation developed a quantitative methodology to help building supervisors maximize benefits and minimize environmental, energy, and financial costs. In a series of studies, companies retrofitted toilets or replaced them with more efficient models; converted to washout or ultra low-flush urinals; retrofitted faucets; replaced showerheads; replaced single-pass cooling devices; and minimized water loss from cooling towers. For one of the buildings, the total package involved an investment of less than $70,000. They then evaluated the economic efficiency of the water-saving improvements. They found that measures all lead to water savings, energy savings, and eventually economic savings. The net present value of installing high-efficiency toilets and non-water using urinals, and replacing faucets and showerheads was over $98,000, and the payback period was 7.2 years.

This graphic shows energy intensity of each stage in the water use cycle with key opportunities for energy efficiency, renewable energy, and water efficiency at each stage.

BEST PRACTICES

- **USE METERING AND AUDITING TO DETECT LEAKS:** Water metering and auditing can identify leaks in pipes and fixtures, which is the low-hanging fruit in improving water efficiency.

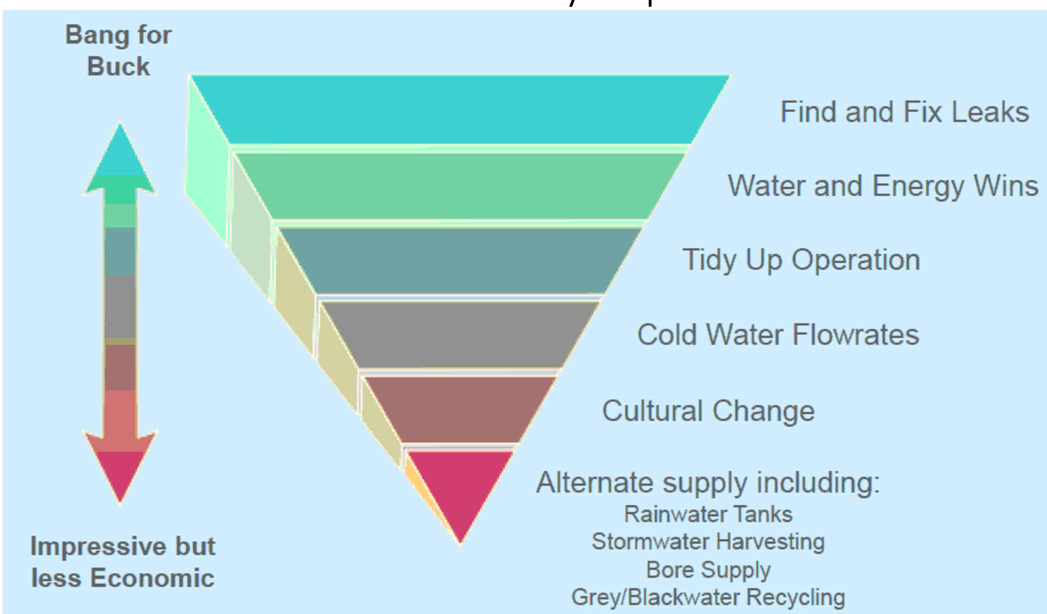
- **USE LOW WATER-USE PLANTS:** Low water use plants require one-tenth as much water as high water use plants.

- **CALCULATE ENERGY AND WATER SAVINGS TOGETHER TO DETERMINE BENEFITS:** Many water efficiency measures can also save lots of energy. To accurately determine the return on investment on appliances, consider the energy savings in addition to the water savings.

- **UTILIZE GREEN SPACE FOR RAINWATER MANAGEMENT:** Gardens can effectively improve wastewater quality while also helping to prevent flooding.

- **CONSIDER HARVESTING RAINWATER AND CONDENSATE:** Rainwater and condensate harvesting can also improve water efficiency.

Cost-Effective Water Efficiency Improvements



This is a ranking of the most cost-effective water efficiency improvements. Finding and fixing leaks is the most economically efficient way to decrease water use.

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