Sustainable Systems Integrated Model (SSIM)

Modeling Techniques for Low-Carbon Cities

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Cities face rising challenges. These range from coping with the stresses of modern urbanization to providing systems to serve growing populations. But the biggest challenge will be that of climate change. The trend is towards designing low carbon cities. Ultimately this will mean modern and environmentally friendly approaches to urban design, city planning, public transit, energy and buildings. The Sustainable Systems Integrated Model (SSIM) is organized around the core themes of mobility, energy, water, building technology, socio-cultural assets, ecology, and carbon footprint and involves a multi-step process utilizing modeling and cost-benefit analysis techniques. The outputs are a sound and defensible whole systems sustainability and carbon reduction strategy. Through this, a developer can optimize the environmental value of the final sustainability program, minimize costs relative to the benefits achieved, develop a low-carbon strategy and achieve exemplary status as a sustainable new community.

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Cities are gatherings of people, infrastructure and systems. But what makes a city sustainable? That is the question posed by many. Can cities face up to the challenges of a carbon-constrained world? How should we respond and, more importantly, how do we plan cities of the future for low carbon purposes? We look at aspects of cities and what these challenges mean. We further introduce a technique, the Sustainable Systems Integrated Model, that has been applied in mainland China for modeling a low carbon city.

Literature Review

We have seen remarkable changes over time in the confluence of people into cities attracted by economic benefits as well as more comfortable lifestyles.

According to Jeffrey Sachs[1]:

'The essence of city life is a non-agricultural community that obtains most of its food by trading with the rural countryside or that extracts food from the countryside in a coercive manner (e.g. taxation, slaveholding, tribute). Where agricultural food sources and supply chains exist to provide for the needs of urban populations, activities such as manufacturing and services flourish as a function of urban density.'

Urbanization or the growth of cities took place as a result of scientific farming methods involving chemical fertilizers, modern irrigation, mechanization and innovations in farming management. This has permitted a small proportion of the world's population to feed all the rest and thereby enabled a rising share of the world to live in cities. People have migrated to cities as opportunities arose allowing them to abandon rural lives in search of more challenging and rewarding jobs. Technology, science and productivity have all advanced due to specialization and division of labor.

In 1900, the urban share of the world's population was 13 percent, rising to 29 percent in 1950 and 50 percent in 2007. Today, the developed world has a proportion of 75 percent urbanization, compared to the developing world's share of 44 percent. By 2030, projections show that the world is expected to reach a 60:40 split between urban and rural populations. In Asia, it is expected that the urban population will significantly outnumber their rural counterparts as early as 2022.

In terms of cities, in 1950, there were only two of what we would term 'megacities' in the world, Tokyo and New York. A megacity is one whose citizens number more than 10 million. By the turn of the century, there were 18 megacities in the world, 10 of which were in Asia, three being in China.

What does this mean for society? There are some implications to consider. Take China for example. According to a report by McKinsey consultants[2], by 2025, the country will have increased its urban population by 350 million. This means that there will be over 200 cities with more than one million inhabitants, 24 cities with more than five million people and eight megacities. This growth will cause major stresses for many mainland cities not just from demand and supply pressures on land, energy, water and the environment but also from the viewpoint of securing sufficient public funding for the provision of social services. The report goes on to state that by 2025, about 1,000 GW of extra power capacity will be needed as well as an increase of 5 million km of road, 28,000 km of railway and 50,000 new skyscrapers.

It is clear that many challenges lie ahead for planners, architects, engineers and other professionals to come up with new ways to serve these densely concentrated populations efficiently and effectively. It is worth noting though that, given comparable income and lifestyle patterns, in reality residents of cities use far less energy per head than equivalent rural communities living in single family houses. Not only is the sharing just in terms of energy but city residents furthermore share walls, floors and ceilings with their neighbors, which means less materials required to build structures in the first place.

In a study conducted on 40,000 residents[3], it was found that the footprint imposed by urban dwellers was significantly lower than their suburban counterparts.

Despite the advantages of scales of efficiency, cities still nonetheless encounter certain problems. Concentrated populations are more prone, for instance, to the risk of spread of infection and the impacts of natural disasters (e.g. earthquakes, floods, landslides) which are amplified in crowded spaces. Pollution caused by man-made activities also accumulates within densely packed communities.

	Suburban	Urban
Residents per hectare	18	140
Areas needed (ha)	2,222	285
Traveling (km per day)	2,000,000	700
CO2 tonnes per year	180,000	65,500

Table 1 Comparison of Urban and Suburban Populations

According to the Clinton Climate Initiative, cities worldwide consume some 75 per cent of the world's energy and are responsible for up to 75 per cent of the greenhouse gas emissions that are linked to climate change. The debate on climate change will no doubt continue beyond 2012, the date that the new Kyoto Protocol commences, but what is apparent is that cities, particularly those located on low-lying coastlines, are vulnerable to any climate change-related events, especially flooding. As outlined by the World Bank[4], cities seeking climate change resilience need to be mindful of certain adaptation strategies:

Guidelines	Examples in Asia
Create institutional mechanisms for dealing with climate change	Singapore National Climate Change Strategy which is a multi-stakeholder initiative
Prepare a climate change strategy Generate public awareness	Tokyo Climate Change Strategy Dagupan City, Philippines which promulgates a culture of safety
Account for and report on GHG emissions	In 2004, Makati City in the Philippines carried out its GHG emission inventory
Create a climate change disaster risk management system	Hanoi city in Vietnam has a dedicated national Disaster Management Unit
Mitigate the impacts of the energy sector	Singapore city has adopted Combined Cycle Gas Turbine technology to improve energy efficiency in buildings
Mitigate impacts of transport sector	Jakarta has instituted the 'three in one' car sharing program during morning and evening rush hours
Mitigate impacts of built environment	Singapore's Green Mark scheme is mandatory for all new buildings
Expand urban greenery	Makati City has established a city policy of tree planting
Invest in infrastructure	Navotas City in Metro Manila, has constructed sea walls and pumping stations along areas vulnerable to flooding

Table 2 Climate Resilience in Cities

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[1] Sachs, J. "Common Wealth, Economics for a Crowded Planet" (2008)

[2] McKinsey Global Institute, 'Preparing for China's Urban Billion' (2008)

[3] Vaughan, A., 'City dwellers have smaller footprint', The Guardian (March 23, 2009)

[4] World Bank, 'Reducing Vulnerabilities to Climate Change Impacts and Strengthening Disaster Risk Management in East Asian Cities" (2009)

As cities develop, other challenges will emerge. Much has already been discussed on population expansion but there will also be a need to re-design more facilities for ageing populations, as the longevity of citizens increases due to better healthcare and living conditions. Urbanization also gives rise to greater and increasing disparities in wealth between economic sub-groups in the cities, much of which is exacerbated by divisions in housing standards with class-oriented buildings.

But the biggest challenge will be that of climate change.

To cope with climate change, there is a growing school of thought that low carbon cities are the direction we should be heading for. This means that modern and environmentally friendly approaches must be adopted for urban design, city planning, public transit, energy and buildings such as:

- Mobility - extensive use of public transport systems and pedestrianized areas, integrated zones for residential, industrial and commercial use
- Optimal building density – vertical as well as lateral structures
- Greater adoption of renewable energy
- Urban water demand management - an integrated approach for safeguarding of supply sources and maintaining efficient delivery and disposal systems
- Large park systems and open spaces with extensive greenery and natural ventilation systems
- Smart growth – reduced urban sprawl and construction of green buildings or green retro-fitting

Land use will take on new forms based on connectivity with smooth grid-like patterns to limit traffic congestion and distance between homes, and walkability where destinations will be in close proximity taking away the need for transport infrastructure. Buildings will be clustered together in specific plot areas so that businesses can provide more appropriate goods and services using small and unique shops to serve community needs, and mixed land uses combining retail, commercial and services with residential and offices in the same area will generate a diversity of people (age, income, culture) and create a stronger sense of belonging. Accessibility to different modes of transit, especially train and light transit, will be key to placing people in closer vicinity to shops and businesses.

Other specific examples include:

Transit-oriented development

Transit-oriented development (TOD) is a means of integrating land use and transportation planning at local and regional level to enhance access to goods and services and maximizing community-oriented travel. TOD uses a mixture of hard and soft measures to promote voluntary travel behavior change which include bicycle and pedestrian-friendly land use initiatives e.g. cycle paths and safe urban spaces. Integration of non-motorized transportation and public transit, access to high quality, frequent and safe public transportation for long distance trips, and promotion of demand initiatives such as car pooling are also implemented under TOD. Use of expanded telecommunications services to facilitate reductions in work and shopping travel are also important. Flexible parking policies are used to complement TOD e.g. parking limitations, pricing, adaptive reuse of parking lots, unbundling of housing and parking costs together with financial incentives e.g. location efficient mortgages and employee preference housing to reduce travel demand.

Green roofs

In cities, green roofs and living walls (building integrated vegetation) can improve thermal performance of buildings by insulating the latter from solar radiation. A study in Chicago showed that the variation in temperature for a green roof was 6 degrees Celsius, compared to a conventional roof temperature difference of 45 degrees Celsius. Depending on the roof substrate, transpiration from vegetation has a greater cooling effect and recycled water can be used to boost evaporative cooling. A roof garden of more than 500 mm of growing medium retains more than 90 percent of its annual rainfall, thereby reducing the need for drainage infrastructure.

Rainwater harvesting

Urbanization results in coverage of porous or previously vegetated areas, which in turn decreases rainfall infiltration and leads to run-off (which is often polluted) and risk of flooding. The use of land resources thus to collect and treat rainwater is a good way to recycle and reuse the latter, as well as reducing the energy intensity associated with more conventional means of water collection, treatment and distribution. A good example is to use natural systems like wetlands[6] to detain and treat water as an alternative to traditional wastewater treatment technologies that are fossil fuel dependent. Minimal fossil fuel energy or chemicals are required to maintain treatment processes in this case.

Methodologies

If a low carbon city is the goal, how do we make sure we are achieving the right results? Sustainability measurements are the answer. Many experts have proposed methods of measuring sustainability in cities.

- The SustainLane US City Rankings is a peer-reviewed national survey that ranks the most populous US cities in terms of their sustainability practices[7].
- Forum for the Future uses a sustainable cities index of 13 indicators ranking the largest 20 British cities[8].
- In Hong Kong, the Canadian Chamber and City University conduct an annual Hong Kong Sustainable Development Index survey to measure sustainability[9].

The Sustainable Systems Integrated Model (SSIM) is a tool not just for measuring sustainability and low carbon performance of development projects but also for helping developers to make strategic project decisions based on what they will get for a certain sum of investment. The model is organized around the core themes of mobility, energy, water, building technology, socio-cultural assets, ecology and carbon footprint, and involves a multi-step process utilizing modeling and cost-benefit analysis techniques. The output is a sound and defensible whole systems sustainability and carbon reduction strategy. Through this, a developer can optimize the environmental value of the sustainability program and minimize costs relative to the benefits achieved to develop a low-carbon strategy, and achieve exemplary status as a sustainable new community.

The model:

- Identifies which alternative masterplan provides the highest level of sustainability
- Creates a Master Sustainability Program for the design and construction of infrastructure, the public realm and buildings

In the long term, cities will be focused on smart solutions such as:

Aspect	Smart technologies
Intelligent buildings	Sensors inside buildings to monitor everything from motion and temperature to humidity, occupancy and light; consumers and business owners to monitor their energy consumption and carbon emission in real time and take action to reduce them. Building envelope (especially roofs) should be used as green roofs, building integrated PV or solar heating appliances.
Smart grids	Cars and city buses to run on new battery technology based on smart grids so that vehicles can be charged in public places with use renewable energy sources, such as wind power, feeding into the grid.
Water systems	Smarter water systems to reduce water waste by up to 50 percent and sewer systems that not only prevent run-off pollution in rivers and lakes, but purify water to make it drinkable. Advanced water purification technologies will help cities recycle and reuse water locally, reducing energy used to transport water by up to 20 percent.
Public safety	Cities to reduce and even prevent emergencies, such as crime and disasters based on state-of-the-art systems for collecting and sharing real time data e.g. automated levee systems to prevent cities from devastating floods.

Table 3 Smart City Solutions

- Identifies carbon reduction and offset strategies which deliver the lowest cost per ton of GHG reduction
- Provides capital, recurring and life-cycle cost estimates and cost/benefit analyses for alternative sustainability strategies
- Provides detailed numerical outputs
- Attributes costs and benefits to various pre-defined cost centers – government, developers and end-users

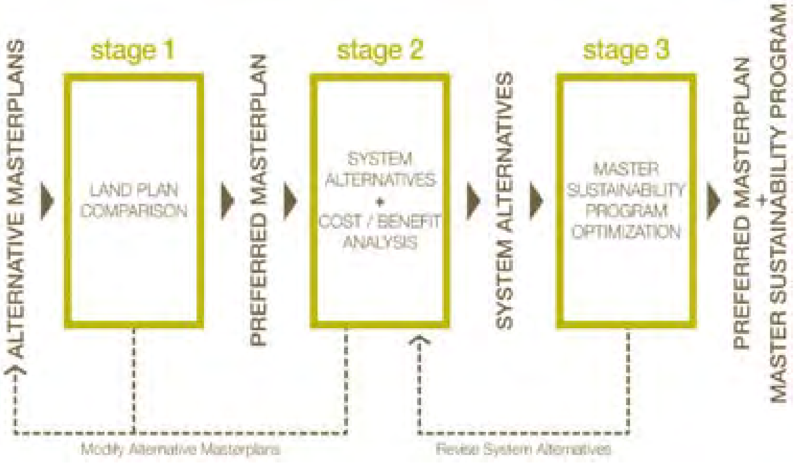

Figure 1 Sustainable Systems Integrated Model

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[6] Kadlec, R. and Knight, R. 'Treatment Wetlands: Theory and Implementation' CRC Press (1995)

[7] www.sustainlane.com/ us-city-rankings

[8] www.forumforthefuture.org/files/sustainable_cities

[9] www.cancham.org/asp/HKSDI_Initiatives.asp

In Stage 1, a GIS-based modeling tool is used to compare the sustainability merits of alternative urban form solutions. A spatial analysis model is used to measure aspects of urban form such as built form density, land use mix, walkability, proximity to transit and amenities, and number of dwelling units. A conceptual sketch is done for each proposed scheme. Each scheme is then evaluated for the lowest inherent carbon footprint per resident or worker, highest level of local trip capture, land use balance etc. Based on the outputs of Stage 1, various modifications and improvements to both the masterplan framework and the land use program can be analyzed.

In Stage 2, the core themes used are residential building energy, retail building energy, office building energy, industrial building energy, transportation, green building, water, public realm energy, ecological systems, socio-cultural infrastructure and urban heat islands. A base case of conventional development and building practices is defined for each core theme followed by 'good', 'better' and 'best' levels of increasing sustainability efficiency. Models for each core theme are run to define which combination of strategies, measures and technologies work most effectively. These form packages of design measures which are individually subjected to first-cost and life-cycle cost analysis and the percentage improvement achieved by each package is compared. Cost benefit analysis is also carried out to determine which combination of design measures achieves the highest reduction in resource use or carbon footprint at the lowest incremental cost.

In Stage 3, a comprehensive all-systems Master Carbon Reduction Program (MRCP) is set up. Outputs of the program are based on total building energy savings, total public realm energy savings, total reduction in vehicle kilometers traveled (VKT), total water savings, total reduction in GHG emissions, total initial costs, and total ongoing monthly costs. The MCRP is tested using various core theme packages until a version is derived that is consistent with the goals, business plan and financial model of the developer. Often the MRCP can attain a total carbon reduction of 15-25 percent based on core theme packages alone. If a higher carbon target is sought, then a freestanding renewable energy or carbon sequestration offset can be added.

Case study – new town in mainland China

The Beitang New Town project, located in the Tanggu District, Tianjin, occupies approximately 10 square kilometers in area and consists of villages (where basic services are lacking or sub-standard), some newer residential development, limited commercial development and significant portions of environmentally degraded and undeveloped land. The Tanggu District was once home to healthy wetlands but suffers from a legacy of former polluting industrial development.

The aim of the project was to redevelop the area into an inhabitable place for an expanding population. The Tanggu District government had broader aspirations to create a new national benchmark for eco-cities in northern China in line with the central government's green policies. The Tanggu District government further believed that the Beitang community could reduce its ecological, climate and resource impacts from the outset while seeking increasing levels of environmental performance as the community developed.

The key challenges faced were:

- Economic Constraints - The situation of the world economy generated additional pressure to achieve meaningful increases in balanced sustainability. Against the backdrop of the recovery market, cost sensitive product solutions would be needed in developing strategies that allowed real increases in energy, water, and mobility efficiencies while maintaining "good fit' within the city's budget.
- Planning Approach – Another key challenge was the lack of a systematic planning approach to help governmental agencies and developers evaluate the complex interrelationship of environmental indicators (e.g. carbon footprint, energy consumption, potable water usage, vehicle kilometers traveled, etc) and the various sustainability measures with valid cost/ benefit economic information.
- Implementation Strategies – As the goals for sustainability are often set without due consideration of the local context, interactions of various systems and cost implications, it was important to have sustainability strategy guidelines that covered the economic implications of decisions.

Using SSIM, the Tanggu Beitang Sustainability Program was developed through the multi-step process utilizing planning concepts, greenhouse gas reduction strategies and system modeling techniques. The process examined the primary land development components that affect energy consumption, water use and greenhouse gas emissions, including:

- Project location –as related to primary job and service centers
- Urban form – the degree the project was organized around centers of jobs, services and higher density land use
- Transportation – both external linkages and the level of connectivity within the project, as well as the level of multi-modal choice
- Building energy –increased energy efficiency within the building stock and the addition of renewable energy on the building and freestanding within the community.

A secondary tier of energy use came from public realm (street lights, parking lot lighting, park and open space), water (treatment and movement of domestic and waste water) and the construction process. In addition to potentially emerging lower energy and carbon requirements for development, there was increasing pressure to reduce domestic water use.

A key contributor of GHG for many new projects is vehicle emissions particularly in lower density areas. The urban design form of a community, the mix of land uses and the densities of cores and centers can significantly reduce VKT and associated emissions. The Tanggu Beitang Sustainability Program reflected an integrated planning process that addressed the interrelationships of these natural and man-made systems. Changes or improvements in one system were leveraged to reduce the costs or improve the performance of other systems.

The process of developing a sustainability program for Tanggu Beitang went through three stages.

Stage 1: Urban Framework Base Modeling

Three alternative master plans were presented: an existing plan and two options. SSIM started by utilizing a proprietary GIS-based modeling tool to compare the sustainability merits of each alternative master plan solution. The urban form of each scheme was evaluated through a variety of indicators to ascertain which has the lowest inherent carbon footprint, highest trip capture, connectivity, land use balance, etc. A spatial analysis model was used to measure an elementary level of sustainability through a limited set of indicators, including:

- Jobs/housing ratio
- Percent overall ecological preservation
- Natural lands connectivity index
- Percent jobs walkable from transit
- Carbon sequestration from urban forestry
- Parks per 1000 population
- Percent land with impervious surface
- Total storm water runoff
- Energy use per person
- Water use per person
- Gasoline consumption per person
- Vehicle kilometers per person
- CO2 Eq MT total
- CO2 Eq MT per person

Figure 2 Alternative Masterplans

These outputs were compared across the three alternatives. On this basis, the master plan with most inherent sustainability potential was identified as the Preferred Master Plan.

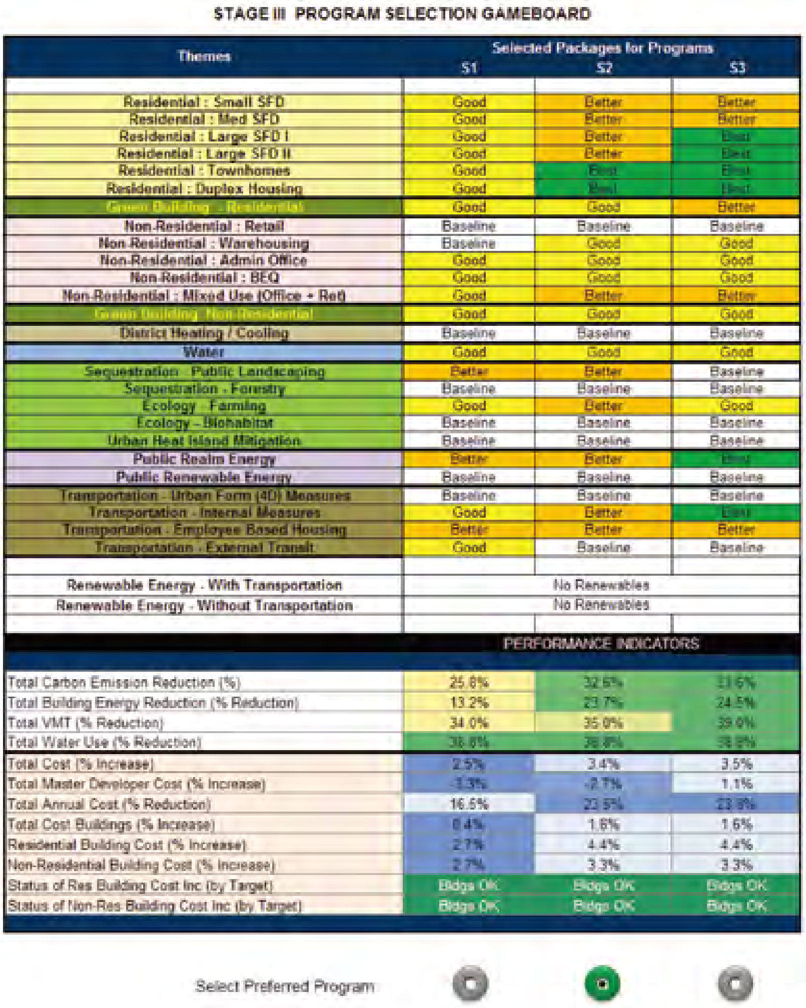
Stage 2: Primary System Optimization

After the Tanggu Beitang Preferred Master Plan was selected, a more intensive evaluation of sustainability practices and measures was applied. This step addressed two questions: "how aggressive can we realistically be in setting sustainability goals", and "what set of sustainability practices allows us to achieve these goals in the most cost-effective manner?" The sub-models developed for each primary system were aimed at increasingly higher levels of resource efficiency while tracking conceptual cost and environmental benefits. The primary systems used to model for Tanggu Beitang included:

- Residential building energy

- Retail building energy
- Office building energy
- Industrial building energy
- Public realm energy
- Water – domestic, storm, waste, recycled, grey
- Transportation

Firstly, a "base case" of conventional development and building practices was defined (annual energy KWhrs consumption, annual water consumption, metric tons CO2 eq/yr, etc). Then 'Good', 'Better', and 'Best' levels of increasing sustainability efficiency were defined for each primary system. The models for each primary system were run to define which combination of strategies, measures and technologies would be required to achieve each target. This formed the basis for the packages of measures.



STAGE III PROGRAM SELECTION GAMEBOARD

Themes	Selected Packages for Programs S1	S2	S3
Residential : Small SFD	Good	Better	Better
Residential : Med SFD	Good	Better	Better
Residential : Large SFD I	Good	Better	Best
Residential : Large SFD II	Good	Better	Best
Residential : Townhomes	Good	Best	Best
Residential : Duplex Housing	Good	Best	Best
Green Building : Residential	Good	Good	Better
Non-Residential : Retail	Baseline	Baseline	Baseline
Non-Residential : Warehousing	Baseline	Good	Good
Non-Residential : Admin Office	Good	Good	Good
Non-Residential : BEQ	Good	Good	Good
Non-Residential : Mixed Use (Office + Ret)	Good	Better	Better
Green Building : Non-Residential	Good	Good	Good
District Heating / Cooling	Baseline	Baseline	Baseline
Water	Good	Good	Good
Sequestration - Public Landscaping	Better	Better	Baseline
Sequestration - Forestry	Baseline	Baseline	Baseline
Ecology - Farming	Good	Better	Good
Ecology - Biohabitat	Baseline	Baseline	Baseline
Urban Heat Island Mitigation	Baseline	Baseline	Baseline
Public Realm Energy	Better	Better	Best
Public Renewable Energy	Baseline	Baseline	Baseline
Transportation - Urban Form (4D) Measures	Baseline	Baseline	Baseline
Transportation - Internal Measures	Good	Better	Best
Transportation - Employee Based Housing	Better	Better	Better
Transportation - External Transit	Good	Baseline	Baseline
Renewable Energy - With Transportation	No Renewables		
Renewable Energy - Without Transportation	No Renewables		
	PERFORMANCE INDICATORS		
Total Carbon Emission Reduction (%)	25.8%	32.6%	33.6%
Total Building Energy Reduction (% Reduction)	13.2%	23.7%	24.5%
Total VMT (% Reduction)	34.0%	35.0%	39.0%
Total Water Use (% Reduction)	38.8%	38.8%	38.8%
Total Cost (% Increase)	2.5%	3.4%	3.5%
Total Master Developer Cost (% Increase)	-3.3%	-2.7%	1.1%
Total Annual Cost (% Reduction)	16.5%	23.5%	23.8%
Total Cost Buildings (% Increase)	0.4%	1.6%	1.6%
Residential Building Cost (% Increase)	2.7%	4.4%	4.4%
Non-Residential Building Cost (% Increase)	2.7%	3.3%	3.3%
Status of Res Building Cost Inc (by Target)	Bldgs OK	Bldgs OK	Bldgs OK
Status of Non-Res Building Cost Inc (by Target)	Bldgs OK	Bldgs OK	Bldgs OK

Select Preferred Program ○ ● ○

Figure 3 Master Sustainability Programs

Each package of measures was then costed to compare the percentage improvement of each package and the cost/benefit ratio. This cost benefit ratio helped inform the team which packages achieved the highest reduction in resource use or carbon footprint at the lowest incremental cost. Decisions were then made on recommended packages to consider for the Master Sustainability Program.

Stage 3: Master Program Synthesis

SSIM was used to combine the individual primary systems (i.e. water, energy, transportation, etc.) into a set of comprehensive, all-systems master program alternatives. At least three master programs were selected and the following outputs were provided for each program based on:

- Total domestic water savings
- Total building energy savings
- Total public realm energy savings
- Total reduction in VMT
- Total reduction in GHG emissions
- Total initial costs
- Total on-going monthly costs

Using this information, the team was able to construct a Master Sustainability Program out of those measures that achieved initial community targets with the lowest impact on housing affordability, pubic agency and land developer cost impact. The SSIM process also resulted in a set of key findings and target verification that could be used to guide project refinement and execution.

The overall result was a blueprint for the complete construction of a new community, ranging from the overall plan of streets and open spaces, through to major elements such as the type and extent of public transport, to the types of light bulbs in streetlights and the required performance of plumbing fixtures. The Sustainability Master Program could further be used to set minimum standards and requirements for the design and construction of infrastructure, buildings, and the public realm.

Conclusions

The Beitang example showed how sustainability planning and carbon reduction is achievable at project development level. The goal is that SSIM

	Old School Thinking	**Low Carbon Future**
Water resources	Engineered solutions to deliver, manufacture, process and dispose of water resources	Scarcity of water resources and increasing unpredictability of storm events will demand new water sensitive urban design forms to use and re-use water
Habitat resources	Disconnected land uses and human made infrastructure encroached on biological habitats	Nodes and corridors of human settlement designed to co-exist with ecological corridors or restored and enhanced biological habitat
Energy sufficiency	Centralized fossil fuel burning plants with inefficient grid delivery systems based on non-renewable, inefficient energy sources	Local generation of energy from renewable and low carbon sources to deliver heat, cooling and power on a district by district and building by building basis
Economic prosperity	Automobile oriented urban land planning policy– synergistic acceleration of real estate, automobile industry and infrastructure engineering	New economies and technologies will provide impetus for new land use planning based on efficient renewable energy and mobility. New models for speculative real estate entrepreneurs to create smart nodes of development
Social equity	Suburban development in many developed economies stratified populations into sub-economic and racial groups	New population demographics and migration leading to a new pattern of diversity to form a valuable socio-economic asset
Mobility	Automobile and airplane have largest impacts on how we move globally, regionally and locally thereby contributing largest amounts of GHG	Concern for carbon footprint and scarcity of oil trigger new technologies and reinvent old technologies (e.g. high speed rail). Policies to redesign urban environments to accommodate new non-motorized systems and transform lifestyles.
Built form	Singular use, large footprint, isolated standalone buildings with profligate use of energy and automotive lifestyle	Mixed use, self-sustaining eco-block developments with integrated smart energy and water saving systems

Table 4 Now and The Future – Low Carbon Cities

can be applied not just for small towns like Beitang but, in the future, for cities and megacities to enable developers and governments to plan and make strategic decisions on investing into low carbon cities of the future. What will these cities look like? The following table provides some insight into a low carbon horizon.

In conclusion:

- Cities will be the answer to urbanization to house systems to serve growing populations. But the biggest challenge will be that of climate change – the answer is to design low carbon cities.
- Ultimately this will mean modern and environmentally friendly approaches to urban design, city planning, public transit, energy and buildings.
- The Sustainable Systems Integrated Model (SSIM) is organized around the core themes of mobility, energy, water, building technology, socio-cultural assets, ecology, and carbon footprint and involves a multi-step process utilizing modeling and cost-benefit analysis techniques. The outputs are a sound and defensible whole systems sustainability and carbon reduction strategy.
- Using tools like SSIM, a developer can optimize the environmental value of the final sustainability program, minimize costs relative to the benefits achieved, develop a low-carbon strategy and achieve exemplary status as a sustainable new community.

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