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The Sustainable City Game: Systems Dynamics Modeling Toward a Democratic Urban Design Process

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1 ABSTRACT

While it has become a buzzword at global conferences, within the scientific and design communities, and among policymakers at a variety of levels, sustainability has largely remained an abstract concept whose abstraction, on the one hand, has served to gather wide-ranging support, but on the other hand, has not been useful in achieving its implementation. The Center for Sustainable Cities in collaboration with Oikodrom, the Vienna Institute for Urban Sustainability, has developed an operational definition of sustainability at the scale of the city-region as a participatory, balance-seeking design process.

Our scenario-building design process of sustainable cities is informed by systemic feedback generated by the Sustainability Engine™, a software utility under development at the University of Kentucky that combines systems dynamics modeling software with the functionalities of intelligent CAD, GIS, and facility management programs. This design process, or what we call the Sustainable City Game, is a democratic method for the generation, governance, and management of sustainable cities in which stakeholders may place any desire on the table, but in order for a given proposal to move forward in the iterative process it must be embedded in a scenario that on a systemic level is approaching balance.

The Sustainable City Game will be explored in the context of two case studies. First will be an examination of a Sustainable Urban Implantation designed for the overbuilding of Vienna's Westbahnhof railroad yard wherein new urban models were developed that are particularly well suited to the flexible urban design process of the Sustainable City Game. Second, will be an investigation of the European Commission sponsored SUCCESS research project wherein seven proto-sustainable Chinese villages were studied and their metabolisms were projected forward as future sustainable cities through the utilization of an early form of the Sustainability Engine™.

2 DEFINING SUSTAINABILITY

Sustainability and sustainable development have been rallying cries for social movements and NGO's and buzzwords of global conferences, however, their true meanings have remained highly contested. The Brundtland Commission definition of sustainable development has been the most popular and has served as a minimalist definition around which most of the current discussion of sustainability has been framed. Its abstract nature, however, has served to conceal as much as it reveals, and thus it has only been helpful in forming a broadly based social consensus. Recently, Simon Guy and his associates, Simon Marvin and Graham Farmer, in light of the myriad interpretations and competing logics of sustainability, have deemed sustainable architecture, sustainable cities, and sustainable development "essentially contested concepts." Applying a social constructivist analysis to sustainability, Guy and his colleagues argue that the "separate but not autonomous" logical frameworks that create the discourse on sustainability effectively prohibit the search for a more encompassing framework of which these individual logics are a part. Lacking an objective datum to anchor the substance of sustainability, for Guy and his associates the sustainable city becomes merely "an open or empty concept which is filled by sets of competing claims about what the sustainable city might become" (Guy and Marvin, 1999: 273).

Without denying the essential contested character of sustainability, the work of the Center for Sustainable Cities at the University of Kentucky and Oikodrom, the Vienna Institute for Urban Sustainability suggests a way out of the conundrum in which social constructivism places sustainability. This avenue lies in working back into the linguistic thicket and eco-scientific renderings of sustainability in order to build the theoretical base of an operational process for actually achieving sustainability—a process that seeks to synthesize and transcend the various competing logics of sustainability expressed in the work of Guy, Marvin and Farmer through the establishment of an objective metric and working within a clear operational definition of sustainability.

First, it is necessary to examine a common misunderstanding within the sustainability movement: the difference between growth and development. While many, including the famous Brundtland Commission, use the terms "sustainable growth" and "sustainable development" interchangeably; Herman Daly and John Cobb have lucidly presented a sharp distinction between the two. Daly and Cobb define 'growth' as "quantitative expansion in the scale of the physical dimensions of [a] system," while defining 'development' as "qualitative change of a physically non-growing…system in dynamic equilibrium with the environment"(1989: 71). They establish the nature of the earth as non-growing and argue that "any system of a finite and non-growing earth must itself also eventually become non-growing"(1989: 71). The term "sustainable growth" then becomes self-contradictory. Similarly, Michael Redclift has shown that complex natural ecosystems initially pass through a phase where growth and production is favored, to a mature and sustainable developmental phase where diversity, regeneration and stability are fostered (1987). Therefore, as Daly and Cobb write, "growth will become unsustainable eventually…but sustainable development does not become self-contradictory"(1989: 71).

Daly and Cobb's rejection of the concept of sustainable growth runs parallel to their rejection of the promethean environmentalists' or "human exceptionalist" school's theoretical means of facilitating this growth: the idea that all natural resources can infinitely be replaced by humanly created substitutes. This theoretical economic tool of substitutability embedded in what has come to be called "weak sustainability," is dismissed by Daly and Cobb in favor of "strong sustainability" that requires "maintaining both humanly created and natural capital intact separately, on the assumption that they are complements rather than substitutes in most production functions"(1989: 72). In 1999, Eric Neumayer wrote in favor of the concept of strong sustainability but lamented that "so far there does not exist a comprehensive study measuring SS [Strong Sustainability]"(p.202) After exploring and rejecting various measures including sustainability indicators and the ecological footprint analysis, in 2000 the Center for Sustainable Cities with Oikodrom formulated the Sustainable Area Budget (SAB) to serve as a yardstick to measure and operationalize strong sustainability (Levine, Yanarella, Dumreicher, Broyles).

2.1 Sustainable Area Budget

The Sustainable Area Budget is an equitable land budget from which a city-region must satisfy its needs now and into the future. This metric of sustainability means that in principle, each individual is entitled to one six billionth of the earth's regenerative capacity interpreted as land area. A city's working budget is the aggregated Sustainable Area Budget of its citizens. Within this fixed land budget, the citizen-stakeholders of a city-region are free to negotiate a way of life according to their own locale, culture and creativity, as long as no harmful imbalances are exported beyond their SAB or into the future.

The Sustainability Indicator method, currently the most popular approach among policy-makers, creates checklists of indicators, intended to measure and incrementally reduce the levels of unsustainability. By disaggregating the problem of unsustainability into many sub-problems, it makes it easier to deal with them in isolation. However, at no point on any of the separate indicator scales or on the aggregated scale is there a place where sustainability can actually be said to exist.

The Ecological Footprint method is a highly quantitative approach that is effective as an analytical tool for assessing the environmental load of a city by calculating the territory appropriated by current human activities. While metaphorically and visually, the approach is a powerful and compelling educational tool, it is not useful in shaping a solution once the magnitude of the problem is recognized because it urges stakeholders to embark upon a succession of separate, incremental movements to reduce their town's Ecological Footprint, rather than dealing with the town as a whole system. Thus, it fails to understand and grapple with the synergistic consequences of the many causes of unsustainability.

By contrast, the Sustainable Area Budget approach begins from the premise that sustainability is an ongoing, balance-seeking process, not a collection of incremental steps. Through seeking a quantitative yardstick from which to launch a policymaking process of democratic deliberations, it produces a paradigm shift from trying to reduce environmental loads, to collectively restructuring a place's processes and lifestyle within an equitable budget of the earth's ecological resources. In doing so, the SAB allows the sustainability agenda to advance beyond the boundaries of weak sustainability into a warranted state of strong sustainability.

2.2 Operational Definition

The Center for Sustainable Cites with Oikodrom have developed an operational definition of sustainability that presents a comprehensive, scientific, democratic, design and governance method that integrates conflicting interests through a scenario-building process:

> Sustainability is a local, informed, participatory, balance-seeking process, operating within a
>
> Sustainable Area Budget, exporting no harmful imbalances beyond its territory or into the future,
>
> thus opening the spaces of opportunity and possibility.(Dumreicher, Levine, Yanarella, 1998-2001)

Sustainability is a local...: Sustainability needs a place to happen. Although problems aggregate and become manifest on a global scale (e.g., ozone depletion, global climate change), offenses to the environment are produced locally. When dealt with locally, where "local" means the city/region, the neutralization or reuse of all negative byproducts must be considered part of the price of doing business. The earlier history of our civilization is the history of city/regions--largely autonomous towns that gained virtually all of their material needs from their local countryside and had to maintain the quality of the countryside in order to sustain their way of life. From this perspective, sustainability can only happen at the scale of the city/region--the largest scale capable of addressing the many urban architectural, social, economic, political and other imbalances besetting the modem world and simultaneously the smallest scale at which such problems can be meaningfully resolved in an integrated and holistic fashion.

… informed...:In order to be able to maintain the quality and the productivity of the local region and its countryside one must understand the consequences of the metabolic activities occurring within the city/region. Earlier towns operating within a largely closed system received rather rapid feedback as to the consequences of their activities. Because almost all activities manifested locally, causes and effects related to those activities were quickly understood. When imbalances threatened the city/system, they were noted and adjusted locally. In the modem world there are effectively no local boundaries and positive activities at a small scale may well have negative consequences at larger scales. By using modern means, however, we gain powerful tools both to design and monitor major energy and material flows and to model the projected implications of different processes we might choose to include in our city/region.

…participatory...: Sustainability is a process by which a local community can decide how it will afford to live within its natural budget and the limits of its own creativity. Such a process starts with the principle that sustainability is nonnegotiable, where in principle everything else is negotiable. That means that all participants in the process must agree that the health, equity and viability of the city/system is the precondition for any other decision. Secondly, as the sustainability process proceeds, stakeholders increasingly realize that they share a common destiny and that significant synergies will result from their creative encounters and negotiations. Through many iterations, the city/region becomes understood more as an urban ecosystem and less as adversarial, zero-sum game. Eventually, the players become partners and more focused on building common wealth.

… balance-seeking process...: The problem with our existing economic system is that it has no built-in mechanism to insure its own long-term survival. It is not designed to pursue balance. As noted above, natural ecosystems in early stages of succession are also designed to maximize production at low levels of diversity, but as such systems mature, and organic material accumulates, the emphasis shifts away from production and toward maximizing diversity, resiliency and maintaining internal balances. This needs to be the model for human ecosystems.

… operating within a Sustainable Area Budget (SAB) ... : In the past, nature was assumed to be so vast as to be able to comfortably absorb any and all offenses that humankind's activities dumped onto it. It is now clear that we have long since exceeded many of nature's capacities. The Sustainable Area Budget is our concept for the natural budget in land area, available for each city/region to

support its way of life. A simple determination of the SAB for a city/region goes something like this: simply divide a country's total land area by its population and multiply by the number of people in the city/region. In the longer term SAB's will need to be defined and applied globally, requiring political consensus in its determination and application.

… exporting no harmful imbalances beyond its territory or into the future: The key idea here is that when the prior part of this definition is realized such a city/region will effectively export no problems beyond its territory or into the future. On the other hand, even this circumstance is negotiable, given our Fifth Operating Principle for Sustainable Cities, which states that "imbalances are to be negotiated outward." This means that in some cases an imbalance may be exported from the city/region, but only if its rebalancing can be accounted for by an agency beyond the scale of the city/region.

… thus opening the spaces of opportunity and possibility: such a process is seen as an empowering and liberating activity that maximizes the principle of locally bounded informed choice within globally recognized limits.

This definition employs the Sustainable Area Budget to offer for the first time a metric of sustainability embedded in an operational process that can allow for the implementation of sustainability projects. The definition formulates the Sustainable Area Budget as a means of defining the sustainability datum of a city-region and describes a kind of balance-seeking game—what the Center has termed the Sustainable City Game—that can come into play. Unlike most current decision-making processes which, because of competing interests, become highly charged power struggles that focus on single issues without taking into account the sustainability of the whole system, the Sustainable City Game is a non-threatening concept through which a sustainable decision making process can be initiated. Engaged in the Game, the citizen-stakeholders of a given city-region negotiate amongst themselves how they can afford to live within the limits of their land budget limited only by their own culture and creativity.

3 THE SUSTAINABLE CITY GAME

The Sustainable City Game begins by encouraging players to place any legitimate needs and ideas on the table. Then, varied teams of stakeholders—together with designers, social scientists, natural scientists, and other professionals—attempt to assemble a number of different design scenarios that represent these competing interests. These design scenarios would all be negotiated within the Sustainable Area Budget of the city. Thus, the design and development of the city becomes an empowerment process, engaging citizen-stakeholders in the shaping of their common, sustainable future. These scenarios are then modeled as both physical designs and energy and material flow models using the Sustainability Engine™, a utility still under development that combines some of the attributes of intelligent CAD, facilities management and GIS software together with systems dynamics modeling software to become the principal feedback, design and management tool in the negotiation of sustainable city-regions (Levine, Yanarella, Radmard, Dumreicher, 2003).

The practice of architecture in recent years has increasingly gravitated toward the delivery of contract documents in intelligent CAD and/or facilities management formats. Through embedded databases these formats provide the capability of extracting many sorts of useful information about the virtual building. Material takeoffs of virtually every nut and bolt together with their locations and specifications are easily charted. Maintenance and replacement schedules can be developed and recorded. Changes made in material, size and energy performance are automatically projected through the building model and its database and the reverberations of those changes can be instantly displayed. It is a small conceptual step from the design and management of conventional buildings to the design and management of sustainable cities. One difference is that in the case of sustainable cities, much more information is attached to the components, systems and building blocks that make up the city model. Within the memory storage of the Sustainability Engine™ will be module libraries of components and building blocks containing myriad attributes—including such things as embodied energy, distance from source, cost, availability within the SAB, labor requirements, recyclability, land use implications, energy and material flow connections to other regenerative systems, and the various inputs and outputs involved in the functioning of the module within the city-system. These modules function as plug-in, "free body" objects that provide inputs and outputs when attached to a larger city-system scenario model.

In the playing of the Sustainable City Game, stakeholders together with architects and scientists attempt to assemble a sustainable city model, drawing on the existing building blocks from the Sustainability Engine™ that most closely meet their needs and desires. If no building blocks are suitable, existing blocks are modified or the architects develop completely new ones that respond to the local architectural vernacular, particular site conditions, material availability, the local technical know-how, and the desires of the stakeholders. Because any urban design that represents the needs or interests of only one stakeholder or group of stakeholders will not contain the diversity or complexity of a real town, such a limited model when run on the Sustainability Engine™ will appear in its first trial run as a city-system that is grossly out of balance. The feedback of this imbalance becomes an important moment for the stakeholder-players. It indicates to them that in spite of the fact that their immediate needs may have been well satisfied by their preferred urban proposal, because their interests represent only a portion of the city-system, many other needs must be met in order for the city-system to be approaching equilibrium. This feedback then supports a significant operational principal of the sustainability endeavor: any proposition may be put on the table, but in order to be carried forward in subsequent iterations of the Game, the overall city-system scenario in which the proposition is embedded must be approaching equilibrium. Very quickly it is seen that no matter how beneficial a given proposition may appear (or however politically powerful its proponent), it must still attach itself to a more extensive network of mutually supportive propositions to form a larger, well-balanced, synergistic scenario in order to remain viable as the Game progresses.

The Game is played through many iterations and at each successive step the scenarios become more sophisticated and more complex. In a similar fashion, the Game itself and its module libraries take the form of learning ecologies through repeated game-playing, becoming more elaborated and accumulating more options and being able to provide more sophisticated feedback. Because of its growing successes the Game and the city models its playing generates, become attractors of people and interests who are in a position to act upon what they have negotiated to be their preferred form and structure of a locally determined sustainable city. As the game becomes sufficiently serious that construction is planned and carried out and people come to live in the city, the same stakeholder

process that generated the city form and structure using the Sustainability Engine™ continues to be employed as the process by which the city advances its development, modification, maintenance and governance (Levine, Yanarella, Radmard, Dumreicher, 2003).

4 WESTBAHNHOF SUSTAINABLE URBAN IMPLANTATION

Our operational definition of sustainability suggests a dense, compact city with a dynamic balance between community and privacy. It suggests a community rich in architectural form, public space, and individual and collective opportunities. It suggests a city with a strong sense of itself as a place, a clear and defined form, and a common destiny. It suggests a human-scaled environment, not one that is over-scaled and sized to primarily accomodate vehicles, industries, and faceless institutions. Yet, it also suggests a city able to find appropriate space for the metabolic and economic processes of a modern city (Dumreicher and Kolb, 2003). In order to proceed from theory to practice, the evolution of a coherent, consistent, and complete theory of the sustainable city-region has been paralleled by the co-evolution of a new urban form. The City-as-a-Hill is a concept first developed by the Center for Sustainable Cities and Oikodrom as an urban implantation to be built over the Westbahnhof railroad yard in Vienna. The City-as-a-Hill is a flexible urban construct that is able to fulfil many of the requirements of the sustainable city-region suggested by the operational definition, making it the sort of new urban model that is particularly well suited for use with the Sustainable City Game.

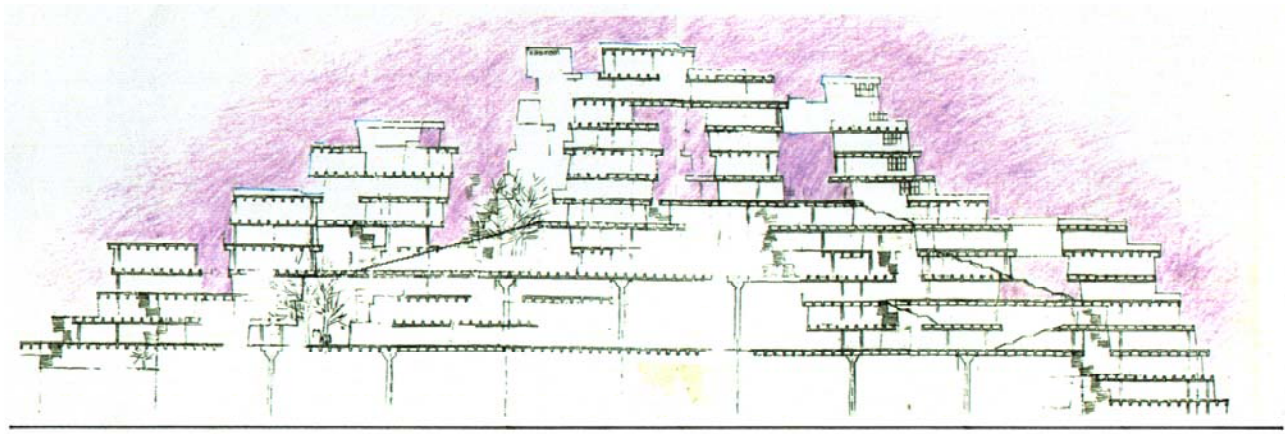

Figure 1: Sectional View of the Westbahnhof City-as-a-Hill Sustainable Urban Implantation

Originally inspired by the dense human-scaled urban fabric of medieval Italian hilltowns, the new model provides a walkable pedestrian scale, which requires few vehicles, and allows for public space such as markets and squares. However, whereas its medieval counterpart was a city built on a hill, the new urban model becomes a city built as a hill, with the inner "hill" being comprised of the many large-scale industrial buildings, mass transportation and other necessary infrastructure that is needed for the operation of a modern city. The sustainable City-as-a-Hill would be surrounded by a large agricultural hinterland corresponding to its population-based Sustainable Area Budget that would supply all of the land-based resources necessary to support its industry and way of life. The construction of the "hill" is made possible by a flexible structural system, the Coupled Pan Space Frame, a post-tensioned concrete structure developed by Richard S. Levine at the University of Kentucky. This space frame spans large distances and at the same time allows for systems infrastructure to be interwoven within the depth of the structure. The space frame system also easily accommodates future expansion and modification of the city, allowing the surface to evolve and increase in complexity over time (Dumreicher, Levine, Yanarella, Radmard, 2000).

5 PROJECTING SUSTAINABILITY FROM THE CHINESE VILLAGE

Recently our Center's focus has shifted from the implementation of sustainability in existing unsustainable cities of the West, as demonstrated by the Westbahnhof Sustainable Urban Implantation, to the identification and projected expansion of proto-sustainable villages within the context of the rapidly developing Chinese urban landscape. Within the next five to ten years at least 400 million Chinese farmers are projected to migrate from their rural villages to hundreds of new or enlarged industrialized cities. There are strong indicators that these new Chinese cities will be massively unsustainable from economic, environmental, social, and cultural perspectives. China's extensive industrialization and urbanization program will have dire consequences not only for China but the rest of the planet as well. It is therefore essential that sustainable alternatives to this detrimental development be created and implemented. The goal of the European Commission sponsored research program "SUCCESS" has been to forge a sustainable future for the Chinese village. Working with seven villages in six Chinese provinces, SUCCESS has initiated sustainable civil society processes which have the potential of increasing the life quality and economic potential of the villages through Sustainability Oriented Means.

The great majority of China's developing cities will be extensions of existing villages which have historically maintained a balanced relationship with their landscapes and resources. Recently, this balance has been interrupted by China's rapid and uncontrolled modernization. However, in spite of a few unsustainable practices that have crept their way into these village-systems, the villagers still produce their own food, provide most of their own labor and material resources, and balance the effects of their way of life on the natural environment. For this reason, the SUCCESS project has identified the traditional village as an appropriate place to begin to implement sustainability processes and to provide a starting point for the modeling of the future sustainable city. Because the villages are much smaller in scale than existing towns or cities, they are much easier to model and understand as a whole. The villages are the repository of generations of collective wisdom that reflect a culture and design that have never been far from a

balance with local resources. They are thereby much easier to bring to sustainability through the playing of the Sustainable City Game.

The SUCCESS project team of 40 researchers worked collaboratively using our operational definition of sustainability. Through synthesizing scientific tools with design and participatory methods, our process seeks to avoid the narrow determinism of specialized scientific disciplines and, in so doing, demonstrate a rich and complex means of accommodating diverse and conflicting interests to create a Sustainable Civil Society (SCS) form of governance.

5.1 Initiating the Sustainable City Game in China

The SUCCESS project researchers worked with the villagers to determine which aspects of their lives were essential to be maintained and which were better to change (Dumreicher and Kolb, 2005). By placing the villagers concerns and suggestions on the table and augmenting them with the researchers' methods and skills, the SUCCESS project initiated the first step in the sustainable city gaming process.

A specific example of this gaming process is the participatory design and construction of a bathhouse in Xia Futou in Henan Province. Without a fully developed Sustainability Engine™, or even a computer, the design negotiation process was acted out in the streets and byways of the village. A number of site plan proposals were "drawn" at full scale with rocks placed in the shape of the proposed building on a site adjacent to the future bathhouse. Through this process, a conversation between the architects of the SUCCESS project and the villagers emerged and eventually led to an agreed upon plan.

5.2 Systems Dynamics Modeling of a Chinese Village

During the SUCCESS project a systems dynamics model was developed for a village named Dujia located in China's southwestern Yunnan province. The relationships among the different parts of the village system were constructed from systems diagrams comprised of "Intelligent" icons that linked together to form an interconnected web of cause and effect relationships. These mathematically-based systems icons represent the metabolism, that is, the energy, time and material flows of a village. It is possible to add or subtract functions from the village model or to change their relative quantities to enable "what if" questions to be asked by citizen stakeholders.

Dujia's main source of income is from the growing of commodity crops for export. Part of the agricultural economy of Dujia was modeled, along with other aspects of their day-to-day life, and modeling experiments were conducted by changing the agricultural allotment for different crops. In conducting this simple "what if" experiment, the model showed that sugar cane, considered to be one of the major cash crops of the village, was associated with a negative net cash-flow. With further analysis it was discovered that the villagers would actually be able to eliminate almost half of their annual labor yet still increase their net earnings if they simply stopped growing and tending to sugar cane. The large amount of income generated bi-annually from the sale of sugar cane had seemed to indicate it was a profitable venture, however the expenses associated with its production which gradually accumulated throughout the year caused a net loss it its procuction.

The causes and effects of this slow aggregation of expenses becomes evident through the systems dynamics modeling process, and from this point the villagers become aware of the kinds of "what if" questions it may be useful to ask and have entered into the systems dynamics modeling process. A positive feedback loop of information is constructed from this participatory process and eventually, more and more complex determinations are made through the numerous "what if" questions to permit villagers to synthesize new scenarios making possible a sustainability enhanced quality of life.

5.3 The Future Sustainable Chinese City-Region

While the SUCCESS project initiated, in seven villages, the empowerment process necessary for the playing of the Sustainable City Game, it will be necessary to look past the scope of SUCCESS in order to generate a sustainable future for China. During the SUCCESS project the current metabolism of Dujia was studied and modeled as an example of a typical traditional Chinese village. Unsustainable practices, such as the use of fossil fuels, agricultural chemicals, and other unsound agricultural techniques were replaced in the systems dynamics model with sustainability-oriented equivalents. This systems model can be used as a template for future models that could project traditional Chinese villages into modern sustainable cities.

If the future Chinese city is to evolve from the village with sustainability as its intention, then merely regurgitating western patterns of "green" projects will not be sufficient. A city that tries to achieve sustainability through a checklist of "best practices" or though accumulating incremental improvements in efficiency through bureaucratic regulations will continuously hit increasingly insurmountable barriers that could inadvertently hurl it further into the chasm of unsustainability. This is because, as previously stated, sustainability is an ongoing balance-seeking urban design process that can only function when developed as a whole system. As standards change, the "best environmental practices" of the present, that merely seek to create a less unsustainable city, will become the unacceptable practices of the future. On the other hand, any city-region that has negotiated its urban balances within its Sustainable Area Budget cannot become obsolete in the future.

For example, establishing criteria for maximum CO2 emissions standards for a given industry is indicative of today's bureaucratically oriented approach, which is, in and of itself, too specific and narrowly focused to make any real steps toward sustainability. In contrast, following the principles outlined here, a sustainable city-region must balance out its total CO2 emissions from all sources according to its Sustainable Area Budget at the scale of its region. If it chose to allocate a particular factory with a large part of that budget, due to its great importance in the town-system, this would be perfectly acceptable as long as the total budget of the city-region-system was not exceeded and CO2 on a net basis was not exported beyond the city's territory. The specific path to balance that each city takes should not be governed by isolated decisions that do not consider the possibilities of seeking equilibrium at the scale of the whole city-region-system.

After the Chinese village is modeled and projected into the future on a sustainable basis, this "proto-sustainable" Chinese village is used as the starting point for the participatory evolution of larger towns and cities whose growth and development proceeds through this same sustainable scenario building, aimed at developing diverse, vibrant new towns for China's future. As the first sustainable city emerges, its success would provide the momentum and enthusiasm for the building of additional sustainable cities, each with different activities and industries and therefore, different urban and architectural design. Because of its architectural flexibility, the City-as-a-Hill urban model, as developed in the Westbahnhof Sustainable Urban Implantation, could be a framework within which the Chinese sustainable city-region could also be developed. The City-as-a-Hill is small enough to be affordable to build in a short period of time and would be much more amenable to mirroring traditional small-scaled Chinese urban and residential patterns than the many foreign-influenced unsustainable urban patterns that are now emerging all over China. A network of such cities could be linked together to form a regional network of synergistic sustainable settlements. In this way, sustainability could be exported from traditional villages to the hundreds of new cities forming across China.

6 CONCLUSION

The massive urban industrialization of China is an extraordinary experiment that will affect the entire world. The traditional Chinese village has operated for thousands of years according to balance seeking proto-sustainability processes. However, this way of life is largely dying because the recent "open door" governmental policies have promoted virtually unchecked industrial growth at a scale and speed never before seen in Earth's history. China is presently the most experimental society on the planet. While most of the experimentation has involved adopting a great variety of western unsustainable practices, the SUCCESS project represents an alternative course that can bring China toward future city models that are rooted in Chinese culture, but also function as modern industrial cities that operate on a sustainable basis. Building on the Westbahnhof Sustainable Urban Implantation and our definition of sustainability, the research initiated in China through the SUCCESS project demonstrates the resources, technology, and, more importantly, the operational process necessary for generating the first modern sustainable city.

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