HIGH-PERFORMANCE CITIES OR BUILDINGS

SEUNG RA
Oklahoma State University

Cities have always been dynamic by nature, being formed and molded and remade by changes in technology, society, politics, and economy. What are the main driving forces that will influence cities in the near future? We can speculate by looking at today's influences, and trying to get a grasp of how those will develop and morph further.

The *International Energy Agency (*IEA) in the *World Energy Outlook,* 2004 reported that the projected increase in worldwide electrification rates from 74% in 2002 to 83% in 2030 would provide a huge impact on social development, education and public health (Stevens, 2006; Schieb, 2006; Andrieu, 2006). By 2050, growing urban populations will reach 50% of the world population, which makes urbanization a critical laboratory for understanding the issues we are facing now politically and environmentally. This incredible rate of growth opens possibilities for studying the performance of our urban spaces and buildings, and the possibilities for the future.

Performance of the cities, rather than a high performance building within the typical grid of urban space, must be a focus and vehicle to see the future of cities. The results would bring changes to basic human life, as well as environmental impact. For instance, reduction of non-sustainable energy and resource use, improved transportation, and better quality of life. As these changes take place, we must simultaneously look at infrastructure on a multi-level scale. The current trend is moving away from a monolithic infrastructural development, yet still the large scale projects create greater impact, economically, socially, and environmentally influencing the future urbanism.

Because of the massive increase of urbanization and proliferation of cities, we must identify how the vital resources will flow and create new styles of urban infrastructure for global cities. Mega projects are not necessarily the answer for mega cities with mega problems. Common urban problems, such as energy intensity and population density, require thinking beyond physical size to issues of efficiency and sustainable generation. Smaller scale approaches combined with advanced technology will help to bring a larger impact on the global level, even if the physical scale is much smaller. By simultaneously looking at smaller individual approaches, we may find additional ways to improve performance at the urban scale.

Figure 1. Image from the film "Urbanized"_A documentary by Gary Hustwit (TOP) & Three Gorges Dam Project, Yangtze River, 2005 by Edward Burntynsky (BOTTOM).

Infrastructure, as a measure of performance, is a medium to facilitate the ground for the city's future and generate the conditions for architecture (Allen,1999). The dual relationship of architecture and city should be examined through the lens of performance of energy and environmental constraints. This performance is not limited to only energy consumption, but includes social and political performance of cities as well.

The rapid growth of urbanization influences the dramatic increasing demand of access to electricity. This incredible rate of growth opens possibilities for studying the performance of our urban spaces and buildings. The current effort in enhancing the performance of building is focused on individual building performance. How can we bring this idea to the larger scale?

Figure 2. Image from the film "Urbanized"_A documentary by Gary Hustwit.

The film "Urbanized" describes cities as corrections of forces: physical, economical, environmental, and political (2011). Brasilia offers a rational, ordered, and simple solution, but it is inhuman. In contrast, the city of Bogota invested in a large-scale infrastructural project to improve the public transportation, developing bike lanes, and pedestrian-friendly walking trails rather than the automobile highways. This large-scale approach has created a more successful environment for city dwellers.

The study has been conducted using three avenues: Adaptation, Integration, and Extension. Adaptation describes how the city responds to existing conditions through a process of slow development over time. Integration deals with incorporating new ideas in the relationship between buildings, energy and systems. Extension focuses on larger-scale interventions to major infrastructure.

Adaptation of Current Performance of Cities

The category of "Adaptation" is the seemingly natural advancement of existing places responding to and countering environmental stimuli. The process of adaptation allows civilizations to thrive under extreme conditions. Through manipulation of structures and spaces, places are able to be shaped to their unique environment.

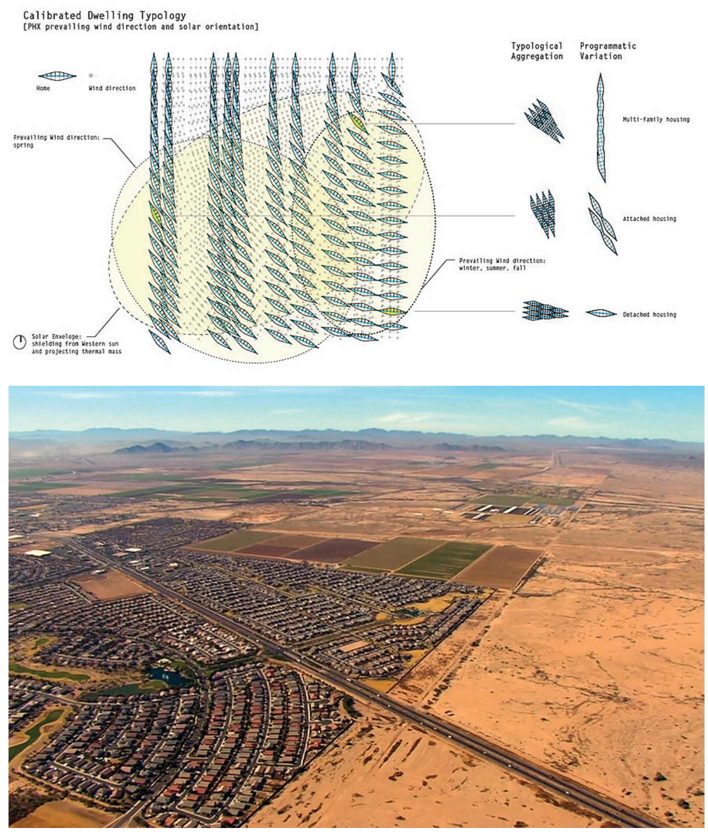

Figure 3. Future Cities Lab's "Xerohouse" Project (TOP) & Image from the film "Urbanized"_A documentary by Gary Hustwit (BOTTOM).

Examples of this include Future Cities Lab's *Xerohouse Project* (2008), a comprehensive study in extreme desert living.

> "Xerohouse is a prototype for desert living; calibrated, tuned and responsive to its desert habitat. It is adaptable, mutable, and variable desert ecology. Contrary to current trends in desert suburban development, Xerohouse is a porous, permeable and evolving habitat in synchronicity with its surroundings – hyper situated, indigenous and local. Xerohouse responds to the DNA of the desert: wind direction, solar orientation, temperature, sand. Xerohouse attempts to reconcile two antithetical and disparate conditions that define modern desert living: extreme climate and extreme sprawl. How can the intense heat, aridity, and blistering sunshine of the desert be reconciled with the vast expanses of single-family homes cooled by central air, surrounded by golf courses, and bordered by artificial lakes? Can the synthetic recombination of these extreme conditions spawn productive new hybrids of desert living machines, landscapes and ecologies?" (Johnson and Gattegno 2008)

Another example is Future Cities Lab's *Thermospheres Project* (2011). It is both a concise proposal for environmental control and a formal response to the nature of heat. Thermosphere is a proposal for a public thermal bath and event pavilion facing the sea. It contains three distinct microclimates – the Caldarium, the Tepidarium, and the Frigidarium. These three intersecting domed spaces are surrounded by a light-weight shade canopy that serves as an urban threshold, public promenade, solar energy collector and microclimate generator. The structural system was developed through a series of catenary experiments that describe the structural and microclimatic performance of the canopy.

The third example of adaptation is *Hylozoic Ground* (Beesley 2010), an Art/architectural installation with intricate, moving fronds triggered by heat and air-sensitive actuators. Mylar foliage collects ambient air particles and deposits them into bladders filled with protocells and microbials. The project is based on 'Hylozoism': the ancient belief that all matter has life. "Hylozoic Ground is an immersive, interactive environment that moves and breathes around its viewers. This environment can 'feel' and 'care'. Next-generation artificial intelligence, synthetic biology, and interactive technology create an environment that is nearly alive (Johnson and Gattegno 2008)." Tens of thousands of lightweight digitally-fabricated components are fitted with microprocessors and proximity sensors that react to human presence. This responsive environment functions like a giant lung that breathes in and out around its occupants. Arrays of touch sensors and shape-memory alloy actuators (a type of non-motorized kinetic mechanism) create waves of empathic motion, luring visitors into the eerie shimmering depths of a mythical landscape, a fragile forest of light.

These types of high-performance environments must be considered at a larger scale as well for integration into the future of the city. They serve as examples of the level of performance that will be necessary going forward at the building and the urban scale.

INTEGRATION

The category of "Integration" involves the true synthesis of buildings, energy, and materials into an urban symphony. Buildings will become interdependent, communicative, and intrinsically organic. One way is by creating an integrated skyline though solar planning on an urban scale. Also, this can be achieved by synthesizing means of transit with their destinations, and utilizing more efficient means of energy transfer using biological precedents.

Examples include Future Cities Lab *Grow DC Project* (2008), a theorized solution to flood problems in Washington D.C. The project is based on the formulation of "eco-hubs". Eco-hubs are Ecological centers from which processes evolve and radiate; clusters of urban energy production, creativity, commerce and transportation. They are catalytic biotopes for activism, remediation and revolutionary change.

> "Some of the 10 acre pods [eco-hubs] will focus on the technical infrastructure delivery of energy generation and water treatment processes. If built today with best practice technology, these pods will generate 4MW of solar energy and 1MW energy from biogas." "Some of the 10 acre pods will focus on food production. An optimized, organically fertilized, and heated farming pod can easily serve vegetables, grains and fruits for over 10,000 people for a year." "Some of the 10 acre pods will focus on water purification. Reed beds, polishing ponds and water fountains make up a matrix of final water cleansing in the pod and can serve the potable water needs for 5,000 households under typical demands of today." (Johnson and Gattegno 2008)

Another interesting biological study involves the performance of Giraffes' skin. Their mottled skin offers a convincing study in biological transfer of heat. The spots function as heat release vents for capillary clusters in the giraffe's skin. This model from nature could provide a parallel for energy capture and release mechanisms for city grids. By isolating urban heat islands, the energy could be harnessed and reused.

Termite Mounds offer another natural example. Compass termites form their mounds to minimize solar heat gain as much as possible,

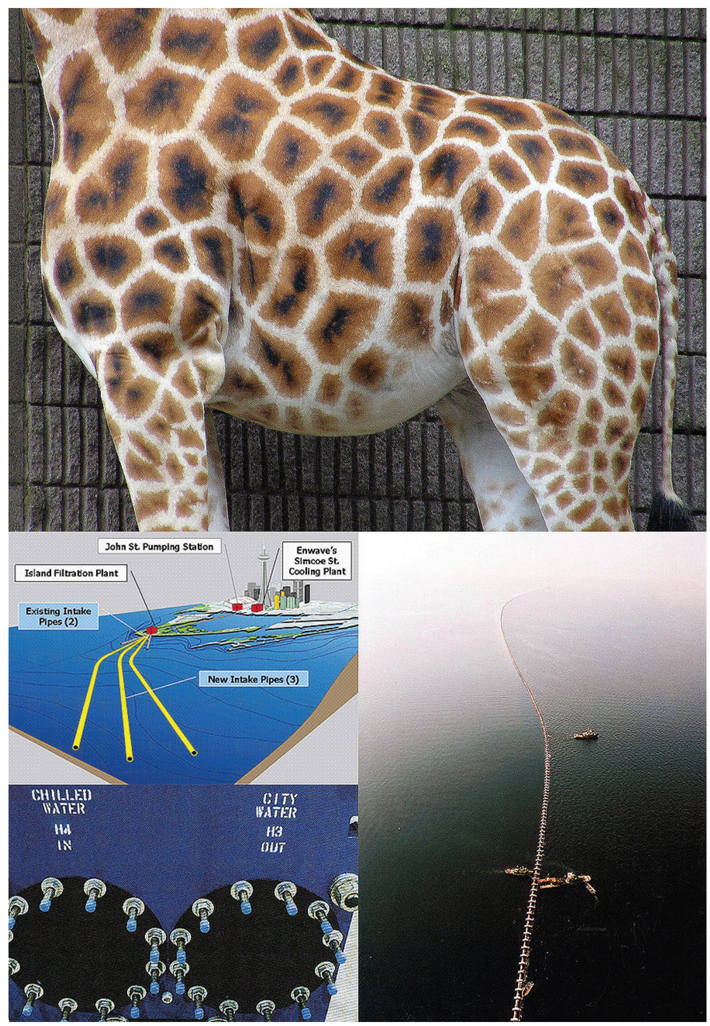

Figure 4. Giraffes' skin (TOP) & the city of Toronto's Deep Lake Water Cooling system, Image from MASSIVE CHANGE (BOTTOM).

by forming a very narrow southern exposure. This case study can be applied to overall skyline design of cities: cooperative buildings shielding each other from sun at different moments in the day.

A current example of integration in action is the city of Toronto. Toronto is adapting the fundamental idea of using Lake Ontario to cool downtown buildings. This system is an example of Deep Lake Water Cooling (DLWC). It is a $170-million project and will reduce overall annual power usage by more than 40 megawatts, and greenhouse gas emissions by almost 40,000 metric tons. This will be comparable to removing 8,000 automobiles from the road (Graham, 2004). As the world's largest lake-source cooling system, the City of Toronto's DLWC system goes beyond energy savings. The system (ENWAVE, 2004): (1) Reduces electricity use by up to 90% compared with conventional air-conditioning (2) Eliminates 79,000 tons of carbon dioxide annually (3) Cuts 45,000 kg of polluting CFC refrigerants (4) Saves more than 61 MW of electricity annually – the equivalent power demand of 6,800 homes (5) Eliminates the need to install cumbersome, expensive cooling equipment and to dispose of it at the end of its useful life (6) Eliminates 145 tons of Nitrogen Oxide (7) Eliminates 318 tons of Sulphur Oxide (8) Provides fresh, potable lake water to taps across Toronto.

Metro Hall, a 27-story office building in Toronto, went online with ENWAVES's Deep Lake Water Cooling system in June 2006. Energy consumption at Metro Hall will be reduced by 3 million kilowatt-hours per year and reduce CO2 emissions by 732 tons annually - equivalent to taking 160 cars off the road. The resulting reduction in water consumption from Cooling Towers for the building was 4,400 cubic meters per year, and the power saved is sufficient to supply 300 homes (The City of Toronto, 2006).

While the concept of cooling by water is not new, and many waterfront cities have taken advantage of their geographical benefit, the scale of infrastructural networks has not yet been ambitious enough to have an impact citywide or beyond. What if DLWC could replace the entire cooling system of a city? And what if high-rises in Shanghai could eliminate massive cooling towers, using all of their mechanical space as usable space? Perhaps Buckminster Fuller's (Mau, et al, 2004) worldwide energy grid could be adapted into the scope of the cooling system in order to "produce energy locally and distribute it globally." (Mau, et al, 2004). Surplus energy generated by the water cooling infrastructure would be redistributed and ultimately less energy would need to be generated through conventional means.

EXTENSION

The category of "Extension" is predicated on the idea of innovation stemming from or resolving an object. Innovations in architectural and urban composition may include: novel technical applications, up-cycling, mirroring buildings with the organic, and biomimetics.

Examples include Doris Sung's Thermobimetal Research (2012) in utilizing the physical properties of metal to pioneer a new, low-energy building material. This creates the possibility for up cycling: metal scraps modified to new building skin. Also, Erodium Seed "Intelligence", which follows the notion of seed self-burial. In what manner may a building distinguish itself from the masses of typical construction? Can the actual materiality/positioning of a building spawn others in the cityscape?

Another example is *SOFT CITIES* by KVA MATx (2010). This innovative urban initiative creates a large scale clean energy solution which overcomes the deficiencies of conventional clean energy generation. A unique form of photovoltaic fabric substitutes the conventional glass-based solar technologies. This textile surface offers a flexible form and the energy source minimizes connecting electric busways.

In the Film *Urbanized* (2011), the city of Bogota invests in the large scale infrastructural project to improve the public transportation, bike lane, and the pedestrian friendly walking trails rather than the automobile highways. This innovative idea allows the infrastructural investment to be focused on the larger population, rather than encouraging the further use of automobiles. It increases the performance of city as a whole by offering abundant alternative modes of transportation.

By offering drastic measures to fundamentally change the approach to urban development, we can often institute effective strategies previously not considered. Another innovative example is the city of Copenhagen. The city removed all of the traffic lights to minimize the automobile congestion of the city. While it may seem to be an extreme measure, it illustrates our perception of conventional truth isn't always the solution to the problem. They are potential future city images that we might not be able to recognize with our current perception of the city. Reinvention of the urban image was the topic of a recent interview by *Next American City* with Rem Koolhaas (2012). He suggested that the city is a machine of emancipation and the Western world's cities have seen less change recently due to the lack of new ideas. He argued this social change drives reinvention and changes our view of the future.

The need to reimagine cities through adaptation, integration, and extension is not necessarily new, but has become more urgent with population growth and dwindling natural resources. The solution of effective urban transformation will embrace many new ideas. Energy-based solutions must address comprehensive distribution and consumption in a multiplicity of scales and systems (Addington, 2010). For example, individual places create complimentary 'subsystems' instead of creating a large solar energy farm separated from the city. It could be part of the city's landscape. Even if the scale and impact might be minimal, in large context, this will truly make a difference at the comprehensive level. We must also look into more fundamental issues of how we use the small-scale renewable energy; more precisely how efficiently we use the environmentally friendly energy.

Roadmap 2050 by the European Climate Foundation and OMA proposed an EU-wide decarbonized power grid by 2050 (Moore,

Figure 5. SOFT CITIES by KVA MATx (TOP) & Solaria by AMO (BOTTOM)

2010). The plan would reduce Europe's GHG emissions by 80-95%, which needs to achieve a 2% energy efficiency savings per year, by 2050. "Through the complete integration and synchronization of the EU's energy infrastructure, Europe can take maximum advantage of its geographical diversity. The report's findings show that by 2050, the simultaneous presence of various renewable energy sources within the EU can create a complementary system of energy provision ensuring energy security for future generations." According to the Roadmap 2050, emissions from power, road transportation, and buildings will be reduced by 95% which will be the most critical part of the overall 80% CO2 reduction. Two sectors, Power and Buildings, will be most influenced by infrastructure and will become a new territory for architecture to return to the where it began. The plan also proposed an EU-wide power grid system with diverse and decarbonized energy sources which will be traded within the network. This return to Fuller's idea, "Electrical-energy integration of the night and day regions of the Earth will bring all the capacity into use at all time (Mau, *et al*, 2004)." This integration could be a key to accommodating energy flow in developing cities.

A recent article in the *Economist* (2010) suggests that Asian cities will determine the prospects for global CO2 emissions in coming years. As an emerging society, and perhaps the global stakeholder of urbanization, Asia is faced with great opportunity and great risk. The current rate and type of development are unsustainable. But unlimited possibilities lie in a sustainable exploration at the infrastructural scale. Expanding infrastructural urbanism is not only relevant to the Asian discourse, but globally. For example, the global demand for both quantity and quality of electrical power will need a global scale of investment in the near future: The Organization for Economic Co-operation and Development (OECD) predicted the total annual worldwide electricity investment needs through to 2030 average around $350 billion and more than half of this investment will be spent on transmission and distribution (Stevens, 2006; Schieb, 2006; Andrieu, 2006).The growing uncertainty of Architecture's mission in current urbanism, especially implementation of multi-scale infrastructural development as an urban intervention, will require its reposition and integration for building a High-Performance City. Based on the historical aspects of transformation of the city and the outlook of global investigation in terms of infrastructural investment, we continue to engage the future relationship between architecture and urban space and how the environment will be rapidly influenced by urban growth. The objective of the paper in building a High-Performance City is to not only encourage more efficient building for the future, but also to facilitate much more efficient networks within the current grid system. As the usage of energy becomes the driving force sculpting the future of our cities and reshaping existing cities, we must fully integrate infrastructural development and architectural design within this new framework.

ENDNOTES

Addington, D.M., 2010. Energy Sub-structure, Supra-structure, infra-structure . In: Mohsen Mostafavi with Gareth Doherty, Harvard University Graduate School of Design, ed. *Ecological Urbanism*. Lars Müller Publishers, pp. 244-251.

Allen, S., 1999, Points + Lines: Diagrams and Projects for the City. New York: Princeton Architectural Press.

Banyan., 2010, THE ECONOMIST, Asia's alarming cities, [online] Available at:<http://www.economist.com/node/16481295> [Accessed 24 April 2012].

Beesley, Philip. PHILIP BEESLEY ARCHITECT INC. [ONLINE] AVAILABLE AT:<HTTP://WWW.PHILIPBEESLEYARCHITECT.COM> [ACCESSED 24 APRIL 2012].

Castells, M., 2004. Space of Flows, Space of Places: Materials for a Theory of Urbanism in the Information Age. In: Braham, M. and Hale, J., ed. Rethinking Technology: A Reader in Architectural Theory, London: Routledge, pp. 440-455.

ENWAVE, 2004. Deep Lake Water Cooling. [online] Available at: <http://www.enwave.com/dlwc.php> [Accessed 28 August 2010].

Graham, S., 2004, Scientific American, Big Chill: An ambitious new project uses lake water to cool off city slickers, [online] Available at: <http://www.scientificamerican.com/article.cfm?id=big-chill> [Accessed 28 August 2010].

Johnson, Jason. and Gattegno, Nataly. Future Cities Lab. [online] Available at:<http://www.future-cities-lab.net/> [Accessed 24 April 2012].

Koolhaas, Rem. Next American City: Rem Koolhaas on the Invention and Reinvention of the city. Interview by Paul Fraioli. Journal of International Affairs, 2012.

KVA MATx., 2010. Soft Cities. In: Mohsen Mostafavi with Gareth Doherty, Harvard University Graduate School of Design, ed. *Ecological Urbanism*. Lars Müller Publishers, pp. 270-273.

Mau, B. Leonard, J. and Institute Without Boundaries., 2004, MASSIVE CHANGE. London: Phaidon Press.
Moore, R., 2010. Roadmap 2050 by Rem Koolhaas's OMA. *The Observer,* [online] 9 May 2010. [online] Available at: < http://www.guardian.co.uk/artanddesign/2010/may/09/roadmap-2050-eneropa-rem-koolhaas > [Accessed 24 April 2012].
Stevens. B., Schieb. P., and Andrieu. M., 2006. A Cross-sectoral Perspective on the Development of Global Infrastructures to 2030. In: *Infrastructure to 2030: telecom, land transport, water and electricity / Organization for Economic Co-operation and Development*. Paris: OECD.
Sung, Doris. DOSU Studio Architecture [online] Available at: <http://dosustudioarchitecture.blogspot.com/>
The City of Toronto, 2006. *What's the City doing to shrink its footprint?* [online] Available at: < http://www.toronto.ca/environment/initiatives/cooling.htm> [Accessed 28 August 2010].
Urbanized, Produced and Directed by Gary Hustwit, 2011.