THE SUSTAINABLE BUILT ENVIRONMENT

Jong-Jin Kim
College of Architecture and Urban Planning, University of Michigan, USA

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Summary

Environmental conservation and technological innovation are two principal forces that drive the building industry toward the future. Technological innovation offers many opportunities to make buildings more dynamic and comfortable, and occupants more comfortable and productive. The necessity of environmental conservation, on the other hand, compels all types of developments and human activities to be environmentally responsive.

As such, environmental conservation is one of the most important factors for shaping a new paradigm of the practice of building industries in all nations of the world, developed or developing alike. Innovative technologies can be and must be utilized for conserving energy consumption, harnessing energy from alternative sources, increasing indoor air quality, and alleviating environmental pollution. Thus, innovation and conservation must be regarded as the two sides of a coin, the sustainable future.

A building is part of the global ecosystem, where a continuous and cyclical flow of resources occurs. The input and output elements for the building ecosystem include building materials, energy, water, consumer goods, and on-site natural resources. These input and output elements of the building ecosystem have diverse environmental implications during the processes of their transmigration. Economy of resources, life-cycle design, and humane design provide a conceptual framework for sustainable built environments. A series of design strategies for greening built environments can be emanated when this framework is holistically incorporated in design.

Our dependency on information technology has led telecommunications networks to become the fourth utility in built environments of all scales. Access to computers and telecommunications networks is indispensable in today's homes and workplaces. Ever evolving technologies require a new approach to building design that allows for the flexible accommodation of new technologies during the life-cycle of a building. Advancement in computer and micro-processor technologies has opened the possibility of automated buildings. Technological innovation in computing, telecommunications, and information technologies has many important ramifications on the design of new built environments.

1. Introduction

Since the Industrial Revolution, human economic activities have long posed a major threat to the environment. Based on the economic paradigm after the Industrial Revolution, technological innovation has been accompanied by a further acceleration of resource consumption and the deterioration of the environment. The conservationists' general tendency against innovation and advanced technology is, in part, a reaction to such environmentally irresponsible technological innovations in the past.

Even after the two energy crises of the 1970s, many consumers, economists, and policy makers regarded the events as energy distribution crises rather than as symptoms of deeper problems. They failed to recognize that the problems arose from the depletion of world resources and the structural resource-dependency of industrialized societies. The ideal of economic development is still ever-higher production, higher consumption, and greater resource exploitation. The success of economic development is traditionally measured by an increase in the Gross National Product (GNP), which favors any economic activities, and production, regardless of their true benefits and effect on long-term societal well-being. Even consumption, demolition, and waste that require further production are credited to the GNP. Consumption has been regarded as a virtue in industrialized societies.

In industrialized countries, this production-consumption based economic paradigm is still dominant. However, by recognition of the environmental threats, real or potential, to the quality of life, the arguments against consumption and waste are increasing. Environmental consciousness is growing within the general public's awareness. The environmental movement has begun in virtually all sectors of industrialized countries including business, manufacturing, transportation, agriculture, and architecture. Efforts have been undertaken to shift the consumption-based economic paradigm to one based on conservation. The methods of deter-mining the true social cost of an economic activity are being developed.

Developing countries have been, by and large, modeling their economic infrastructure on those of their industrialized counterparts. Today, economic activities in developing countries around the world, (Pacific Rim countries in particular), are far more noticeable than two or three decades ago, and their share of the world economy is increasing. All quantitative economic indices such as per capita income, GNP, amount of foreign trade, and the amount of building construction indicate that their economies are strong and growing rapidly.

However, in the name of economic development, abuse of the natural environment is occurring without acknowledging that the undisturbed natural environment is also valuable. The loss of environmental quality and quality of life attributed to industrialization are not justifiably taken into account by a measure of a country's GNP. In the United States alone, billions of dollars have been spent cleaning up an environment subjected to uncontrolled development. The ecological havoc created by the production-consumption based economic paradigm is only now beginning to be discovered.

Since the end of the Second World War, many countries around the world have experienced unprecedented economic growth. Along with such a rapid expansion of the world economy, the demand for new buildings was high, including homes for urban white and blue-collar workers, office spaces for new business corporations, and industrial buildings to accommodate manufacturing facilities. As the income levels grew, more cultural, recreational and service related facilities such as museums, performance halls, amusement parks, hotels and restaurants were needed.

The high demand for buildings imposed significant pressure on not only major metropolitan cities, but also small rural towns and villages to sprawl into suburban areas. A boom in building construction became noticeable throughout the world. While the construction of new buildings contributed to local and national economies, they have imposed a significant burden on the environment. While construction activities were stimulated by government policies, appropriate regulations or guidelines for reducing the negative impact of buildings on the environment and the quality of life were not concurrently instituted. As such, after the four-decades of economic development, the ever-increasing building construction activities have emerged as a major threat to the global environment.

1.1. Environmental impacts of building

Diverse environmental problems ascribing to heating and cooling buildings, constructing new buildings, and transporting people between buildings have been observed. The deterioration of water and air quality due to the pollutants released from buildings, construction sites, and automobiles, the infringement of sonic privacy by the noise generated from building construction sites, and the disruption of natural scenery caused by buildings built in visually sensitive natural environments are only a few of those examples.

1.1.1. Shortage of building materials

Before the turn of the century, most of the materials used in building construction were procured domestically in that particular country. Most buildings have been built with materials obtained from local forest or earth, such as wood, bricks, or adobe. The natural resources for these building materials seemed to be unlimited. However, the high construction volumes during the last thirty years in many developed countries have drastically depleted these natural resources. The shortage of natural resources for building construction has become a problem. Even sand and gravel are becoming scarce, and must be imported from neighboring countries. Alternatively, sand and gravel from the seacoasts are being used in building construction. Though they go through a desalt process, their use in construction raises a major concern regarding a building’s structural integrity and durability. Because timber-producing trees have become scarce, wood structures are seldom built in many countries in Asia and Europe. Concrete masonry structures represent the majority of low-rise commercial and residential buildings. Steel structures are used in high-rise commercial buildings, and are increasingly being adopted in high-rise residential buildings. The substitution of wood with steel may solve the short-term resource shortage problem, but may not be an ultimate solution.

1.1.2. Noise, vibration, dust, and traffic disruptions

The noise, vibration, and dust produced from construction sites are major sources of environmental pollution that affect the quality of life for people living or working nearby. Dust from construction sites is detrimental to air quality and health. Construction activities disrupt local pedestrian and automobile traffic causing inconvenience and wasting the time of commuters. Methods of construction that do not create such environmental disruptions must be practiced.

1.1.3. Food wastes

Because of the high population density, the management of organic food waste is a major problem. The grinding and disposing of food waste into the sewer from each household increases the content of organic materials in sewers to such a high level that it becomes practically impossible to treat such sewer water at municipal water treatment plants. Releasing sewage without proper treatment into creeks or rivers causes grave pollution. For this reason, the use of in-sink grinders is prohibited in high-density cities. In many countries, there is a legal requirement to separate organic food waste from other domestic solid wastes. Methods of using organic waste produced from households, commercial buildings, and entertainment installations in ways beneficial to nature must be developed.

1.1.4. Water pollution

In most parts of the world, single-family homes, and other small commercial buildings in rural communities, are not connected to municipal water treatment systems. The sewage generated from these buildings is released untreated to creeks and rivers that are the sources of freshwater withdrawal for major cities downstream. The lack of sewage treatment systems in rural communities upstream pollutes creeks and rivers, and worsens the quality of potable water. Currently, most people in major cities rely on bottled water for drinking. They do not, and cannot, drink municipal water without domestic treatment. The release of untreated sewage from rural communities upstream is the main cause of this low quality water problem.

1.1.5. Disruption of natural scenery

High-rise residential and office buildings, hotels and other entertainment installations, warehouses and other industrial buildings constructed on mountains, farmlands, or at the edges of rivers, lakes, or ocean coasts disrupt natural scenery and serenity. Tall buildings built on a hill or a farm without regard to topography and drainage are not uncommon in rural areas. Although they may not cause physiological harm to people and the environment, as is the case with polluted water or air, they ruin the visual quality of nature. Though built on private land to meet the interest of their owners, such buildings deprive the public of their right to see and enjoy beautiful scenery and wilderness. They diminish the economic and environmental value of not only the land they stand on but also that of adjacent land. For these reasons, building on virgin lands and sensitive natural areas must be judiciously regulated.

The notion of nature-friendly land development must be understood among building and civil engineering professionals. Often hills and mountains are cut into, or even flattened, for the purposes of building or land development. Human intervention with nature in architectural and civil engineering projects has been overly excessive. The building industry must be more conscious of constructing buildings in harmony with nature.

1.1.6. Disappearing green spaces in urban areas

Urbanization is a worldwide phenomenon. Today, over 50 percent of the world populations live in an urbanized area. With the urbanization of world population, urban sprawl is a problem that virtually all cities and communities in the world are facing. Suburban farmlands and forests are encroached upon by ever expanding residential and commercial zones. Green spaces are increasingly scarce in urban areas. The lack of green spaces degrades the visual environment and psychological well-being of urban residents, and it contributes to the heat-island effect. In summer, night-time air temperatures in major cities remain uncomfortably high, causing an increase of electricity consumption for air-conditioning. For these psychological and energy-related reasons, expanding green spaces and planting more trees are beneficial in large cities.

1.2. Environmental impact of economic development

Resource consumption and economic status have a strong correlation. As the income level of a society increases, its resource consumption increases accordingly. With a few exceptions under special circumstances, this is the case for any society, whether it is a family, a city, or a country.

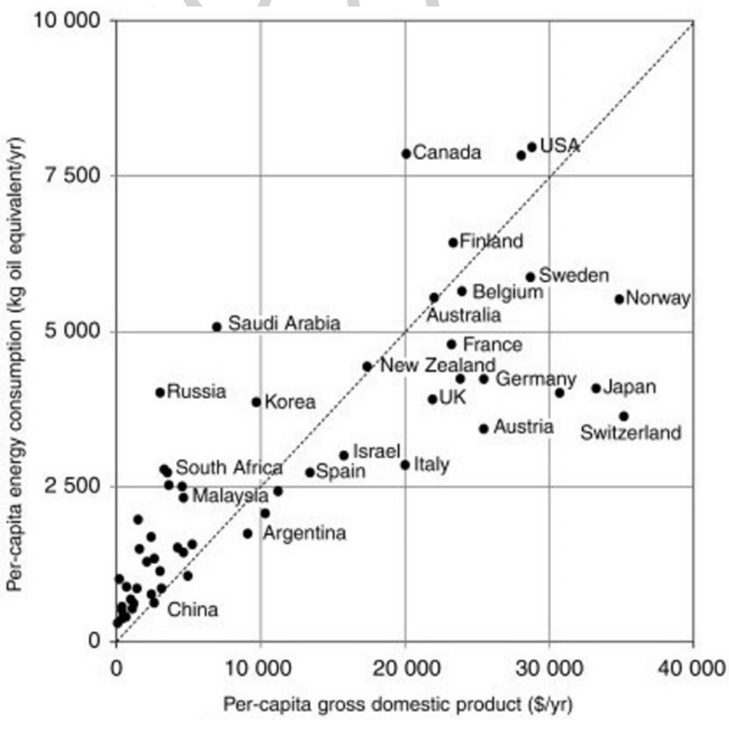

Figure 1: Correlation between per capita income and per capita energy consumption of selected countries.

The correlation between per capita income and energy consumption of various countries demonstrates this trend (see Figure 1). Among industrialized countries, the energy intensity of Canada and the United States is the highest, consuming more energy per capita than European countries with similar per capita incomes. Conversely, the energy intensity of Japan is much lower than other industrialized countries. In spite of its higher per capita income than the United States and most European countries, Japan consumes less energy per capita. This implies that it is feasible for a society to establish resource-efficient social and economic infrastructures while raising its economic status. A society with such an infrastructure will be less susceptible to resource shortages, more self-reliant, and thus, more sustainable in the future.

As might be expected, the emission of environmental pollutants to the atmosphere is also strongly correlated to economic status (see Figure 2). The correlation between per capita income and per capita pollutant-emission follows a pattern nearly identical to energy consumption. Industrial countries produce more pollutants per capita than developing countries. If developing countries were to follow the economic paradigm of developed countries, their share of global environmental pollution can be expected to increase in the future. Developing countries would do well to learn from these lessons of environmental ill practice and failure from developed countries, not to emulate them. The analyses of income and energy production and energy consumption and energy production reveal no significant correlation (see Figures 3 and 4). This implies that energy-intensive countries need to either produce more energy or, preferably, conserve energy to achieve equity with producing countries.

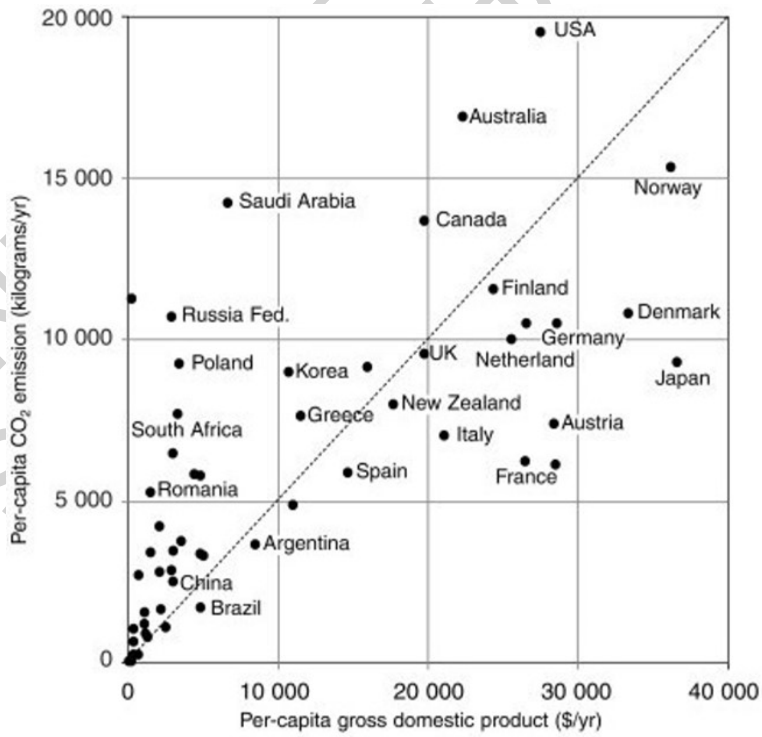

Figure 2: Correlation between per capita incomes and per capita CO2 emission of selected countries.

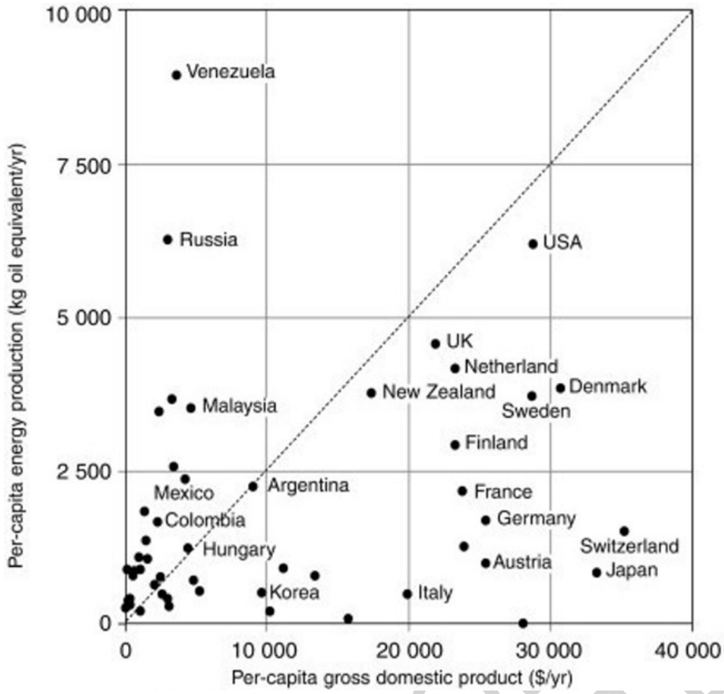

Figure 3: Correlation between per capita income and per capita energy production of selected countries.

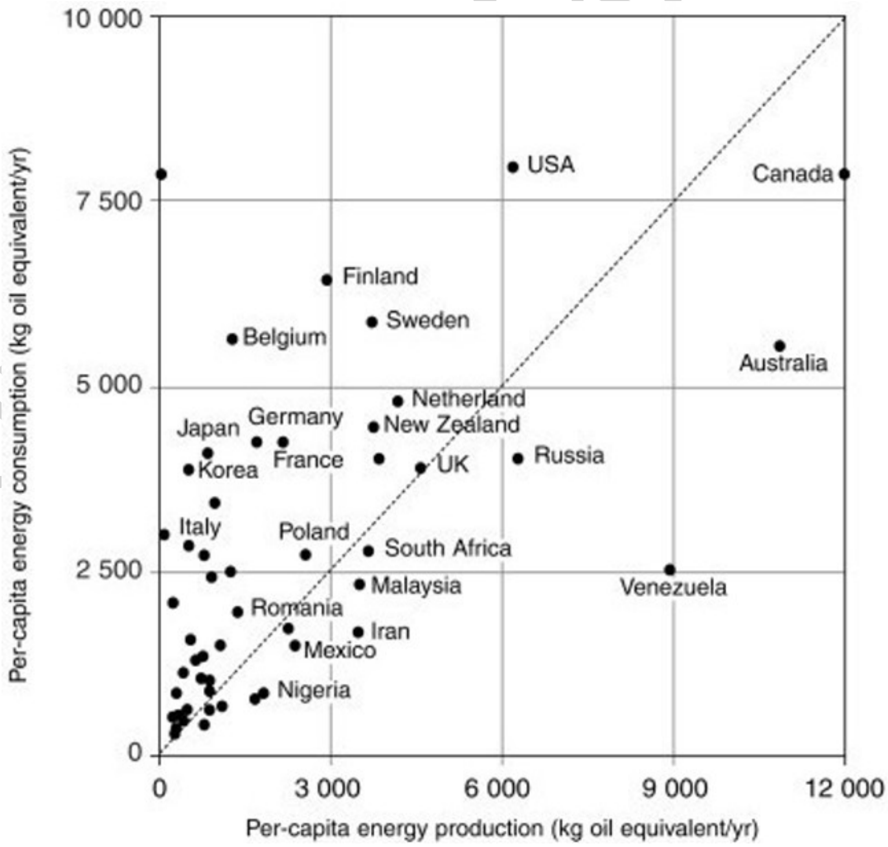

Figure 4: Correlation between per capita energy production and per capita energy consumption of selected countries.

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Biographical Sketch

Dr. Jong-Jin Kim is an associate professor at Taubman College of Architecture and Urban Planning, University of Michigan. The principal theme of his research and scholarly work is to explore architectural ramifications of technological innovation and environmental conservation. He teaches and conducts research on sustainable design and building intelligence.

His research work on building technology spans three continents. In the late 1970s, he worked on developing a building energy analysis model for passive solar buildings at the University of Texas at Austin Numerical Simulation Laboratory. In the 1980s, he worked on the research staff at the Lawrence Berkeley Laboratory, University of California, Berkeley, where he received his Ph.D. in Architecture. He has gained international recognition through his work on computer modeling of radiation flux exchange. In 1985, Dr. Kim served as a visiting academic to the University of Strathclyde, and collaborated with European researchers for the EEC Building Research Consortium. From 1989 to 1994, he served as a US representative to the International Energy Agency Task XII group. In January 1994, he served as the chair of the 1994 ACSA (Association of Collegiate Schools of Architecture in North America) Technology Conference under a theme “Design and Technological Innovation for the Environment.”

He has published, and given many lectures internationally, on sustainable design and building intelligence. In the 1990s, at the University of Michigan, he developed the “Architectural Compendium for Environmental Education (ACEE),” which is one of the first educational resources for teaching sustainable design in architecture. This compendium is being disseminated among architectural educators in the United States. His article entitled “Intelligent Building Systems” was featured on McGraw Hill’s Time Saver Standards.

Dr. Kim has collaborated with many local and international architectural firms on award winning green building projects. In 1997, the Korean Institute of Energy Research, in the design and construction of the first green office building in Korea, invited him to be the “green-building” consultant. In 2001, he constructed a mock-up building called “Smart Building Module,” which is a full-scale experimental facility to showcase and conduct studies on advanced building control technologies. Currently, he is writing a book entitled *Building Intelligence: Building Technology of the Future.*