Chapter 7. Investing in Resource-Efficient Infrastructure

Infrastructure investments often establish a country's pattern of energy use for subsequent decades. If traditional low-efficiency infrastructure is introduced, the economies and the sustainability of resource use will suffer in the long term. Thus, private and public investors in developing countries should consider opportunities to bypass conventional or outmoded infrastructure solutions, that is, to "leapfrog" over them by shifting investments to more resource-efficient alternatives.

Investment Needs in the Region

Developing countries need to invest in all types of infrastructures, including energy, transport, and water, to improve living standards and to achieve MDGs. ADB estimates that $60 billion per year is needed to expand urban infrastructure services between 2006 and 2010 for water supply, sanitation, solid waste management, slum upgrading, urban roads, and mass transit systems.

The *Asia Water Watch 2015* study commissioned by ADB, WHO, UNDP, and United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) estimates that annual investments of $8 billion will be needed over the next decade to meet MDG targets for safe drinking water and sanitation alone. In addition, investments are needed in irrigation services, river basin management, flood management and mitigation, and wastewater management.[222]

While funding agencies can continue to play a key role in delivering and leveraging investments (Box 7.1), the infrastructure needs in the region will not be met unless the public and private sectors make massive and unprecedented investments. There is a clear need for expanded use of innovative financing measures—involving public-private partnerships—to respond to the heavy financing requirements of provincial and municipal governments for their infrastructure needs.

The nature of this infrastructure will determine the sustainability of resource use in the region for decades to come. It is not necessary to follow long-established centralized designs from the developed world that may have serious flaws even there. Instead, a considerable amount of investment can be shifted to more resource-efficient alternatives while providing the same level of service. There is a need for rigorous analysis of projected demand and cutting-edge technologies (such as those described in Chapter 8) that provide higher, long-term efficiency and that can be upgraded as new technologies become feasible.

Leapfrogging Conventional Solutions

There is great potential for leapfrogging over older-generation technologies to more advanced solutions with greater long-term resource efficiency, savings in costs, and environmental benefits. Society and the environment are beneficiaries of this investment, especially when older and more resource-intensive and polluting infrastructure is closed in the process.

Such systems may offer a means of skipping a stage of conventional infrastructure development. System designs can integrate advanced technologies and practices to optimize resource use and reduce the volume of waste through environmentally

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222 ADB, UNDP, UNESCAP, and WHO. 2006. *Asia Water Watch 2015*. Manila. Available: www.adb.org/Documents/Books/Asia-Water-Watch/default.asp

Box 7.1: ADB: Delivering and Leveraging Investment in Water, Solid Waste, and Clean Energy

As a financer, the Asian Development Bank (ADB) can help deliver and leverage much needed investment in infrastructure services in the water, solid waste, and clean energy sectors. In each of these sectors, ADB assistance is helping support commercialization and private sector participation. In recent projects, there has been increasing reliance on market mechanisms for the delivery of infrastructure and services, particularly in large cities. Successful private sector participation in water supply and solid waste management in some developing member country cities indicates the potential for wide-scale development of public-private partnerships in these and other urban services.

Water sector. In response to the significant challenges in the region, ADB formulated the Water Financing Program (WFP), which seeks to make water a core investment area for ADB. Under the WFP, ADB proposes to increase its water investments to well over $2 billion annually. Launched at the 4th World Water Forum in March 2006, WFP builds on ADB work in the first 5 years of implementing the "Water for All" policy. It includes a large number of programmed water investments, a wide array of knowledge and awareness products, and regional cooperation services. The new program focuses on the delivery of substantial investment, reform, and capacity development in three key areas: rural water services, urban water services, and river basin water management. Concrete outcomes of the program will be safe drinking water and improved sanitation for about 200 million people, improved irrigation and drainage services affecting livelihoods of 40 million people, reduced flood risk for about 100 million inhabitants in rural and urban areas, and integrated water resources management introduced in 25 river basins.

The move recognizes the clear link between clean water and reducing poverty and is intended to make a significant contribution to the achievement of the Millennium Development Goals (MDGs).

Solid waste. ADB has financed projects across Asia and the Pacific to improve urban waste management—primarily the collection and disposal of municipal and industrial solid wastes. Over the past decade, approximately $900 million have been spent on projects with such components. Often these investments have been part of integrated urban development programs covering entire municipalities or sections of major cities and, in many cases, they also have involved public-private partnerships. There are also increasing efforts underway to reduce waste through refuse recovery or recycling, including the following projects:

- The Metro Manila Solid Waste Management in the Philippines project contributed to a more realistic view of the role of recycling in a solid waste management strategy for the city and provided individual local governments with assistance on recycling initiatives and related infrastructure development.
- Part of the loan funds for the Waste Management in Cook Islands project were used to construct a recycling center. A national waste strategy was also developed.
- The Efficient Utilization of Agricultural Wastes Project in the People's Republic of China is raising income through the generation of cheap energy and improved soil fertility. It has proven so successful that it is now being scaled-up across many provinces.

Clean energy. Out of the 99 environmentally classified loans approved by ADB from 1995 to 2005, 10 were energy projects worth $1.01 billion or 15% of the total cumulative lending of $6.8 billion. ADB has also supported a variety of policy and technical measures to promote energy efficiency and clean energy, having contributed over $30 million for 36 technical assistance activities over the past 10 years. Some recent projects are:

- Under a multitranche assistance for the development of renewable energy in Pakistan, several run-of-river hydroelectric power plants will be installed to expand power supplies in rural areas.
- Indonesia's hydropower and geothermal resources are being harnessed through a renewable energy development sector investment program.
- A financing facility is helping India's Tata Power Company Limited, a private sector company, implement two wind power projects with a total capacity of 100 megawatts.

ADB also seeks to significantly increase its investments in the clean energy sector in Asia through specialized private equity funds. Equity investments in clean energy funds, such as the FE Clean Energy Asian Sub-fund, are helping catalyze capital flows into energy efficiency, renewable energy, and other clean energy projects, especially in small- and medium-sized enterprises.

Source: ADB.

sensitive design and process optimization. However, after all value from the flow of residuals is captured, sound downstream disposal facilities will still be required.

These systems can sometimes require higher up-front costs, but costs usually be recouped over time through efficiency gains. Due to the small-scale and decentralized nature of such solutions, they may require developing innovative project designs that can be replicated in many parts of the region, in contrast to the usual way of funding few large projects. For instance, to operate effectively in the long term, large-scale wastewater reuse operations will require governments to develop the means of allocating costs and revenues, encourage or oblige those accustomed to disposing of wastewater for free to use the new system, and reform building codes and land-use regulations to permit and encourage wastewater recycling. When all these measure are taken, such operations can contribute to overcoming local water scarcities on a larger scale.[223]

For all these efforts, institutional capacity and arrangements are of paramount importance, in large part so that the costs and benefits of projects can be apportioned in a fair, equitable, and transparent manner. This is true on many levels. On the village level, it might include apportioning seasonal runoff for maximum usage and minimum losses of water and soil. On the national level, it includes institutionalizing rule-making and adjudication and ensuring that large projects do not accentuate inequalities.[224]

Through their agencies and extension services, governments can speed dissemination and promote education. They can also bring much-needed capacity in analysis, financial management, and infrastructure support and can also play a lead role in coordination and reconciliation. NGOs can play an important role in design, knowledge dissemination, and construction, and researchers can act as catalysts by introducing new research to decision makers or directly to families or farmers.

Three examples are provided below: decentralized wastewater systems, resource recovery and recycling systems, and green buildings. These options are compared with conventional solutions to give an idea of the benefits of leapfrogging to more sustainable solutions.

Centralized versus Decentralized Wastewater Systems

Centralized sewage treatment systems and their network of sewers are still the preferred choice of most civil engineers. In developed countries, such systems have been extremely successful in many cities. Singapore, lacking land area for more reservoirs, constructed separate drainage and sewerage systems to safely drain water into existing local reservoirs. The Public Utilities Board, the country's water authority, was able to collect all used water (in a country which is 100% sewered).

However, for many developing countries, there are a number of disadvantages in investing in costly, centralized systems. The major challenge for wastewater reuse schemes is that large-scale systems will probably not pay for themselves out of revenues. Capital-intensive systems take up considerable urban land and import technologies that are typically inappropriate. Thus, while selling treated water can cover operational costs, the capital costs are typically too high and/or maintenance proves too difficult. For example, a heavily engineered wetland was installed for Battambang, Cambodia to recycle all the wastewater of this small city. This system, funded by the International Development Research Centre, was found to be too maintenance-intensive and eventually stopped functioning.[225]

Other common problems of centralized systems are:

- The uncertain projections of future demand create a disincentive for increasing efficiency of water use and lowering the volume of effluents. The investment results in major consumption of materials and energy for construction.
- The benefit of investment is derived only in the long term, after an extended period of design, construction, and commissioning. Maintenance of the plant and sewer system adds to the operating costs, offsetting returns.
- The six different types of wastewater—high

223 Ibid.

224 Brooks, David. 2002. *Water: Local-level Management.* Ottawa: International Development Research Centre. Available: http://www.idrc.ca/water/ev-9440-201-1-DO_TOPIC.html

225 Ibid.

organic excrement, yellow water (urine), potable water for transportation of biomass, domestic wash water, industrial process and cleaning water, and storm water—are typically combined and a large volume of potable water is needed to move sewage through the collection and processing system.

- The combining of streams mixes toxic and nontoxic inputs and prevents reuse of the latter, such as storm water.
- If the treatment plant yields reusable secondary water, investment is required to build separate lines for its distribution.
- Sludge from treatment plants contains pollutants, which make use as by-products unsafe; the sludge consumes landfill space or pollutes river or marine ecosystems, and wastes an important material and energy resource.[226]

Decentralized wastewater systems can reduce public investment, increase efficiency of water use, generate renewable energy and organic fertilizer, and avoid solid waste disposal of sludge. Thus, they can resolve water, energy, and materials resource issues simultaneously. Some specific benefits are:

- Total investment is incremental and much smaller since it avoids the cost of long sewer lines, which are typically 80–90% of the construction cost.
- Small, decentralized treatment plants start operation within weeks to months, yielding direct and immediate benefits in wastewater treated and in revenues.
- The six different wastewater streams can be treated separately, enabling safer handling of toxic and septic flows, and easier processing and reuse of nontoxic streams. Secondary water is reused close to the source.
- Anaerobic digesters handle the separate flow of excrement, possibly blending it with garbage or farm biomass for production of methane.

Such systems have been in operation in some European cities for over 20 years, demonstrating their ability to deal with issues of hygiene and public health. Water managers have installed full-scale applications in India, Indonesia, Thailand, and other Asian countries.[227] Typical uses for secondary water include: industrial, construction, landscape and agricultural irrigation, scenic water, toilet flushing, road cleaning, car washing, and fire fighting

As discussed in Box 7.2, Beijing regulations require public and private buildings over a certain size to install their own sewage treatment plant. Three hundred systems are in place and another 100 planned. The city also built a secondary water system to make the output available for municipal and industrial uses.

Landfills and Incineration versus Resource Recovery and Recycling

Because of the rapid increase in the volume of waste, the cost of disposing of it through landfilling or incineration is growing. Yet, many cities that are finally starting to address their waste management problems are turning primarily to conventional solid waste management solutions, such as sanitary landfills or incineration that focus on improving downstream disposal, while failing to fully pursue upstream options to reduce the waste load.

This is clearly a mistake, as overreliance on conventional solutions is unsustainable. Waste disposal is expensive, both financially and in lost resources. It requires substantial inputs of labor (e.g., collection and processing); materials (e.g., construction of wastewater, landfill, or incineration facilities); energy (e.g., collection, water treatment, and incineration); and/or land (e.g., incineration or water treatment facility or landfill). Local governments in Asia spend a lot of money on waste collection and disposal (in some cities, solid waste management accounts for the largest proportion of

[226] Based on Jules B. van Lier and Gatze Lettinga. 1999. Appropriate Technologies for Effective Management of Industrial and Domestic Waste Waters: The Decentralised Approach. *Water Science Technology.* 40-7: 171-183 and Christ, Oliver. 2002. Decentralized wastewater treatment systems. International Wastewater Symposium by Huber. 1 October. Available: http://data.huber.de/ueberuns/symposium/Symposium_Dr_Christ_DeSaR_e.pdf

[227] van Lier, Jules B., and Gatze Lettinga. 1999. Appropriate Technologies for Effective Management of Industrial and Domestic Waste Waters: The Decentralised Approach. *Water Science Technology.* 40–7: 171–183l and Wilderer, Peter A. 2002. Decentralized Sanitation and Reuse: a new concept for economic water management worldwide. International Wastewater Symposium by Huber 1 October. Available: http://www.huber.de/hp570/International-Wastewater-Symposium-by-Huber.htm

Box 7.2: Beijing Decentralized Water Treatment System

In 1987, the Beijing Municipal Government issued the Management Regulation on the Construction of Wastewater Reclamation Facilities in Beijing (trial). According to this regulation, hotels with construction areas exceeding 20,000 square meters (m^2) and all other public buildings with construction areas exceeding 30,000 m^2 should construct their own wastewater reclamation facilities. Also, new residential areas were encouraged to implement wastewater reuse. This last category was detailed in 2001 through a regulation that required residential communities exceeding 50,000 m^2 to build a reclamation facility.

By 2002, more than 154 distributed wastewater reclamation systems (DWRSs) had been built in the Beijing central region, of which approximately 120 were in operation. The Water Saving Office of the Beijing Water Authority estimates that in 2006 approximately 300 DWRSs are in operation and another 100 are under construction, spread over the city on various scales and with different technologies.

According to their estimations, these systems are producing 50,000–60,000 cubic meters (m^3) of second quality water per day or 18–22 million m^3 per year. In 2005, the gross amount of recycled water used by agriculture, industry, community, and administration was estimated at 200 million m^3 per year which indicates that the share of the reused wastewater from the on-site facilities is approximately 10% of the total.

Pay-back times on the investments for the systems are typically 8–14 years for public owners and 4–6 years for private sector owners. This difference is because conventional water costs are about twice as great for the private sector as for the public sector.

Source: Mels, Adriaan, et al. 2006. Decentralised Wastewater Reclamation Systems in Beijing—Adoption and Performance under Field Condition. Paper presented at First *SWITCH Scientific Meeting.* University of Birmingham, 9–10 January.

the revenue budget), and typically devote more labor and transport to solid waste management than to any other municipal service. Siting these facilities is also difficult because of high land costs and "not in my back yard" attitudes in society. Cities that can afford advanced technology, such Singapore and Hong Kong, China, have chosen incineration because they cannot afford the land for landfills.

Also, while modern landfills now have advanced systems that can treat leachate and state-of-the-art incinerators satisfy stringent environmental parameters, these technologies are not infallible. For instance, leachate changes in terms of strength, biodegradability, and toxicity as wastes in a landfill ages over time. Bearing in mind that landfilled wastes may take up to 100 years to stabilize, finding fail-safe solutions can be a challenge.

Landfills are also a major source of methane. Along with heavy compaction and great depths, liners foster the very oxygen-starved conditions in which methanogenic microbes thrive, releasing methane as a by-product of decomposition of the organic material. Even in modern landfills with sophisticated methane capture systems, a large portion of the gas that is created over the lifetime of the landfill eventually escapes uncontrolled into the atmosphere, contributing to global warming

Source: AFP.

Box 7.3: Landfilling and Greenhouse Gas Emissions

Decomposition of organic waste (such as paper, food scraps, yard trimmings) under anaerobic conditions leads to the formation of biogas consisting of approximately 50–60% methane, 40–45% carbon dioxide, and trace amounts of other gases. Methane is a potent greenhouse gas (GHG), and among the anthropogenic emissions it is the second largest contributor to global warming after carbon dioxide. Methane produced at solid waste disposal sites (SWDS) contributes approximately 3–4% of global anthropogenic (GHG) emissions.

Methane generation in SWDS depends on several factors: (i) the total amount of solid waste, which is determined by population size and affluence; (ii) composition of the waste; and (iii) characteristics of the SWDS (i.e., climate, size/depth, degree of acidity, moisture). Growing populations, increases in incomes, and expanding industrialization can lead to increases in the amount of solid waste generated and, thus, escalating methane emissions from SWDS.

Climate change concerns and the disadvantages of traditional waste management methods have already influenced waste policies in some developed countries. In the European Union (EU), it was decided that the earlier strategy favoring landfilling was no longer acceptable and the amount of organic matter permitted to enter solid waste facilities was limited by the EU Landfill Directive (1999/31/EC). As a result of the directive and related national legislation, methane emissions from landfills in EU-15 decreased by almost 30% between 1990 and 2002. By 2010, GHG emissions from waste in the EU are projected to be more than 50% below 1990 levels.[1]

In 1993, the United States issued its Climate Change Action Plan (CCAP), which calls for cost-effective domestic actions and voluntary cooperation with states, local governments, industry, and citizens to reduce GHG emissions. To achieve the goals outlined in CCAP, the Environmental Protection Agency initiated several voluntary programs, including the Landfill Methane Outreach Program, which aims to reduce landfill methane emissions by encouraging projects that use landfill gas to produce energy.

There are two basic approaches to mitigation of GHG from SWDS: (i) reduction of organic waste (through recycling, composting, etc.), and (ii) collection of generated landfill gas. In developing countries, composting can provide an affordable, sustainable alternative to controlled landfilling. Composting decomposes organic waste aerobically into carbon dioxide, water, and humid fraction so that methane emissions can be avoided. An Israeli study analyzed the costs associated with GHG mitigation options for the waste sector and showed that the most cost-effective means to treat the degradable organic components of waste was by aerobic composting (investment of less than $10 to reduce emissions of 1 ton of carbon dioxide equivalent per year). The high organic content in municipal solid waste in developing countries and the relative simplicity of composting make this option highly applicable.

Sources: Eggleston H.S., L. Buendia, K. Miwa, T. Ngara, and K. Tanabe, (eds). 2006. *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Kanagawa, Japan: Institute for Global Environmental Strategies; Deuber, O., M. Cames, S. Poetzsch, and J. Repenning. 2005. *Analysis of Greenhouse Gas Emissions of European Countries with Regard to the Impact of Policies and Measures*. Report by Öko-Institut to the German Umweltbundesamt. Berlin. 253 p. European Environment Agency (EEA). 2004. Greenhouse gas emission trends and projections in Europe 2004. *Progress EU and Its Member States Toward Achieving Their Kyoto Targets*. EEA Report no5/2004. Luxembourg, ISSN 1725-9177. 40 p; Ayalon, O., Y. Avnimelech, and M. Shechter. 2000. Alternative MSW Treatment Options to Reduce Global Greenhouse Gases Emissions - the Israeli Example. *Waste Manage Res*. 18 (6): 538—544.

(Box 7.3).[228] In contrast, a viable alternative to managing organic waste—segregation and composting—does not create substantial greenhouse gases if done properly.

Given all the problems associated with overreliance on conventional solutions, it is essential that countries start viewing their waste streams as resources and as business opportunities, rather than as a dead loss. Waste disposal must be viewed as just one part, although an important one, of implementing integrated solid waste management. To be truly cost-efficient and sustainable, equal attention should be paid to upstream options to reduce waste for final disposal and to reuse and recycle valuable resources.

To this end, governments should be responsible for promoting appropriate and cost-effective technologies to manage partly recyclable products and unrecoverable wastes properly. Institutional infrastructure, including systems for collection, transportation, treatment, storage, recovery, and disposal, need to be established. Governments

228 Anderson, Peter. 2007. Landfills: A Failed Technology. Presentation at General Assembly of the EcoWaste Coalition. Quezon City, Philippines. 25 January.

should also take measures to improve the working conditions and minimization of work-related toxic exposure at collection, dismantling, recovery, and disposal facilities.

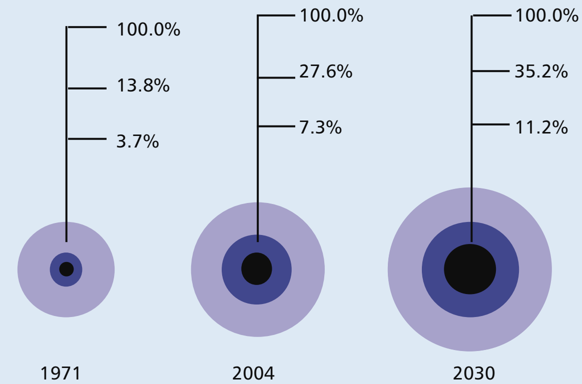
Analyzing the relative economic costs of waste disposal versus reducing, reusing, and recycling reveals that many options for more efficient resource management are cost effective and that there are many viable investment opportunities in resource efficiency. Upstream action is almost always more cost effective than disposal.

Conventional versus Green Buildings

The energy performance of buildings will become increasingly important to the energy outlook of Asian countries, as the built environment continues to boom throughout Asia. The PRC is constructing almost half of the world's new buildings and the built-up area in India more than doubled from 2000 to 2005. As a result, buildings in Asia are consuming more energy and producing more GHG emissions. As shown by Figure 7.1, buildings already account for 25–30% of Asia's total energy consumption as opposed to an estimated 7.3% of the world's energy consumption.[229] Asian building energy consumption could reach 35% of the region's total energy consumption by 2030.

Initial design of a building or retrofitting an existing one can greatly reduce the energy, water, and other resources needed for the life of the facility. Progressive corporations are choosing to build sustainable office buildings and other facilities because "green design" is proving to be less expensive in the long term. For instance, Ford Company rebuilt its largest factory by installing skylights and a "living roof" of sod that reduces toxins, boosts productivity, and saves money. Genzyme Corporation's new headquarters in Cambridge, Massachusetts, has a sod roof, skylights, blinds, and uses waste steam for heating. New York City's football stadium was designed to use solar cells and wind turbines to reduce energy and it sells excess energy to the electric grid. In Malaysia, a new skyscraper uses louvered windows and sky gardens to cool air.[230]

Figure 7.1: Energy Consumption of Buildings in Asia



Source: Hong, Wen. 2007. Trends in Asia's Building Energy Efficiency Policies. Presentation at International Conference on Climate Change. Hong Kong, China, 29–31 May. Available: http://www.hkie.org.hk/iccc2007/docs/PPT/5A%20-%20Energy%20Efficiency%20Policies.ppt

High-performance design creates the possibility that the building's management or owner can gain revenues from selling energy and recycled resources internally or externally. The cost savings alone would pay back any added cost of the resource-efficient design in relatively few years. Further savings can be gained through energy conservation practices in the operation of the building. Most of the possible high-performance innovations have been demonstrated to be cost effective in the operation of hotels, apartments, and office buildings, as well as individual residences.

In practicing high-performance design, architects and engineers draw on a variety of design choices to lower the energy and water demand of large buildings. The major physical systems are:

- highly resource-efficient design of the building envelope and equipment, such as elevators and heating and cooling systems;
- closed-loop system for generating bioenergy and recycling the water and biomass output of the building for its landscaping;

229 Hong, Wen. 2007. Trends in Asia's Building Energy Efficiency Policies. Presentation at International Conference on Climate Change. Hong Kong, China. 29–31 May. Available: http://www.hkie.org.hk/iccc2007/docs/PPT/5A%20-%20Energy%20Efficiency%20Policies.ppt

230 ADB. 2005. *Asian Environmental Outlook: Making Profits, Protecting Our Planet.* Manila.

- geothermal heat pump system to provide a share of heating and cooling through a commercially proven technology that taps the constant temperature of underlying soils or groundwater to provide radiant heating and cooling; and
- wind and solar energy units on the roof or building façade to complete the energy system.

Source: AFP.

High-performance buildings can use some or all of these design features together. For instance, designers of an apartment building or complex of buildings may install a closed-loop system for sewage and garbage, with anaerobic digesters processing the biomass. The resulting methane may be used as a direct input to the apartments or as a fuel for generating electricity. The clean, composted biomass output can be used as nutrient for rooftop gardens and landscaping. Other renewable energy sources can allow the building or complex to generate most of its own energy, or possibly a surplus. These renewable technologies include ground heat pump, solar water heating, wind generators, and photovoltaics integrated with roofing or façade surfaces. Concepts as simple as the orientation of the building in relation to the sun's path (optimal solar orientation) and passive solar design of the building envelope reduce total energy demand enough to significantly decrease commercial energy required in its operation over the years.

Life-cycle savings for operation of the building can be estimated and factored into the total financial analysis. For instance, highly efficient design of the building shell and windows and passive solar features reduce the energy requirements per square meter, enabling lower costs for equipment. Avoided public costs and GHG reductions are also accounted for in the financial analysis. Realizing these advantages also calls for innovation in real estate financing analysis.

A mainstream design and construction publication in the US in late 2006 noted that

> … the financial sector of the real estate industry, heretofore a casual bystander, suddenly woke up to green building—not necessarily because its members had miraculously developed an insatiable urge to save the planet, but because they had begun to see a viable new investment opportunity. In a market that has been flooded with cash, and amid a growing body of evidence that green buildings might in fact have some quantifiable advantages over 'conventional' buildings, developers, property investors, building owners, brokers, appraisers, lenders, banks, property insurers, real estate investment trusts, and pension funds started to open their eyes—and their pocketbooks—to the green building movement.[231]

[231] Building Design+Construction. 2006. *Green Buildings and the Bottom Line*. Available: http://www.bdcnetwork.com/article/ca6390371.html