REPORT 14

SUSTAINABLE CONSTRUCTION
IN THE UNITED STATES OF AMERICA
A PERSPECTIVE TO THE YEAR 2010

GODFRIED AUGENBROE

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NATIONAL REPORT

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1. PREFACE

This report is part of a series of national reports produced by the CIB-W82 (Future Studies in construction), subgroup on Sustainable Construction 2010. This report is the United States contribution to that effort. The information in this report is a compilation of material that was obtained from most of the known sources on sustainability in the United States of America (USA). This report is used as a contribution to a global assessment of sustainable construction in a synthesis report, which will be presented by CIB-W82 at the next CIB World Congress in June 1998.

"The future always comes too fast and in the wrong order"
Alvin Toffler in Future Shock

2. INTRODUCTION

This chapter introduces the concerns, constraints and issues that are particular to the building practice in the USA. It also introduces a variety of national initiatives and programs that have been put in place to confront these issues and it points to the shift in paradigm that this will require.

2.1 National concerns

Both globally and in the United States of America (USA), the construction industry is one of the main contributors to the depletion of natural resources and a major cause of unwanted side affects such as air and water pollution, solid waste, deforestation, toxic wastes, health hazards, global warming, and other negative consequences. And although the traditional attitude of having unlimited resources and space is still dominant in the USA, the awareness of environmental impacts is growing and many movements seeking to address sustainability concerns are gaining momentum.

Buildings represent more than 50 percent of the nation’s wealth in the USA. In 1993 new construction and renovation activity amounted to approximately $800 billion, representing 13 percent of the GDP, and employed ten million people. [1] Buildings account for one-sixth of the world’s freshwater withdrawals, one-quarter of its wood harvest and two-fifths of its material and energy flows.[2] Nearly one-quarter of all ozone-depleting chlorofluorocarbons (CFCs) are emitted by building air conditioners and the processes used to manufacture building materials.[3] 54% of U.S. energy consumption is directly or indirectly related to buildings and their construction.[4] Urban settlements affect the local ecosystem, air quality and transportation patterns of communities, thus having additional impact on the sustainability of our society. It is paramount that the building industry adopts ‘environmental performance’ as one of its leading principles alongside economic efficiency and productivity principles.

Specific national concerns in the USA are many. The nation has a wide diversity of climatic zones, and traditional building technologies vary from region to region. Severe winters, hot summers, and variations in climate from northern sub-arctic to

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1 National Science and Technology Council, Washington, 1993

2 Roodman, D., and Lenssen, N. (1995). «A Building Revolution: How Ecology and Health Concerns Are Transforming Construction,» *Worldwatch Paper 124*, March.

3 Energy Resource Center. (1995). *Sourcebook: A Guide to the Energy-Efficient and Environmentally Friendly Features of Sustainable Design*. Southern California Gas Company, Downey, CA.

4 Kirsten Chiles, in Loken, S., Miner, R., and Mumma, T. (1994). *A Reference Guide to Resource Efficient Building Elements, 4th ed*. Center for Resourceful Building Technology, Missoula, MT.

desert and subtropical present different sets of bio-regional sustainability issues. Because of this diversity and the legal domination by individual States in controlling construction practices, building codes vary from state to state. There are more than 76 million residential buildings and almost 5 million commercial buildings in the USA, with an additional 15 million buildings projected by the year 2010[5]. Existing buildings use more than one-third of all primary energy consumed in the country, and account for two-thirds of the total electricity use. Lighting accounts for 20-25% of the electricity used in the U.S. annually.[6] Offices in the U.S. spend 30 to 40 cents of every dollar spent on energy for lighting power, making it one of the most expensive and wasteful building features.[7] Over 30% of the total energy and 60% of the electricity use in the United States is in buildings.[8] This energy use produces nearly one-quarter of the country's total carbon emissions, a significant contribution to climate change. In addition to energy considerations, many regions suffer from air and water pollution. Despite the seriousness of present impacts, considerable progress has been made and both air and water are cleaner than they were a few decades earlier.

Another national concern is the inner cities. Urban infrastructure has steadily deteriorated in recent decades, causing a focus on the revitalization of the nation’s inner cities. These blighted inner cities represent a cross section of socially and environmentally unsustainable communities, with decreasing property values and declining neighborhoods. Present inner city problems may be a harbinger of the problems of the «megacities» of the future.

Other local and national issues are worth mentioning:

- *An estimated 400,000 brownfield sites nationwide.* These sites were once productive factories, warehouses, processing plants, and other operations, but are now abandoned facilities with perceived contamination. Sources estimate that cleanup of these contaminated sites will take 75 years and cost about $750 billion.
- *A wave of deregulation that is sweeping the country.* This political trend has made it hard to press for more federal government control.
- *Sustainability in the USA as a community-driven, grass roots movement*. Although broader support is building, expectations are that most improvements will have to come from bottom-up initiatives, carried out by local communities.

A typical and long debated concern in the USA, especially in the context of sustainable communities, is the effect of urban sprawl. Sustainable communities are concerned with the physical layout of their land and activities and the fundamental effects of land use on sustainability. Three factors have converged to generate haphazard, inefficient, and unsustainable urban sprawl:

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[5] US Census Bureau; http://www.census.gov/

[6] Energy Resource Center. (1995).

[7] ibid.

[8] Barnett, D.L. and Browning, W.D. (1995). *A Primer on Sustainable Building*. Rocky Mountain Institute, Snowmass, CO., p.59

- *Zoning ordinances* that isolate employment locations, shopping and services, and housing locations from each other
- *Low-density growth planning* aimed at creating automobile access to increasing expanses of land
- *Low cost fuel for automobiles*, recently observed at 71 cents per gallon in Atlanta, GA, resulting from federal and state subsidies of social and environmental costs

The complex problems shared by cities throughout the USA are evidence of the impacts of urban sprawl: increasing traffic congestion and commute times, air pollution, inefficient energy consumption and greater reliance on foreign oil, loss of open space and habitat, inequitable distribution of economic resources, and the loss of a sense of community.

2.2 Constraints

The American economy is capitalistic and consumer- and consumption-oriented. The general result is people buying things they don't need, with money they don't have, creating waste that they leave to the next generation to worry about. This attitude is also reflected in the way that society has arranged its public spaces. It has led to (sub)urban areas with uncontrolled and unsustainable growth patterns dominated by short term economic indicators. Decaying urban areas have been the inevitable result. Only recently have government and the private sector begun to address the vital issues of land-use decisions, environmental contamination, and the need for durable and adaptable buildings. The road to (sub)urban revitalization will be a long and painful one, although the present economic climate has never been more favorable to make a significant breakthrough.

Constraints related to government involvement are evidence of the general mistrust of federal intervention that seems to be prevalent in local communities in the USA. Energy and pollution taxes, although extremely minor compared to most European countries, meet strong public resistance. In a society where fossil energy prices are among the lowest in the world and space is not a scarce commodity, public awareness of sustainability issues is low. Inevitably, it is hard to get broad public attention and support for these pressing issues. Moreover, since the private sector has traditionally had a minimalist view on buildings as the facilitator of the core processes of enterprise, their facilities typically offer less than satisfactory conditions to the average worker. For lack of proper guidelines and broadly accepted non-economic indicators, many assets in the private sector are not being managed for optimal use.

In the public sector, in spite of the ongoing debate, society does not seem to be able to properly fund, maintain and expand the public infrastructure. Another constraint, not unique to the USA, is the fact that there seems to be no 'stakeholder' acting on behalf of the building stock or the workers that spend a great deal of their productive lives in them. The litigious climate inherent in both the public and private sectors inhibits even the most beneficial actions. For example, law suits against remediation agents in the USA have resulted in only 700 of the estimated 75,000 Superfund (special government funding dedicated to cleanup activities) sites being cleaned, with litigation resulting from failure of the sites to meet arbitrary environmental quality standards.

Other constraints are operational in nature. For example, while use of innovative materials is growing, many liability-conscious designers and contractors are reluctant to try materials which are not yet "tried and true," particularly in civil engineering projects where public funding is involved and where failure could mean the loss of many human lives. Building codes, environmental legislation, and other regulatory restrictions impose further limitations on the use of recycled or innovative materials, often taking years to catch up to changes in materials technology. Finally, the sheer number of potential resources available to designers and contractors in the USA makes sustainable design and construction a nearly impossible task.

These constraints to U.S. sustainable construction, ranging from a national scale to the scale of individual building materials, compound each other to make adoption of sustainability principles a slow and often arduous process. The following chapters will deal with indicators of change motivated by the need to overcome the above constraints.

2.3 Issues

In 1997, the USA Building Futures Council (an independent, nonprofit corporation composed of senior executives representing all built environment stakeholders) issued its list of environmental issues facing the building and construction industry. They have identified eight critical elements:

1. *Superfund Reauthorization and Risk sharing***:** a new approach to sharing risks of cleanups is needed as remedial action contractors and their insurers have voiced concern over liability issues associated with the performance of cleanup contracting.

2. *Cleanup standards***:** selected standards must be based on positive comparative determination and be in the best public interest

3. *Brownfields***:** Redevelopment of the estimated 400,000 brownfield sites nationwide can be critical to urban revitalization efforts

4. *Environmental justice***:** (may need to define for the international audience) Leaders of cities, states and federal agencies need to establish new policies to begin to address and correct past environmental practices, while preventing future injustice

5. *Environmental infrastructure privatization:* the water/wastewater industry has the potential for significant growth, providing the required legislative and regulatory framework is put in place. DOE (Department of Energy) believes privatization will provide substantial savings over traditional contracting approaches.

6. *Navigation improvements:* There is an urgent need to provide channels to accommodate a new generation of container ships that are now in operation and capable of carrying 6,000 container units

7. *Environmental protection during the construction process:* The control or prevention of environmental pollution and damage requires consideration of air, water and land resources

8. *Water minimization and recycling:* Environmentally sustainable construction can be achieved to a significant extent if the proper studies, guidelines, technology dissemination and incentives are developed.

Other institutions councils have published similar lists, such as the President's Council on Sustainable Development list.

Many of the issues recognize that a refocus has to occur on commercial buildings as important productivity assets, with a focus on durable, user centered performance criteria, adding to the overall and long lasting utility of the building. A shift towards maintenance, adaptation and refurbishment and new (modular) construction technologies is the key to improvements in these areas. In the residential sector, a community and life cycle centered approach to the residential fabric is needed, taking into account all dimensions of public space, mobility, energy, waste, public and private satisfaction.

Better control over the export of construction technologies to the developing world is another issue that deserves careful attention. The construction industry is exporting its current practices in increasing volumes to the rapidly developing parts of the world, most notably parts of Asia. How to stop the ongoing export of unsustainable technologies to developing nations is a global concern.

2.4 The future building stock

As a point of departure, we must acknowledge that the future of our building stock is determined both by what we built in the past and what we are building today. Creating a more sustainable future is a long and ongoing process, and the short-term visibility of results is typically poor. Whatever tools, policies and new technologies we adopt in the construction industry, if they are not embedded in proper environmental policies on national, state and community level, they will not work

Trends in Design and Construction Practices

De-construction and re-use of building components is expected to be a big challenge on the near term. These strategies involve open building approaches and modular building systems during design and construction, allowing flexible infills and adaptation to changing requirements and occupancies. Short-term use of disposable buildings such as strip malls is a uniquely American problem. A re-thinking of the service life of a facility has to happen soon.

Destining building for a longer service life and easy adaptation will create a need for lightweight materials, new assembly and disassembly techniques, and flexible re-modeling of building services systems. These techniques will also be deployed in refurbishment of existing buildings. Open building is an approach to design, construction, and long-term adaptation of buildings based on principles at work in historic environments that have stayed vital.[9] It applies to both residential and non-residential architecture: a base building, designed to last, but without specific interior fit-out designed to have a life related to individual households and other kinds of occupancy. Open building practices represent a long-term trend to prevent early obsolescence.

Trends in Facility Uses

Alternative officing strategies are being adopted, enabling more intensive use of office space and reducing the need for more space, and mobility of office workers.

Trends in Resource Needs of Facilities

DOE has set a target for the energy saving in the built environment. In meeting its energy-efficiency goals, Buildings for the 21st Century will reduce the annual USA energy consumption in the year 2010 by one and a half quadrillion Btu, cutting carbon emissions by 32 million metric tons per year. It will reduce the consumption of the earth's natural resources not only by reducing energy usage, but also through more efficient use and recycling of building materials.

Trends in Building Materials and Technologies

Construction materials technology has changed rapidly in recent years, with significant changes including increased reuse and recycling of construction and demolition waste materials like timber, steel and concrete, improvements to traditional products such as fiber-reinforced concrete and plastic-reinforced wood, and development of completely new technology such as geotextiles. New materials such as engineered wood products are being widely employed to make use of materials formerly perceived as waste. Increased attention is being paid to the needs of environmentally sensitive individuals with the development of a new generation of environmentally benign finish products such as low-VOC paints and water-based adhesives.

Trends in construction practices include increased automation and off-site fabrication of components, leading to less waste generation on site. Alternative contracting strategies and organizational environments, and an overall reduction in adversarial relationships among construction stakeholders, are resulting in more cost-effective

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[9] Stephen Kendall, Open Building, an approach to Sustainable Architecture. To be published.

construction projects with more flexibility to incorporate sustainable building practices. Collaborative relationships such as partnering and cost-sharing among construction stakeholders are resulting in cost savings, reduced conflict, and lower levels of risk for all parties involved.

2.5 National organizations, programs and initiatives

American efforts in sustainable construction are not driven by the federal government. The federal government does participate, largely on the sidelines, by setting an example of what can be accomplished. The result has been several highly visible projects such as the Greening of the White House, the Greening of the Pentagon, green construction efforts by the National Park Service, the creation of a draft green building guide by the Air Force, and a wide range of other programs designed to reinforce the general trends in the country.

Among the national programs there is presently an emphasis on energy efficiency programs.

US Geen Building Council's LEED rating system

The Leadership in Energy and Environmental Design (LEED) green building rating system is one of the most significant recent initiatives The LEED Green Building rating system is a priority program of the US Green Building Council. It is a voluntary, consensus-based market-driven building rating system based on existing proven technology that evaluates environmental performance from a 'whole building' perspective over the building service life. LEED is intended to be a definitive standard for what constitutes a 'green building'. The system is designed for rating new and existing commercial, institutional and high rise residential buildings. It is a feature oriented system where credits are awarded to applicants that earn different levels of available credits and meets all prerequisites. LEED is expected to be expanded in the future to cover all types of buildings and include the full range of life cycle assessment criteria.

Buildings for the 21st century

Buildings for the 21st Century is an effort by the Department of Energy, Office of Building Technology, State and Community programs to increase the energy efficiency of new homes by 50%, and existing homes and new and existing commercial buildings by 20% by the year 2010. In a series of workshops, key stakeholders were brought together to help accelerate the adoption of the whole buildings or systems integration approach to achieve this objective.

Passive Solar Industries Council

The Passive Solar Industries Council (PSIC) has developed passive solar design guidelines for both new construction and remodeling projects. The manual provides climate-specific design information, worksheets, and examples. PSIC also offers for sale "BuilderGuide," a PC-spreadsheet-based design tool that automates the design guidelines. One-day workshops, combining residential design information and the use of BuilderGuide software, are offered to builders, homeowners, architects, utility representatives, and engineers.

Million Solar Roofs Initiative

Responding to President Clinton's call to unleash creative power to meet the challenge of climate change, Secretary of Energy Federico F. Peña has announced the administration's "Million Solar Roofs Initiative." The initiative calls for the Department of Energy to lead an effort to place one million solar energy systems on the roofs of buildings and homes across the USA by the year 2010[10].

EPA Programs

EPA’s Energy Star and Green Lights Programs are voluntary program that provide technical assistance, resources, and tools to businesses, institutions, government agencies, and other organizations to produce energy efficient buildings and replace inefficient lighting with new, high-efficiency lighting systems. These programs have helped participants save an average of 30 percent on energy costs.

EPA’s Energy Star Residential Programs aim to promote residential energy efficiency. For example, the Energy Star New Homes program works with builders to provide new homes that are at least 30-percent more efficient than the 1992 Model Energy Code. Energy Star Programs and Products works with utility, product distribution, retail, and government procurement partners to market, sell, and purchase Energy Star products. Energy Star Financing provides long-term equipment financing and innovative mortgage options, with no additional down payment to consumers. The Energy Star Heating, Ventilating and Air-Conditioning Program helps consumers find more efficient heating and cooling equipment for their homes.

Note: EPA is also heavy into pollution prevention (P2), whereby they or their contractors help manufacturers optimize their production processes to eliminate potential pollution at the source. Benefits realized from EPA’s P2 programs include reduced environmental liability, particularly for processes involving hazardous or toxic materials where waste can be prevented. More importantly to US businesses, however, is P2’s potential to save money not only on disposal costs but also by reducing the requirements for input materials.

The American Council for an Energy-Efficient Economy (ACEEE) program

ACEEE offers several publications related to energy-efficient buildings, including Consumer Guide to Home Energy Savings, which discusses the entire spectrum of

[10] DOE's fact sheet, "Million Solar Roofs."

home energy savings and residential appliances, including a list of the most energy-efficient equipment and appliances available; and Guide to Energy-Efficient Office Equipment, which offers recommendations about the types of equipment to purchase and how to best operate it for maximum energy efficiency, as well as energy-use characteristics of microcomputers and displays, printers, copiers, and fax machines.

Home Energy Rating Systems (HERS) and Energy-Efficient Mortgage Programs (EEMS)

HERS programs rate the energy efficiency of new and existing homes, and offer recommendations for energy improvements. These energy ratings are often used in obtaining energy-efficient mortgages (EEMs). Several states have HERS programs, which operate under Energy Rated Homes of America, a national nonprofit organization.

The US Department of Energy, in accordance with the Energy Policy Act of 1992, published a set of voluntary HERS guidelines. DOE is encouraging utilities and the mortgage industry to adopt them. The new guidelines rate new and existing homes according to how closely they follow the insulation requirements of the Council of American Building Officials' Model Energy Code, as well as other requirements. The homes are then awarded an energy efficiency rating between 0 and 100, with 100 being a home that is completely energy-self-sufficient.

In 1995, the National Association of State Energy Office Officials and Energy Rated Homes of America founded the Residential Energy Services Network (RESNET) to develop a national market for HERS and EEMs. An EEM is a type of mortgage that allows energy-efficiency features to be included in a mortgage loan. EEMs can also allow a buyer to qualify for a higher mortgage, because the reduction in utility bills allows more debt.

National R&D programs

In spite of recent funding opportunities such as DOE's CREST program[11] and the National Renewable Energy Lab program[12], there is a need to intensify broad national research programs that specifically put sustainable construction on the national funding agenda. In a study by CERF[13], a global research agenda for the construction industry was established. Sustainability in the 21st century was declared as the main mission. The R&D themes were divided into 5 focus areas:

1) management and Business practices

2) Design Technology and Practice

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[11] CREST: http://www.crest.org

[12] NREN lab: http://www.battelle.gov

[13] CERF, Construction Industry Research Prospectuses for the 21st century, (1996) Civil Engineering Research Foundation, New York, NY.

3) Construction and equipment

4) Materials and systems

5) Public and government policies

The CERF initiative could serve as the template for any future national initiative in sustainable construction, especially in the civil engineering sector. Its strong emphasis on engineering and construction management is an important parallel track that needs separate attention in an industry wide approach to sustainable construction.

2.6 The need for a paradigm shift

It goes without saying all of the above initiatives of section 1.4 as such are not sufficient to bring about the change that is needed. Aiming for a sustainable built environment requires mire than that. It requires a paradigm shift in the way we approach time, cost and quality constraints, as depicted in Figure 1[14].

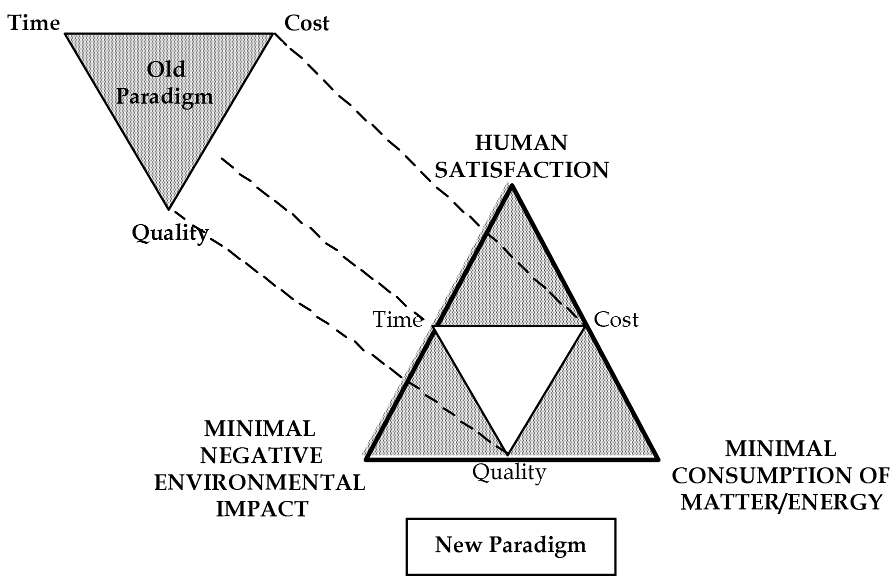

Figure 1: Sustainability calls for a new paradigm

The paradigm shift forces us to take a much broader look in both time (full life cycle assessments), space (the object in its wider system settings) and costs (greener cost metrics than pure monetary), than we used to do in traditional engineering. This wider perspective can be made operational through the introduction of a suite of sustainability indicators, as part of a framework that will be introduced in chapter 2.

14 Vanegas, J.A., DuBose, J.R., and Pearce, A.R. (1996). «Sustainable Technologies for the Building Construction Industry.» *Proceedings, Symposium on Design for the Global Environment*, Atlanta, GA, Nov. 2 - 4.

3. METHODOLOGY

Given the broad range of issues and challenges facing the USA in its quest for creating a sustainable built environment, stakeholders desperately need a consistent framework of indicators to measure progress and set research agendas. This chapter introduces one possible framework to classify sustainability indicators. The framework is used to define indicators of change and position them properly in the wide context of sustainable construction. Its purpose is to support the causality that needs to be established between the current situation, expressed by a set of indicators, the momentum created by new initiatives and policies, and indicators of change.

These indicators of change can also be used, through proper measurement and extrapolation, to forecast opportunities for improvement and priorities for change through new policies and incentives.

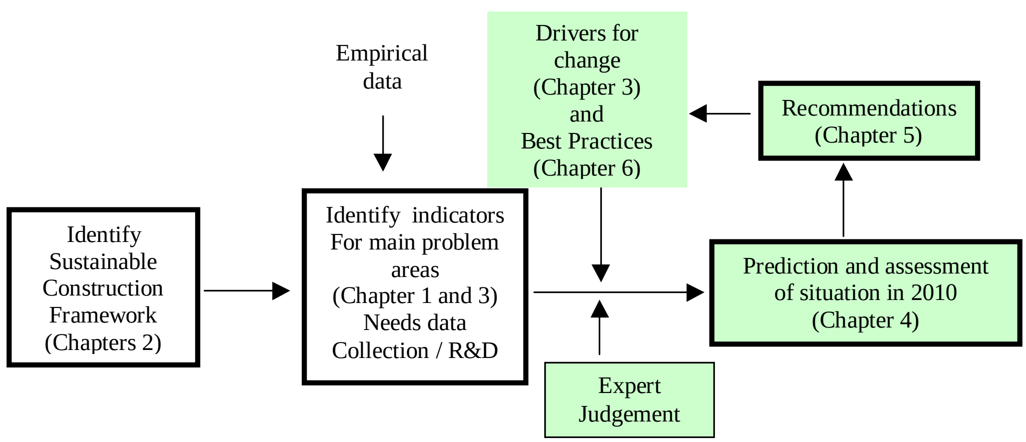

Figure 2: A methodology to predict and measure change in sustainable building

The figure explains the approach in detail. Within the framework (this Chapter) it is easy to identify the problem areas discussed in Chapter 1. Chapter 3 will attempt the definition of drivers for change, such as new policies, funding initiatives, new styles of process management etc. These will be presented to a selected forum of experts in order to arrive at a prediction of change by the year 2010 (Chapter 4). Based on these predictions, a number of recommendations (Chapter 5) will be formulated.

The approach will be primarily applied in a qualitative manner, as proper metrics for most indicators have not been defined yet, and what is more, empirical data is lacking to quantify the progress that we hope to make between now and 2010. In fact, it is of the highest priority to provide the empirical evidence in order to establish the contribution of the different drivers for change to improved sustainability of the built environment.

3.1 A framework for sustainable construction indicators

Figure 3 defines sustainable construction in a methodological framework, consisting of three main axes: System (boundary), Process (actor) and Aspect (sustainability).

It expresses that in different *life cycle phases* of a building, different *actors* are dealing with the designed or built artifact, each of them within distinct *system boundaries*, while responsible for different *sustainability aspects*.

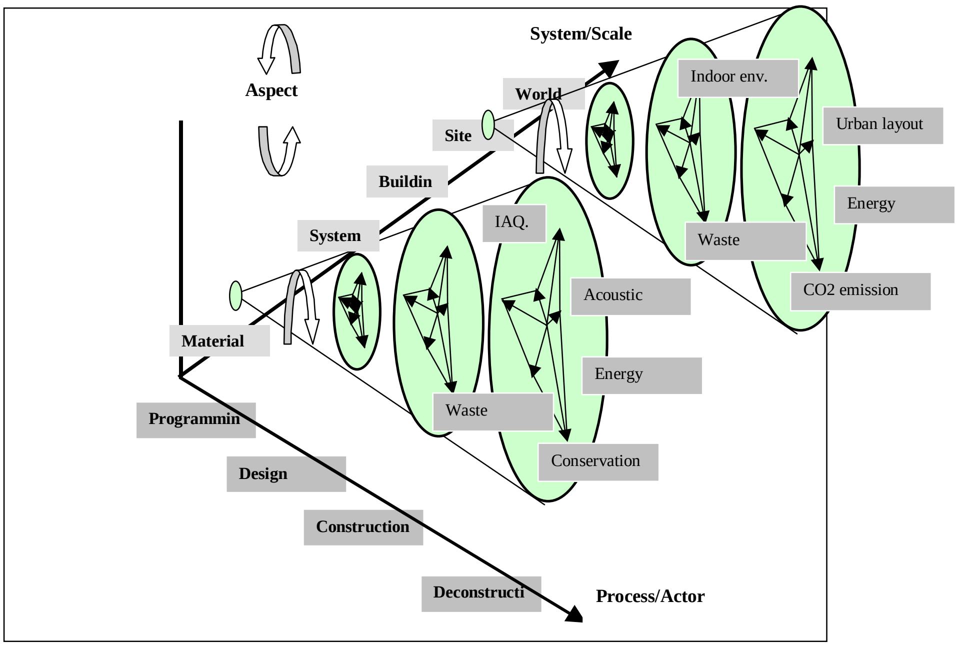

Figure 3: A framework to identify process/actor and system boundary versus Performance Aspect

The *system* axis spans building-internal composition levels (from material to assembled components whole building systems) to building-external macro and meso levels (building, city, ecosystem, world)

Along the *process* axis, clusters of actors are connected in collaborative tasks. Depending on the scale of the observation (system boundary), different actors (individual owner, design team, regulatory bodies, government) fade in and out of focus.

Aspects are depicted as radar charts that evolve through the life cycle stages of the facility. Certain aspects are decided upon in a particular life cycle stage. They fade in and out of the design/construction/maintenance process over time. The complexity of a construction project is apparent and one should realize that sustainability is just one of many performance requirements that the design, engineering and construction team is trying to meet. As such, sustainability can not be separated from improvements of the construction industry as a whole, i.e. through a more integrated and better managed process.

The figure also shows the typical system specific approach to the control of desired aspects, e.g. on component level (somewhere in between material and building system level) certain aspects will be dominant whereas on other system scale (e.g. regional level) the urban development indicators will be the dominant design objectives.

On a superficial level the figure obscures the real problem, i.e. on the transition or boundaries between two system levels, between actors and across life cycle stages.

Another issue that is not immediately apparent is the present lack of support for an integral comparison of different design alternatives. For the time being the value system to compare different envelopes on the radar chart is lacking. Ultimately, the objective is to provide the value system that would allow the mapping of all performance aspects onto the ‘Value Triangle’ of Figure 1.

Sustainable construction can now be defined in operational terms based on the set of performance aspects with suitable indicators. Along the Process axis, the need for operational instruments to optimize performance, can be identified. The framework allows us to measure how different process phases deal with resources at various scales of the built environment. The ultimate goal of the operational framework is to develop the instruments to ascertain in what way the built environment can be self sustainable within system boundaries at meso or even macro levels (i.e., no inputs or outputs crossing the system boundary means fully self-sustaining). The performance indicators enable us to measure how well the 'product' performs. It is paramount that these performance metrics reflect the multiplicity of performance indicators, enabling integral performance assessments.

Along the process axis we need to measure the effectiveness of the process, i.e., how well stakeholders undertaking each process work together in meeting the sustainability objectives at different system boundaries. Transparency of objectives and tasks across system boundaries at different system levels is a key performance requirement, since many mistakes of the past can be traced back to a lack of task and objectives coordination.

Each system boundary poses its own set of sustainability issues apart from the issues resulting from the aggregation of its subsystems. An acute challenge is finding the system boundaries, process phases and actors that in current practice have the greatest impact on the resulting performance of the built environment.

3.2 Sustainable construction metrics

The construction industry uses a major part of the 6 billion tons of industrial raw material that we deplete from the earth's resources each year. Environmental impacts are tremendous but hard to measure objectively for each single construction project. The trend in sustainability evaluation in the USA is toward life cycle assessments for each material used in a particular building, i.e., a micro-level analysis. Few if any attempts have been made to evaluate environmental or sustainability impacts at larger scales[15]. But LCA based methodologies are far from operational at this point, mainly because of the following reasons:

- *An LCA has to address a wide range of environmental aspects*, usually split up into three domains: *pollution* (emissions of hazardous material into the environment), *depletion* (use of biotic and a-biotic raw materials), and *impairment* (all negative structural effects in the environment). Many of these aspects are very hard to quantify in an objective way. In fact, for the latter category, hardly any physical, measurable inputs and outputs have been defined.
- *Combining different aspects of the LCA domains into one integral eco-rating is very difficult*, since there are no reliable indicators to distinguish the relative importance of the various indicators. Moreover, emergent properties on the system scale are an important parameter in the determination of relative importance[15]. Not surprisingly, so-called eco-labeling of products in other industrial sectors is usually done on the basis of a very narrowly defined LCA method (e.g., pollution through acidification (NH3) and eutrophication (phosphates), as in the case of detergents). Needless to say, such disparate indicator labeling does not make much sense for building products
- *The underlying data for an LCA is usually very hard to obtain*, especially objective, quantitative data about emissions, wastes and energy inputs in the production process due to proprietary information concerns by profit-driven corporations

A future objective of sustainability research is the definition of environmental or ecological impairment indicators such that they can enter an LCA method to produce an integral sustainability assessment.

Impairment has very different system scale effects. Inside a building, for example, human comfort and health (sick buildings, VOC's, stress factors) are important aspects. On larger system scales we find effects on mobility, traffic, groundwater, and indeed the whole ecosystem to be the key factors. But we are far removed from deployment of full LCA in all of these areas.

What we witness is a shortcut to so-called performance profiles (sometimes presented as radar charts as in figure 2). These methods typically define a distinct number of system boundaries, and a select set of indicators for each system. The key to the success of these sets of indicators is that they find acceptance in the design and

[15] Pearce, Annie R, Dissertation Georgia Tech, 1998

engineering community and that (re)design methods can be developed that reflect them. Additional material on measurement procedures and facility assessment tools can be found in the quoted dissertation.

Towards a new set of performance indicators

Environmental performance indicators need to be defined along with metrics and agreed evaluation procedures. There have been early attempts to define quantifiable indicators at various system scales and boundaries but standardized ways to measure the environmental performance of alternatives do not yet exist. Moreover, many innovative building products and designs will not pass present prescriptive regulations and therefore never enter the market, irrespective of the potentially improved performance.

Table 1 shows an example of the type of performance indicators that need to be assessed for building materials.

Table 1: Sample Information Requirements for Sustainable Building Materials

Environmental Performance	Technological Performance	Resource Use Performance	Socio-Economic Performance
Impacts on Air Quality	**Durability**	**Energy**	**Occupant Health/ Indoor Env'l Quality**
• Carbon Dioxide	**Service Life**	**• Embodied**	**• VOC Outgassing**
• Hydrocarbons	**Maintainability**	**• Operational**	**• Toxicity**
Impacts on Water Quality	**Serviceability**	**• Efficiency**	**• Susceptibility to biocontamination**
Impacts on Soil Quality	**Code Compliance**	**• Distributional**	**Appropriateness for:**
Ozone Depletion Potential	**R-value**	**Degree of Processing**	**• Scale**
Site Disturbance	**Strength**	**Source Reduction**	**• Climate**
Assimilability	**Constructability**	**Materials**	**• Culture**
Scarceness		**• Renewable**	**• Site**
Impacts during Harvest		**• Recycled/ Recyclability**	**Economics:**
Processing Impacts		**• Reused/ Reusability**	**• Contribution to Economic Dev't.**
		• Renewability	**• Cost**
		• Local/Transport Distance	**• Labor Skill Requirements**
		• Packaging Requirements	**• Labor Amount Requirements**

4. DRIVERS FOR CHANGE IN THE CONSTRUCTION INDUSTRY

This chapter lists the potential drivers for change in those areas that have been identified as the main problem areas in sustainable construction (Chapter 1). Policies, technologies, etc. are described briefly in order to prepare the predictions in Chapter 4, on how these drivers will have contributed to a change in sustainable construction in 2010.

Many divers in this chapter will be elucidated by describing current trials, emerging technologies, and early policies. This list is by no means intended to be exhaustive but intended as guidelines in the assessment of effectiveness of the individual drivers and their prioritization by experts in the field.

4.1 Energy conservation measures

Measures to improve the energy efficiency of buildings hold tremendous potential. The Congressional Office of Technology Assessment estimates that commercially available, cost-effective energy technologies could reduce overall energy consumption in the USA by as much as one-third--worth some $343 billion. Strategies such as proper siting and airtight construction, as well as installing energy-efficient equipment and appliances and renewable energy systems will reduce the amount of energy a building needs to operate and to keep its occupants comfortable.

Buildings for the 21st Century is a national approach to create a new generation of buildings which are energy efficient, high quality, affordable and environmentally sustainable. With this approach, our country uses energy efficient and solar technologies and designs now available to save 20% of the energy currently used in buildings, and to reduce the energy use of new buildings by 50% relative to present building practices.

Buildings for the 21st Century has the goal of achieving that vision by the year 2010. To meet that goal, it will draw together the diverse knowledge and technologies of many buildings- and energy-related programs at the USA Department of Energy. It will also bring together such partnership programs as ReBuild America, Building America, and the President's Million Solar Roofs Initiative. Using this combined expertise, Buildings for the 21st Century will work to spread the word to those who really need to hear it: a diverse list that includes architects, builders, contractors, local governments, homeowners, mortgage companies, and many others.

Other renewable resources such as wind and geothermal energy systems can also supply energy to buildings. It is important to do complete site and resource assessments to ensure that the system or resource being considered can supply the necessary energy. This is a guideline, not an indicator.

Current policies are aimed at a market based approach, recognition of clean energy alternatives, collection of empirical evidence that a policy is effective, and long-term orientation.

Some ‘winners’ indicate that there is reason for optimism: R&D of renewable energy has brought down the cost of renewables to the point that wind energy competes favorably with conventional electric power in some areas of the country. The government’s natural gas policy, which promotes competition, has produced a market that is supported by ample supplies at reasonable prices. Technology innovation, aided by government energy efficiency policies, has resulted in improvements in the efficient use of energy, even in the face of declining energy prices.

4.2 Land use regulations and urban planning policies

There is no lack of measurable indicators. From 1970 to 1990, the density of urban population in the USA decreased by 23 percent. From 1970 to 1990, more than 30,000 square miles (19 million acres) of once-rural lands in the USA became urban, as classified by the USA Census Bureau. From 1969 to 1989, the population of the USA. increased by 22.5 percent -- and the number of miles driven by that population ("vehicles miles traveled" or "VMT") increased by 98.4 percent.

There is no discussion that placing green building projects within easy access of public transportation, medical facilities, shopping areas, and recreational facilities decreases the need for automobiles and encourages bicycling and walking. In addition, successful green buildings blend into the community, preserving natural and historical characteristics, and will utilize existing infrastructure in order to reduce sprawl.

4.3 Waste reduction opportunities

Recycled-Content Materials

There are already many building products available today that are manufactured from recycled materials. For example, organic asphalt shingles contain recycled paper, and some shingles are made from re-manufactured wood fiber. Cellulose insulation is manufactured from recycled newspaper.

Alternative building materials can conserve resources, as well. Technologies that allow more efficient use of lumber include stress-skin panels; engineered framing products, such as I-beams, glue-laminated products, and finger-jointed lumber. These products allow for the use of "scrap" lumber that might otherwise be landfilled, as well as the use of small-dimension lumber.

Materials Reuse

Lumber and other products, such as windows, doors, cabinets, and appliances, can be salvaged when buildings are demolished or rehabilitated. It makes sense to employ materials that are still useful, rather than destroying or disposing of them. This approach not only uses resources more efficiently, but also conserves valuable landfill space.

Other building techniques use "waste" materials such as straw bales and used tires to as building elements. These materials reduce costs of construction while maximizing resource efficiency. Native, or "indigenous," materials, such as clay or stone have low embodied energy and can serve as resource-efficient building materials.

Construction-related waste accounts for about one-fourth of total landfilled waste in the USA (source?). Yet many construction materials can be recycled, including glass, aluminum, carpet, steel, brick, and gypsum.

Construction and renovation waste can also be reduced by salvaging, rather than land-filling, including items that have some remaining life, such as appliances, household goods, office equipment and furniture, building materials.

Construction waste can also be reduced/minimized by designing buildings to use standard-dimension lumber and through adaptive reuse (renovating existing buildings, rather than destroying them and erecting new ones).

4.4 Resource Conservation strategies

Use of waste and recycled building materials

Opportunities in this area will depend mostly on the introduction of new materials on the market and emerging brokerage services to re-use building materials.

Water Conservation

Installing energy-efficient appliances and fixtures, and changing irrigation practices and behavior can reduce water consumption by 30 percent. Low-flow shower heads, faucet aerators, and water-conserving toilets can conserve a considerable amount of water, energy, and other costs, such as water treatment costs. Many water utility companies offer rebates or incentives to install water-conserving fixtures and appliances

Graywater--water used for bathing, clothes washing, and similar tasks--or collected rainwater can be used to water landscape or for irrigation purposes.

4.5 Indoor Air Quality Control

Energy-efficient buildings are more airtight and therefore hold greater potential for indoor air quality problems. Because many building products can contribute to poor air quality, one can reduce these potential problems by selecting materials lower in chemicals and toxins, and installing mechanical ventilation systems to ensure an adequate fresh air supply.

4.6 Proliferation of environmental energy technologies

Urban scale «Cool Communities»

Important improvements will result by matching available technologies with the appropriate applications. A good example is reported in DOE study[16] on a «Cool Communities» strategy applied in hot climates, e.g., in southern California. Research on the use of lighter colored reroofs, resurfaced pavements, and shade trees has found that these measures can directly lower annual air conditioning bills in Los Angeles by $200M, cool the Basin by 3 degrees C , indirectly save $160M more in air conditioning, and reduce smog by 10%, worth another $360M.

Photovoltaics

In the wake of the oil crisis in the 70's, the USA began an extensive research and development program on Photovoltaics (PVs). During the 80s, a series of full-scale tests in commercial buildings were performed. In the 90s, a few far-sighted utilities have begun to install distributed PV systems integrated in their grid, slowly shifting away from fossil energy sources.

In June of 1993, DOE and the National Renewable Energy Laboratory put a $25M program in place to foster integrated PV systems in commercial buildings.

The potential market for PV application in the USA is big; it is only a matter of time until market forces aided by proper government incentives will approach that market with competitive building-integrated PV systems.

Similar expectations exist in other markets such as heat pumps, high performance glazing, co-generation and wind energy.

4.7 Re-engeering of the Design Process

Looking at the building from a "whole building" or systems engineering perspective, buildings will be viewed as integrated systems rather than a series of independent components. Incorporating this perspective into the designing, planning, and building stages can have significant effects on the outcome. For instance, efficiency improvements that might be hard to justify on their own accord are seen in a different light when they result in a smaller heating and cooling system for the building. Synergies such as these are common in building designs, but are often overlooked. Increased consideration of potential synergies will foster the use of advanced building

[16] Arthur H. Rosenfeld et.al. Direct and Indirect Savings: Magnitudes and Implementation policies, Designing for the global environment, Nov. 1995, Atlanta.

technologies that incorporate solar and other forms of renewable energy; and an integrated approach both to new-building construction and old-building renovations.

Co-engineering strategies: ‘Design for Performance’

Green buildings are achieved through an orchestrated activity of the team of actors involved in the process of programming, designing, construction, use and recycling of the facility. Many improvements are necessary in the orchestration of the complicated process, in order to take benefit of available technologies and products.

Integrated design systems are becoming more common place in the building engineering domain[17]. Technical building systems are the prime application fields of integrated design approaches. The aim is to support collaboration between owner, designers, part manufacturers and engineers, usually referred to as 'co-engineering' where architectural designers and engineers work jointly towards better technical solutions. Optimal co-engineering will be enabled by better coordination of the search and specification of technical solutions through the different process stages, i.e., design, manufacturing, construction and site assembly and maintenance.

4.8 Proactive role of building manufacturers: made to order

Product manufacturers are entering a new era when all or most product information is exclusively available electronically. Companies are aware that the Internet will change the way that product data is accessed, selected, ordered, and specified during the design stages. There are enormous challenges involved in «going electronic» with present paper-based catalogues, in order to consolidate a competitive edge once companies are on the net.

The designing ‘demand side’ will start adapting its traditional role of 'buyer' of the product to a one-to-one co-engineering relationship with the manufacturer. Such relationships enable products made to meet a sustainability performance requirements profile.

4.9 The move towards new ‘Cost’ metrics: LCC+LCA

Future buildings will actively involve the adoption of life-cycle, whole cost accounting based on economic and ecological value systems, accelerating the use of sustainable technologies and establishing the concepts of system engineering in all phases of building design, construction, financing , and operation. The move to new ways of measuring costs will also serve to educate the public about the true costs of a building's ownership, occupancy and operation, along with the energy and non-energy contributions that a properly designed building can make to productivity, personal health, comfort and sustainability.

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[17] Godfried Augenbroe, A CO-ENGINEERING APPROACH TO BUILDINGS, VIII Rinker Conference, Gainesville, Florida, Febr. 1998.

New metrics will be based on a combination of life cycle cost (LCC) and environmental life cycle assessment (LCA), with the potential of beginning a new era of cooperation in community planning, construction, financing, and the establishment of affordable housing.

4.10 New partnerships and stakeholders

New partnerships among local governments, utilities, energy service firms, and private industries, will be formed with the goal of increasing investment in research and large-scale implementation of new practices.

Specifically, sustainability is about working with community partners to increase their awareness and use of the many technologies and concepts now available, while working to advance those technologies and concepts. Some communities will need help to modify their building codes and standards; others may need help implementing a net metering program with a local utility; others may need workshops on building design or best environmental practices for home building. Moving the construction industry toward sustainability will involve collaboration on the part of all stakeholders to find common solutions to problems like these.

4.11 Adoption of performance-based standards

The development of performance-based specifications is being undertaken in many countries of the world already. These specifications will likely be preceded by the development of performance-based building codes. Different stakeholders will benefit from performance based specifications. These specifications will improve the reliability of buildings and build in guarantees to reduce their environmental impact. Owners and manufacturers will benefit from the increasing opportunities to apply new materials and new technologies

LEED Rating system

The wide spread adoption and implementation of the LEED rating system is closely linked to performance based standards. It should be noted that LEED is unique in that it was not created by an organization representing a national government. LEED rates the environmental aspects of a building and the behavior of its occupants to arrive at a final score that results in a platinum (highest level), gold, silver, or bronze plaque being awarded. A wide range of issues are evaluated to include energy and water use, indoor health, recycling for occupants, access to mass transit, materials impacts, landscaping, construction waste management, building siting, and maintenance. If successful, the LEED Building Rating System could profoundly alter the types of buildings being created in the USA.

4.12 Product innovation and certification

Directories and councils fostering the development and use of new products are important catalysts for change.

Certification of materials as being produced in a sustainable fashion is a very important component of sustainable construction. Wood is the dominant material in residential construction in the USA and vast quantities are consumed each year in the form of dimensional lumber, plywood, oriented strand board, and other products. The Smartwood Program of the Forestry Stewardship Council (FSC) is making inroads into traditional American forestry practices by motivating wood product companies to have their forests certified as being managed to produce a sustainable harvest and respect the plant and animal biodiversity of the forest. If Smartwood is successful in applying a strategy of simultaneously influencing consumers and producers of wood products, the forestry industry in the USA could be transformed to an activity that is truly sustainable.

The National Fenestration Rating Council (NFRC) was formed to develop a voluntary, national rating system for windows, doors, and other fenestration products. NFRC's uniform energy performance rating and labeling system allows builders and consumers to compare the efficiency of fenestration products. *NFRC Certified Products Directory* contains information on the U-value of more than 20,000 certified products.

Green Building Products and Materials Resource Directory, produced by the North Carolina Department of Commerce, Energy Division, and the North Carolina Recycling Association, is an online database providing information on environmentally-friendly and energy- and resource-efficient building materials. The entries include information on each product's composition, waste products, recyclability in design, recycled content, embodied energy, and energy efficiency, among others.

*Green Building Resource Guide p*rovides information on The Green Building Resource Guide, a database of more than 600 green building materials and products. The Guide is available as either a reference manual or a CD-ROM database.

*Rainforest Action Network l*ists suppliers of innovative building alternatives, recycled/salvaged lumber suppliers, certifiers of sustainably produced lumber, and builders of alternative housing (such as straw-bale and rammed earth).

Lighthook's Strawbale House and many similar lists provides information on strawbale building technology, as well as links and resource lists.

Used Building Materials Association (UBMA) is a non-profit, membership-based organization representing companies and organizations involved with acquiring or redistributing used building materials. The "Exchange" portion of its Web site includes online directories of building materials available and building materials wanted.

4.13 Adoption of incentive programs

The US Environmental Protection Agency (EPA) offers several programs that aim to reduce energy consumption in buildings. The Energy Star Buildings Program is a voluntary energy-efficiency program for commercial buildings in the USA. The program focuses on profitable investment opportunities available in most buildings using proven technologies. Program participants can expect to reduce their building's energy consumption by about 30 percent.

4.14 Education and training

The success of sustainability in general and sustainability in the built environment in particular is very much dependent on how institutions of higher learning respond to the ideas generated as a result of widespread interest in sustainable development. An organization known as Second Nature has as its core mission changing what is taught at American universities by embedding environmental literacy in the curriculum, and has been conducting training sessions on how to accomplish this change. A number of other organizations have similar, parallel efforts underway, including Campus Ecology, a branch of the National Wildlife Federation, and the World Resources Institute. Campus Ecology works with student leaders on campuses, training them on issues and activities that will help make their institutions more environmentally responsible. Similarly, the World Resources Institute is working with Colleges of Business in the USA to help them begin including environmental issues as a factor in business decision making. A wide range of other efforts where organizations work with Medical Schools and Law Schools at universities will probably have an aggregate impact on the progress of sustainability in the USA.

4.15 Recognition of commercial buildings as productivity assets

The World Health Organization estimates that 30% of all new and remodeled buildings suffer from poor indoor environments caused by noxious emissions, off-gassing, and pathogens spawned from inadequate moisture protection and ventilation, resulting in $60 billion annually in lost white-collar productivity from Sick Building Syndrome (SBS) in the U.S. alone.

Several recent studies have shown that making a building environmentally responsive can increase worker productivity by 6% to 15% or more. Since a typical commercial employer spends about 70 times as much money on salaries as on energy, any increase in productivity can dramatically shorten a green building's payback period.

Achieving improved productivity requires better control of indoor performance, utility, and serviceability of the built asset, better maintained through adequate investments in facility management, regular building diagnostics and proper maintenance.

5. RECOMMENDATIONS

The following is a list of recommendations based on discussions with experts, results from the survey and research experiences from the authors.

Metrics

- The application of finance and accounting theory to the valuation of new energy and efficiency options[18]. The experience in manufacturing over the last two decades indicates that traditional accounting-based procedures for valuing new technologies significantly understate their benefits.
- Present eco-rating procedures are inadequate, incomplete, and poorly embedded in a framework for integrated sustainability assessment. Diversifying these tools for different actors, stakeholders and system boundaries, and a migration path along intermediate products, is important.
- Develop a complete set of environmental performance indicators with suitable metrics
- Define procedures to obtain reliable LCA data for materials and components on all aggregation levels encountered in the facility
- Build a data base with reliable and up-to-date LCA data for construction materials
- Develop nation-wide accepted performance based specifications for materials and systems

Process

- An analysis of present constraints posed by regulations is important to remove the barriers impeding new practices and products in the building industry. A re-engineering of the way we regulate the building process though codes and regulations is probably unavoidable.
- Collaborative engineering models, protocols and systems must focus on integral assessments of design through the different design phases. They must incorporate sustainability indicators in performance based strategies that match client requirements with assessed design performance (ASTM). Tools must be embedded in collaborative CAD environments and should be accessible by all actors in the process.
- Develop useful tools that appeal to different actors and stakeholders and that can easily be embedded in existing practice. Rather than adapting the practice to the tool, the new generation of design tools should reflect the diversity in skills and objectives of its user base
- Develop new generation of multi disciplinary integrated design environments
- Develop an integrated life cycle environmental and financial cost measure that can work within various system boundaries

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18 Shimon Awerbuch, Designing for the global environment, Nov. 1995, Atlanta.

- Build co-engineering partnerships for customized product development and remove barriers to shorten time to market

Policy

- Ecologists and economists arrive at different unreconcilable conclusions as to what is absolutely necessary and economically feasible in the next 20 years. This calls for new concepts rather than incremental improvements.
- Improvements in energy efficiency in general and gradual removal of dependency on fossil fuels are targets that will become realistic in the next 50 years. Between now and 2010 a major breakthrough in energy reduction in new buildings should be accomplishable.
- Remove regulatory barriers and streamline innovation
- Develop performance standards, building guidelines and practices
- Conduct benchmarking on new systems for performance evaluation
- Target technologies that produce buildings that use 50% less energy than the present norm (AHRAE 90.1)
- Identify best practices
- Build showcases and monitor and diagnose systems in practice
- Build a timely national data base to cultivate and promote proven technologies; extend to a life-cycle information system for constructed facilities
- Establish a process to manage liability concerns

Technology

- Design for recyclability. Design should distinguish between re-use of components and recycling of the materials of a component. The latter requires extensive research into optimal combinations of materials and new components made from their recycled waste.
- Expand rationalized industrialized building practices
- Develop components and integrated solutions through co-makership alliances
- Develop plug and play building components that are re-configurable
- Explore and advocate an international dimension to system modularity in building components and systems

Education

- Expand education and training on implementing new technologies and building practices
- Share knowledge with developing countries and adopt local sustainability metrics in exported technologies

6. CASE STUDIES

This chapter lists a random selection of industrial case studies and best practices. The latter have been supplied by the CIB Task Group 16.

6.1 Industrial Best Practices

Interface Inc.

Interface, Inc is a $1 billion a year international manufacturer and marketer of commercial interior products: carpet tile, broadloom carpet, fabrics, raised flooring and specialty chemicals. Energy efficiency projects first received serious attention at Interface in 1995. The interest in reducing energy consumption has been driven by two different but compatible forces: Interface's CEO, Ray Anderson and COO, Charlie Eitel.
The company has launched an enterprise wide initiative called QUEST (Quality Utilizing Employee Suggestions and Teamwork) aimed to eliminate all waste. Waste is broadly defined as anything that goes into end products that does not come out as value to the customer.

In 1994 CEO Ray Anderson created a movement called EcoSense to push Interface toward sustainability.

The two programs together have resulted in thousands of projects ranging from lighting retrofits to photovoltaic arrays, saving the company a cumulative $40 million. To respond to the challenge, Interface is currently developing a strategy to pull together its resources into one toolkit that will be presented to the facility managers at our 28 sites around the globe.

Interface has declared seven fronts for sustainability: Eliminate Waste, Benign Emissions, Renewable Energy, Closing the Loop, Resource Efficient Transportation, Sensitivity Hookup, Redesign Commerce, Eliminate Waste

Hellmuth, Obata & Kassabaum (HOK)

Being one of the world's largest design firms, HOK has demonstrated a special commitment to sustainable construction through implementing a variety of procedures, guidelines, databases, and protocols to stimulate and support the generation of sustainable designs.

A significant element is the 'Sustainable Design Guide', which is a tool to assist project teams in defining and prioritizing sustainable design goals. The checklist is organized by three design phases: Pre-Design, design and Documentation, Construction Administration, and by sustainable design topic: Planning and Site work, Energy, Building Materials, Indoor Air Quality, Water Conservation, and Recycling and waste Management.

A new and very complete version of the Design Guide has recently become available[19].

6.2 Current practice

6.2.1 Planned Developments

Suburban development in the US has contributed to many environmental problems, most significantly the dependency on the automobile and loss of productive land. The size of most planned unit developments (PUDs) is probably their greatest value in sustainable construction. Individual buildings can be built in a green manner, and sustainability issues beyond the walls of an individual home or commercial building that impact the whole community can also be addressed in a logical long-term large-scale manner.

Village Homes

The development of Village Homes in Davis, California was begun in 1975 and was based on principles of self-sufficiency, community, energy conservation and market appeal. It occupies 70 acres and was designed for 200 homes. The main components of the development are narrow streets, cul-de-sacs, on-street parking, interconnected pedestrian ways, communal green space, including agricultural land, smaller lots, and the orientation of every house lot for southern exposure. Commercial and recreational uses were provided in the community center to decrease automobile usage. The streets in Village Homes are 25 ft. wide, as opposed to 35 ft. for typical subdivisions at the time. The narrower streets cost less money to build, and they also slow traffic, mitigate automobile noise, help reduce stormwater run-off, and leave more land for green space. Parking is either in on-street parking bays or in detached garages

Dewees Island

Dewees Island is a 1,206 acre barrier island off the coast of South Carolina. The premise of the development is a high-end retreat in tune with the 350 acres of existing wildlife preserves on the island. Environmental regulations for wetlands and coastal development as well as environmental groups placed severe restrictions on development. The first phase was 10 home sites ranging from $200,000 on 1 1/2 acres inland to $315,000 on 2 1/2 acres on the waterfront. The total maximum allowable build-out is 150 single family homes on 420 acres of developable land. The other 786 acres is protected by covenant from any development. For any given property lot, averaging more than one acre apiece, no more than 7,500 sq. ft. may be disturbed by construction. As part of a community outreach environmental education program, the developers built an education center on the island for visitors and residents to have an information source to learn about the native flora, fauna, and ecosystems.

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[19] HOK, Sustainable Design Guide, January 1998. Senior Editor: Sandra Mendler , HOK, Washington DC.

Civano-Tucson Solar Village

Civano in Tucson, AZ is the first attempt to create a new land development with social amenities, affordable housing, and a job-to-housing balance required to make it economically feasible while also designing in energy and water efficiencies in the buildings, landscape and infrastructure.

6.2.2 Traditional Neighborhood Development (TND)

Traditional neighborhood development (TND) grew out of Andres Duany and Elizabeth Plater-Zybek's belief in the connection between community form and function: if the structural elements that embody a traditional American small town are recreated in new and infill developments, then the values and functions of community will follow. Duany and Plater-Zybek began developing the TND concept in their work for Robert Davis at Seaside, Florida. The beachfront property on the «Redneck Riviera» was to be a return to the classic small American town. The architects traveled through the Southern USA, especially Charleston, South Carolina and Savannah, Georgia, observing the physical structures which give these towns their qualities of pedestrian life, defined neighborhoods, public space, identifiable organization, and architectural character. They were also able to identify and codify land-use hierarchies and densities from commercial centers, to mixed-use and multi-family neighborhoods, to single-family neighborhoods. The overriding principle of these neighborhoods is that they have a radius no greater than one-quarter mile from the center to the furthest dwelling. The basis for implementing TND is a set of codes which mirror the structure of typical land-use ordinances by defining land uses, lot sizes, setbacks, and height. However, TND ordinances go beyond the measurable character of land uses by also defining aesthetic and materials codes for buildings.

Seaside in Florida

Seaside was the first built expression of the TND principles begun in the mid 1980's. The 80 acre town is expected to grow to about 650 dwellings and 2,000 residents. The plan consists of a mixed-use town center located off the main through-road with a pattern of limited access streets radiating outward to the small, detached single-family home lots. A grid overlay ties the radial streets together and connects to the main through road, distributing traffic throughout the community. Parking is limited to areas outside the development and on-street within the development. A strict architectural code determines the materials and appearance of the development as well as ensuring certain features such as front porches and picket fences which are meant to engender community interaction. The code prescribes features that are indigenous to the vernacular architecture, recreating not only the appearance but also the natural ventilation and shade that pre-air-conditioned dwellings utilized for passive cooling. Sand and shell walkways behind structures form the pedestrian network. All the home lots are small with a shallow front setback that moves the porches closer to the street and creates a tight urbanistic facade.

Haymount, Virginia

Haymount is a 4,000 dwelling unit, 1,605 acre development on farmland in eastern Virginia on the Rappahannock River. The land planning process used an extensive environmental assessment overlay mapping process that outlined all environmentally sensitive areas and individual trees of 18 inches in diameter or greater. Approximately 37% of the site will be developed and the existing agricultural land will be converted to organic farms. The land plan consists of 5 neighborhoods with 750,000 sq. ft. of integrated office and retail space. There are 22 types of housing ranging from more expensive single -family dwellings to smaller single-family homes and a variety of multi-family dwellings. The sewage treatment will be provided by constructed wetlands at a scale of 6 for the first phase of 300 homes. The multi-disciplinary planning team, common to the best of sustainable construction, included planners, landscape architects, architects, engineers, and hydrologists.

Harbor Town in Memphis, Tennessee

Harbor Town is built on an island in the Mississippi River in Memphis, Tennessee. The development is meant to embody the traditional values of Southern town through its physical character. The plan is a combination of a grid and axial street system, with three major focal points. The homes are built on smaller lots, 3,000 to 5,000 sq. ft., with front porches, many small neighborhood parks, and back alleys with parking on the streets. Smaller single family homes are designed in the «shotgun» style, a traditional form so-called because it utilizes an circulation spine through the building from front to back, with the front and back doors in line. This style makes cross-ventilation feasible with front and back porches to cool the air as it passes. Lots for these homes are 31 ft. by 91 ft. long and the homes themselves are 1,500 sq. ft. without garages. By setting the 18 ft. wide homes 10 ft. back from one side and 3 ft. from the other side, cars can be parked beside the dwelling, saving the necessity to build garages while eliminating the ubiquitous American garage door facade. The rectangular shell, the circulation path which passes from one room to the next without use of a hallway, and the use of one room for living, dining, and kitchen, reduces materials use to the absolute minimum.

Celebration in Florida

Celebration is a 4,900 acre new town developed by The Celebration Company, a subsidiary of The Walt Disney Company, and opened in 1996. Celebration was planned by architects Cooper, Robertson & Partners and Robert A. M. Stern to create a model of neo-traditional planning. The major design elements are; a central commercial «downtown» core, mixed housing types, a public school, health facilities, a 109 acre office park, and a golf course. An advanced infrastructure system of telecommunications and fiber optics, pedestrian paths and trails are all intended to reduce transportation needs and create a pedestrian friendly environment. The development uses a series of guidelines and controls, including approved builders and stylistic controls, for the architecture of housing types. These types range from townhouse to single family, with designs based on traditional American architecture. The land development pattern creates a secondary street network of alleys and hidden or rear-located garages to remove vehicles from the principal street frontage.

6.2.3 Transit Oriented Development (TOD)

The architect and planner Peter Calthorpe developed the design strategy for cities called Transit Oriented Development (TOD) in the 1980's. The foundation for this development type centered around mass-transit is the high rate of automobile use in the USA. Vehicle Miles Traveled (VMT) per household has been determined to have increased by 82% from 1969 to 1990 while the US population has only increased by 21% during the same period. The average transportation mode split in the US is calculated as 86% by auto, 8% walking, 3% bicycle, and 3% by transit. TOD is an attempt to alter these patterns. The guiding force is transportation efficiency and the fundamental connections between home and work and one community to the next. 'Pedestrian pockets' link the nodes of commerce and transit stops with the residential and recreational areas in close proximity. TOD is explicitly energy conserving by supporting mass-transit, pedestrian access, density and mixed-use, infill around existing transportation infrastructure and consequently, the preservation of surrounding natural areas.

Laguna West in Sacramento, California

Laguna West in Sacramento County, 12 miles south of Sacramento, California is the first expression of the TOD concept. The 1,045 acre development will have 3,300 dwellings in 1,800 detached homes and 1,500 townhouses and apartments. The town core will have 300,000 sq. ft of parking and 1.4 million sq. ft of commercial space. As a bedroom community serving Sacramento, this development could have been another example of suburban sprawl, except that it is linked by mass-transit and carries through Calthorpe's "pedestrian pockets" concept which is the core of TOD.

Habitat for Humanity

Habitat for Humanity is a non-profit non-denominational religious international organization devoted to the construction of 10,000 low-income housing units annually. The group sells completed homes to qualified participants with interest-free loans. Participants are obligated to contribute personal sweat-equity in the construction of both their own home as well as others, along with community volunteers and vendors who contribute labor and materials. Homes are constructed over the course of several weekends when a full crew of dozens of volunteers assemble for intensive housing-raising sessions.

The Jordan Commons project is a 200 home, 40 acre project meant to provide affordable sustainable housing in the lower-income community of Homestead, Florida which was severely damaged by Hurricane Andrew in 1992. The principles of community, community services, energy-efficiency, and affordability make this project a comprehensive approach to sustainable development. Specifically, the ideas of environmental responsibility, economic viability, and social equity are combined in one project using housing as the foundation. The premises of pedestrianism and energy-efficiency are particularly important economic considerations for lower-income groups.

6.2.4 Individual Buildings

Individual efforts and buildings have been the mainstay of the sustainability movement in the US beginning with solar energy based dwellings in the 1970's. More recent sustainable buildings are employing holistic approaches to deal with the impacts of buildings on the environment and their human occupants.

Rocky Mountain Institute - Office and Residence

The Rocky Mountain Institute (RMI) is a non-profit organization that promotes energy-efficiency and sustainable construction world-wide, based in Snowmass, Colorado. The founder of the Institute, Amory Lovins has become an renowned expert in the design of energy-efficient building systems with a focus on lighting and the calculation and documentation of the benefits of efficient commercial building systems for both utility savings and productivity gains resulting from good indoor environmental quality. RMI focuses on the reduction of electrical power consumption due to the enormous environmental costs of its production. Electrical consumption uses one-third of all the fuel in the US and produces one-third of carbon dioxide pollution

Sustainable Development and Construction Initiative, Inc. - Abacoa Residences

Sustainable Development and Construction Initiative, Inc. (SDCI), is a non-profit group centered around the University of Florida, Center for Construction and Environment, in Gainesville, Florida. The group consists of academics, architects, developers, engineers, building contractors, and energy and waste specialists devoted to sustainable construction education and implementation.

The Abacoa development in Jupiter, Florida is a 2,000 acre mixed-use development that is expected to build-out in 20 years at 6,000 dwellings, plus approximately 3,000,000 sq. ft. of commercial space, a university branch and a baseball training camp. The development is located adjacent to a mass-transit rail system which links it to cities along the Florida southeast coast. The existing land is pine flatwoods and agricultural land that is expected to be restored to its native ecosystems within the community as a whole and through a wildlife corridor «greenway» which extends completely through the development.

Southern California Gas Company - Energy Resource Center

Southern California Gas Company is one of the largest utilities in the U.S. They have just this year, 1995, completed the Energy Resource Center for large commercial customers that utilizes the cutting-edge of material and energy resource efficiency in a model sustainable construction showcase and educational facility.

This 43,000 sq. ft. office building in Downey, California uses an existing office building that was partially dismantled and renovated. Approximately 400 tons or 70% of the original building materials were either reused directly or put into recycled waste stream. The building cost between $5.9 million and $6.5 million to build, excluding an estimated $3.2 million saved by using the existing site and materials. The specific green features of the building add about $225,000 to $275,000 to the cost, but operating savings are expected to be $25,000 dollars a year giving a simple payback of 10 years.

Croxton Collaborative - Audubon House

The Croxton Collaborative architectural firm is one of the leading U.S. architectural practitioners of green design and construction. They have been involved in several high profile design projects including the Natural Resources Defense Council office renovation and the National Audubon Society office renovation, both in New York City.

The Audubon House was created from the renovation of an 1891 office building, reusing the resources and restoring the architectural character of an existing structure instead of building a new building. This decision was calculated to have reused 300 tons of steel, 9,000 tons of masonry, and 560 tons of concrete. The existing building was 8 stories and a 9th floor penthouse was added to create 100,000 sq. ft. of office space. A major component of the effort was the multi-disciplinary approach that also brings the client and non-traditional consultants such as environmental scientists and indoor air quality experts into the design team to a greater extent than is typical. This holistic approach was utilized to realize sustainability design goals of a healthy and pleasant working environment, environmental soundness, and quantifiable dollar, energy and material-use reduction. The economics of energy-efficiency were a major consideration with a maximum cumulative payback period of 5 years for all of the energy-related systems.

Environmental Showcase Home

The largest single user-group of the Good Cents Environmental Home Program are various electrical utilities around the country. The Arizona Public Service utility in Phoenix, Arizona, used the guidelines of the Goods Cents program and consultation with Steve Loken of CRBT to design and build a demonstration home using all of the sustainable construction goals of energy, water and material conservation. Water-use and extreme variations in temperature are paramount concerns in the desert Southwest, whereas a high availability of solar energy presents a unique opportunity for the utilization of solar energy systems.