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Extending the Sonoran Desert Conservation Philosophy: Green Building in Pima County

I Problem Statement and Objective

Pima County has been facing dwindling water supplies for some time, a situation exacerbated by the current drought. As such, water conservation measures beyond the levels promulgated by the federal government and currently adopted code need to be enacted to preserve the future of our desert environment. However, water resources cannot be regarded in isolation as they are inextricably related to other resources such as energy. Each kWh of thermoelectric generation requires approximately 25 gallons of water with additional amounts used for operating pollution control devices. The U.S. Geological Survey estimates that in 2000, 346 billion gallons of freshwater were used per day in the U.S accounting for approximately 39% of total freshwater withdrawals. While only 3% of these withdrawals are actually consumed by the generation process, it still accounts for approximately 10.4 billion gallons per day in 2006. Hence low performance buildings and the manufacture of building materials requiring large amounts of energy contribute indirectly to taxing our water resources.

In addressing development issues relating to water and energy, it is deemed more efficient to tackle associated issues for the preservation of our desert environment. These include reducing landfill waste and improving air quality by shifting building material usage to more sustainable and local materials, and improving quality of life and financial productivity through more comfortable, more efficient and less hazardous interior environments.

The objective of this paper is to shed some light on issues pertaining to sustainable building and propose their mitigation through a strategic green building program.

II Green Building Scope and Context

Green or sustainable building may be defined as construction striving to enhance or mitigate functionality, energy and water efficiency, quality of indoor environment, waste management, air emissions, site disturbance, and storm water management.

Sustainable building spans the economic, social and ecological aspects of construction. These aspects will be addressed below under the sections of: economic analysis, design and construction, site and landscape, building water, building energy, interior environment, and green building

materials. They will also be viewed within the Sonoran Desert environment where links to other regulatory programs will be highlighted.

The built environment has complex and potentially devastating impacts on the biosphere. While only representing 8 percent of the US gross domestic product, the construction industry consumes 40 percent of raw materials extracted or harvested in this country and generates about half a ton of waste per person each year. An expanded human/land impact footprint has resulted among many things in: lowered land carrying capacity, loss of biodiversity, rise in air quality toxicity, water supply shortages, and greater energy requirements. In response to these conditions the green building movement was born which in the US coincided with 1970, the year the EPA was created. The first major federal government green building project was the "Greening of the White House" in 1993, and that year saw the creation of the United States Green Building Council (USGBC) which released the first Leadership in Energy and Environmental Design (LEED) 1.0 rating system in 1998. Four versions later the most recent standard for new commercial construction is LEED-NC (version 2.2). The mission of the USGBC is to "promote buildings that are environmentally responsible, profitable and healthy places to live and work."

While the USGBC produces many standards, LEED-NC is the most widely regarded standard in the US today. It is based on a series of obtainable points in six distinct categories: sustainable sites: 14, water efficiency: 5, energy and atmosphere: 17, materials and resources: 13, indoor environmental quality: 15, and innovation and design process: 5, for a total of 69 points. USGBC certifies buildings based on the number of points obtained: Certified: 26-32, Silver: 33-38, Gold: 39-51, and Platinum: 52-69. With LEED, even a silver designation is quite an accomplishment, resulting in building performance gains of at least 30% over new conventional construction.

There has been a near doubling of LEED certified buildings each year since 1998. If this trend holds, within eight years high performance green buildings will constitute the majority of new construction in the United States. The City of Tucson is a LEED silver jurisdiction and the City of Scottsdale is a LEED Gold. Other LEED certification programs include programs for shell buildings, tenant improvements, existing buildings and homes (currently in pilot testing). In addition, the Sustainable Buildings Industry Council (SBIC), the National Association of Home Builders (NAHB) and a few other organizations have also developed green standards. At the local level, the Southern Arizona Home Builder's Association (SAHBA) has created a committee to investigate green construction, and John Wesley Miller Companies is building in Tucson's Armory Park del Sol neighborhood what is arguably the most highly performing development of modern-equipped homes in the world to date.

III Economic Analysis

While we know from a Cahners Publications survey that 36 percent of new home buyers are willing to pay an extra $5,000 for green features and 20 percent are willing to pay an extra $10,000 for reasons of good environmental stewardship, sustainable construction can be evaluated strictly on a cost/benefit perspective by looking at life-cycle costing. A recent report to the California Sustainable Building Task Force indicates that a 2 percent additional investment in performance features would produce 10 times the return over the building life-cycle. For example, an additional

$100,000 investment in a $5 million building should produce at least $1 million in savings for a building with a 20-year life cycle.

The US Department of Energy's Pacific Northwest National Laboratory (PNNL), the National Renewable Energy Laboratory (NREL) and other organizations have compared the cost/benefit of investing in high performance commercial buildings. Findings generally reflect the following patterns: While capital costs increase in the order of 2 percent or $2 to $5 per square foot for silver/gold rated LEED buildings, the total net present value (TNPV) of the energy savings over a 20-year life cycle is $5.79 per square foot. Additional per square foot savings for reduced emissions ($1.18), water ($0.51), and operations and maintenance savings from proper building commissioning ($8.47) bring the aggregate TNPV to $15.95 per square foot. Added to this number are yet further potential savings gleaned from improvement of interior environments. More efficient and healthy interiors reduce medical costs and produce a gain in productivity estimated by some as high as $36.89 TNPV per square foot for a certified/silver and $55.33 for a gold/platinum rated buildings. Cost/benefit data is further broken down per section below.

While most available studies have been conducted on commercial buildings, single family dwellings do seem to follow the same general pattern. Strictly from an economic perspective, available data clearly demonstrates that sustainable construction financial benefits more than offset the initial increased capital costs. Furthermore, we also need to consider the market value of green buildings. As indicated above, if homeowners are willing to pay more for green features, there would be perceived value associated with a certification process for green buildings. While LEED certifies commercial buildings, it does not do so for single family dwellings. Green home certification could therefore be accomplished through Pima County Development Services, hence contributing to raising market value for sustainable residences.

IV Design and Construction

Instrumental to the green building process is the coordination among the different designers and contractors from a systems analysis standpoint. The mainstream independent design-bid-build process employed today cannot function for high performance buildings where systems become more interrelated. For example, site placement of structures for optimal passive solar orientation, passive air circulation within interior spaces and building commissioning all require far greater coordination between the respective designers, contractors and inspectors. The LEED system accounts for this by forcing the integration of the green building team through its document submittal requirements.

Key items for consideration in this process are to: involve all players from the start, work concurrently and cross-functionally, work in short feedback loops, and work in detail from the start. Education of designers and contractors in the methodology of sustainable design and implementation is instrumental to achieving green building objectives. Lastly, the owner needs to have a clear idea of the level of capital investment beyond that required for conventional construction that he or she is willing to make toward a high performance building. A life-cycle cost analysis should be provided to decide whether the breakeven point is satisfactory to warrant the additional capital costs.

V Site and Landscape

Sustainable sites and landscaping are perhaps the most intuitive items in green construction. Approaches affecting the Sonoran Desert environment include: location in terms of the comprehensive plan, building on land previously utilized when possible, using native and drought tolerant plants, reducing size and footprint of buildings, minimizing earthmoving and recompaction of soil during construction, orienting structure to maximize passive solar heating and cooling, planting native trees for shade, using light colored paving and roofing materials to avoid heat islands, minimizing impervious areas on site, using alternative stormwater management technologies to assist with on-site groundwater recharge, and reducing outdoor light pollution (currently mitigated through the Pima County Outdoor Lighting Code).

Of the above items, orientation of the structure on the property to minimize solar gain through windows, providing natural shade, and reducing heat islands may be the largest site factors directly affecting energy. Urban areas typically have a higher temperature of 2-10 degrees Fahrenheit over rural ones, primarily due to dark color paving.

Water conservation is highly impacted by landscaping. Tucson Water estimates that during the summer, 60 percent of water usage occurs outdoors. Covering swimming pools, replanting for native species, and introducing more efficient irrigation systems are therefore important strategies to achieve. Regarding alternative stormwater management and technologies to assist with on-site groundwater recharge, Development Services will look to Pima County Regional Flood Control District for direction.

VI Building Water

The landmark legislation concerning potable water consumption is the Energy Policy Act of 1992 (US Code Title 42 Chapter 77) which required plumbing fixtures to reduce water usage. While locally adopted codes have in some instances reduced flow requirements even further, in essence we are still operating under those same 1992 guidelines.

High performance building water usage addresses two major components of the hydrological cycle: the supply of potable water and the disposal of wastewater. Strategies for decreasing water supply usage include: minimizing hot water piping runs, tankless water heaters, manifold systems of small ID pipe diameters, substituting grey water for potable water where permitted by local codes and regulations, using ultra low-flow fixtures, and installing electronic controls for fixtures and waterless urinals in commercial buildings. Further green systems such as harvesting rainwater for toilet flushing is probably beyond the scope of cost/effectiveness in the Sonoran Desert due to the limited rainfall.

Another supply item currently considered by the Water Conservation Task Force is individual metering of common ownership properties. Studies have shown that water usage is reduced when a person receives individual billing for consumption. While this is not a green related performance criteria for buildings, it is emblematic of a larger problem—the lack of education regarding impact on water supplies.

Regarding disposal of wastewater, options include providing on-site greywater systems for landscape irrigation or recharge purposes. Cost effectiveness of individual greywater systems need to be evaluated and the effects of increased waste concentration delivered to treatment plants analyzed. Development Services will look to Pima County Wastewater Management for direction regarding greywater systems.

LEED offers a total of 5 points for water efficiency. While this does at first sight appear to be a low priority, especially in the context of our desert environment, there are limited performance gains obtainable in buildings with limited water harvesting resources. Performance related building water gains pale compared to what is achievable through both outdoor water reduction and education. The latter are the principal water items which need to be mitigated.

VII Building Energy

Energy and atmosphere is the category containing the most possible points, a total of 17 in the LEED-NC rating system. Buildings in the US consume 36 percent of the country's primary energy and 65% of electricity production, impacting water resources and air quality. A nominal US commercial building consumes on the order of 100,000 BTUs per square foot per year. Today's green buildings reduce this number to less than 50,000 BTUs but the potential exists to reduce this number further to 10,000 BTUs.

In a Capital E survey of 60 LEED-rated buildings conducted by Gregory Kats in 2003, these buildings consumed an average of 30 percent less energy than new buildings meeting ASHRAE Standard 90.1-1999. It is noteworthy that the latter standard was considered a progressive energy benchmark when first released.

Strategies for high performance design include: using building simulation tools to assist designers in minimizing energy consumption, optimizing passive solar and ventilation design, maximizing thermal performance of building envelope, minimizing building loads including lighting and HVAC, and incorporating renewable energy use. Perhaps more than any other field, energy technology is rapidly evolving in areas such as high performance chillers, radiant cooling, energy recovery ventilators, fiber optic and LED lighting, building integrated photovoltaics, fuel cells, and smart building energy management systems.

There are examples in the US of entirely off grid buildings such as the Audubon Center in Debs Park outside of Los Angeles. This LEED-NC platinum building has 5,022 square feet of fully enclosed space and 2,816 of partially enclosed areas. Energy is supplied through three solar systems: a photovoltaic array generating the building's electricity, an array of glass vacuum tube solar collectors providing high temperature hot water to an absorption chiller for air conditioning, and a passive solar domestic hot water system. Passive strategies are used throughout and wastewater is treated on site using microfilters and microorganisms. Closer to home, the City of Tucson will be constructing its first LEED platinum building at Reid Park Zoo, currently in the design phase.

Reducing energy usage in buildings is a high priority of the federal government. The Department of Energy (DOE) is creating multiple programs for homeowners including the Zero Energy Home initiative seeking to build homes 50% more efficient while meeting their own energy needs. Energy Star is another program of DOE for businesses and individuals. There are multiple other federal, state and utility programs listed at www.dsireusa.org per regional location, offering residential and commercial grants, credits or deductions totaling thousands of dollars.

VIII Interior Environment

Interior environment issues include: indoor air quality, reduced sound/noise transmission, lighting quality, climate control, building materials, furnishings, and floor coverings. Mitigating sick building syndrome by reducing the use of materials releasing volatile organic compounds and other contaminant emissions receives many LEED points. LEED-NC awards a total of 15 points for interior environment and includes such items as CO_2 monitors and furniture using green products including wheatboard made from wheat straw. Herman Miller is a manufacturer of green office furniture currently purchased by Pima County.

Providing better and more local control over lighting and temperature also contribute to a large gain in productivity. A study by Gregory Kats of Capital E indicated a 20-year life, health, and productivity savings of $36.89 per square foot for LEED certified/silver buildings and $55.33 for gold/platinum ones. A paper by William Fisk of the Indoor Environment Department at Laurence Berkeley National laboratory estimated that the US could save $6 to $14 billion from reduced respiratory disease, $1 to $4 billion from reduced allergies and asthma, $10-$30 billion from reduced sick building syndrome, and $20 to $160 billion from direct non-health related improvements in worker performance resulting from better indoor environments. While these numbers are difficult to verify empirically, they do point at the weight researchers place on high quality indoor environments.

IX Green Building Materials

Green building materials are materials that have a lower environmental impact compared to their alternatives. This impact includes the material proper and the energy required to manufacture and deliver the product to its destination. As an example, a typical home built in the US requires about 1 acre of forest to build and generates 4 lbs of waste per square foot. Manufacturing the portland cement alone for the concrete foundation consumes large quantities of energy and generates over 20,000 lbs of CO_2 emissions.

General strategies for maximizing green materials include: reusing existing structures, reducing materials use, using materials created from renewable sources, reusing building components, using recycled materials, and using locally produced materials.

In terms of structural materials, we have at our disposition regionally local materials such as adobe, rammed earth and even strawbales. When possible, we can also move away from portland cement which has caused many problems in older adobe structures due to its brittle and impervious

qualities, and return to the use of lime cement for traditional construction. For structural concrete construction, portland cement usage can be reduced by mixing in flyash or furnace blast slag resulting in increased performance through the addition of these recycled products.

LEED-NC provides 13 points for materials selected, but from a certification standpoint, it remains problematic as to how green a building material really is since there is no overarching agency actually certifying individual products. For the construction of new homes, this category therefore becomes the most difficult to assess.

X Building Commissioning

Building commissioning is an integral part of delivering a high performance building and is currently mandated for all federal construction projects. Commissioning includes the HVAC system and all other installed products and equipment including electrical systems. A Capital E report put the 20-year savings in operations and maintenance costs due to building commissioning at $8.47 per square foot. Third party commissioning ensures that all systems are operating as intended by the design as well as per their listing or manufacturer installation requirements.

XI Conclusion

From an economic, ecological and quality of life perspective, moving toward sustainable construction appears to be in the best interest of Pima County and is in line with the Sonoran Desert Conservation Plan. All changes in methods and habits, however, require education and incentives until the new direction becomes ingrained in the culture. To this end, Development Services proposes to take a leadership role in promulgating green construction through an incentive-based program until such time that sustainable construction enters the mainstream.

While green building construction requirements will require inputs from Department of Environmental Quality, Wastewater Management, Regional Flood Control District, and the Planning division of Development Services, it is proposed that the program be absorbed within the present Building Codes Division structure within a subcommittee of the joint County/City Building Codes Committee. This green building subcommittee forum will be open to all citizens wishing to provide input and will work closely with stakeholders including SAHBA to ensure that interests are met across the community.

XII Green Building Program

The Pima County Green Building Program will consider incentives including credits against permitting fees, reducing permitting turn-around times, and issuance of green building certificates. Credits against permitting fees will be absorbed within Development Services operations or within the Development Services reserve fund as required. Incentive credit amounts are yet to be determined. For commercial structures, the amount of credit will be contingent on the size of the building as well as the type of LEED or other commercial certification sought for and obtained.

For International Residential Code (IRC) structures, the amount of credit will be contingent on the size of the building as well as the number of points achieved on an eventual green building rating system.

The Green Building Subcommittee will evaluate available rating systems for IRC structures such as LEED-H, NAHB, SBIC, and the City of Scottsdale standard, to secure a rating system that is most in alignment with the Sonoran Desert environment and wherever possible integrates other programs such as those available through local water and energy utilities. It is proposed that certificates be issued for three different levels of IRC sustainable buildings based on the number of points obtained. The recommendations produced by the Pima County Water Conservation Task Force will also be incorporated into the program.

In line with the promotion of the Green Building Program and resources conservation, Development Services will strive to provide community educational materials on green building design, construction, commissioning, and maintenance.

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