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SOLUTIONS SOFTWARE TECHNOLOGY

Green Building Rating Tools and Energy Efficiency

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Abstract

Buildings in the USA account for 70% of the electricity consumption. The situation in South Africa is not dissimilar and has prompted the establishment of the Green Building Council of South Africa during 2008. Green Building rating tools such as Green Star™ have been developed to assist developers, building owners and facility managers to reduce the environmental impact of buildings. This paper will introduce green building rating tools and discuss how energy efficiency and resource use can be improved and operating costs reduced by using these tools without any significant increase in building cost.

Introduction

According to the United Nations Environment Program (UNEP) [1], worldwide, 30-40% of all primary energy is used in buildings. The building and construction sector typically provides 5-10% of employment at national level and normally generates 5-15% of the GDP [1]. In a developing economy such as South Africa, construction is a key driver for economic growth. These benefits can be offset by the potentially serious negative impacts of buildings on the environment. According to the US Green Building Council [2], buildings represent 39% of U.S. primary energy use and are one of the heaviest consumers of natural resources. They account for a significant portion of the greenhouse gas emissions that affect climate change. In the U.S., buildings account for 39% of all CO2 emissions.

Buildings represent a huge opportunity for reducing energy consumption which provides significant benefits to owners, tenants and the environment. Few buildings constructed prior to the 1990's considered energy efficiency due to the low cost of energy and unavailability of energy efficient technologies.
Reductions in energy consumption also enable companies to deliver products and services at a lower cost. These increased profits accrue directly to the bottom line. Potential savings from an integrated approach to energy-efficient upgrades can be 35% or greater. According to the US EPA [3], energy bills for existing US commercial buildings of approximately 7.3 billion m^2, total $110 billion annually. The US EPA estimates that increasing the energy efficiency of this space could save more than $25 billion.

Green and High Performance Buildings

Wikipedia[4] describes Green Buildings as "*the practice of increasing the efficiency with which buildings use resources — energy, water, and materials — while reducing building impacts on human health and the environment, through better siting, design, construction, operation, maintenance, and removal — the complete building life*". The concept of green buildings has been taken further and some practitioners now refer to High-Performance Buildings.

The US Department of Energy [5] defines a High-Performance Building as *"a building with energy, economic, and environmental performance that is substantially better than standard practice. It's energy efficient, so it saves money and natural resources. It's a healthy place to live and work for its occupants and has relatively low impact on the*

environment. All this is achieved through a process called whole-building design". Benefits of whole-building design include:

- Reduce energy use by 50% or more
- Reduced maintenance and capital costs
- Reduced environmental impact
- Increased occupant comfort and health
- Increased employee productivity

The design and upgrade guidelines for high performance buildings can be used to improve energy efficiency in any building.

Green Building Councils

Buildings constructed prior to the 1990's did not consider resource use and energy efficiency as a high priority. During the 1990's, environmental concerns prompted a number of countries to establish Green Building Councils. During 2008 South Africa became the 13th member of the World Green Building Council. Green building councils are non- profit organizations that [6]:

- Promote sustainable green building
- Establish a rating system and rate green buildings
- Educate property industry people about green buildings
- Make knowledge and resources on green building available

The Green Building Council of SA (GBCSA) has adopted and customised the Green Star building rating tools of the Green Building Council of Australia (GBCA) for the following reasons [7]:

- GBCA offers free IP to other GBCs
- Green Star is customisable
- South Africa and Australia use common metrics and similar standards
- The environmental issues in both countries are similar.

The South African version of the Green Star rating tool has been customised to reflect the applicability of the credits and benchmarks and has introduced new credits where applicable. The tool had also been modified to reflect the standards and references used in South Africa. Green Star SA was created to [8]:

- Establish a common language and standard of measurement for green buildings
- Promote integrated, whole-building design
- Identify building lifecycle impacts
- Raise awareness of green building benefits
- Recognise environmental leadership
- Transform the built environment to reduce the environmental impact of development

Green Building Rating Tools

The GBCA has 7 Green Star building rating tools with another 5 tools in a pilot phase [9]. The US Green Building Council's (USGBC) LEED rating system has 9 different tools with 2 under development. These tools cover the full spectrum from design, construction and operation of buildings in various sectors. This is shown in Figure 1 below

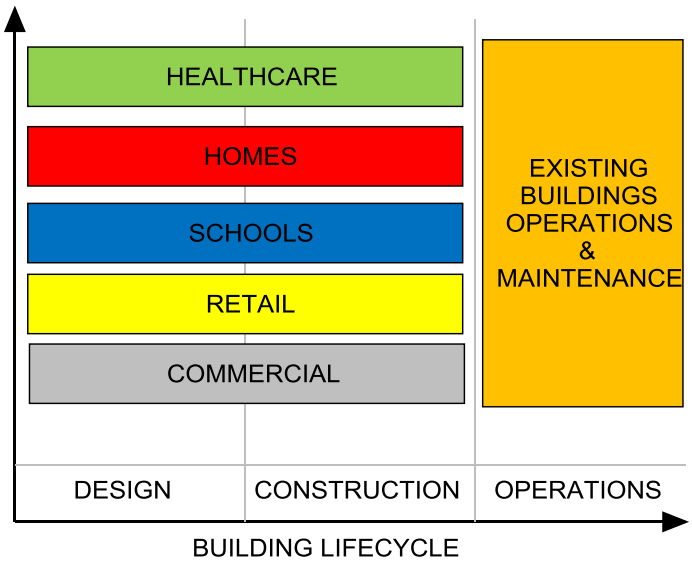

Figure 1: Green Building Rating Tools

As of the end of 2008, GBCSA has one building rating tool – Green Star Office V1 [10]. This was developed to validate the environmental initiatives of the design phase of new office construction or base building refurbishment; or construction and procurement phase of a commercial office building. The rating tool aims to:

- Encourage the implementation of new and emerging technologies
- Reduce the environmental impact of development
- Encourage new design and construction approaches by rewarding best practise
- Ensure design strategies are implemented without overlay of operational management and user behaviour
- Allow different designs to have their environmental initiatives fairly benchmarked.

The Green Star SA Office V1 rating tool includes nine separate environmental impact categories. These are:

- Management
- Indoor Environment Quality
- Energy
- Transport
- Water
- Materials
- Land Use and Ecology
- Emissions
- Innovation

Each category is divided into credits which addresses and initiative that has the potential to improve the building's environmental performance. Points are awarded for each credit where the project has met the overall objectives intended by that credit. Once all the credits are assessed, a percentage score is then calculated. Each category has an environmental weighting factor which is then used to calculate a single score. This is illustrated in Figure 2 below:

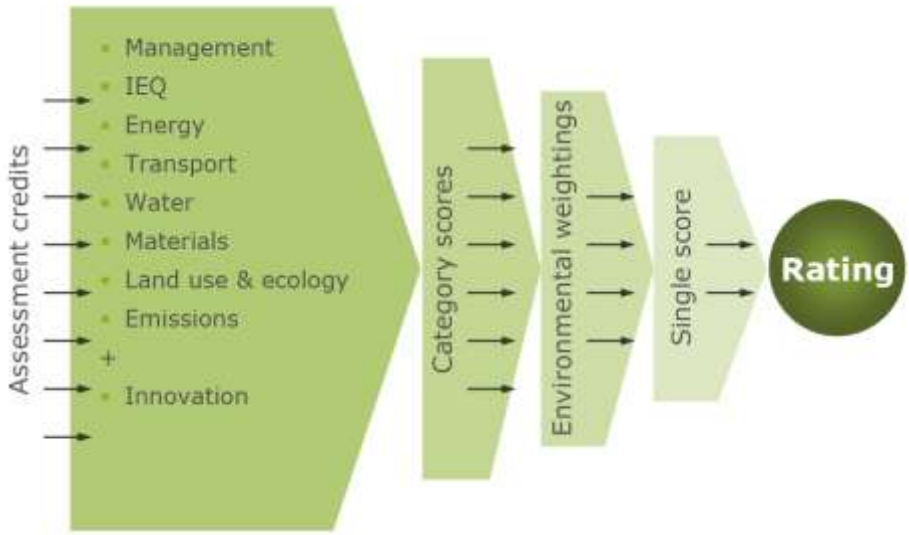

Figure 2: Structure of Green Star SA Rating System [8]

The rating is then used to award "stars". Only projects that achieve a score which equates to a 4 star or higher rating is eligible for formal certification. This is in line with the position that Green Star recognises and rewards market leaders. This is shown in the figure below:

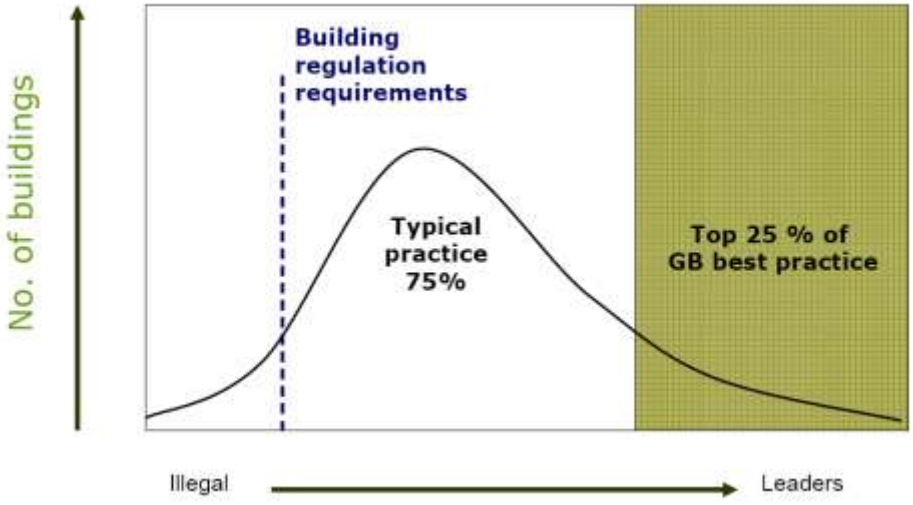

Figure 3: Green Building rating tools recognise and reward best practise.

The overall score and ratings are shown in the table below:

Overall Score	Star Rating	Outcome
10-19	One Star	Not eligible for certification
20-29	Two Star	Not eligible for certification
30-44	Three Star	Not eligible for certification
45-59	Four Star	Certified 4 Star – " Best Practise"

60-74	Five Star	Certified 5 Star –"SA Excellence"
75+	Six Star	Certified 6 Star – "World Leadership"

Table 1: Green Star SA Rating Tool Scores

Energy Efficiency and Green Building Rating Tools

As can be seen from figure 2, there are 9 separate credits categories in the Green Star SA rating tool that are used as input to determine the final project score. In total there are 67 separate credits that are rated. While these credits all determine the environmental impact of the project, only specific credits relate to energy.

The Energy credit category carries the largest environmental weighing and targets an overall reduction in energy consumption, that minimises the greenhouse gas emissions associated with operational energy consumption and maximises the potential operational energy efficiency. A total of 30 category points (25% of the total) is available in this credit category. The credits in the Energy category are as follows:

- Conditional Requirement
- Greenhouse Gas Emissions
- Energy Sub-Metering
- Lighting Power Density
- Lighting Zoning
- Peak Energy Demand Reduction

Conditional Requirement.
There are two conditional credit requirements for eligibility of a project under Green Star. One of these is the building energy performance. Under the GBCA Green Star Office V3, the project's predicted greenhouse gas emissions must not exceed 110kg CO_2 / m^2 /annum [11]. In South Africa to meet the conditional energy requirement, the building must demonstrate energy performance equal to or better than a notional building constructed to the "deemed to comply" fabric and building services clause of SANS 204:2008.

Greenhouse Gas Emissions (20 Category Points)

This credit encourages and recognises designs that minimise greenhouse gas emissions associated with operational energy consumption. Up to 20 points are awarded where it is demonstrated that the buildings predicted greenhouse gas emissions have been reduced below the conditional requirements. The full 20 points are achieved when the building has a net zero operating emission base building (Carbon Neutral). This credit encourages the reduction of energy consumption through the following design practises

- Passive Energy Reduction:
    - Energy efficient building design
    - Building orientation
    - Design of the building façade
    - Shading
    - Insulation

- Active Energy Reduction
    - Energy-efficient heating, ventilation and air-conditioning (HVAC)
    - Energy-efficient lighting
    - Energy-efficient equipment in the base building (e.g. lifts)
    - Building management which minimises or eliminates wasteful energy consumption

The greenhouse gas emissions can also be reduced by the use of renewable or low carbon emission energy sources within the building. These include:

- Solar water heating

- Photovoltaics
- Wind energy
- Co-generation
- Biogas generated from waste products
- Alternative fuels (e.g. bio diesel or natural gas)

Note that in order to claim the points for this credit, the greenhouse gas emissions or energy consumption must be predicted. This could require sophisticated computer modelling.

Energy Sub-metering (2 Category Points)

This credit encourages and recognises that the installation of energy sub-metering will facilitate the ongoing management of energy consumption. The category points are awarded for:

- Sub-metering of any substantive energy use within the building (metering of any loads greater than 100kVA). For a typical office building this would include:
    - Chillers
    - Air Handling Units
    - Lifts
    - Common area lighting
    - Common area power
    - Parking areas
- In addition to the above there is separate sub-metering for lighting, each floor or tenant (whichever is smaller)

For both of these conditions, there must be an effective mechanism for monitoring the energy consumption data

Lighting Power Density (4 Category Points)

This credit encourages and recognises designs that provide artificial lighting with minimal energy consumption. It rewards the efficiency of the luminaires and lighting system independent of the design lighting levels. The credits are provided at one point for the energy use of 3.0 Watts/m^2 per 100 Lux. One additional point is provided for each energy reductions of 0.5 Watts/m^2 per 100 Lux. The maximum of 4 credit points are earned when the energy use is 1.5 Watts/m^2 per 100 Lux.

Efficient lighting can be provided by:

- Using electronic ballasts
- New generation metal halide, fluorescent and solid state (LED) lamps
- Efficient luminaires
- Correct spacing of light fittings
- Designing for the correct lighting levels
- Lighting control zoning
- Maximum use of daylight with perimeter dimming

Lighting Zoning (2 Category Points)

This credit encourages and recognises lighting design practises that offer greater flexibility for light switching, making it easier to light only occupied areas. Points are awarded where:

- All individual or enclosed spaces are individually switched and the size of the switched lighting zones does not exceed 100m^2 for 95% of the usable area.
- An additional point is available an individually addressable lighting system is available for 90% of the usable area.

Light switches must be clearly marked and accessible by the building occupants. Motion occupancy sensors can be used but it must be possible for the occupants to manually override the sensors. All the lights need to be automatically switched off after normal hours to prevent the lights being switched on by security guards patrolling the building at night. Daylight sensors that automatically dim the lights do not qualify under this credit. They will however reduce the overall energy consumption and will contribute to the Greenhouse Gas Emissions credit.

Peak Energy Demand Reduction (2 Category Points)

This credit encourages and recognises designs that reduce peak demand on energy supply infrastructure. Points are awarded as follows:

- One point when the peak electrical demand is reduced by 15% or where the difference between the peak and the average demand does not exceed 40%
- Two points when the peak electrical demand is reduced by 30% or where the difference between the peak and the average demand does not exceed 20%

The following peak demand reduction systems are examples that could provide the necessary energy to meet the requirements of the credit:

- Distributed energy systems
- Cogeneration
- Micro Turbines
- Photovoltaics with battery storage
- Fuel cells
- Energy and thermal storage systems
- Batteries and inverters
- Ice Storage
- Phase change materials

Note that the peak energy is limited to the requirements of the base building and not the occupant loads. Careful design of the building heating, cooling and ventilation system is usually required as this is often a major contributor to peak loads. Where intermittent, renewable energy sources are used such as wind and photovoltaics, it will be necessary to provide energy storage (e.g. in batteries) as the peak demand may not coincide with the operation of these sources.

Energy Efficiency From Other Green Building Credits

There are a number of credits outside of the Energy category that also relate to energy efficiency and greenhouse gas reductions. These include the following:

- Management Category
    - Commissioning Clauses. Ensuring equipment and building services are operating at optimal design potential at handover.
    - Building Tuning. To ensure that the designed occupant comfort levels and energy efficiency is maintained or improved after handover.
    - Independent Commissioning Agent. Ensures that the building systems are commissioned and fine tuned to meet or exceed design objectives.
    - Building User Guide. Ensures that the building users can optimise the environmental performace of the building.
- Indoor Environmental Quality
    - Daylight. By making use of good levels of daylight, the energy requirements for lighting he building will be reduced.
    - High Frequency Ballasts. This credit is intended to reduce the flicker sometimes associated with fluorescent lamps. These ballasts are also more energy efficient than conventional magnetic ballasts.

    - Electric Lighting Levels. This credit attempts to ensure that lighting is not overdesigned. This credit will also assist in reducing energy consumption.
    - Thermal Comfort. By providing the optimal level of thermal comfort for the building occupants, energy is not wasted over heating or over cooling the building.
    - Individual Thermal Comfort. This credit also contributes to the optimal amount of heating, ventilation and cooling being used.

- Innovation. This credit category is included to encourage, recognise and reward the spread of innovative technologies, designs and processes for commercial building applications that impact on environmental performance. Up to 5 points can be awarded for pioneering initiatives in sustainable design, for substantially improving on an existing Green Star credit and for introducing sustainable design initiatives that are currently outside of the scope of the Green Star tools. New sustainable technologies, processes and techniques are constantly being developed that can improve energy efficiency in buildings.

Business Case for Building Green

The additional cost of building sustainable green buildings has been cited as a reason for not adopting designing and building this way. Real estate and construction professionals have overestimated the costs of green building by up to 300%. Comprehensive research has been conducted by both the US Green Building Council [12] and the GBCA [13] where it was shown that the initial cost of building green is between zero and 10 percent more, depending on the building rating being sought. The business and other benefits of building green far outweigh these costs. Some of these are:

- Building green saves money
    - The cost per square metre for buildings seeking Green Building certification falls into the existing range of costs for buildings not seeking certification.
    - Building sale prices for energy efficient buildings are as much as 30% higher per square metre than conventional buildings.
    - An upfront investment of 2% in green building design, on average, results in life cycle savings of 20% of the total construction costs – more than ten times the initial investment.
- Perceived cost benefits of green building:
    - Operating costs decrease 8-9%
    - Building value increases 7.5%
    - Return on investment improves 6.6%
    - Occupancy ration increases 3.5%
    - Rent ratio increases 3%
- Building green stimulates the economy by creating a demand for green jobs and workers that can contribute directly to creating a sustainable future. The US economy could generate 2 million green jobs in as short a stretch as two years.
- Green buildings consume less energy and fewer resources. In comparison to the average commercial building:
    - Green buildings consume 26% less energy
    - Green buildings have 13% lower maintenance costs
    - Green buildings have 27% higher occupant satisfaction
    - Green buildings have 33% less greenhouse gas emissions
- Green building occupants are more productive:
    - A study by Carnegie Mellon University measuring the relationship between increased lighting control and productivity showed an increase of up to 26% in productivity and 27% headache reduction.
    - The Pennsylvania Department of Environmental Protection found that employee relocation within one building cost about $2,500. Flexible design features found in the integrated green building helped cut employee relocation costs by 90%.
    - Sales in stores with skylights were up to 40% higher compared to similar stores without skylights. Of 108 stores operated by chain retailer, 2/3 had skylights and 1/3 had electrical lighting, mostly fluorescent.

    - Students with the most daylighting in their classrooms progressed 20% faster on math tests and 26% faster on reading tests in one year than those with the least day lighting.
    - Corporate perception of whether green fosters innovation: 57% agree; 28% neutral and 15% disagree.
    - Improvements in indoor environments are estimated to save $17-$48 billion in total health gains and $20-$160 billion in worker performance.
- Green building occupants are healthier
    - People in the U.S. spend about 90% of their time indoors.
    - The US Environmental Protection Agency (2008) studies indicate indoor levels of pollutants may be up to ten times higher than outdoor levels.
    - Significant associations exist between low ventilation levels and higher carbon dioxide concentrations – a common symptom in facilities with sick building syndrome.

Conclusion

The application of sustainable building practises to improve energy efficiency does not only reduce the environmental impact of buildings. It also makes good economic sense. The initial incremental cost, if any, is quickly offset by a significant number of benefits. Green Building rating tools such as Green Star SA can be used to guide and benchmark the process. Even where a formal certification is not required, the rating tools can provide a number of positive suggestions for improving energy efficiency

References

[1] United Nations Environment Programme, *Buildings And Climate Change. Status, Challenges and* Opportunities, UNEP 2007

[2] U.S. Green Building Council, *Green Building Facts. Green Building by the Numbers*, US GBC, September 2008

[3] U.S. Environmental Protection Agency, *ENERGY STAR® Upgrade Manual for Buildings*, US EPA, December 2004

[4] Internet: http://en.wikipedia.org/wiki/Green_building, September 2008

[5] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. Internet: http://www.eere.energy.gov/buildings/highperformance/design_approach.html, September 2008

[6] Kerswill, Bruce, *The Green Building Council of South Africa: Delivery and Energy*. Presentation at the SAPOA Conference, May 2008

[7] Malanca, Michelle, *The Development of Green Star SA*. SAPOA Conference, Presentation at the GBCSA Conference, Cape Town, November 2008

[8] Green Building Council of South Africa, Technical Manual Green Star SA – Office Design and Office As Built V1 2008. First Edition, November 2008

[9] Green Building Council of Australia. Internet: http://www.gbca.org.au/green-star/rating-tools/green-star-rating-tools/953.htm, December 2008

[10] Green Building Council of South Africa. Internet: http://www.gbcsa.org.za/greenstar/ratingtools.php, December 2008

[11] Green Building Council of Australia, Green Star– Office Design and Office As Built V3 2008 Technical Manual. First Edition, January 2008

[12] US Green Building Council Leed Rating System . Internet: http://www.usgbc.org/DisplayPage.aspx?CMSPageID=222 , December 2008

[13] Green Building Council of Australia, Dollars & Sense of Green Buildings 2008. Preview Edition, 2008