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Green Building classification system for developing countries

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This paper explores the current issues with existing green building rating systems. It also addresses how the lack of a universal definition of what constitutes a "Green Building" and the current absence of consistent data sources, benchmarks, and metrics on Green Buildings has prevented greater participation in the industry. The drivers behind creating Green Buildings in developing countries are briefly reviewed and the case for a new Green Building qualification system is proposed (EDGE). This new system is supported by a tool that provides technical solutions and quantifies the cost savings with investment paybacks. The paper explains the need for three main innovations to create a large-scale adoption of Green Building Standards in developing countries. These are: 1) Simplification of assessment criteria by removing subjective, weighted 'credits scores', 2) Sharp focus on areas of resource use in buildings, i.e. consumption of energy, water, and materials, and 3) Provision of an integrated tool which recommends cost-effective solutions to make the building design and specification at a level universally defined as 'green'. The paper then describes how the EDGE tool can create a market transformation by providing quick and inexpensive means for building owners and developers in developing countries to classify their building as 'green' and enabling financial institutions interested in Green Building investments to assess risk reduction due to lower utility bills.

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Introduction

Background – buildings and greenhouse gas emissions

Today, buildings account for 15% of the world's Greenhouse Gas (GHG) emissions (IPCCa, 2006). The building sector is also one of the fastest growing. The IPCC estimates building-related GHG emissions to double by 2030 under a high-growth development scenario (Levine, 2007). This increase would take place almost entirely in the developing world.

McKinsey forecasts that the majority of low-cost abatement measures are to be found in the building sector (McKinsey, 2009). Developing countries present the greatest opportunity for GHG reductions through the design of Green Buildings, underscoring the need to adopt sustainable building practices and to capitalize on this emission reduction potential.

State of Green Building rating tools

Success of Green Building rating tools

Despite the compelling GHG abatement and business opportunity, the real estate industry, among other stakeholders, lacks a universal definition of what constitutes a "Green Building" as well as consistent data sources and metrics on Green Buildings. These deficits make an assessment of the profitability of Green Building investments difficult and therefore hold back stronger investor interest to implement them.

Existing Green Building rating tools such as LEED, Green Star and BREEAM are being widely used globally. Local indigenous systems are emerging but most use the basic platform outlined in LEED or

BREEAM. Many countries are either currently pursuing Green Building standards or are planning to pursue them in the near future. This reflects the popularity of voluntarily labeling a building as "green."

These systems share inherent problems such as:

- Details and specifications that should be basic to fundamental practice are included as 'green' elements (Lstiburek, 2008), Measures like 'indoor environmental quality', 'durability', disability access or occupational safety and health issues can be found in many of the rating tools, taking the focus away from the primary issue of GHG.
- The mandatory minimum performance is too lenient in many cases and fails to provide adequate reassurance that the "green" building will provide lower energy costs.
- They make subjective judgments [weighting] of different environmental issues [health, energy consumption, water consumption] in the name of contextual economic and social concerns or priorities. The importance of the issues vary widely across the systems for instance, BERDE awards only 9% of the 'credits' for energy efficiency as compared to LEED which offers 33% and BREEAM that puts forward 19%.
- They do not suggest technology solutions to improve efficiency and related cost savings.
- They rely on complex energy simulation software to predict energy use (Schendler, 2005), which often lack accuracy in specific local contexts. These software packages rarely provide design direction in the initial conceptual stage. This results in a large number of iterations to the design and a time and budget loss for the Green Building project.
- The assessment process is lengthy and expensive (Schendler, 2005), especially for clients in developing countries. This limits the number of prospective builders/owners adopting Green Building strategies.
- Banks and financial institutions need to be able to assess the financial viability of a Green Building investment through reduced risks from lower utility bills, which is not possible with the present rating systems.

Understanding priorities in developing countries

In order to affect market transformation, it is important to understand the drivers for green buildings in developing countries which are largely unlike those in developed countries. The key drivers that will push the adoption of green buildings in developing countries are as follows:

Table 1. Key drivers

Avoiding emissions growth	Developed countries account for the vast majority of buildings-related CO_2 emissions, but the bulk of growth in these emissions over the past two decades was seen in developing countries (IPCC 2007b). Developing countries could significantly increase global GHG emissions. They will experience the largest growth in population, new construction, and a rise in consumer standards, with a corresponding growth in use of air-conditioning and electrical gadgets and the building of larger homes. As an example, the World Bank estimates that about 50% of the world's new building construction between 2008 and 2015 will take place in China (World Bank, 2008)
Reducing the financial burden of fossil fuel imports and capital investments in energy/water infrastructure	Energy security is an issue for almost all countries. The steep increase in the cost of fossil fuels has a major consequence for socio-economic growth in the poorest countries. Efficiency improvements provided by greener buildings will result in direct benefits to the balance of trade of fossil fuel importing countries. Reducing the infrastructure investment requirement (e.g., power stations, water supply reservoirs, and supply lines) and making the best use of existing supply capacities to improve access to energy are also very important drivers, especially in high-growth countries (such as Brazil, and India) and in those countries where there is no readily available local sources of energy. Efficient buildings can help governments supply energy to more people with the existing supply capacities. This is often a limitation in poor countries of Africa and Asia (World Energy Council, 2008).
Reducing utility costs	In several developing countries, urban households allocate more than 5% of total expenditure to energy, indicating its direct importance in household budgets (Bacon, 2010). The prices of electricity have been rising rapidly over the last decade and should continue to do so as countries remove subsidies and fuel costs rise.

Table 1. Key drivers (continued)

Minimise resource depletion	While energy costs are rising, water, metals, wood, cladding materials, and other resources are becoming critically depleted. Lack of regular access to clean, potable water is a major socio-economic issue in many developing countries, particularly low-income countries.
Providing a market stimulus to the 'sustainability industry'	The specification of new or innovative products such as solar panels or rainwater harvesting systems can stimulate a market for the development of these products. Incentives in this field will enable developing economies to compete in a growing market for more sustainable products.
Balance between mandatory regulations and financial incentives	Unlike in developed countries where energy efficiency is largely tackled by mandatory building regulations that require a minimum level of energy efficiency, most developing countries lack building energy efficiency regulations or governments technically capable of implementing them (Katrina, 2011). A large part of the building industry in developing countries is also unable to access the necessary capital to adopt higher efficiency standards. It is in these cases that a voluntary system linked to financial incentives needs to play a catalytic role in promoting resource efficiency.

The need for a new Green Building rating tool

Developing countries currently lack a green building assessment and rating tool that addresses their unique needs. Most existing green building tools are complex, expensive, and time-intensive, as they require a considerable investment in training and a laborious data entry effort -- making the entry into this field unnecessarily difficult. This underscores the need for a simple, quick, and affordable tool that focuses on the efficient use of energy, water, and materials while exposing investment costs and length of payback time.

Factors that can lead to higher penetration of green building practices

In order to achieve significantly better market penetration in developing countries and a meaningful impact on resource efficiency, a GB rating system needs to have the following features:

- Ability to provide efficiency impacts: GB tools must have the ability to provide various resource efficiency measures (REMs). The stakeholders of the GB project will be enabled to choose those REMs that make the most impact. e.g.: it would be better for stakeholders to choose 5 REMs that result in an aggregate of 25% of cost savings compared to 15 REMs that provide an aggregate of 20% of savings in that particular locality. This a la carte capability to rapidly determine the best technical solutions is critical in new, emerging markets where a streamlined process compensates for an absence of technical expertise and administrative skills.
- Capability to provide design direction early: There is a clear need for a tool that starts informing decisions based on efficiency early in the design process. It is preferable to have a ballpark estimate early in the design process rather than use complex accurate modeling, particularly in new developing markets, which may or may not get used in the design and may not actually give any more accuracy.
- Ability to provide cost information: Choices of REMs should be based on investment costs and payback, as stakeholders in developing countries are particularly sensitive to the bottom line. With information on the capital costs, as well as potential savings in operation costs, the stakeholder can calculate the payback and make a more financially informed decision.
- Capacity to measure building performance objectively: The classification system must provide some level of certainty in terms of efficiency. e.g., 20% reduction in energy, water, and embodied CO_2 of materials correlates to 20% lower bills. The rating tool must provide efficiency information that is objective, un-weighted, and tangible.
- Potential to manage without expensive consultant resources: Most developing countries do not have access to Green Building professionals. The tool must assume a level of simplicity that eliminates the need for GB professionals, enabling competent building consultants (architects, civil engineers, mechanical engineers, electrical engineers, and plumbing/sanitary engineers) who have no prior knowledge of green buildings.

Three main innovations are required to create a large-scale adoption of Green Building Standards in developing countries: 1.) Simplification of assessment criteria and therefore reducing the time and cost to meet the standard, 2.) Sharp focus on areas of resource use in buildings i.e., energy consumption, water consumption, and materials consumption, and 3.) Provision of an integrated tool which recommends cost-effective solutions to make the building design and specification 'green'.

It is with this background that Excellence in Design for Greater Efficiencies (EDGE) was conceptualized and initiated.

The EDGE classification system

The EDGE classification system assesses the efficiency of a new building at the design stage with respect to its energy, water and materials consumption. The EDGE classification system is supported by an 'EDGE tool' that provides a choice of technical solutions for improving resource efficiency and quantifies the cost savings with investment paybacks associated with such solutions. In this way, a building's inherent efficiencies are revealed quickly, easily, and affordably. The supporting market-specific criteria make the cost-savings tangible while reducing environmental impact.

Green Building criteria has been defined in a manner that enables customization to local conditions, including the following: passive design and energy efficiency, use of renewable energy, efficient water use (including rain water management), waste water treatment and recycling, and environmentally sustainable construction materials.

Why is EDGE important?

The large-scale adoption of Green Building Standards in developing countries requires an innovative approach to assessing buildings.

EDGE expects to create a market transformation by providing quick and inexpensive means for building owners and developers in developing countries to classify their building as 'green' and enabling financial institutions to assess the viability of a Green Building investment due to risk reduction from lower utility bills.

The EDGE tool is a key platform of the assessment system that aims to accomplish the following objectives:

- Global Tool for Green Buildings: Developing countries across the world would be able to use the tool. This tool is not only a rating tool but also provides the users with benchmarking and simplified energy simulation capability. EDGE can be used by building professionals without the need for expensive green building specialists.
- "Green measures" Investment-Planning Tool for Building Owners and Developers: EDGE enables quick but well-informed decision-making. Building owners and developers are able to understand the nuances of green investment and the returns that they would be able to expect.
- Assessment Tool for Financial Institutions: Financial institutions currently lack a simple and effective tool by which they can judge the financial viability of a Green Building investment. Moreover, there is no global standard available by which they can assess risk reduction from lower utility bills. The Green EDGE Classification system provides the basis on which financial institutions can benchmark a building as 'green'. While it is not mandatory that financial institutions need to use the EDGE tool to arrive at the classification, the tool has been developed to make the adoption easy.

The EDGE Tool

The tool has been created in MS Excel spread across four spreadsheets. The logic behind choosing this particular application was its inherent flexibility in offering possibilities of complex calculations without the need to resort to specialized proprietary software.

Sheet 1: Design Parameters: This worksheet is an interface to enter the building design and location parameters. Data requirements include the number of floors, number of rooms (in a hotel), total built-up area, geographic location of the building, and type of fuel and electricity rates. EDGE has built-in default data on electricity and fossil fuel rates, location characteristics (degree cooling / heating days, etc.).

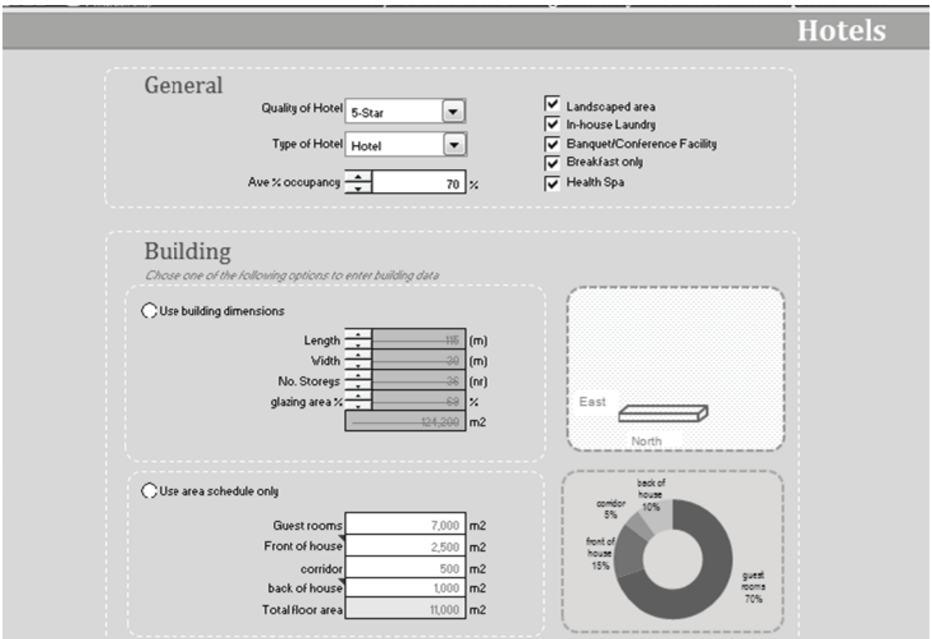

Figure 1. Screenshot of EDGE - Data Entry Sheet for Design Parameters

Sheet 2&3: Energy and Water Efficiency options: There are a number of measures outlined that lead to energy and water efficiency. By selecting one of the measures, the software demonstrates the savings potential and the operational savings that is possible as a result. The user is provided with direct inputs as to which measure would earn the project the maximum savings.

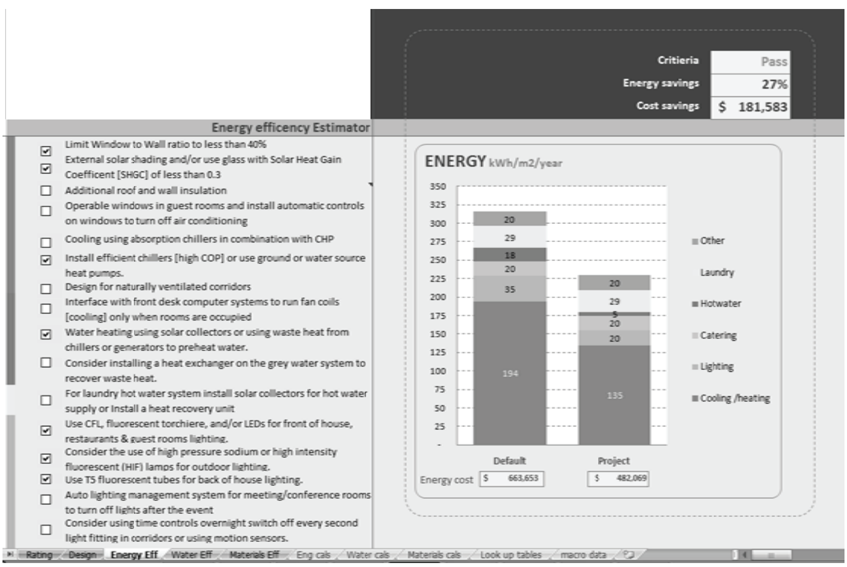

Figure 2. Screenshot of EDGE - Energy Efficiency Sheet

Sheet 3: Water Efficiency Parameters: This is the next most important resource efficiency measure towards making a building green. Dwindling fresh water sources and increased urbanization leading to inefficient catchment of rainwater makes water efficiency an important parameter for judging the 'greenness' of a building.

Sheet 4: Materials Efficiency Parameters: This is the third and last of the measures for making a building green. The measure for materials efficiency lies in low GHG emissions (measured in tons of CO_2) for the material. Available data on Life Cycle Analysis (LCA) on the GHG emissions data of construction materials from across the world has been incorporated into the tool. The major point of reference for LCA data has been the Inventory of Carbon and Energy (ICE), developed by the University of Bath. This data is available in the public domain (Geoff, 2010).

The EDGE classification system focuses on efficiency

The intelligence of the classification system lies in its simplicity. The rating is a simple pass / fails system. In order to secure a "pass" in energy efficiency, water efficiency, and materials efficiency the project must show a minimum percentage saving of 20% compared to a baseline model which does not incorporate energy / water /material saving measures. Reliance on percentage savings as a measure of efficiency keeps the focus on efficiency. Most rating tools use nomenclatures (like Platinum, Gold, etc. or 1-star. 2-star,etc) which brings in a certain level of haziness and uncertainty to the issue of efficiency. The focus on minimum efficiency is a conscious effort to bring a level of certainty and to keep the classification objective.

Methodology for the Tool

The development process of EDGE began with gaining an understanding of constructing a baseline. In order to do this, studies of various national and international minimum performance standards were carried out. After an exhaustive research, base case models were constructed. The next step was to create a list of resource efficiency measures that required to be adopted. This list has been derived out of a wide set of best practices that are currently utilized across the world. A performance calculation engine based on building physics, water efficiency, and material embodied energy was then created which essentially is the central intelligence of the entire system.

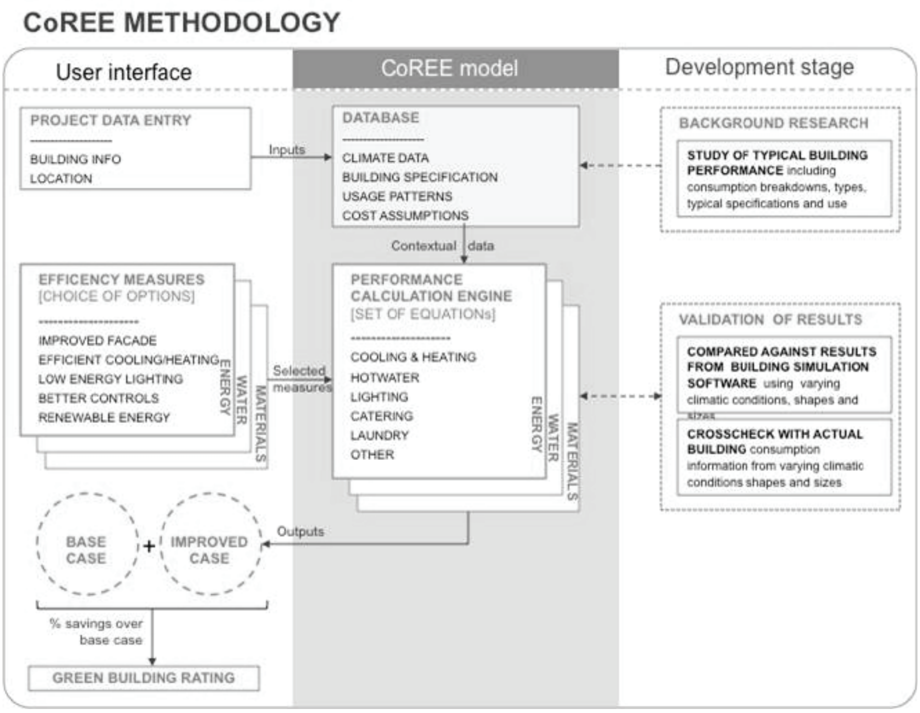

Figure 3. EDGE Methodology

Creating a base case model

First a base case model was created to represent the properties of a typical building that would be found in a particular context. The factors considered in the base case are classified into the following four divisions:

a. Climatic Data: The climate of a locality is one of the key elements in understanding building performance. Data such as annual temperatures, average maximum and minimum temperatures, humidity (both relative and absolute), rainfall patterns and quantities, solar radiation, etc. are input into the model.

b. Building Specifications: The model of a building has various properties such as height, width, and length, number of floors, height per floor, number of car parks, approximate size of the plot, where it is located, etc.

c. Usage Patterns: The model of the building is then subjected to a further set of usage parameters like occupancy numbers, hours, intensity, and patterns.

d. Logic of the Baseline Model Properties and Reference with Other Systems: The baseline parameters are broadly classified into Energy, Water, and Materials efficiency. For energy efficiency, for commercial buildings, ASHRAE-90.1-2004 has been referred to since it is an internationally accepted standard. There are differences based on localization that needed to be considered since EDGE will be used in developing countries. Some of the highlights of issues considered while establishing the baseline properties are as follows:

i. Lighting and HVAC System: The logic behind establishing the baseline has been to verify if there is an Energy Efficiency Code (EEC) in practice in any of the target countries. E.g. China already has an EEC in place. In such cases, the Baseline parameter is automatically derived from the EEC. In the absence of EEC in a particular country, ASHRAE Baseline (as outlined in ASHRAE-90.1-2004) has been adopted. HVAC consultants across the world are aware of the standards set by ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers).

ii. Building Envelope: The energy efficiency of the building envelope is characterized by the following parameters. In the absence of an EEC governing the building envelope energy efficiency, ASHRAE baseline standards were referred.

- Roof and Wall U-value: Considering that EDGE is focused on developing countries, it was the team’s view that most developing countries would not adopt insulation practices unless they are regulated as this adds to the capital cost of the building owner/developer. The U-values of un-insulated concrete for roof and 230mm brick masonry have been considered for roof and wall respectively.
- Window to Wall Ratio (WWR): The baseline for WWR in ASHRAE has been fixed at 40%. An Internet image study of facades of building typologies across various regions show wed that commercial buildings have an average WWR ranging from 50-60%. Therefore as the baseline WW R of 55% was set.

Performance Calculation Engine (PCE)

This is the core intelligence of the programme and the key differentiator between other software programmes and EDGE. The PCE is essentially a set of mathematical equations based on the principles of climatology, heat transfer, building physics, water use, carbon footprint of materials, and other such aspects. It is a large set of calculations that are synthesized into creating a single picture of building performance. The final performance is expressed in terms of energy used (kWh – kilowatt-hours), water used (liters / cubic meters), and GHG emissions (in tons of Carbon Dioxide). Performance parameters like heating loads, cooling loads, water consumption, and energy consumption have been calculated using the following variables:

- Cooling / Heating Loads from outdoor environment: Window to wall ratio, U-value of windows, U-value of walls, Delta T (difference between the mean outdoor temperature and the desired temperature for indoor), cooling / heating degree days, solar absorption factor, shading coefficient, air-conditioning usage factor, etc.
- Cooling / Heating Loads due to indoor factors: equipment heat loads, number of pieces of equipment, people heat loads, people occupancy numbers and density, etc.
- Water usage loads: occupancy, usage rates, rate of water flow through the fixtures, etc.
- Hot water loads: ambient temperature of water, solar water heating potential, etc.
- Materials: Inventory of Carbon and Energy (ICE) developed at the University of Bath has been used to measure the energy consumed during the extraction, processing, and use of the materials measured in mega joules.

The EDGE PCE is uses a quasi-steady state model for the assessment of the annual energy use for space heating and cooling. The calculation methodology is based on the European CEN standards and ISO 13790[i]. Although accredited dynamic simulation models will also be acceptable in the future to show compliance with EDGE Standard.

A similar approach has been taken by energy efficacy building codes (e.g., COMcheck[ii] in the US, Simplified Building Energy Model (SBEM)[iii] and SAP[vi] in UK) and Energy Performance Certificates (EPCs in EU) to find a quick and cost effective way to benchmark buildings and to quantify carbon emission reductions.

Validating the logic

In order to ensure that the PCE was reasonably accurate, the base case was modeled for 9 locations across the world with differing climates. The logic of the equations was validated by using the following two methods:

- Building Energy Simulation Software (BESS): The base case parameters were fed into the BESS (in this case, eQuest Software was used) and results were taken for each of the 9 locations and then compared with the PCE results.
- Actual Building Data: Actual building energy usage of similar buildings in these 9 locations were also taken and then correlated with the PCE results.

It was found the results largely correlated although there were slight discrepancies, which could later be diagnosed and accounted for.

Improved case

After the creation of a baseline, the model was then subjected to a variety of performance parameters. By changing the performance parameters of the existing base building, the new model started to show improvements in the relevant parameter. As an example, the introduction of an energy-efficient chiller would show an automatic improvement in the energy efficiency. Hence the new model would suggest the amount of energy saved and thereby the savings in operational cost. It would also show the difference in capital investment required and would calculate the simple payback of the particular measure.

Innovative features of the EDGE Tool

The methodology used in developing the tool leads to some innovative features.

Some of the innovative features of EDGE are:

- Adherence to Good / Best Practice for Buildings in Developing Countries: In decades to come, the bulk of new construction (as a portion of the global total) will occur in developing countries. This makes EDGE an important intervention as it encourages practices leading to more resource efficient buildings. Energy-optimized façade design, energy efficient chillers, energy efficient lamps, and water efficient taps and fixtures are some of the examples.
- Compatible with National Building Performance Regulations: Most of the measures for a particular country are compatible with the respective national building performance codes. Care has been taken to ensure that the relevant base cases would reflect the presence of the building codes and therefore the owners are encouraged to design buildings that perform 20% better than those existing building regulations.
- Weighting Indicators to Suit Different Climate Zones: The data from different climate zones has been incorporated into the tool and therefore the building performance mimics that of the real-case scenario.
- Translation of Green Practices into Economic Savings: The calculations and inclusion of capital and operational costs of various green measures address economic and business concerns.
- Inexpensive Software Platform: The tool has been created in MS Excel and thus brings down the level of investment required for software purchase. Professionals across the industry can use it without having to purchase expensive proprietary software.
- Open Source and Transparent Calculation Method: As the tool has been built on MS Excel, it is simple enough to create a transparent calculation method that can easily be peer reviewed, corrected, and updated.
- User-friendly from Broad Usage: This is a tool that requires minimal entry of data. The type of data required is simple and obvious, such as "total built-up area", "number of

rooms in hotel", etc. and therefore can be utilized by people who are not necessarily specialists in the areas of energy efficiency.

- Quick Assessment at a Reasonable Cost: EDGE will be offered at an affordable price for use in developing countries.

How will EDGE aid market transformation

Better Value due to Green Label

As the diagram below shows, the potential of EDGE is to cater to the projects that fall in between – those that can afford to perform above the statutory regulations but do not have access to the more expensive rating systems. EDGE intends to democratize the green buildings market – making it accessible to people across the different sectors of the building industry -- by creating a better value-building labeling system for clients in developing countries.

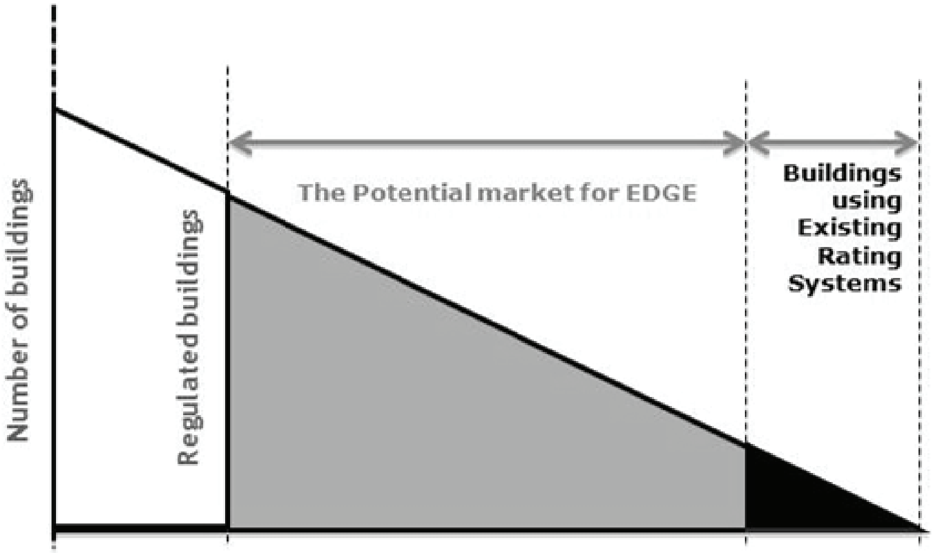

Figure 4. Potential of EDGE tool

Ability for financial institutions to administer green mortgages

A green mortgage is simply a type of mortgage that provides borrowers with A bigger loan than normally permitted or a money-saving discount as an acknowledgement for making energy-efficient improvements or for buying a home that meets particular energy-efficiency standards.

Green mortgages hinge on the principle that a more energy-efficient home means lower utility bills and, as a result, greater net income for the homebuyer over the course of the loan, allowing the purchase of a more expensive house. EDGE will allow a bank to make an assessment of the exact resource savings that the owner will be able to achieve through the employment of certain measures. This assessment provides the financial institutions the ability to gauge their investment in a transparent and objective manner.

a. Improved loan performance (since socially responsible homeowners tend to have better on-time payment records)

b. Better image branding as a provider of "green" products.

Conclusion

EDGE will be rolled out on a pilot basis across projects. The feedback gained will be used to improve and debug the product in preparation for its first launch.

In conclusion, there are a variety of reasons why developing countries would benefit from the wide-scale adoption of Green Building practices. Not only would there be a reduction in buildings-related CO_2 emissions and the depletion of valuable resources, but there would be positive economic benefits from less fossil fuel imports, less infrastructure investments, reduced utility costs, and the birth of a new sustainability industry. Since most buildings in the coming decades will be constructed in developing countries, it is essential that a classification system exists that correlates directly to the unique drivers of these marketplaces.

EDGE matches the exact needs of emerging markets with answers in a way that other prominent classification systems have not: by prioritizing efficiencies and the reduction of GHG emissions, by providing a technical set of solutions at the early design phase, and by basing the calculations on market-specific metrics for the most objective and accurate results. EDGE avoids the pitfalls of other systems by offering an easy-to-use tool built on commonly available software that does not require a lengthy process or expensive consultants for implementation. Instead, EDGE spells out the most effective technical measures to reduce the building owner's utility costs, measuring the short amount of payback time required.

Through the simple requirement of a reduction of energy, water, and materials by 20%, EDGE offers a pass/no pass formula that guarantees Green Buildings will out-perform conventional buildings, no matter where they are located. The performance calculation engine that exists below the surface of EDGE's simple interface was built upon the standards of ASHRAE and the Inventory of Carbon and Energy with the logic validated and models tested in different regions of the world. EDGE will continue to be test piloted repeatedly across various markets to ensure the accuracy of results and will remain open source, allowing other professionals to finesse it over time to ensure the highest level of integrity.

EDGE fills the chasm between regulated buildings in the developing world and buildings in developed countries that can afford expensive rating systems. By lessening environmental impacts while simultaneously providing cost incentives, EDGE provides the financial traction that has long been missing in order to gain momentum from investors, buildings owners, and developers, providing a strong catalyst for the future of Green Buildings in emerging markets.

Endnotes

[i] *ISO 13790 (2008) www.iso.org/iso/catalogue_detail.htm?csnumber=41974*

[ii] *COMcheck product group http://www.energycodes.gov/comcheck/*

[iii] *SBEM – Simplified Building Energy Model www.ncm.bre.co.uk*

[iv] *Standard Assessment Procedure* SAP 2005 http://projects.bre.co.uk/sap2005

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