Virtual Energy for Comfort: To present discomfort and reward passive design in EDGE

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Abstract
EDGE (Excellence in Design for Greater Efficiency) is a green building certification for mass market application in developing countries. To meet the EDGE standard, a building must achieve a 20% reduction in energy and water consumption and embodied energy in materials, compared to a city-specific base case. Over half a million square meters of buildings have been EDGE-certified since October 2014 globally. EDGE has introduced a new concept to the analysis of energy efficiency and thermal comfort: “Virtual Energy for Comfort”, measured in kWh equivalence. In order to calculate a building’s energy efficiency, EDGE takes into account the impact of passive design on the projected use of heating or cooling to maintain thermal comfort, even when a building does not include related heating or cooling systems at present or designed as free-running building. As incomes rise and air conditioning becomes more popular in developing countries it is essential to encourage good design today which will minimize potential air conditioning load or chances of discomfort in the future. Hence the importance of this new concept. This paper presents the methodology of calculating “Virtual Energy for Comfort” and explains the benefits and challenges of putting such a concept into practice.

Keywords: EDGE, Virtual Energy, Thermal Comfort, Passive Design, Green Buildings

1 Introduction to EDGE
EDGE, a green building certification system, is available in more than 100 emerging markets (EDGE, 2015). An innovation of IFC, a member of the World Bank Group, EDGE has been used to certify more than half a million square meters of building floor space since October 2014. EDGE is a simple, smart and affordable certification applicable to residential, retail, hospital, hotel and office buildings across the price spectrum. To date, EDGE aims to certify 20% of new build in seven years in five countries of special initial focus: Costa Rica; India; Indonesia; South Africa; and Vietnam.

Using a free online application (www.edgebuildings.com) incorporating a simulation engine, EDGE empowers the discovery of technical solutions at the early design stage to reduce operational expenses and environmental impact. Based on the user’s basic information inputs and then selection of green measures, EDGE provides projected operational savings and reduced carbon emissions within minutes. This overall picture of the financial and environmental performance of a building helps to articulate a compelling business case for building green.
Figure 1. Examples of EDGE certified projects, with countries where EDGE certification is available marked in green.

The suite of EDGE tools includes building type specific design simulation engines connected to user guides providing both technical explanations and also procedural guidance on certification.

EDGE has been designed and developed by the in-house green building team of the Climate Business Department of the IFC (International Finance Corporation). IFC is the private sector investment arm of the World Bank Group. EDGE was originally designed to assess the IFC’s own investment projects and help clients take the decision to build green. Now EDGE certification is being offered through a global network of certifiers and is being used across the emerging markets in Asia, Africa, Middle East, Eastern Europe, North Africa and Latin America.
1.1 The EDGE Standard
In order to meet the minimum requirements of the EDGE standard, a building project must achieve 20% energy savings, 20% water savings and 20% reduction in embodied energy in materials compared to a city-specific base case. The base case for each city is defined based on local construction techniques, building codes, building use patterns and climate. Thus, EDGE applies a uniform simulation methodology while adjusting the base case to the context of each location.

EDGE focuses on resource efficiency for a streamlined approach that enables market adoption of green buildings at scale because most actions reduce operating costs. The process is simple, with only a handful of measures required to reach the minimum requirements. The result is lower utility costs, extended equipment service life and less pressure on natural resources.

1.2 How are energy savings calculated?
EDGE utilizes building physics calculations to determine the building’s overall energy demand, including requirements for heating, ventilation and air-conditioning, as well as domestic hot water, lighting demands and plug loads. EDGE also estimates water demand and the embodied energy of materials related to non-structural building elements, in order to create a comprehensive analysis of projected resource usage.

Since a building generally uses more than one fuel from different carriers (i.e., gas, diesel, district cooling/heating, electricity, etc.), EDGE creates a link among the sources, converting primary energy into “delivered” energy values. The combined outputs for energy use are relayed as delivered energy (rather than primary energy or carbon dioxide emissions) in order to best communicate efficiency gains to users, who relate more easily to results when expressed as lower utility bills.

Accounting for renewable energy. For the sake of simplicity, renewable energy generated on site (i.e., electricity from solar photovoltaics or hot water from solar collectors) is deducted from the building’s improved case and is expressed as “energy savings” on delivered energy.

Heating, ventilation and air conditioning calculations. EDGE uses a monthly quasi-steady-state calculation method based on the European CEN and ISO 13790 standards to assess annual energy use for the space heating and cooling of a residential or non-residential building. The method was chosen for its ease of data collection, fast response time, reproducibility and cost effectiveness of inputs gathering for the data base.

The energy efficiency calculation process. The first step in assessing the energy efficiency of a design is to establish a project specific base case. A designer enters basic project data (e.g. size, location, building type, expected occupancy level) into the EDGE software, which calculates the project “Base Case” by drawing upon location-specific databases for parameters such as climate, business as usual building practices and local usage patterns. To encourage early-stage planning of green options, the EDGE software provides many default (see the Design page of the EDGE software) options to a designer who has not yet decided on the details of a project. The base case includes “non-regulated” energy usage (such as from catering and appliances) in order to provide a complete picture of projected energy usage and savings.
An “Improved Case” is next created when the user selects technical measures for inclusion in the design. If Improved Case energy consumption is at least 20% less than that of the Base Case a building meets the EDGE standard. In addition to energy consumption savings, the EDGE software also reports water savings, reduction of embedded energy in materials, GHG emission avoidance and operational cost reductions. For non-residential buildings, incremental costs for the selected technical measures and the payback period from utility savings are also presented.

Figure 2 provides an example of how the energy saving in a hotel building is displayed in the EDGE software by presenting the Base Case alongside the Improved Case.

![Image of energy savings comparison]

Figure 3. Showing energy savings in a hotel building amounting to 32.4% over the Base case

**Thermal comfort assumptions.** EDGE uses a fixed thermal comfort set point for heating and cooling systems. The set point is fine-tuned for cities where an in-depth market study has been performed, such as cities in India, South Africa, Costa Rica, Vietnam and Indonesia. Other country data will be added as data become available. The set point drives heating and cooling load calculations for base case and improved case. However when building uses natural ventilation the comfort set point changes to the adoptive thermal comfort conditions, see table 1.

<table>
<thead>
<tr>
<th>Heating and cooling set points for EDGE homes (EDGE 2014)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Temperature</strong></td>
</tr>
<tr>
<td>Heating set point (homes)</td>
</tr>
<tr>
<td>Cooling set point (homes)</td>
</tr>
<tr>
<td>Comfort conditions in natural ventilation mode</td>
</tr>
</tbody>
</table>
For additional information on the EDGE methodology see the report published online: www.edgebuildings.com/updates-and-guides/#methodology.

2 Why is Virtual Energy for Comfort important?
Passive design improves thermal comfort in a building, thus reducing demand for heating or cooling. In many developing countries, however, most occupants do not currently heat or cool, due to economic constraints, as well as climate conditions which border lines comfort conditions such as cold winters nights in Johannesburg South Africa or warm summer days in San Jose Costa Rica. At the same time, as incomes rise, there is a strong tendency to introduce cooling and heating systems. If we recognize and reward passive design features that improve thermal comfort today we diminish the risk of having to install HVAC systems in the future, or we at least ensure that such systems will be smaller and less frequently used. Or in case the heating or cooling system is not installed due to high cost, at least people should not suffer from discomfort indoors. To provide an example, in San Jose Costa Rica, if a house being designed with high level of glazing and small opening sizes, the internal temperature will easily rise above 30°C and natural ventilation will not be enough to remove the internal heat gains and solar gains. This is why Virtual Energy for Comfort is important.

To illustrate how Virtual Energy for Comfort is calculated, consider a building without air conditioning today which uses a passive design feature like window shading to reduce solar thermal gain. The EDGE software calculates how much less energy the building would need if it had a virtual air conditioning system in order to maintain thermal comfort. That amount of energy used in the virtual system is the Virtual Energy for Comfort.

The graph bars in Figure 5 reflect Virtual Energy for Comfort for a project which does not have HVAC systems today but does incorporate passive design to reduce the need to heat or cool the building. It is important to clarify that Virtual Energy for Comfort savings of course have no impact on utility cost savings in the EDGE software.

Until now, green building efforts have centred on reducing energy consumption in designs that already consume large amounts of energy in the first place, and then presenting savings to show projects are green. Given the target of EDGE in all range of income categories, for example in low income housing, in many instances in developing countries today there is no HVAC but we can predict with high levels of probability that HVAC will be installed within the next decade or so if comfort conditions ignored. With the Virtual Energy for Comfort approach one can guide today’s construction without HVAC towards efficiency over the buildings life taking into account the trend toward more cooling (or heating).

The Virtual Energy for Comfort virtual baseline. The heating\(^1\) or cooling system baseline assumed in the EDGE software is in line with ASHRAE 90.1 2007 Appendix G, as the methodology for energy modelling for LEED and BREEAM international, which defines:

“c. Where no heating system exists or no heating system has been specified, the heating system classification shall be assumed to be electric, and the system characteristics shall be identical to the system modelled in the baseline building design.

\(^1\) EDGE uses heating energy source as per city conditions not necessarily electric
d. Where no cooling system exists or no cooling system has been specified, the cooling system shall be identical to the system modelled in the baseline building design.” (ASHRAE, 2007)

The above shows that energy model protocol under ASHARE 90.1 2007 also uses similar concept to Virtual Energy, however savings in ASHARE are reported as energy cost savings and comfort issue is not highlighted as it is in EDGE. Discomfort conditions in ASHRAE 90.1 Appendix G, are counted as unmet hours for system sizing, however in naturally ventilated buildings, system sizing becomes irrelevant.

**An award for thermal comfort.** Despite using the Virtual Energy for Comfort concept in EDGE to assess energy efficiency, the EDGE certification does not set a minimum comfort level as part of its standard. Nevertheless, there is potential to use this concept in the measurement of thermal comfort in general. CIBSE states that less than 1% of operating/occupancy hours should go beyond 28°C for offices and schools and 26°C for Dwellings (CIBSE, 2006). However CIBSE does not lay out criteria regarding the maximum time indoor temperature can be below any specified level. For example how many hours per year indoor temperature can go below 18°C? If a over cooling requirement was clarified by CIBSE in addition to the existing over heating requirement, the overheating and overcooling could be also displayed in number of hours under EDGE results as a next step.

We do propose a similar rule to overheating:

“Less than 1% of annual operating/occupancy hours should go below 18°C for offices, schools and dwellings to prevent overcooling.”

![Figure 4 Comparison of Base Case and Improved Case in a building with HVAC system](image-url)

The bar graph A. shows the setting of one (1) Baseline Building with HVAC compared with (2) Improved Case where passive and active strategies have been used to improve the efficiency of the HVAC system in order to reduce energy consumption (kWh/m²·yr). No Virtual Energy is analyzed in this graph.
3 Results:
As a green building assessment tool the EDGE software illustrates the potential issues with discomfort in buildings and has created the concept of Virtual Energy for Comfort which provides for a way to present potential thermal discomfort. This approach is used to award for design solutions which improves thermal comfort even in a fully free running building. Despite the inclusion of requirements for overheating in CIBSE, overcooling has not been assessed. However, overcooling can be an issue, mainly in the developing world, for example in cities such as Lima, Bogota, and Delhi, where cooler indoor temperatures can occur frequently. This may be a new area for research and design guidance for reduction of discomfort.

EDGE has taken a step toward measurement of potential thermal discomfort and rewarding thermal comfort in free running buildings. Future developments in EDGE can include ways to report the discomfort hours either for overheating (i.e. above 28°C) or overcooling as a percentage of total occupancy hours.

References

Figure 5 Comparison of Base Case and Improved Case in a fully naturally ventilated building
EDGE, 2014, *EDGE Methodology Report*, Washington DC, USA, Online publication by International Finance Corporation,

EDGE, 2015, *EDGE User Guide for Homes*, Washington DC, USA, Online publication by International Finance Corporation,