Excellence In Design
For Greater Efficiencies

EDGE Methodology Report

Version 1.0

International Finance Corporation
WORLD BANK GROUP

EDGE METHODOLOGY REPORT

I. INTRODUCING EDGE

A. About EDGE ("Excellence in Design for Greater Efficiencies")

EDGE is a building design tool, a certification system, and a global green standard for nearly 100 emerging economies. The platform is intended for anyone who is interested in the design of a green building, whether an architect, engineer, developer or building owner.

EDGE empowers the discovery of technical solutions at the early design stage to reduce operational expenses and environmental impact. Based on the user's information inputs and selection of green measures, EDGE reveals projected operational savings and reduced carbon emissions. This overall picture of performance helps to articulate a compelling business case for building green.

The suite of EDGE tools includes homes, hospitals, offices, hotels and retail supported by building-specific user guides.

EDGE is an innovation of IFC, a member of the World Bank Group.

B. A Global Green Standard

To achieve the EDGE standard, a building must demonstrate a 20% reduction in operational energy consumption, water use and embodied energy[1] of materials as compared to typical local practices. EDGE defines a global standard while contextualizing the base case to the occupants and their location.

Only a handful of measures are required for better building performance that results in lower utility costs, extended equipment service life and less pressure on natural resources.

II. EDGE METHODOLOGY

The EDGE Methodology Report states how a base case is established, how demand is calculated and how local climate conditions influence results for those who are inquisitive about underlying assumptions, equations and data sets.

EDGE is based on the following:

1. Climatic conditions of the location
2. Building type and occupant use
3. Design and specifications
4. Building orientation (for select building types)

The above categories are not mutually exclusive, but together generate the energy, water and embodied energy consumption for the building. Even though prescribed data is used in these categories the results of the resource use will become more nuanced as a user's inputs are updated and refined, making the model responsive and dynamic.

Note: The intention of EDGE is to produce consistent and reliable evaluations of resource demand for building certification purposes. While EDGE assists decision-makers by providing financial analysis of their design choices, it does not replace complex modeling software and should not be used for system sizing.

A. Climatic Conditions

The following location-specific information exists within EDGE for nearly 350 large cities in developing countries:

- Monthly average wet and dry bulb temperature
- Monthly average outdoor wind velocity
- Monthly average outdoor humidity
- Solar radiation intensity
- Annual average rainfall
- Carbon dioxide intensity of the electricity grid
- Average cost of energy (by fuel type) and water

Climatic Conditions (cont'd.)

If a city is not included as an option then data from a nearby city can be used. As the localization process is further developed, climatic conditions for more cities will be added.

B. Building Type

EDGE is available for the following building types:

- Homes: for both apartments and houses (assumptions for area and occupancy are based on income categories)
- Hotels: for both hotels and resorts (assumptions for area, occupancy and the type of support services are based on the star rating of the property)
- Offices: assumptions are based on occupancy density and hours of use
- Hospitals: assumptions are based on the type of hospital (i.e., nursing home, private or public hospital, clinic or diagnostic center)
- Retail: assumptions are based on the type of retail building (i.e., department store, mall or supermarket)

Equipment in a building is determined by the building's purpose. Specific equipment and its operational use in a hotel, for example, will differ considerably to that of an office or hospital. The actual usage of equipment itself and in some cases presence of certain equipment is often dependent on the type of building, (i.e., whether a hotel is 3-star or 5-star).

Because it is uncommon for a user to have a complete set of building parameters at the design stage, EDGE conveniently provides default data to initiate the base case in each type of building. For instance, in a hotel, if the user only knows total building area, the number of guest rooms and the number of stories, EDGE suggests dimensions for the key functional spaces in order to help with early design stage decision-making. EDGE provides the user the opportunity to fine tune the assumptions in order to achieve a more precise prediction of results.

C. Design and Specifications

The design parameters (such as size and geometric shape) and the specifications (property of the glazing or cooling equipment, for example) greatly influence the final energy performance of a building. For the base case design and specifications parameters, EDGE relies on information from typical building practices and national building performance codes where they are in existence. For heating, ventilation and air conditioning systems in commercial buildings where standard specifications are commonly used, the base case relies on specifications from either ASHRAE-90.1 2007[1] or stricter national/local standards.

To enhance accuracy in the target market of developing countries, the supporting data in EDGE has been adjusted where necessary. Following are a few issues considered while establishing the properties of the base case:

- Thermal properties of the building envelope: most building owners/developers in developing countries won't readily adopt certain practices that are un-regulated and often add significantly to the capital cost. The base case of a building's thermal properties therefore reflects the most common practice in the specific country. Some of the assumptions for residential buildings, which will be updated based on local market surveys, are as follows[2]:
    - No solar shading devices
    - Un-insulated concrete roof
    - Un-insulated walls with plaster brick masonry
    - Single glazed metal windows
    - Split units for air conditioning (where A/C is used)
    - Conventional boilers for space heating and hot water (where fuel boilers are chosen)
    - Incandescent bulbs and T12 florescent tubes for lighting with no lighting controls
    - Water fittings with high flow rates
    - No reuse or recycling of water
- Window to Wall Ratio (WWR): A study of façades of building typologies across various regions indicates that non-residential buildings have an average WWR ranging from 50-60%, therefore a WWR of 55% was set for the base case for non-residential buildings. A WWR of 30%[3] was set for the base case for residential buildings, which was determined based on IFC's experience with housing clients.

[1] https://www.ashrae.org/resources--publications/bookstore/standard-90-1
[2] The final assumptions may vary in countries where EDGE has been calibrated and contextualized
[3] The final number may vary in countries where EDGE has been calibrated and contextualized

D. Building Orientation

Whether a building can optimize passive heating and cooling is dependent upon its site orientation. For residential projects, the building orientation is assumed as the average of 8 directions (i.e., omnidirectional) for the following reasons:

1. Given that EDGE is focused on simplicity and scalability, an average of all 8 orientations is preferable to requiring the user to calculate the orientation and geometry of each flat/apartment or house which may add cost and time to the certification process.
2. It is impractical for large projects and apartment blocks to orient all units in the direction that is most ideal from the optimization perspective.

Hotels will typically be oriented towards favorable views or to take advantage of street visibility and therefore their more random orientation was also averaged for 8 directions. EDGE incorporates its own calculation model for orientation in non-residential buildings such as offices, retail and hospitals where designers have a greater chance of controlling the building's orientation and reducing excessive solar heat gain.

E. Base Case vs. Improved Case

The base case for a typical building is the starting point for resource reductions within EDGE. Since buildings at the design stage are still on paper, assumptions are used to create the base case. Every project's unique base case is developed using empirical data from actual buildings reflecting current practice around the world. 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 created when the user selects technical measures for inclusion in the design. The difference in consumption between the base case and the improved case defines whether a building meets the EDGE standard. In addition to consumption savings, EDGE also reports GHG and operational cost reductions. For non-residential buildings, incremental costs for the selected technical measures and the payback period are also revealed.

To determine the base case parameters for efficiency in energy, water and materials, EDGE relies on information gleaned from typical building practices as well as national building performance codes, where they are in existence. If there is an energy efficiency code (EEC) in practice in a certain country, such as South Africa, then it is used to support the base case calculation. Typical systems efficiencies for heating, ventilation and air conditioning systems have been based on ASHRAE-90.1 2007[4].

While EDGE has been developed for global use, the intention is to customize the tool at the local level through the support of country-based institutions that provide market studies and data collection. Through their support, further granularity will be brought to the base case parameters and assumptions, and the choice and qualifications of the resource efficiency measures will be fine-tuned. This method will allow EDGE to become increasingly relevant and applicable to local standards and practices.

Note: The measures within EDGE are interlinked to ensure efficiencies are not double-counted. For example, there are two options for window improvements (either low-E coated glass or higher thermal performance glass). If the user selects both, EDGE will only recognize the more advanced option. This is also true for measures that have overlapping impact such as lower glazing value and improvements to window U values that collectively affect the overall savings. EDGE takes into account these interactions.

[4] https://www.ashrae.org/resources--publications/bookstore/standard-90-1

III. CALCULATING END USE DEMAND

EDGE utilizes thermal 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 use and the embodied energy of materials used in constructing the building, in order to create a comprehensive analysis of projected resource usage.

A. Overall Energy Demand in Buildings

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. As EDGE evolves it is possible that primary energy may replace delivered energy calculations.

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".

B. Heating, Ventilation and Air Conditioning Demand

EDGE uses a monthly quasi-steady-state calculation method based on the European CEN[5] and ISO 13790[6] 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, reproducibility (for comparability and in case of legal requirements) and cost effectiveness (of inputs gathering). For additional clarification, refer to Appendix 1: *Types of models for energy performance.*

A similar approach has been taken for energy efficiency building codes ((e.g., COM*check*[7] in the U.S., Simplified Building Energy Model (SBEM)[8] and SAP[9] in the UK, and Energy Performance Certificates (EPCs in the EU)) to find a quick and cost-effective way to benchmark buildings and to quantify energy savings.

The assessment of a building's energy performance comprises the following:

- Space heating
- Space cooling
- Ventilation
- Lighting
- Hot water
- Other (appliances, cooking, fans and pumps)

C. Virtual Energy for Comfort

When there are no plans for HVAC in a building, EDGE assumes that air conditioning or heating will eventually be installed for human comfort. EDGE demonstrates this future required energy for comfort as "virtual" energy, articulating it separately for ease of understanding. While the base case utility costs in the results do not reflect the virtual energy, EDGE determines whether a building is projected to achieve 20% energy efficiency by subtracting the improved case with virtual energy from the base case with virtual energy.

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[5] European Committee for Standardisation (CEN)
[6] ISO 13790:2008 gives calculation methods for the assessment of annual energy use for space heating and cooling of a residential or a non-residential building
[7] http://www.energycodes.gov/comcheck/
[8] www.ncm.bre.co.uk
[9] http://projects.bre.co.uk/sap2005/

D. Energy Demand for Hot Water Requirements

EDGE broadly uses EN 15316-3[10], which has both the specification of hot water requirements for different types of buildings and the energy calculations needed to provide them. The basic calculation for annual hot water demand uses the following parameters:

- Cold water supply temperature (derived from the mean annual temperature of the project's city)
- Hot water delivery temperature (the temperature of the hot water at the delivery point, which is set at 40^0C)
- Daily hot water demand (based on water usage patterns and the number of days used)
- Energy need for hot water (hot water consumption per day x the water usage factor x the number of days/year x the boiler efficiency)
- Fuel energy needed (the fuel's hot water heating energy x (the fuel's consumption in lts/the fuel's calorific value)/the boiler's efficiency)

E. Lighting Energy Demand

EDGE uses the "quick method" under EN 15193's energy requirements for lighting to estimate the annual energy use for lighting a building. The calculations are based on installed lighting power and annualized usage according to building type, occupancy and lighting controls.

F. Water Demand in Buildings

Estimating water demand is relatively simple in comparison to energy. EDGE measures fresh water use in order to determine overall water output. For the sake of simplicity, recycled water or rainwater harvested on site is deducted from the building's improved case and is rendered as water "savings".

Although there are no international standards to calculate water use in buildings, the EDGE methodology is similar to that of many other calculators used around the world (such as the UK government's "The Water Efficiency Calculator for New Dwellings[11]").

EDGE estimates annual water use through the following:

- Number of water fixtures (showers, taps, toilets, etc.)
- Water usage loads (occupancy, usage rates and the rate of water flow through the fixtures)

EDGE does not calculate water use for such external activities as heat rejection or car washing.

G. Estimating Rainwater Harvesting or Recycled Water Onsite

- Rainwater Harvesting: EDGE requires that the collected rainwater be used indoors (such as for toilet flushing, hand washing, etc.) as this has a direct impact on water use reduction. EDGE calculates the maximum quantity of water that can be collected by a rainwater harvesting system using rainfall data from the project location and the size of the roof area from the design sheet. The following basic calculation is used: Total annual rain water: Area of Catchment (i.e., roof area-m^2) x Amount of Potential or Volume of Rainfall (mm) x Filter Coefficient (assuming 20% losses) x Run-off Coefficient
- Recycled Grey Water: EDGE calculates the potential supply and reduces the demand for flushing toilets by that amount. EDGE assumes that all wastewater from kitchens and bathrooms is collected and stored in sufficient quantities to meet the demand for flushing toilets. If the quantity of wastewater is insufficient, then EDGE simply deducts the wastewater available from the total demand.
- Recycled Black Water (effluent treatment): EDGE calculates the potential supply and reduces the demand for flushing toilets by that amount. EDGE assumes that most of the wastewater (80%) from flushing toilets is collected, treated and stored in sufficient quantities to meet the demand for future flushing.

[10] http://iristor.vub.ac.be/patio/arch/pub/fdescamp/bruface/products/dhws/15316-3-1-Need.pdf
[11] https://www.gov.uk/government/publications/the-water-efficiency-calculator-for-new-dwellings

H. Embodied Energy of Building Materials

EDGE incorporates available embodied energy data of construction materials from around the world. The major point of reference for the data, which is also referred to as Materials Life Cycle Analysis, is the Inventory of Carbon and Energy (ICE) developed by the University of Bath. This data is available in the public domain (Geoff, 2010).

Embodied Energy is calculated using the following basic equation:

Embodied Energy per Unit Area (MJ/m^2) = Thickness (m) x Density (kg/m^3) x Embodied Energy (MJ/kg)

IV. VALIDATING THE LOGIC

To ensure that EDGE energy results are consistent and reliable, the calculation methodology was validated by using dynamic simulation software (eQuest[12] was used) and the results for each of the nine locations were compared to EDGE results.

Additionally, initial reviews of EDGE for Homes have been conducted by third-party consultants in the Philippines and Mexico to validate the tool for local markets:

- In the Philippines, third party consultants (WSP Group[13]) conducted a study to compare results between EDGE and IES[14] dynamic simulation software. The test concluded a variation of 5%.
- In Mexico, Lean House Consulting was commissioned to compare results between EDGE and two dynamic simulation softwares, DOE[15] and Design Builder[16] for four locations: Cancun, Guadalajara, Hermosillo and Mexicali. The test concluded a variation of 7-8%.

As a rule of thumb, given the simplicity of the EDGE model relative to dynamic simulation software, a less than 10% variance between them was deemed acceptable.

V. ENVISIONING THE FUTURE

EDGE is intended to meet the demand for a simple, quick and affordable tool that can be used to plan and assess the design of resource efficiency in order to scale up green building growth in emerging markets. The complexity of the underlying methodology lies beneath the application's interface so that industry professionals can easily determine resource efficiency and associated cost savings without the necessity of hiring expensive energy specialists or purchasing additional modeling software.

EDGE will constantly evolve as data becomes available, standards become more demanding and additional markets begin implementation of the product. To ensure EDGE continues to improve, we welcome and rely on insights from building professionals around the world. For ideas on how we can enhance the product, clarify the methodology and reach mass markets, email IFC at edge@ifc.org.

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[12] www.doe2.com/equest/
[13] www.wspgroup.com
[14] Software - Integrated Environmental Solutions www.iesve.com/software
[15] www.doe2.com
[16] www.designbuilder.co.uk

Appendix 1: *Types of models for energy performance*

Model types	**Calculations**	**Advantages**	**Disadvantages**
Empirical model	Rules of thumb, incorporates tables of benchmarks, uses historical data from a large sample of existing buildings and generates an energy consumption baseline	• Useful reference at the concept stage • Mainly used for benchmarking existing buildings and stock data[17]	• Low levels of accuracy • Cannot be used to evaluate new designs or efficiency improvements • Requires actual building performance data for a large set of existing buildings which is typically not available in most markets
Steady-state model	Steady-state heat loss method; simple methods generally average variables over a diurnal or annual basis; mainly uses accumulated temperature differences or 'degree days' or simplified monthly heat balance calculations	• Requires less time • Relatively little input information required • Easy to use by a standard building professional • Typically used for building regulations (e.g. UK/Netherlands) • Adequate for expressing simple energy calculations (heating and cooling demands[18])	• Does not take account of the dynamics of building response • Not suitable for detailed analysis of complex building forms
Dynamic simulation model	Dynamic thermal based on hour-by-hour (or higher resolution) outputs, detailed comfort analysis	• Higher level of precision • Useful for detail design and modeling internal temperature conditions • Takes into account thermal mass	• Low levels of transparency (i.e. the ability to analyze the calculation process and verify inputs) • Poor data quality may introduce greater uncertainty than is associated with the modeling itself[19] • Not scalable for mass use (such as building regulations, energy performance certificates) • Data intensive and time consuming[20] • Requires the technical expertise of skilled building simulation analysts

The Case for Using a Steady State Model

Dynamic simulation, although credible in terms of results, is difficult to use by the average building professional and lacks transparency in terms of auditing the calculation process[18]. The simplified steady state model, on the other hand, proved easier to use and while the generated results lacked complete credibility, in most cases the results were repeatable and transparent. Absolute precision is not the most important consideration in a mass market tool, especially if it compromises the other attributes such as scalability. The important outcomes are the actions that result. For new buildings these are the design decisions that governments, investors, developers and building owners are encouraged to consider.

[17] Steadman, Bruhns et al. 2000, "An Introduction to the National Non-Domestic Building Stock Database." Environment and planning B: Planning and design 27: 3-10
[18] Mervin D.D., 2008, Investigation of Dynamic and Steady State Calculation Methodologies for Determination of Building Energy Performance in the Context of the EPBD, Dublin Institute of Technology, Ireland
[19] Poel, B. et al 2006, Tool for the Assessment of the Energy Performance of Non-Residential Buildings in the European Countries, Improving Energy Efficiency in Commercial Buildings (IEECB"06) Frankfurt, 26-27 April 2006
[20] Roger Hitch, 2007, HVAC System Efficiencies for EPBD Calculations, BRE Environmental, Watford, UK
http://www.rehva.eu/projects/clima2007/SPs/C04A1002.pdf