Excellence In Design For Greater Efficiencies

EDGE Methodology Report

Version 2.0

IFC International Finance Corporation
WORLD BANK GROUP
Creating Markets, Creating Opportunities

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I. INTRODUCING EDGE

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

EDGE is a green buildings platform that includes a green building standard, a software application, and a certification program for more than 150 countries. 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 projects 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 building types includes homes, hospitals, offices, hotels, retail and education buildings. The building typologies are supported by 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] in 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 outlines the basis for the underlying assumptions, equations and data sets used in EDGE. It explains how a base case is established, how demand is calculated and how local climate conditions influence results.

EDGE calculations are based on the following:

1. Climatic conditions of the location
2. Building type and occupant use
3. Design and specifications

The above categories are not mutually exclusive. Rather, they interact to generate the projected energy and water consumption of the building as well as the embodied energy of the construction materials. Even though prescriptive data is used in these categories by default, the outputs of EDGE become more nuanced as user inputs are updated and refined, making the model responsive and dynamic.

Note: The purpose of EDGE is to produce consistent and reliable evaluations of resource demand for building certification purposes. While EDGE assists the design process, it is first and foremost a model for directional financial comparisons. It should not be used for making decisions that require a finer level of detail. If the performance of a feature is critical to the project, it is prudent to use an appropriate modelling tool. For example, EDGE should not be used for system sizing, or precise payback calculations for financial decision-making.

A. Climatic Conditions

The following location-specific information exists within EDGE for all cities built into the EDGE software:

- 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

[1] Embodied energy is the energy required to extract and manufacture the materials required to construct and maintain the building.

Climatic Conditions (cont'd.)

If a city is not included as an option, then a city that is nearby or similar in weather can be used as the location. In such a case, the monthly average outdoor temperature, latitude and average annual rainfall data should be updated under the key assumptions for the base case to match the city where the project is located. Climatic conditions for more cities are continuously being added.

B. Building Type and Occupant Use

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 (e.g., nursing home, private or public hospital, clinic or diagnostic center)
- Retail: assumptions are based on the type of retail building (e.g., department store, mall, supermarket, light industry or warehouse)
- Education: assumptions are based on the type of educational facility (e.g., pre-school, university or sports facility), as well as occupancy density and hours of use.

Equipment in a building is determined by the building's purpose. Specific equipment and its schedule of operation in a hotel, for example, will differ from that of an office or hospital, or between hotels if 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 provides default data to initiate the base case in each type of building. For instance, in a hotel, if the user only knows the total building area, the number of guest rooms and the number of stories, EDGE suggests dimensions for the key functional spaces to help with early design stage decision-making. EDGE provides the user the opportunity to fine-tune the assumptions to achieve a more precise prediction of results.

C. Design and Specifications

Base Case vs. Improved Case:

The base case for a typical building is the starting point for resource reductions within EDGE. Assumptions are used to create the base case for buildings at the design stage. Every project's unique base case is developed using empirical data from actual buildings reflecting current practices around the world. The base case includes the "non-regulated" energy usage of the building (such as from catering and appliances) to provide a complete picture of projected energy usage and savings.

The improved case shows savings 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. Incremental costs for the selected technical measures and the payback period are also projected.

Baseline Assumptions:

While EDGE has been developed for global use, the software has been customized at the local level through the support of country-based institutions that provided market studies and data collection. Through their support, further granularity has been brought to the base case parameters and assumptions, and the choice and qualifications of the resource efficiency measures has been fine-tuned. These assumptions are updated as the market evolves. This method allows EDGE to become increasingly relevant and applicable to local standards and practices.

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/local building performance codes, where they are in existence and being enforced. If there is an energy efficiency code (EEC) in practice in a certain country, such as in South Africa, then it is used to generate the base case calculation. Typical systems efficiencies for heating, ventilation and air conditioning systems are based on ASHRAE-90.1 2007[2]. Baseline assumptions have been adjusted where necessary to improve the match to local conditions.

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

Following are a few issues that were considered while establishing the properties of the base case:

- Thermal properties of the building envelope: Most building owners/developers do not readily adopt certain practices that are un-regulated and add to the capital cost. The EDGE base case of a building's thermal properties therefore reflects the typical practice in the specific country. Some of the global assumptions for residential buildings, which are updated based on local market surveys, are as follows[3]:
  - No solar shading devices
  - Un-insulated concrete roof
  - Un-insulated walls with plastered brick masonry
  - Single-glazed metal windows

  Other residential characteristics include:
  - Room air conditioning (where A/C is used)
  - Conventional boilers for space heating and hot water (where fuel boilers are chosen)
  - A mix of incandescent bulbs, CFL, LED 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 as the baseline for non-residential buildings. A WWR of 30% was set as the baseline for residential buildings, based on IFC's experience with housing clients.

- Building Orientation: For residential projects, the building orientation is assumed as the average of eight directions (i.e., omnidirectional) for the following reasons:

  1. Requiring the user to calculate the orientation and geometry of each flat/apartment or house in a development would add cost and time to the certification process.
  2. It is impractical for large projects and apartment blocks to optimize the orientation of all units in the ideal direction.

EDGE accounts for orientation in non-residential buildings such as offices, retail, hospitals and education where designers have a greater chance of controlling the building's orientation and reducing excessive solar heat gain. The only exception is hotels which are typically oriented towards favorable views or to take advantage of street visibility, and therefore their orientation is also averaged over eight directions.

Note: The measures within EDGE are integrated 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 only recognizes the more advanced option. This is also true for measures that have overlapping impact such as lower WWR value and improvements to window U-values that collectively affect the overall savings. EDGE takes these interactions into account.

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 in materials used in constructing the building, 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 (e.g. electricity, natural gas, diesel, or district cooling/heating), EDGE converts primary energy into "delivered" energy values to provide a common metric. The combined outputs for energy use are relayed as delivered energy (rather than primary energy or carbon dioxide emissions) 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 projections may also be provided.

Renewable energy generated on site (e.g. 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

[3] The final assumptions may vary in countries where EDGE has been calibrated and contextualized

EDGE uses a **monthly quasi-steady-state calculation method** based on the European CEN[4] and ISO 13790[5] 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*[6] in the U.S., Simplified Building Energy Model (SBEM)[7] and SAP[8] 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 is comprised of the following main categories:

- Space heating
- Space cooling
- Fans
- Pumps
- Lighting
- Other (appliances)
- Hot water
- Cooking

C. Virtual Energy for Comfort

When there are no plans to install a heating or an air-conditioning system in a building, EDGE calculates the energy that is required to ensure thermal comfort, with the assumption that eventually HVAC systems, fans or heaters will be installed. EDGE demonstrates this future required energy for comfort as "virtual" energy, articulating it separately for ease of understanding. While the utility costs in the results do not reflect 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.

D. Energy Demand for Hot Water Requirements

EDGE algorithms are based on EN 15316-3[9], which has both the specifications 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 location)
- 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 L/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 estimates fresh water use to determine overall water consumption. Recycled water or rainwater harvested on site is deducted from the building's improved case and is rendered as water "savings".

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[4] European Committee for Standardisation (CEN)
[5] 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
[6] http://www.energycodes.gov/comcheck/
[7] www.ncm.bre.co.uk
[8] http://projects.bre.co.uk/sap2005/
[9] http://iristor.vub.ac.be/patio/arch/pub/fdescamp/bruface/products/dhws/15316-3-1-Need.pdf

Although there are no international standards to calculate water use in buildings, the EDGE methodology is similar to many other calculators used around the world (such as the UK government's "The Water Efficiency Calculator for New Dwellings[10]").

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 car washing.

G. Estimating Rainwater Harvesting or Recycled Water Onsite

- Rainwater Harvesting: 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 inputs. 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 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 to meet the demand for future flushing or other outdoor uses.

H. Embodied Energy in Building Materials

EDGE incorporates available embodied energy data of global construction materials.

The main source is a custom study conducted by the UK-based firm thinkstep for EDGE called the "EDGE Materials Embodied Energy Methodology & Results" report that is also available on the EDGE website. The environmental impacts of materials vary according to where and how they are manufactured and used. Due to the global scope of EDGE, incorporating accurate impact data for materials in all locations is not yet possible. Instead, a targeted and phased approach is adopted that initially provides a single global Emerging Economies Construction Dataset (the "EDGE Dataset") for embodied energy of construction materials based on a life cycle assessment (LCA) model. Future phases will provide datasets for specific countries for use in national implementations of EDGE, which may consider other impact categories such as climate change.

Another source of reference for the data is the Inventory of Carbon and Energy (ICE) developed by the University of Bath. This data is available in the public domain.

Embodied Energy is calculated using the following 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[11]) for buildings in nine locations 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 software for local markets:

- In the Philippines, third-party consultants (WSP Group[12]) conducted a study to compare results between EDGE and IES[13] dynamic simulation software. The test concluded a variation of 5%.

[10] https://www.gov.uk/government/publications/the-water-efficiency-calculator-for-new-dwellings
[11] www.doe2.com/equest/
[12] www.wspgroup.com
[13] Software - Integrated Environmental Solutions www.iesve.com/software

- In Mexico, Lean House Consulting was commissioned to compare results between EDGE and two dynamic simulation softwares, DOE[14] and Design Builder[15] for four locations: Cancun, Guadalajara, Hermosillo and Mexicali. The test concluded a variation of 7-8%.

A less than 10% variance was deemed acceptable.

V. ENVISIONING THE FUTURE

EDGE is intended to meet the demand for a quick, easy and affordable online application that can be used to plan and assess the design of resource efficiency to scale up green building growth. 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 energy specialists or purchasing additional modeling software.

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

[14] www.doe2.com
[15] 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[16]	• 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[17])	• 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 thermal mass into account	• 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[18] • Not scalable for mass use (such as building regulations, energy performance certificates) • Data intensive and time consuming[19] • 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 a very high degree of accuracy, in most cases the results were repeatable and transparent. Absolute precision is not the most important consideration in a mass market application, 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.

[16] 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
[17] 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
[18] 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
[19] Roger Hitch, 2007, HVAC System Efficiencies for EPBD Calculations, BRE Environmental, Watford, UK http://www.rehva.eu/projects/clima2007/SPs/C04A1002.pdf