

EDGE Cost Model

Version 1.0 (March 2015)

An outline methodology

Revision 1.0 (7th April 2015)

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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 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 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 energy¹ 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. MEETING CONSTRUCTION COST CHALLENGES

Facility developers and owners are faced with a number of challenges, during the design and development stages of building projects. These challenges include optimizing facility performance against user requirements, as well as return on investment and/or ‘value-for-money’. Such optimization requires access to indicative costs of alternative design options at the early design stage.

In many cases, the performance and cost impacts of design options are complex and inter-related across a number of building components and systems. For example, a change in window:wall ratio might affect costs of external walling and windows, as well as the size of internal heating and cooling systems, interior lighting and natural ventilation. The initial construction cost and operational cost impacts of green building opportunities need to be considered holistically between the base case and improved case. The EDGE Cost Database is intended to assist in calculating the capital cost impacts of design decisions. Using this cost information, the EDGE software provides comparative capital and utility cost impacts of these decisions.

A. Complexities of international cost comparisons

One of the challenges faced by the construction industry, globally, is the need to understand construction costs within the context of specific national economies. The factors influencing construction costs include, but are not limited to:

- Availability and cost of raw materials or components;
- Source/s of raw materials or components – import duties, local taxation, etc.;
- Transportation and handling of materials;
- Skills requirements and availability for the installation of components and systems;
- Prevailing practices relating to the construction of building components and elements;
- Availability, cost, and levels of utilization of construction plant (mechanization);
- Prevailing levels of component quality and workmanship;
- Prevailing levels of workplace and supply-chain productivity;
- Materials wastage, recovery, and re-use / recycling;
- Underlying regulation, monitoring, and supervision;
- Prevailing environmental conditions.

Considering the factors listed above, the local cost of an identical building element (e.g.: a brick cavity wall) could be entirely different in two national contexts.

The introduction of green building measures into the design of a building may require access to approximate cost estimates of components / systems which are not in regular use within the target country. The EDGE Cost Database incorporates an international cost conversion tool, for the purpose of providing indicative building component and system construction costs. This conversion tool is described in detail within the next section.

B. Relationship of Component / System Cost to Performance

Some green building measures imply a change to component / system specification, such as system size, performance rating, thickness, or material content. Revised component / system costs therefore need to be estimated to provide the developer with the indicative cost-benefit of these measures. In order to provide illustrative changes in capital cost resulting from the selection of improved efficiency of building systems, or improvements in component specifications, a mathematical relationship between cost and performance has been developed for most components and building systems used within the EDGE software.

III. INTERNATIONAL COST CONVERSION TOOL

A. Background research

International construction costs for selected countries are published regularly by a number of cost consultancies and industry bodies. These publications generally offer a variety of selected elemental and/or 'per square meter' construction costs, in selected countries, for a selection of building types. In general, the costs provided are for the construction of the whole facility, and are not dis-aggregated to elemental or component level.

The dis-aggregation of these 'whole facility' costs would be entirely dependent on the nature of the construction contract, time taken to construct, construction methods employed, materials selection and quality, labor intensity on site, technology content and manufacturing source of this technology, plus many other potential influencing factors.

Economist Eric A. Best refers to these, as well as other major challenges in developing international construction cost conversions, in his numerous papers on this topic¹. Best proposes a conversion model based upon the comparative costing of a basket of construction related goods and labor (Basket of Locally Obtained Commodities, or BLOC), in a similar manner to the calculation of Purchasing Power Parity², published by Eurostat and the Organization for Economic Co-operation and Development (OECD).

Another well-known and often referenced international cost comparator is the Big Mac Index, maintained and published by The Economist. As discussed by Best and many others, the Big Mac index is based on an extremely limited basket of goods, and is therefore not a robust indicator to defend the supporting theory of Purchasing Power Parity, the Law of One Price (particularly for the entirely unrelated construction industry).

Since the development by Best of his BLOC Model, the World Bank Group has continued to develop Best's approach, using a refined basket of goods and services, through its International Comparison Program (ICP) in 2005. The ICP regularly publishes cost comparator indices for a broad selection of industries, including Construction, on a six-year cycle.

The basket of goods and services approach was abandoned after the ICP's 2005 round of publications, due to the complexity and cost of data collection, analysis, and interpretation. A revised approach, adopted for the 2011 round of publications, generally uses input costs of labor, material, and equipment hire, in a weighted mix, to describe comparative international construction costs. Certain countries are still assessed using a basket of goods, with their results being normalized using Russia as a pivotal point (Russia is assessed using input costs, as well as a basket of goods and services).

The subject of comparative international cost modelling remains complex, and as yet not entirely conquered. Following a literature review and consideration of the complexities and challenges remaining unresolved, the ability to apply normalized³ ICP 2011 Construction PPP (CPPP) Indices was incorporated within the EDGE cost model.

¹ Best, Eric A, 2008, The Development and Testing of a Purchasing Power Parity Method for comparing Construction Costs Internationally, University of Technology, Sydney.

² Purchasing power parity conversion factor is the number of units of a country's currency required to buy the same amounts of goods and services in the domestic market as the U.S. dollar would buy in the United States.
<http://data.worldbank.org/indicator/PA.NUS.PPP>

³ CPPP indices are normalised to a target date, within the context of the target country, as described in section IIIB of this document.

B. Cost conversion methodology

The process of cost conversion from source country cost, at source date, to target country cost, at target date, consists of a number of consecutive steps. These steps are described below:

Step 1: Fetch and adjust the ICP CPPP 2011 index to target date

This process step adjusts the ICP CPPP 2011 index to an equivalent index at target date. This process is carried out for both source country and target country.

Note: ICP CPPP 2011 indices are available for a number of industry areas. The EDGE Cost Database Tool uses the ICP CPPP 2011 "Construction" indices for general construction cost adjustments, and uses the "Plant and Equipment" indices for mechanical and electrical components and systems, where deemed appropriate.

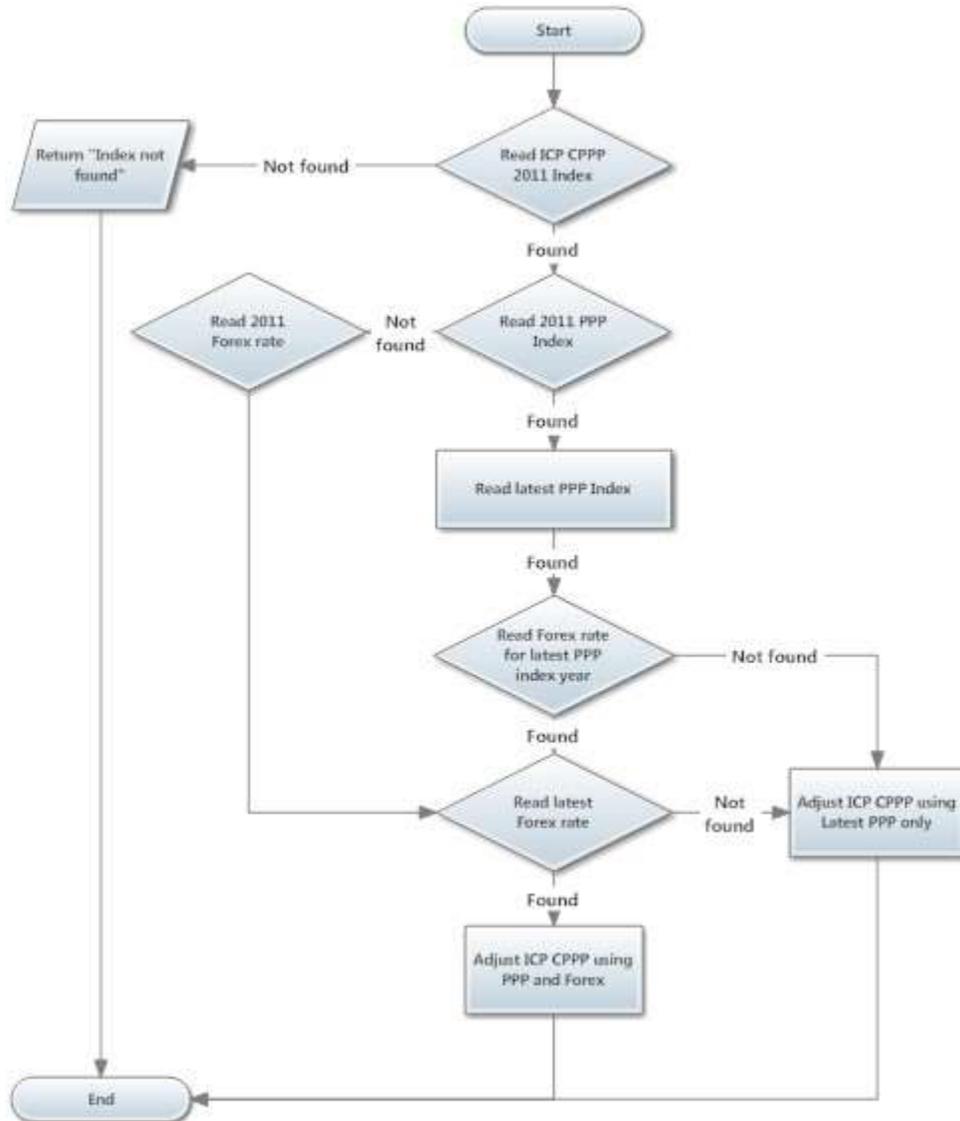


Figure 1- Re-basing the ICP CPPP 2011 Index to target date

The indices used within these calculations are obtained from various publicly accessible web-based sources:

- ICP CPPP 2011 Indices from the World Bank Group ICP (2011) Data (Table D3): US\$=1⁴;
- PPP Indices from the World Bank Group WDI databank: Table PA.NUS.PPP: PPP conversion factor, GDP (LCU per international \$)⁵;
- Forex rates from the World Bank Group WDI databank: Table PA.NUS.FCRF: Official exchange rate (LCU per US\$, period average)⁶. For countries within the Euro Monetary Union, Euro rates are applied.

Step 2: Fetch and adjust the source cost to target date (in source country)

This process step takes the cost (reflected in source country currency) and adjusts this cost to target date (reflected in source country currency), using source country CPI (or similar) cost indexation.

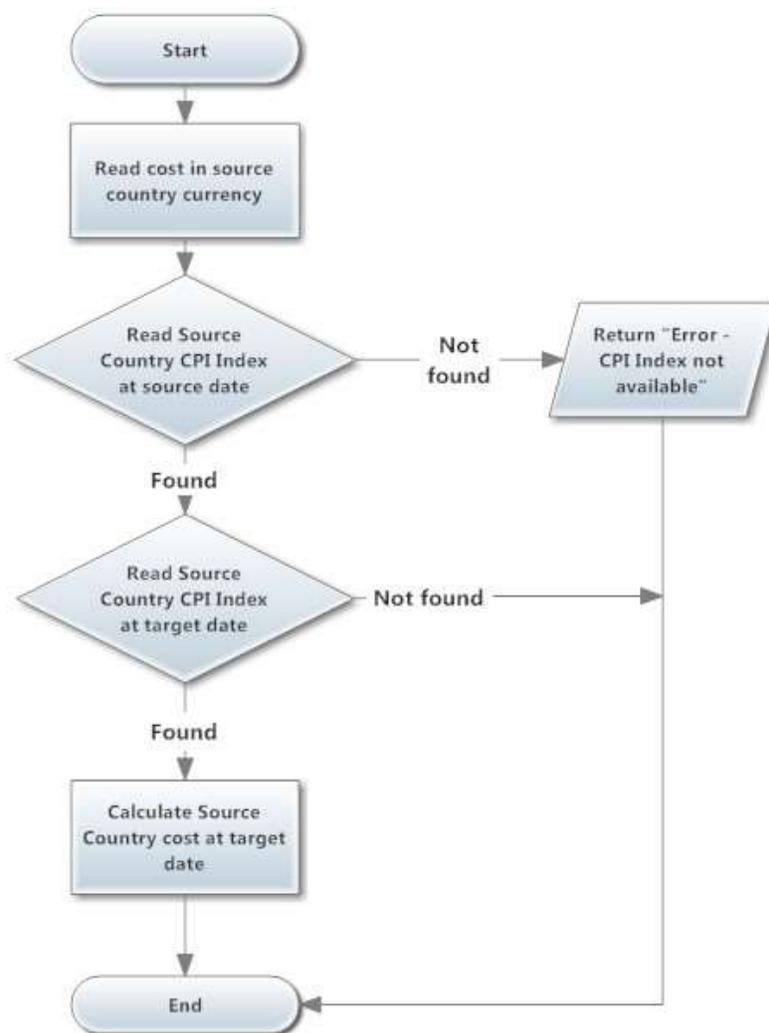


Figure 2 – Re-basing Source Country cost to target date

The CPI Indices rates used in these calculations are obtained from the World Bank Group WDI databank: Table FP.CPI.TOTL: Consumer price index (2010 = 100)⁷.

⁴ <http://siteresources.worldbank.org/ICPINT/Resources/270056-1183395201801/2011-International-Comparison-Program-results.xlsx>

⁵ <http://api.worldbank.org/countries/all/indicators/PA.NUS.PPP?format=xml>

⁶ <http://api.worldbank.org/countries/all/indicators/PA.NUS.FCRF?format=xml>

⁷ <http://api.worldbank.org/countries/all/indicators/FP.CPI.TOTL?format=xml>

Step 3: Cost adjustment to target country

This process step takes the cost (reflected in source country currency at source date) and adjusts this cost to target country currency at target date.

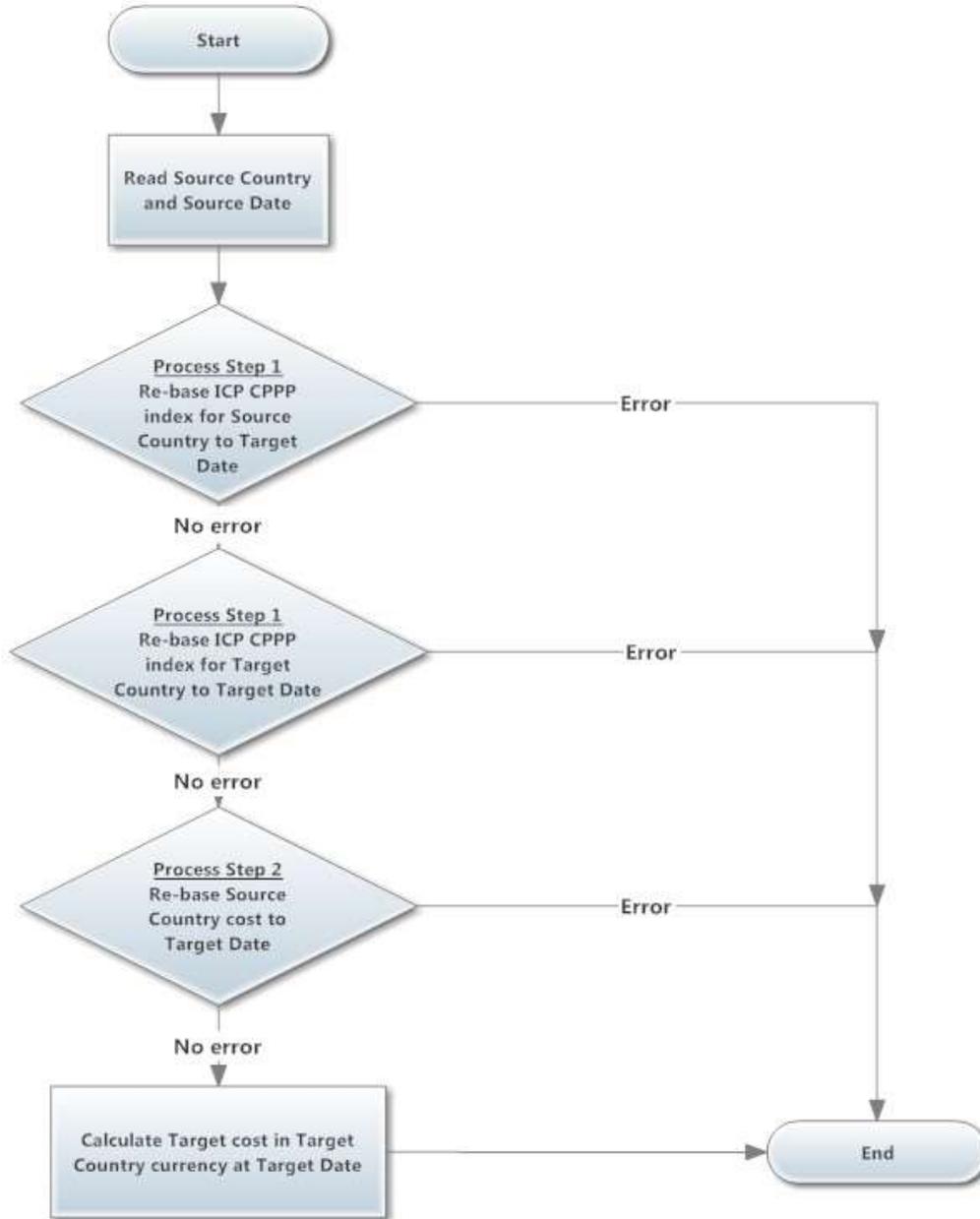


Figure 3 - Calculation of Target Cost at Target Date

The resultant estimated component or system cost is in the target country currency at target date. The cost database is used to calculate a full set of EDGE component and system costs in US dollars in the current year.

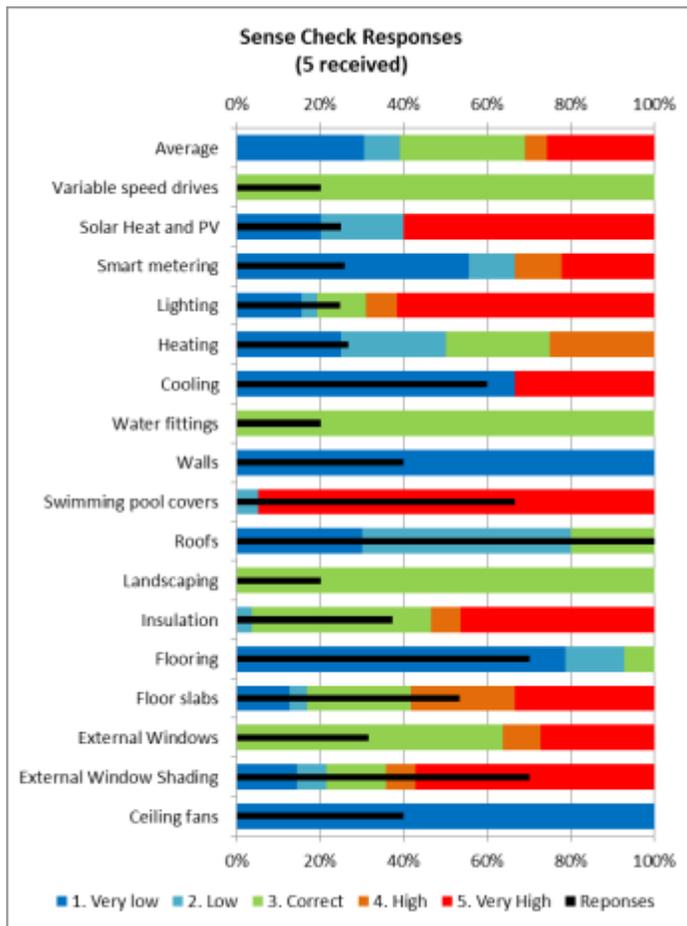
C. Validation of international cost conversion process

A selection of building component and system costs were prepared and distributed to EDGE representatives in the following countries, for the purpose of 'sense-checking' against known or estimated in-country costs:

- Colombia
- Peru
- Cost Rica
- Viet Nam
- Brazil

The chart below provides an overview of the returns received from these countries, per component / system group:

The average band along the top of this chart illustrates a central tendency of cost data across all components and systems.



Certain estimated component and system costs show a low or high tendency – mostly attributable to the size of the sample dataset within the Cost Database, or regional / national variations in component or system specification.

In certain cases, source cost data currently held within the Cost Database has been sourced from developed countries, due to lack of available reference costs from the target developing countries. As the penetration of EDGE software into the marketplace increases, further cost data will be accumulated from target countries, allowing further refinement of these cost estimates.

Working with regional / national EDGE and project team members will also assist in developing a deeper understanding of cost implications of localized variations in component and system specifications, interpretation of cost inclusions, etc.

The volumes of in-country cost data received from participating countries were as follows:

- Colombia 20%
- Peru 14%
- Costa Rica 43%
- Viet Nam 49%
- Brazil 68%

In a number of cases, components/ systems listed for pricing were not commonly encountered in the region.

Where specific country costs indicate consistently high or low tendency, cost adjustments may be applied to the international cost conversion process for that country, component or system, using the rate adjustment table described in section IV(C) below.

IV. COST – PERFORMANCE RELATIONSHIPS

A. Component and system cost analysis

The Cost Database contains cost data specific to selected EDGE building components and systems, collated from various sources. A schedule of components and building systems included in the Cost Database may be found in Appendix A of this document.

Tabulated costs include labor, materials, and plant required for the construction or installation of the component or system. Costs also include import duties, local taxes payable by the contractor / installer for those materials, wastage allowances, and system commissioning. Costs specifically exclude site and contractor overheads, profit, risk allowances, and design fees.

In general these costs are tabulated, including a short description of the item and source of data, source (base) country and source (base) year, target country, and target year. The figure below illustrates such a table:

Glazing

Construction	Source	Glazing	Coating	U-Value	SHGC	Glazing Type	Base Country	Base Year	Base Cost	Target Country	Target Year	Target Cost /m ²
DOUBLE PANE - CLEAR - 6mm Temp Clear Glass IFC - previous data collection project		Double	Light	3.24	0.76	Double	Philippines	2012	5,784.70	United States	2014	616.12
DOUBLE PANE - LOW E - 6mm Temp Low E glass IFC - previous data collection project		Double	Mid	2.61	0.42	Double	Philippines	2012	6,361.10	United States	2014	677.51
DOUBLE PANE - REFLECTIVE - 6mm reflective ter IFC - previous data collection project		Double	Dark	3.24	0.42	Double	Philippines	2012	6,069.40	United States	2014	646.44
DOUBLE PANE - CLEAR - 6mm Temp Clear Glass IFC - previous data collection project		Double	Light	3.24	0.76	Double	Philippines	2012	2,659.70	United States	2014	283.28
DOUBLE PANE - LOW E - 6mm Temp Low E glass IFC - previous data collection project		Double	Mid	2.61	0.42	Double	Philippines	2012	3,423.50	United States	2014	364.63
DOUBLE PANE - REFLECTIVE - 6mm reflective ter IFC - previous data collection project		Double	Dark	3.24	0.42	Double	Philippines	2012	3,041.60	United States	2014	323.95
SINGLE PANE - CLEAR - 6mm Tempered, Aluminu IFC - previous data collection project		Single	Light	6.30	0.86	Single	Philippines	2012	617.40	United States	2014	65.76
SINGLE PANE - LOW E - 6mm Tempered, Aluminu IFC - previous data collection project		Single	Mid	3.18	0.78	Single	Philippines	2012	4,166.60	United States	2014	443.78
SINGLE PANE - REFLECTIVE-6mm Tempered, Alur IFC - previous data collection project		Single	Dark	6.13	0.50	Single	Philippines	2012	4,125.00	United States	2014	439.34
SINGLE PANE - TINTED - 6mm Tempered, Aluminu IFC - previous data collection project		Single	Mid	6.30	0.72	Single	Philippines	2012	720.00	United States	2014	76.69
SINGLE PANE - CLEAR - 6mm Tempered, Aluminu IFC - previous data collection project		Single	Light	6.30	0.86	Single	Philippines	2012	473.00	United States	2014	50.38
SINGLE PANE - LOW E - 6mm Tempered, Aluminu IFC - previous data collection project		Single	Mid	3.18	0.78	Single	Philippines	2012	1,791.60	United States	2014	190.82
SINGLE PANE - REFLECTIVE-6mm Tempered, Alur IFC - previous data collection project		Single	Dark	6.13	0.50	Single	Philippines	2012	1,736.10	United States	2014	184.91
SINGLE PANE - TINTED - 6mm Tempered, Aluminu IFC - previous data collection project		Single	Mid	6.30	0.72	Single	Philippines	2012	560.00	United States	2014	59.64
SHGC, Single Glazed - Clear Ref. FL6 6mm IFC - previous data collection project		Single	Light				Viet Nam	2012	496,000.00	United States	2014	122.09
SHGC, single Glazed AGC 6mm - Classic dark IFC - previous data collection project		Single	Dark				Viet Nam	2012	583,000.00	United States	2014	143.50
SHGC, Single Glazed - CLR FL6 6mm IFC - previous data collection project		Single	Light				Viet Nam	2012	895,000.00	United States	2014	220.30

Once building component and system costs have been converted to target costs (the default is USD), these costs are analyzed to provide single indicative component / system costs using linear regression capability of Excel® where appropriate, or median / average cost of the group where linear regression yields results of low reliability.

The EDGE Cost Database reduces listed component and system costs into a fixed and variable cost per performance unit. For example, insulation costs are reduced to a fixed (intercept) value and a variable (co-efficient) which is multiplied by the R-value of insulation required.

Group	Description	Unit of Measure	Cost / Performance factors		
			Intercept	Measure	Coefficient
<u>Insulation</u>					
Insulation	Polystyrene	Cost / m ² of insulation	3.90	R-Value	0.22
Insulation	Mineral Wool	Cost / m ² of insulation	4.40	R-Value	0.04
Insulation	Glass Wool	Cost / m ² of insulation	3.10	R-Value	0.03
Insulation	Polyurethane	Cost / m ² of insulation	1.81	R-Value	0.07

$$\text{Cost / m}^2 \text{ of insulation} = \text{Intercept Value} + [\text{Coefficient Value} \times \text{R-Value}]$$

In some cases – particularly in mechanical and electrical installation components – the EDGE Cost Database sub-divides components or systems into capacity size groups, to improve linear regression reliability. This is illustrated below, for DX Split Units in Heating, where system size determines which multipliers to use in calculating cost per kW.

Element	Unit of measure	Input Variable	Intercept	Coefficient
Heating				
DX Split System				
(2kW - 5kW)	Cost / kW	(COP 3.0 - ~3.4)	-	0.00 158.24
(5kW - 10kW)	Cost / kW	(COP 3.0 - ~3.4)	0.06	116.61
(10kW - 15kW)	Cost / kW	(COP 3.0 - ~3.4)	-	0.00 99.52
(15kW - 20kW)	Cost / kW	(COP 3.0 - ~3.4)	-	0.09 87.53

Cost / kW = Intercept Value + [Coefficient Value x COP]

B. Application of the Cost Database within the EDGE Software

The USD intercept and coefficient cost variables are loaded from the Cost Database into the EDGE modelling software, where they are applied to quantities and performance ratings of building components and systems.

Changes in quantities and performance ratings, resulting from selection of various green building measures within the EDGE software, are then used to calculate overall change in construction cost.

Please note: These cost calculations are for illustrative purposes only, at early design stage, and are not intended to provide definitive construction cost estimates.

C. Country-specific cost adjustments

The EDGE Cost Database provides a facility for the further modification of the international cost adjustment outputs for specific countries. This facility has been included to allow fine-tuning of specific country costs where estimated costs produced by the database are consistently higher or lower than expected for that country.

V. MAINTAINING THE COST DATABASE

The Cost Database will be regularly reviewed and updated, by a panel of referees, with a view to:

- Inclusion of new materials and technologies;
- Changes in cost / efficiencies of maturing technologies;
- Changes in specific component or system costs resulting from changes in national / global demand.

The international cost conversion methodology will be reviewed after publication of the next round of International Comparison Program findings anticipated during 2017.

Appendix A: EDGE Building Components and Systems

The following tables within the Cost Database support cost calculations relating to green building measures within the Materials, Energy, and Water Efficiency sections of the EDGE software:

A. Building Components

Building Component	Notes / Information Source
Floor slabs	Cost analysis of various floor slab constructions, with costs built up from component costs, areas, and volumes: <ul style="list-style-type: none"> • In-Situ Reinforced Concrete Slab • In-Situ Concrete with >25% GGBS • In-Situ Concrete with >30% PFA • Concrete Filler Slab • Precast RC Planks and Joist System • Concrete Beam Vault with Insulation • Concrete Beam Vault without Insulation
Roofs	Cost analysis of various roof constructions, with costs built up from component costs, areas, and volumes: <ul style="list-style-type: none"> • In-Situ Reinforced Concrete Slab • In-Situ Concrete with >25% GGBS • In-Situ Concrete with >30% PFA • Concrete Filler Slab • Precast RC Planks and Joist System • Clay Roofing Tiles on Steel Rafters • Clay Roofing Tiles on Timber Rafters • Micro Concrete Tiles on Steel Rafters • Micro Concrete Tiles on Timber Rafters • Brick Panel Roofing System • Concrete Beam Vault with Insulation • Concrete Beam Vault without Insulation • Ferro Cement Roofing Channels • Corrugated Zinc Sheets • Reflective paint
Walls	Cost analysis of various wall constructions, with costs built up from component costs, areas, and volumes: <ul style="list-style-type: none"> • Common Brick Wall • Honeycomb Clay Blocks Wall • Medium Weight Hollow Concrete Blocks • Solid Dense Concrete Blocks • Autoclaved Aerated Concrete Blocks • Fly-Ash Stabilized Soil Blocks • Compressed Stabilized Earth Blocks • GGBS Stabilized Soil Blocks • Rammed Earth Blocks/Walls • Precast Concrete Panels • Straw Bale Blocks • Timber Stud with Insulation • Phosphogypsum Panel with Fibre Glass Insulation • Ferro cement Wall Panel • In-Situ Reinforced Wall • Cellular Light Weight Concrete Blocks • Local Limestone Blocks • FaIG Block • Steel Profile Cladding • Aluminium Profile Cladding • Reflective paint
Flooring	Cost analysis of various floor finishes: <ul style="list-style-type: none"> • Ceramic Tile • Vinyl Flooring • Stone Tiles/Slabs • Finished Concrete Floor • Linoleum Sheet • Terrazzo Tiles • Nylon Carpets • Laminated Wooden Flooring • Terracotta Tiles

Building Component	Notes / Information Source
Insulation	Cost analysis of insulation materials: <ul style="list-style-type: none"> • Polystyrene • Mineral Wool • Glass Wool • Polyurethane
Glazing	Cost analysis of glazing types, considering: <ul style="list-style-type: none"> • Glazing type – triple, double, single glazing • Coatings – dark, mid, and light • Gas filling – air filled, argon filled.
External Shading	Cost analysis of external shading (louvred sun control)
Ceiling Fans	Cost analysis based on number and sizing of ceiling fans, with the result describing cost / m ² of treated area.
White Goods (Appliances)	Cost analyses of various appliances within the context of relevant building types: <ul style="list-style-type: none"> • Fridge freezers • Washing machines • Clothes dryers • Dishwashers • Commercial refrigeration
Water fittings	Cost analyses of various water fittings, providing cost uplift from base case to improved case: <ul style="list-style-type: none"> • Shower heads • Faucets / Taps, aerators, and flow controllers • WC flush valves • Urinal flush valves • Grey water recovery • Black water recovery • Condensate recovery • Rainwater harvesting • Kitchen pre-rinse valve
Landscaping	Cost analyses of various irrigation systems: <ul style="list-style-type: none"> • Conventional Sprinkler Irrigation • Sub-surface Drip Irrigation - with rain shut-off • Sub-surface Drip Irrigation - without rain shut-off
Swimming pool covers	Cost analyses of various swimming pool cover systems: <ul style="list-style-type: none"> • Summer cover • Winter cover • Slatted (self-deploying)

B. Building Systems

Building System	Notes / Information Source
Heating Systems	Cost analyses of various heating systems: <ul style="list-style-type: none"> • Electric Heat Pump • DX Split System • Ground Source Heat Pump • Electric Resistance • Fossil Fuel Boiler: Gas fired • Fossil Fuel Boiler: Oil fired • Fossil Fuel Furnace • Enthalpy recovery • Heat recovery
Cooling Systems	Cost analyses of various cooling systems: <ul style="list-style-type: none"> • Air Cooled Chiller

Building System	Notes / Information Source
	<ul style="list-style-type: none"> • Water Cooled Chiller • DX Split System • PTAC, Packaged Terminal Air Conditioner • PTHP, Packaged Terminal Heat Pump • Electric Heat Pump • Ground Source Heat Pump • VRV Systems • Absorption Chiller • Radiant Cooling • Air economisers • Earth air tunnels • CO2 sensor controls • Evaporative cooling
Natural Ventilation	<p>Cost analysis of proportion of window opening for timber and uPVC window frames. Resultant cost factors available for:</p> <ul style="list-style-type: none"> • Timber frames • Powder coated steel frames • Aluminium frames • uPVC frames
Solar Heating and PV	<p>Cost analyses of solar thermal and solar photovoltaic systems.</p>
Lighting	<p>Cost analyses of various lighting installations and lighting controls:</p> <ul style="list-style-type: none"> • T8 Fluorescent • T5 Fluorescent • Compact Fluorescent • LED • Incandescent: Gallery • Incandescent: Decorative
Variable Speed Drives	<p>Calculation of cost impacts of including variable speed drives to fans in ventilation systems.</p>
Smart Meters	<p>Incremental cost of smart meter installations.</p>

