Rwanda Embodied Carbon Calculator (RwECC) User Guide

MASS.  ARUP

This document is an output from the research project *A Toolkit for Built Environment Practitioners to Measure and Reduce Embodied Carbon in Rwanda;* a collaboration between MASS Design Group, The University of Rwanda and Arup.

The project is funded by the Royal Academy of Engineering's Africa Catalyst Sustainable Infrastructure programme.

This guide was authored by James Kitchin of MASS Design Group.

Version 1, June 2022

Project Team, Reviewers and Contributors

James Kitchin, MASS Design Group; Rosie Goldrick, MASS Design Group; Francis Fotsing, MASS Design Group; Obed Sekamana, MASS Design Group; Noella Nibakuze, MASS Design Group; Alex Ndibwami, University of Rwanda; Valerien Baharane, University of Rwanda; Innocent Nkurikiyimfura, University of Rwanda; Edward Hoare, Arup

Contents

Introduction

The document explains how to use the Rwanda Embodied Carbon Calculator (RwECC), which is to be used for calculating embodied carbon across the whole life of a project. It is recommended that users new to embodied carbon start by assessing a project, with a completed design, using the RwECC. The calculator simplifies the assessment because it is populated with data appropriate to typical construction in Rwanda and material quantities are entered in a convenient format e.g. m^2 of wall or m^3 of concrete. The calculator can be used for reporting and evaluating design options.

Refer to *Measuring and Reducing Embodied Carbon in Rwanda's Built Environment* for more information behind the calculation methodology.

Reporting

Embodied carbon assessments should be performed as part of the design process, and results should also be reported. Reporting to a database is required to enable analysis across a large number of projects, so research can be performed to develop benchmarks that can inform embodied carbon targets for future legislation and improve industry understanding of embodied carbon in the built environment.

When the RwECC is used to perform an assessment, the spreadsheet should be sent to James Kitchin, at jkitchin@mass-group.org. No information is needed that can identify the building so if privacy is a concern, please anonymise the information. All data will be provided upon request.

All members of an organisation should be encouraged to perform and report embodied carbon assessments, however they should be verified by an experienced assessor.

Instructions

1. There are 7 tabs in the spreadsheet, only the Summary and Input tabs have user inputs.
2. Yellow cells require user input and all other cells should be left as is.
3. Comments are provided in the spreadsheet of the calculator with useful instructions.
4. In the Summary tab: Enter project and assessment information into the yellow cells.
5. In the Input tab:
    5.1. Select the most applicable material or assembly type from the dropdown box in the "Materials and Assemblies" column.

5.2. The ″Input Units″ column will automatically populate with the required units.
5.3. Enter the quantity of the material or assembly in the ″Quantity″ column making sure it is in the correct units.
5.4. Select the relevant option from the ″Building Element″ column that corresponds to the line item. It is important to separate the same materials into different rows if they are attributed to different building elements. For instance, if concrete is provided as a single value in a BOQ, this may need to be proportioned between substructure and superstructure.
5.5. An optional ″Comments″ column is provided to help keep track of data inputs and any separate calculations performed.
5.6. Follow these steps for all materials and assemblies in the project being reported. The table can be dragged down to provide more rows by clicking and dragging the symbol in the bottom right hand corner of the table.

6. Review the ″A1-3″ column, which is conditionally formatted to show the highest emitting line item. This can help identify any errors in the data input.
7. Sort the column AF in the Input tab by Largest to Smallest to update the graph ″Embodied Carbon to Practical Completion of Top 10 Materials and Assemblies (includes biogenic storage).”
8. Review the Summary tab to see if the numbers make sense. The following points are generally correct for typical buildings and provide helpful checks:
   8.1. Does the structure and substructure account for the greatest amount of embodied carbon out of the building elements?
   8.2. Does concrete and steel account for the greatest amount of embodied carbon out of the materials?
   8.3. Does life cycle stages A1-3 account for over half the embodied carbon?
9. Have the assessment verified by someone else.
10. Submit the spreadsheet to James Kitchin, at jkitchin@mass-group.org

Contact

Please contact James Kitchin, at jkitchin@mass-group.org, if you have comments, find errors, need support, or a would like a tutorial on how to use the calculator.

Inputs

The number of inputs has been limited to make the assessments simple and consistent across different projects.

Materials and Products

Data input is easiest and quickest if there is a Bill of Quantities (BOQ) or a Building Information Model (BIM), which can be used to summarise quantities of materials in a project quickly. The assessment can be completed by any member of the project team; however, it is normally easiest for Architects or Quantity Surveyors to complete the assessment.

There will be cases when the exact assembly or material in a project is not an option in the calculator. In this case then either:

1. Choose the most appropriate material or assembly out of the options available
2. Enter a quantity of available material or assembly that is equivalent to the actual material or assembly. For example, if the brick wall is 150mm thick but the only options in the calculator are 100mm or 200mm thick, then use the 100mm thick option but enter 150/100 = 1.5x the actual material quantity.
3. Email James Kitchin, at jkitchin@mass-group.org, with details of the material or assembly to be added to the calculator

Table 1 provides advice on selecting the appropriate material or assembly.

Category	Input Unit	Comments
Cement	kg	If the number of bags of cement is known, the typical bag weight in Rwanda is 50kg. Unless noted otherwise, when selecting the pozzolana content, assume any imported cement has 0% and local cement has 15%.
Concrete	m3	Unless noted otherwise structural concrete should be assumed to be C25/30 and blinding concrete assumed to be C8/10.
Door	m2	Unless otherwise noted, assume locally made doors are either wood or steel and imported doors are aluminum.
Finish	m2	If a substrate is typically required for a finish it is included in the assembly and should not be double counted. For instance, ceramic tiles assume a mortar backing and acoustic panels assume a support structure.
Hardscape	m2	If a substrate is typically required for a hardscape it is included in the assembly and should not be double counted. For instance, an asphalt road includes the subbases and pavers include a sand base.
Insulation	m3	The input unit of m3 has been used rather than Rsi for convenience, however this means a representative Rsi value has been assumed for the insulation.
Misc	m3, m2	Contains materials and assemblies that do not conveniently fit into other categories.
Mortar	m3	The mortar assumes Cimerwa 32.5N cement is used which has 32% pozzolana.
Services	m	A small number of pipes and culverts are provided. The most appropriate value should be chosen

Soil and rock	m3	If the design quantity is known then assume it is compacted. If the purchase quantity is known then assume it is loose.
Steel	kg, m2	Mesh reinforcement can be input in m2. All other steel shall be input in kg, which may require converting steel section lengths to weights. Weight per length (kg/m) of steel sections can be easily found on the internet, otherwise this link can be used steelconstruction.info/Steel_section_sizes
Wall	m2	Varies wall assemblies and thicknesses have been provided. The thicknesses have been provided because the impact of some wall assemblies does not scale linearly with thickness and a common error when estimating quantities is to incorrectly calculate the thickness of an element. Use the closest thickness available and adjust the quantity to accurately represent the volume of the wall if required.
Window	m2	Unless otherwise noted, assume locally made windows are steel framed and imported windows are aluminum.
Wood	m3, m2	Panelised wood, such as plywood and OSB, have input units of m2. All other wood options have input units of m3. The quantity of wood members is often known by their length, therefore the length (m) must be multiplied by the cross-sectional area (m2) to calculate volume (m3). A common mistake is to incorrectly enter in the units.

Table 1: Material and assembly options

Building elements

Each material and assembly should be assigned to one of the following building elements. Table 2 provides advice on assigning the building element.

Building elements
Substructure e.g. foundations, basement walls, slab on grade
Structural frame e.g. beams, columns, structural walls, suspended slabs, decks, trusses, purlins
Roof finishes e.g. tiles, roof sheeting
Stairs and ramps
Non-structure walls e.g. non-structural walls
Windows and doors
Internal walls and partitions
Wall finishes e.g. plaster, paint, tiles, cladding
Floor finishes e.g. screed, tiles, carpet
Ceiling finishes e.g. acoustic tiles, plasterboard
External works e.g. hardscape, pavement, parking surfaces, external retaining walls, culverts, drains

Table 2: Building categories embodied carbon should be reported under

Spreadsheet Tabs

There are 7 tabs in the spreadsheet. Yellow cells require user input and all other cells should be left as is. Comments are provided in the cells of the calculator with instructions.

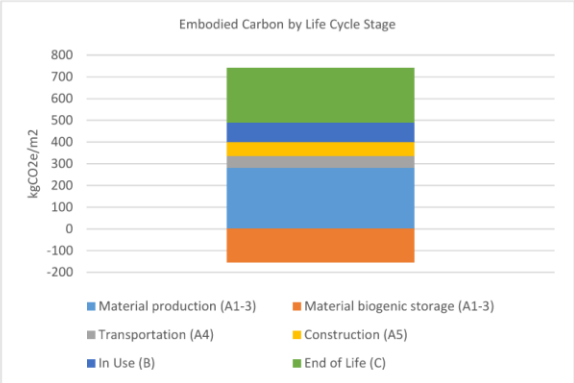
Intro (Introduction)

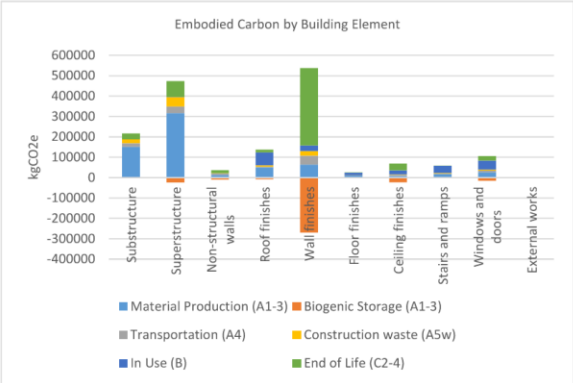
This tab introduces the project, calculator, supporting documents, and version control. There are no user input cells on this tab.

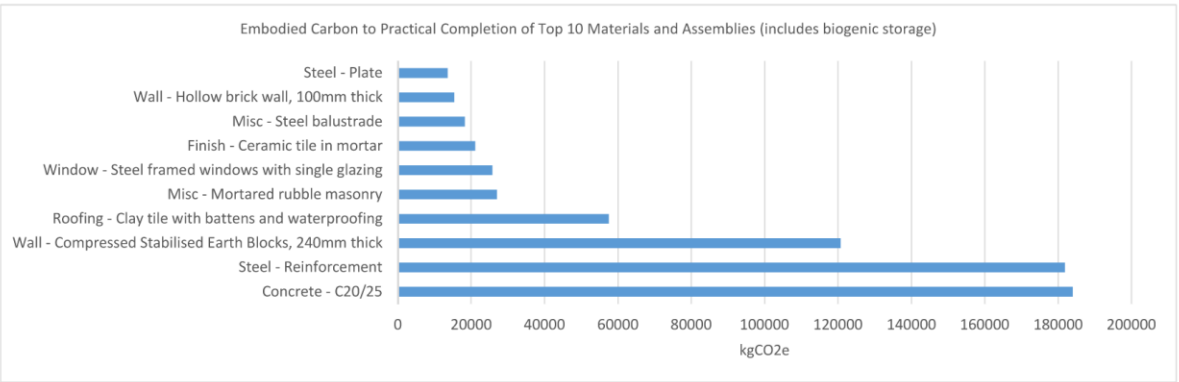
Summary

This tab provides the project embodied carbon results with summarising tables and graphs. The user is required to input project and assessment information into this tab.

Building information		Life Cycle Stages	kgCO2e	kgCO2e/m²	kgCO2e/ m²/yr
Project name	RICA Y2+3	Material production (A1-3)	651477	283	4.7
Project stage	In Use	Material biogenic storage (A1-3)	-353987	-154	-2.6
Building classification	Educational	Transportation (A4)	119033	52	0.9
Building use	Residential building for 86 students at an agricultural university	Construction (A5)	153115	67	1.1
		In Use (B)	204063	89	1.5
Date of practical completion	01 August 2021	End of Life (C)	578357	251	4.2
Project district	Bugasera				
Email contact	jkitchin@mass-group.org	**Building Information**		**Which building elements are included in the assessment?**	
Name of assessor and organisation	James Kitchin, MASS Design Group	Gross floor area (m²)	2300	Substructure	Yes
Assessment date	27 May 2022	Service life (years)	60	Superstructure	Yes
Structural system(s)	Rubble masonry substructure. Compressed earth block superstructure with timber roof structure.	# of occpuants	86	Non-structural walls	Yes
		# of above ground floors	2	Roof finishes	Yes
		# of below ground floors	0	Wall finishes	Yes
Building description	Clay tile roofing and façade. Earth plaster. Limited finishes			Floor finishes	Yes
				Ceiling finishes	Yes
				Stairs and ramps	Yes
Notes on assumptions and limitations of assessment	Building services and external works not included			Windows and doors	Yes
				External works	No







Input

This tab is where the materials and assembly type and quantities are entered by the user. The quantities need to be entered in, in the units that appear when a material is selected. The building element type should be entered for each line item. If more lines are needed, the excel table can be pulled down which adds the cell functions and dropdown box formatting to the additional cells. The A1-3 column is conditionally formatted to see the highest impact line items, which is helpful to identify errors.

					Embodied Carbon by Life Cycle Stage (kgCO2e)						
Comments	Materials and Assemblies	Quantity	Input unit	Building Element	A1-3	A1-3_seq	A4	A5w	B	C2	C3-4
1000 gauge Damp proof Membrane layer	Misc - Damp Proof Membrane	1061	m2	Substructure	4297	0	64	777	0	12	31
Damp proof course;Bituminous felt or an	Misc - Damp Proof Membrane	1196	m2	Substructure	4844	0	72	876	0	14	35
150mm thick hardcore fill, compacted to	Soil and rock - Compacted aggregates and gravel	119.25	m3	Substructure	1550	0	2537	931	0	1193	3101
50 mm Thick blinding under strip foundat	Concrete - C8/10	22.35	m3	Substructure	4683	0	571	327	0	268	697
Stone masonry, jointed with 1:4 cement/	Misc - Mortared rubble masonry	263	m3	Substructure	17245	0	6924	2879	0	3255	8462
Ground Beams	Concrete - C20/25	111	m3	Substructure	29011	0	2834	1928	0	1332	3463
Column bases and Sub- columns	Concrete - C20/25	12	m3	Substructure	3136	0	306	208	0	144	374
125mm bed slab	Concrete - C20/25	145.125	m3	Substructure	37930	0	3705	2521	0	1742	4528
8, 10, 12, 16 mm diameter bars	Steel - Reinforcement	17827	kg	Substructure	35476	0	474	6401	0	89	232
B.R.C mesh fabric reinforcement A142 W	Steel - A142 Mesh Reinforcement excl. laps	1161	m2	Substructure	5129	0	69	925	0	13	34
Dowel Bar	Steel - Reinforcement	394.6082	kg	Substructure	785	0	10	142	0	2	5
B12 Starter Bars not exceeding 1500mm	Steel - Reinforcement	1635.375	kg	Substructure	3254	0	43	587	0	8	21
110mm diameter heavy gauge PVC perfo	Services - uPVC below ground Pipe, 110mm diameter	420	m	Substructure	2851	0	396	172	0	5	12
Concrte upstands	Concrete - C20/25	53	m3	Superstructure	13852	0	1353	921	0	636	1654
Stair and ramp concrete	Concrete - C20/25	11.7	m3	Stairs and ramps	3058	0	299	203	0	140	365
REINFORCEMENT: As described in Engine	Steel - Reinforcement	4969.18	kg	Superstructure	9889	0	132	1784	0	25	65
Reinforced Compressed stabilized Earth E	Wall - Compressed Stabilised Earth Blocks, 240mm thick	1117.99	m2	Superstructure	35710	0	6062	5084	0	2849	7408
Factory Fired burnt clay brick as manufac	Wall - Hollow brick wall, 100mm thick	278.4	m2	Superstructure	7914	0	967	2110	0	216	560
Stud walls	Wall - Wood stud wall with plasterboard each side, 125r	600	m2	Non-structural walls	4615	-4170	2974	668	0	64	5914
Wall reinforcement	Steel - Reinforcement	5589.95	kg	Superstructure	11124	0	149	2007	0	28	73
Tiles to screeded beds as described in:-	Finish - Ceramic tile in mortar	224.04	m2	Floor finishes	4990	0	247	434	5940	75	194
External Plaster: Prepare and apply 15mr	Finish - Earth plaster	2139.9	m2	Wall finishes	143	0	819	261	2610	385	1001
Tiles to screeded beds as described in:-	Finish - Ceramic tile in mortar	211.17	m2	Wall finishes	4704	0	232	409	5599	70	183
P1:Paint to interior condition to Concrete	Finish - Paint	1719.51	m2	Wall finishes	68	0	14	5	96	3	7
External Plaster: Prepare and apply 15mr	Finish - Earth plaster	420.36	m2	Wall finishes	28	0	161	51	513	76	197
2.8m high 50x200mm thick Treated and (	Wood Structure - Softwood	211.7248	m3	Wall finishes	29958	-176557	26657	13948	0	570	244902
C6A: Suspended timber Ceiling including	Finish - Wood wall/ceiling	333.49	m2	Ceiling finishes	944	-5562	840	439	4394	18	7715
C4: 1:4 c/s mix Interrior Plaster and 3 coa	Finish - Plaster and paint	530.34	m2	Ceiling finishes	779	0	159	55	1102	30	78
C9 Ceiling comprising 12.5mm thick Plas	Finish - Painted plasterboard	43.14	m2	Ceiling finishes	142	0	85	12	246	2	5
C12:Papyrus ceiling Comprising; 8mm ste	Finish - Wood wall/ceiling	34.67	m2	Ceiling finishes	98	-578	87	46	457	2	802
Supply and Install purpose made Hollow :	Window - Steel framed windows with single glazing	137.145	m2	Windows and doors	7585	0	1611	1095	10358	19	49
4320X2750mm high overall size Curtain \	Window - Steel framed windows with single glazing	24.118	m2	Windows and doors	1334	0	283	193	1822	3	9
Supply and Install timber framed door to	Door - Wood	132.45	m2	Windows and doors	1424	-8394	1267	663	6631	27	11644
High Quality Hollow steel frame with all f	Door - Steel framed glass door with single glazing	50.731	m2	Windows and doors	2519	0	546	345	3432	6	16
Slab concrete	Concrete - C20/25	272.015	m3	Superstructure	71094	0	6945	4726	0	3264	8487
Slab reinforcement	Steel - Reinforcement	19749.31	kg	Superstructure	39301	0	525	7091	0	99	257
Reinforced Compressed stabilized Earth E	Wall - Compressed Stabilised Earth Blocks, 240mm thick	1762.95	m2	Superstructure	56311	0	9559	8016	0	4493	11681
Factory Fired burnt clay brick as manufac	Wall - Hollow brick wall, 100mm thick	113	m2	Superstructure	3212	0	393	856	0	87	227
Stud walls	Wall - Wood stud wall with plasterboard each side, 125r	926.83	m2	Non-structural walls	7129	-6441	4595	1032	0	98	9135
Wall reinforcement	Steel - Reinforcement	26378	kg	Superstructure	52492	0	701	9471	0	132	343
2.8m high 50x200mm thick Treated and (	Roofing - Clay tile with battens and waterproofing	211.7248	m2	Wall finishes	7881	-1412	650	1005	10316	68	2124
Roof bracing	Steel - Closed members	582.36	kg	Superstructure	1473	0	136	286	1747	3	8
Roof connections	Steel - Plate	964	kg	Superstructure	2371	0	415	495	0	5	13
Truss fitch plates	Steel - Plate	1631.5	kg	Superstructure	4013	0	702	837	0	8	21
Slab edge balustrade	Misc - Steel balustrade	424.29	m2	Stairs and ramps	14223	0	1316	2760	35266	28	73
Trusses	Wood Structure - Softwood	12.8436	m3	Superstructure	1817	-10710	1617	846	0	35	14856
Purlins	Wood Structure - Softwood	1.76205	m3	Superstructure	249	-1469	222	116	0	5	2038
Roof sheathing	Wood Structure - Plywood, 12mm thick	1288.87	m2	Superstructure	5340	-12625	1835	1272	0	39	16859
Clay tiles on roof	Roofing - Clay tile with battens and waterproofing	1288.87	m2	Roof finishes	47977	-8598	3957	6117	62796	414	12930
Wooden suspended ceiling	Finish - Wood wall/ceiling	288	m2	Ceiling finishes	815	-4803	725	379	3795	15	6663

No Input_S_Assem (Summary of assemblies)

This summarises the assemblies created in the Assem (Assemblies) tab. There are no user inputs in this tab.

No Input_Assem (Assemblies)

Assemblies are created here from different materials. The Service Life of an assembly is added here too. There are no user inputs in this tab.

No Input_Mat (Materials)

The impacts of individual materials are added to this tab. They are collected into Assemblies in the Assem (Assemblies) tab. There are no user inputs in this tab.

No Input_Ref (Reference)

The transportation emissions table is here which is referenced in the other tabs. There are no user inputs in this tab.