Embodied Carbon RegisTree

Written by:

Madona Aziz
Rema Cheikhali
Anuradha Kadam

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Section 1 - Introduction

1.1 Purpose

The purpose of this code is to sequester carbon in the city of Baltimore by establishing the minimum requirements of trees that must be planted for building sites according to the amount of embodied carbon used in construction materials.

1.2 Requirements

1.2.1 The owner must plant enough trees to sequester at least 2% of embodied carbon per year for the new building. This will offset the embodied carbon of the building in 50 years.

1.2.2 The owner is required to plant a minimum amount of trees (Tmin) on the building lot according to the building lot area (A), which can be calculated using *Formula 1* below. This formula dictates that for lots below 500sf, there are no trees required onsite; for lots between 500sf and 8,000 sf, there is a minimum of 1 tree required onsite, and for buildings above 6,000sf, there will be one tree added for every 2,000sf of additional land (so for an 8,000sf lot, there is a minimum of 2 trees required on side, for 10,000sf lot, there is a minimum of 3 trees required, etc.). These trees can be placed anywhere on the lot, including within or on top of the building.

Formula 1:

For A < 500 sf: *Tmin = 0 Trees*

For 500 sf < A < 8,000 sf: *Tmin = 1 Tree*

For A > 8,000 sf: *Tmin = 1 + (A - 6,000) / 2,000)*

Where Tmin is rounded down to the nearest whole number.

A = Building lot area

Tmin = Minimum Trees Required on Building Lot

1.2.3 The remaining trees, also known as the surplus trees, must be planted elsewhere on private land, also known as the surplus lot, that is property of the developer. This surplus lot must be located within Baltimore County, preferably within Baltimore city. The developer must maintain ownership of this surplus lot and submit proof of tree installment on offsite private property.

1.2.4 The surplus trees on this lot may be harvested for timber construction, as long as proof of tree replenishment and compliance of harvesting procedures (established by the USDA) are submitted.

1.3 Scope

This standard applies to all lots that undergo construction or renovation of a building.

1.4 Definitions

Building Lot - Land that contains or will contain a building or structure.

Developer - Owns the property that contains or will contain a building or structure.

Embodied Carbon (EC) - the quantity of non-renewable energy emitted per unit of building material, component, or system. It is measured in the amount (kg) CO2 emitted. For this standard, embodied carbon is calculated using the *Embodied Carbon in Construction Calculator* (EC3) Tool, made by the Carbon Leadership Forum which focuses on the indirect supply chain emissions of construction materials OR using *Tally* Application, which can be used while working in Revit. It is also known as indirect supply chain emissions, of the materials used to construct the new building.

Net-Zero Carbon Buildings - Buildings that generate as much energy onsite via renewable energy sources (does not emit any carbon) than they consume, if not more. The amount of carbon dioxide emissions on an annual basis is zero or negative. These buildings often have greater energy efficiency and reduced loads.

Owner - Owns and operates the building or structure that will be built on a lot.

Surplus Lot - Land that contains the remaining / surplus trees. Must be property of the developer and/or the owner. Must be located within Baltimore County, preferably within Baltimore city. The surplus trees on this lot may be harvested for timber construction, as long as these trees are replenished and follow harvesting procedures established by the USDA.

Target Offset Carbon (TOC) - A percentage of the embodied carbon that will be sequestered by the planted trees per year. This standard requires a minimum of 2% embodied carbon to be sequestered by trees per year, but the owner is encouraged to offset more carbon per year or plant more trees than the minimum.

Formula 2:

$$Minimum\ TOC = (0.02 \times EC)$$

Tree-to-Embodied Carbon (TEC) Ratio - The amount of CO_2 (kg) sequestered per year by a single tree divided by the target offset carbon (TOC) of a new building. This ratio is used to determine the amount of different tree species required to reach the TOC sequestered per year. The owner may also use the EC RegisTree Calculator provided by this code.

Formula 3:

$$TEC\ Ratio = (CO_2\ (kg / yr)) / TOC$$

Section 2 - Calculations

2.1 Procedure

The owner must calculate the embodied carbon of a building design using the *Embodied Carbon in Construction Calculator (EC3)* tool OR the *Tally* Application in conjunction to the *CUFR Tree Carbon Calculator (CTCC)* to calculate carbon sequestration (in kg CO_2) provided by the individual trees that must be planted to offset at least 2% of the embodied carbon (EC) for the building throughout the lifespan of a building and tree. This means it will take 50 years for the trees to sequester enough carbon to offset the indirect supply chain emissions from construction materials of the new building.

Step 1: Input all materials and quantities into the EC3 tool or Tally plug-in for Revit to calculate the total embodied carbon (EC) of the new building.

Step 2: Calculate target offset carbon (TOC).

Formula 2:

$$Minimum\ TOC = (0.02 \times EC)$$

Step 3: Use the CTCC to select trees local to the region where the new building is located. Find tree species and corresponding kg CO_2 sequestered per year (per tree) and input into provided *EC RegisTree Calculator* (Excel file) to calculate amount trees required per species.

Formula 4:

$$Amount\ of\ Single\ Tree\ Species = TOC\ /\ (CO_2\ (kg\ /\ yr))$$

Use the *EC RegisTree Calculator* Excel file (*see appendix)* to calculate amounts of up to 5 different tree species required to reach the TOC sequestered per year. Or, use the TEC Ratio to determine the amount of different tree species by inputting n_1 and solve for n_2 in the following equation.

Formula 5:

$$TEC_1 * x_1 + TEC_2 * x_2 + \ldots TEC_n * x_n = 1$$

$$x_n = Amount\ of\ tree\ species\ n$$

$$TEC_n = TEC\ associated\ to\ tree\ species\ n$$

Section 3 - Tree Types & Procedures

3.1 Tree Sourcing

Local government shall recommend plant nurseries and locations to obtain trees. Trees will be provided by state governments to governmental institutions and non-profit organizations. All other buildings must obtain their own trees, and can apply for federal funding or aid from local agencies like *Baltimore Tree Trust*.

Tree species are carefully selected by agencies such as *Clean Green Baltimore County* for factors such as ecosystem functions, mature size, native range, safety and aesthetics.

3.2 Growth Rates

Building lots should have different species of trees of different growth rates to maximize shorter and longer term carbon sequestration.

The rate of carbon sequestration depends on the growth characteristics of the tree species, the conditions for growth where the tree is planted, and the density of the tree's wood. Carbon sequestration rates are greatest in the younger stages of tree growth, between 20 to 50 years.

3.3 Tree Types

The plants used on site must be local and native trees and plants according to agencies such as the *BALTIMORE COUNTY EPS Reforestation and Urban Tree Canopy List* or the CTCC. *(See appendix).*

3.4 Initial Tree Size When Planting Onsite

Trunk diameter when initially planted must be at least 1” - 2.5”.

Root balls must be large enough to allow for a healthy growing tree. Smaller trees to be planted to decrease root loss of trees during transplantation. No small seedlings allowed to be planted on site. Trees should be planted during the dormant season: in the Fall after leaf drop or Spring before bud break.

3.5 Tree Protection

All trees that are planted for carbon sequestration must remain in place and not cut down or removed. Permanency in plantations is an important component of climate mitigation.

Within six months of the estimated date of substantial completion, prune all dead or hazardous branches larger than 2 inches in diameter from all trees to maintain tree health.

All pruning shall be done in accordance with ANSI A300 (part 1), ISA BMP Tree Pruning (latest edition, and the "Structural Pruning: A Guide for the Green Industry", Edward Gilman, Brian Kempf, Nelda Matheny and Jim Clark, 2013 Urban Tree Foundation, Visalia CA.

The Owner will be fully responsible to ensure that enough water is provided to all trees on site. Soil moisture must be maintained above the permanent wilt point to a depth of 8 inches or greater.

3.6 Diseases / Tree Damage

Trees have to be replaced with trees of similar species that sequester as much carbon or more than the one before and also has an equivalent trunk diameter to the tree(s) being replaced.

Any tree that is determined to be dead, damaged, or has a disease shall be immediately removed at no additional penalty to the owner. Tree removal has to include clean-up of all wood parts, grinding of the stump to a sufficient depth, removal of all chips from the stump site, and filling the resulting hole with topsoil.

Tree removals on site shall be performed by ISA Certified Arborists and companies that have appropriate licenses and insurance for tree removal operations. The owner may apply for federal aid in tree removal services.

A person may not cut down, trim, mutilate or in any way injure any roadside tree without a permit or work order issued by the Maryland Department of Natural Resources (DNR).

3.7 Penalties

Any owner that removes damaged trees without permission from the city will be fined with up to $1,000 or higher depending on the damage caused. If the damage affects other trees on the property, this will be assessed at the rate of $200 per diameter inch of the tree measured 4.5’ above grade.

Any trees or plants damaged by the owner shall be replaced at their own expense in addition to fines and penalties.

Section 4 - Exceptions

4.1 Excess Trees Planted

If the owner decides to plant at least 25% more trees than the minimum required, then the owner is permitted to plant all of the trees offsite on an surplus lot, and not required to plant any trees on the building lot. This means that the additional trees will sequester more carbon, which will offset embodied carbon of the building in less than 50 years.

4.2 Low Embodied Carbon / Net-Zero Carbon Buildings

If the embodied carbon of the new building is under 16 kg CO2 / total sf OR if it is a net-zero carbon building, the owner does not need to plant any trees on this lot or the surplus lot.

4.3 Carbon Sequestration Index (Other Methods)

If the owner decides to use alternative methods of carbon sequestration that can be found in the *Carbon Sequestration Index* of approved carbon sequestration technology, then the owner is not required to plant any trees on the building lot. The owner must submit proof of carbon sequestration equivalent to at least 2% of EC of the new building before construction and implement the alternative method after construction. *(See appendix).*

Appendices

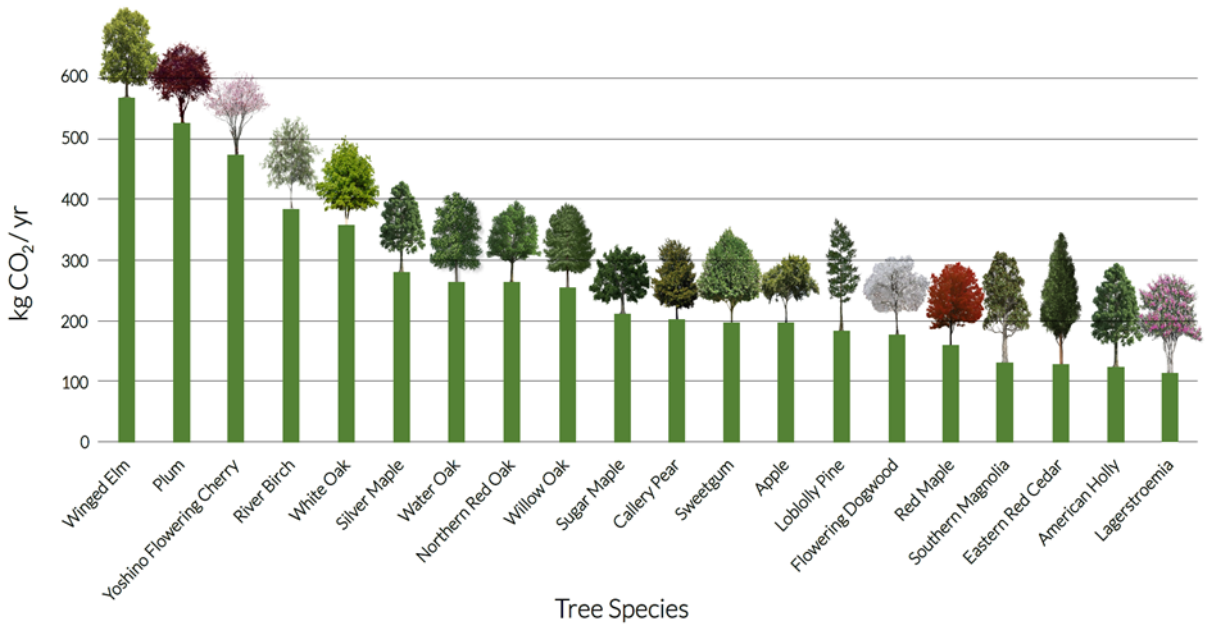
Appendix A: Carbon Sequestration Index (Excerpt)

Some examples of technologies include:

- Algae-farms
  - Since algae cannot sequester as much carbon dioxide as trees can, one is permitted to sequester less than the minimum 2% of embodied carbon by algae farming as long as the energy stored as oil is extracted and refined into sustainable biofuels.
- Kelp-farming
  - Since kelp farming can sequester up to 20 times more carbon per acre than forests, one can farm less kelp or seaweed than they would have to plant trees.
- Shrubs / Plants
- Vertical Farming
- Green Roof / Vegetative Roof
- Carbon Offset Credits - Circular Ecology

Appendix B: Tree Species (Local to Baltimore, MD)

Carbon Dioxide Sequestered in Trees Local to Baltimore, MD Per Year



Some examples of trees that *should not* be planted because they store little carbon are

- Willow
- Douglas-fir
- Cottonwood

Appendix C: Traditional Office Building Calculations Example (Using ECR Calculator)

Amount of up to 5 different tree species required to sequester 2% EC:

BUILDING LOT INFORMATION

Building Address	
Lot Dimensions (ft x ft)	
Lot Area (sf)	12000
Building Footprint Dimensions (ft x ft)	
Building Footprint Area (sf)	
Total Building Square Footage (sf)	
Number of Floors	
Floor-to-Area Ratio (FAR)	

MINIMUM ONSITE TREES

For every building lot area greater than 1,000sf, there must be at least 1 tree planted.
For building lot areas greater than 6,000sf, there must be 1 tree planted for every additional 2,000sf

Minimum Trees on Building Lot	4
Planned Trees on Building Lot	

MINIMUM OFFSITE TREES

Total Embodied Carbon (kg CO2)	792,000
Target Embodied Carbon (2% EC)	15840
Goal Embodied Carbon (5% EC)	39600
Minimum Trees Planted (2% EC)	**28**
Goal Trees on Surplus Lot (5% EC)	69

ACTUAL TOTAL AMOUNT OF TREES

For up to 5 different species of trees

Tree Species	kg CO2 / yr / tree	Amount of Planned Trees	TEC Ratio (2% EC)	Amount of Surplus Trees	**Totals**
Plum	527		0.033	**28**	**28**
Apple	199	2	0.013		**2**
Northern red oak	264	2	0.017		**2**
White oak	359		0.023	**42**	**42**
None	0		0.000		
TOTALS		4		70	**74**

When there is no input for "Amount of Planned Trees," the "Amount of Surplus Trees" shows the amount of trees needed if only that one tree species is being used and "Minimum Area Required" shows area required when only that one tree species is used

References

- Maryland Department of Natural Resources (DNR)
- Department of Recreation & Parks
- Carbon Storage & Sequestration by Urban Trees in the USA
- Tree Canopy Change in the City of Baltimore
- EC3 Primer
- EC3 Material Baselines
- EC3 Methodology Report
- CTCC Download