

# RESEARCH REPORT

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## THE METHODOLOGY OF CALCULATING THE CARBON FOOTPRINT OF A BUILDING

### INTRODUCTION

The thesis research topic I chose is the methodology of calculating the carbon footprint of a building. I chose this topic because I care a lot about our environment and sustaining it. How can I take a site and not wipe it clean and start with my own ideas and design, but to sit back and look at how the site itself can guide my design? I've been working on studying different types of building materials and calculating their individual emissions. I will further research how to adapt or change those materials to reduce carbon emissions. I think it is important to realize that we are first and foremost integrating into nature and not throwing up a build and then going back to integrate nature back within the site. I was at a hunting cabin a couple of weeks ago and they told the story of how they built the cabin and they had said that each tree that was cut down for the location of the cabin was planned out and used for the structure and finishes. Materials that belong on the site are used on the build. I really want to work towards being more aware of the existing site and working more on my perspective of existing elements and how important they are. Destroying existing elements within a single site is “small” & “unimpactful” is not the way to think while designing architecture because the Earth is our site. The more we ruin and destroy individual sites will result in destroying our Earth. I started researching how to calculate a buildings carbon footprint and struggled to find enough information to realistically find out results. This thesis topic intrigued me to study a deeper way to be able to understand the carbon footprint of a design before it is built and how to reduce an existing building’s carbon emissions.

## METHODOLOGY

My first plan off attack was to “simply” figure out how to calculate the carbon footprint of a building. I found out that this was not so simple. I was able to find a lot of websites that businesses can pay for and use to find out their results; but this didn’t help me. I wanted to know HOW to calculate, not just the results. So, first things first, what makes a carbon footprint? This is the question that needs to be defined before anything else. This is the problem, so I need to fully understand what the problem is before trying to solve it.

### CARBON FOOTPRINT

What is a carbon footprint? It is spoken about worldwide. The term is used to specify a problem; seems like a big problem at that. Nobody seems to use this term in joyful way. The definition of carbon footprint is “the total amount of greenhouse gas emissions caused by an individual, event, organization, service, place or product, expressed as carbon dioxide equivalent”. So, this led to further investigating. With guidance from Professor Ganapathy Mahalingam, I was introduced to Building Transparency’s EC3 tool. This was the start to it all.

### EC3 TOOL

Building Transparency is a website that fosters a better building future by addressing embodied carbon’s role in climate change. It allows you to create an account and import Revit models in. You can also upload multiple models to be able to compare them. This site also allows to explore many different material types and learn about each of those material’s emissions. EC3 is a great tool for my thesis. It has really allowed me to learn in so much detail about material choices and carbon emissions.

### TALLY

I found the Tally extension through Building Transparency website. They provide Tally as a sister software. Tally is a Revit extension that allows the flow of data from Revit to the EC3 tool. This software was game changer. It plugs right into Revit and is easy to learn. It takes all of your components on your model (floor, doors, windows, roof etc.) and allows you to choose a specific material to define it. Once all of the components are defined, you are then able to convert it over to EC3 to collect your results.

## RESULTS

Throughout researching, I have found a way of using multiple software that can be used together to calculate existing data. I have created a YouTube video that allows anyone to see the process I used to convert a Revit model to the EC3 tool. I have included all of my slides that make up my video. These slides capture the majority of what I have learned while researching the methodology of calculating the carbon footprint of a building.

## CONCLUSIONS & PROJECTIONS

From here I will go on in the spring semester to pick an existing building and create a model of it in Revit. Then I will insert the current materials that are being used. I will then run it through EC3 and figure out the starting carbon emission data. Then I will go back into Revit and Tally and choose different materials and work to reduce the carbon emission for an end result.

I am very proud of where I am at this point. I hope that this process that I have went through will benefit not only the way we design but also the Earth. I hope to find additional ways to help reduce carbon emissions in the future to help do my part to help our world.

## YOUTUBE VIDEO

I am including the link to my YouTube video for ease of access.

<https://www.youtube.com/watch?v=sfgvYCzDcmo>

Below are my slides of my video, but they are missing the audio so make sure to check out the full video with audio.

# Converting Revit Model to EC3 Tool



Created By: Kaitlyn Kane

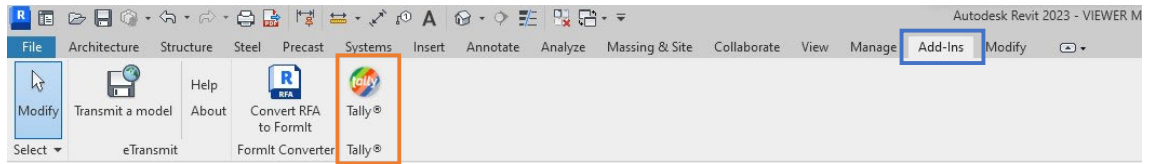
Guided By Professor Ganapathy Mahalingam

## Software Needed



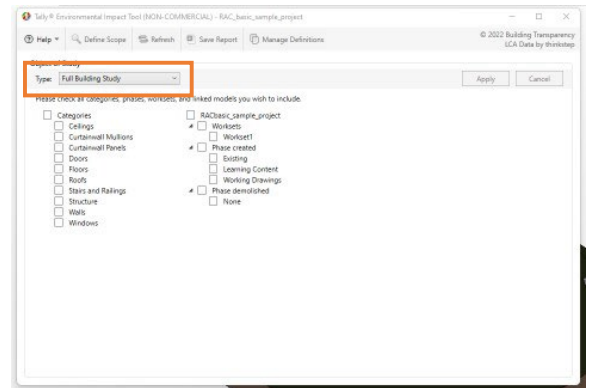
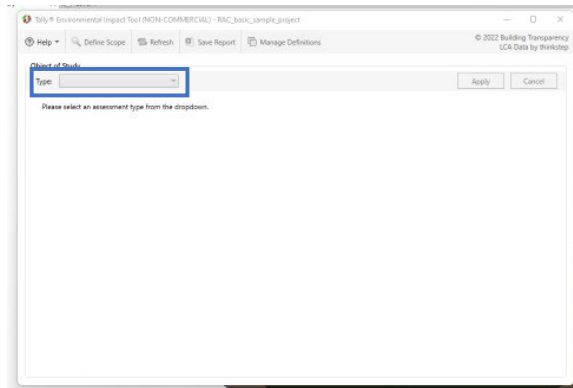
**Step 1:**  
User left click on "Add-Ins"

**Step 2:**  
User left click on "Tally"



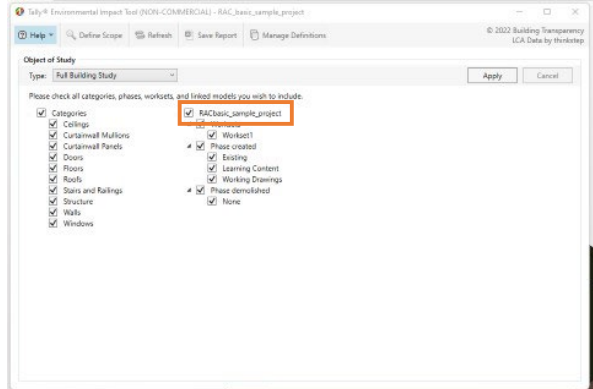
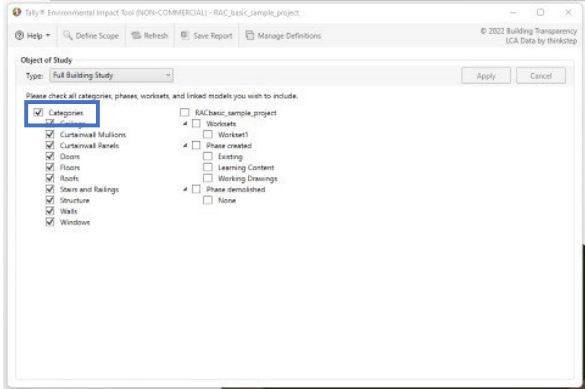
**Step 3:**  
User left click on "Type" dropdown box

**Step 4:**  
User left click on "Full Building Study"



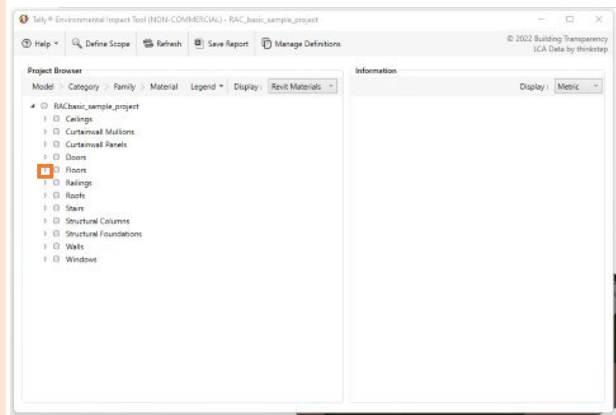
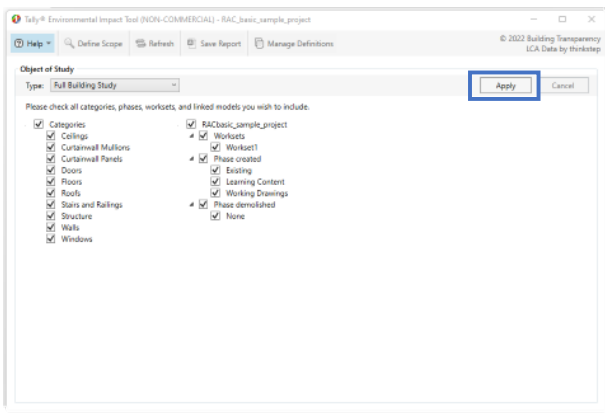
**Step 5:**  
User left click on "Categories" box

**Step 6:**  
User left click on the current project box (RACbasic\_sample\_project)



**Step 7:**  
User left click on "Apply"

**Step 8:**  
User left click on "Floors" drop down arrow



### Step 9:

User left click on "Timber Suspended Floor" drop down arrow

- RACbasic\_sample\_project
  - ▷ Ceilings
  - ▷ Curtainwall Mullions
  - ▷ Curtainwall Panels
  - ▷ Doors
  - ▲ Floors
    - ▷ Concrete-Domestic 425mm
    - ▷ Generic 150mm
    - ▷ Generic 300
    - ▷ Insitu Concrete 225mm
    - ▷ Timber Suspended Floor
  - ▷ Railings
  - ▷ Roofs
  - ▷ Stairs
  - ▷ Structural Columns
  - ▷ Structural Foundations
  - ▷ Walls
  - ▷ Windows

### Step 10:

User right click on "Carpet"

- RACbasic\_sample\_project
  - ▷ Ceilings
  - ▷ Curtainwall Mullions
  - ▷ Curtainwall Panels
  - ▷ Doors
  - ▲ Floors
    - ▷ Concrete-Domestic 425mm
    - ▷ Generic 150mm
    - ▷ Generic 300
    - ▷ Insitu Concrete 225mm
    - ▲ Timber Suspended Floor
      - Carpet (1)
      - Structure - Timber Joist/Rafter Layer
  - ▷ Railings
  - ▷ Roofs
  - ▷ Stairs
  - ▷ Structural Columns
  - ▷ Structural Foundations
  - ▷ Walls
  - ▷ Windows

### Step 11:

User left click on "Edit definition"

- RACbasic\_sample\_project
  - ▷ Ceilings
  - ▷ Curtainwall Mullions
  - ▷ Curtainwall Panels
  - ▷ Doors
  - ▲ Floors
    - ▷ Concrete-Domestic 425mm
    - ▷ Generic 150mm
    - ▷ Generic 300
    - ▷ Insitu Concrete 225mm
    - ▲ Timber Suspended Floor
      - Carpet (1)
        - Structure - Timber Joist/Rafter Layer
        - Structure - Timber Joist/Rafter Layer
  - ▷ Railings
  - ▷ Roofs
  - ▷ Stairs
  - ▷ Structural Columns
  - ▷ Structural Foundations
  - ▷ Walls
  - ▷ Windows

- Edit definition
- Copy definition from
- Set as dummy material
- Clear definition
- Isolate in Revit View
- Reset Temporary Hide/Isolate
- Select Elements

### Step 12:

User left click on "Finishes" drop down arrow

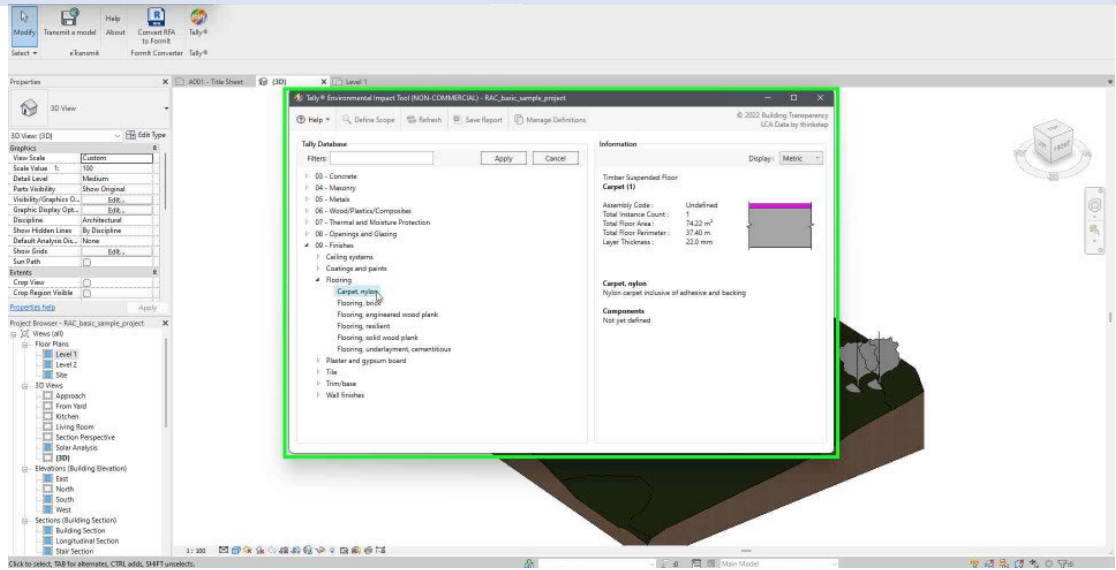
- ▷ 03 - Concrete
- ▷ 04 - Masonry
- ▷ 05 - Metals
- ▷ 06 - Wood/Plastics/Composites
- ▷ 07 - Thermal and Moisture Protection
- ▷ 08 - Openings and Glazing
- ▲ 09 - Finishes
  - ▷ Ceiling systems
  - ▷ Coatings and paints
  - ▷ Flooring
  - ▷ Plaster and gypsum board
  - ▷ Tile
  - ▷ Trim/base
  - ▷ Wall finishes

### Step 13:

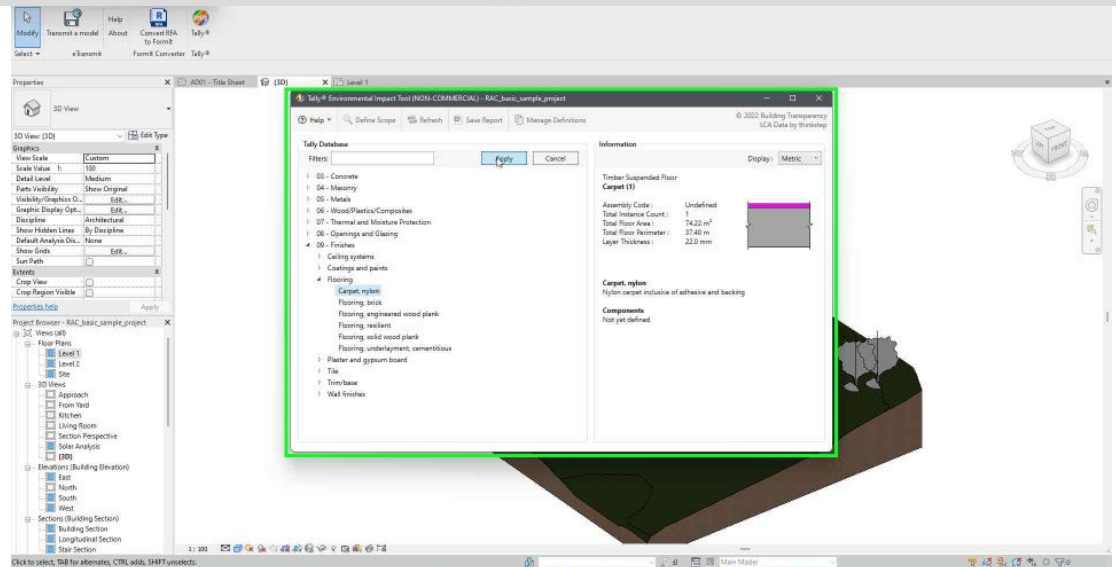
User left click on "Flooring" drop down arrow

- ▷ 03 - Concrete
- ▷ 04 - Masonry
- ▷ 05 - Metals
- ▷ 06 - Wood/Plastics/Composites
- ▷ 07 - Thermal and Moisture Protection
- ▷ 08 - Openings and Glazing
- ▲ 09 - Finishes
  - ▷ Ceiling systems
  - ▷ Coatings and paints
  - ▲ Flooring
    - ▷ Carpet, nylon
    - ▷ Flooring, brick
    - ▷ Flooring, engineered wood plank
    - ▷ Flooring, resilient
    - ▷ Flooring, solid wood plank
    - ▷ Flooring, underlayment, cementitious
  - ▷ Plaster and gypsum board
  - ▷ Tile
  - ▷ Trim/base
  - ▷ Wall finishes

**Step 14:**  
User left click on "Carpet, nylon"



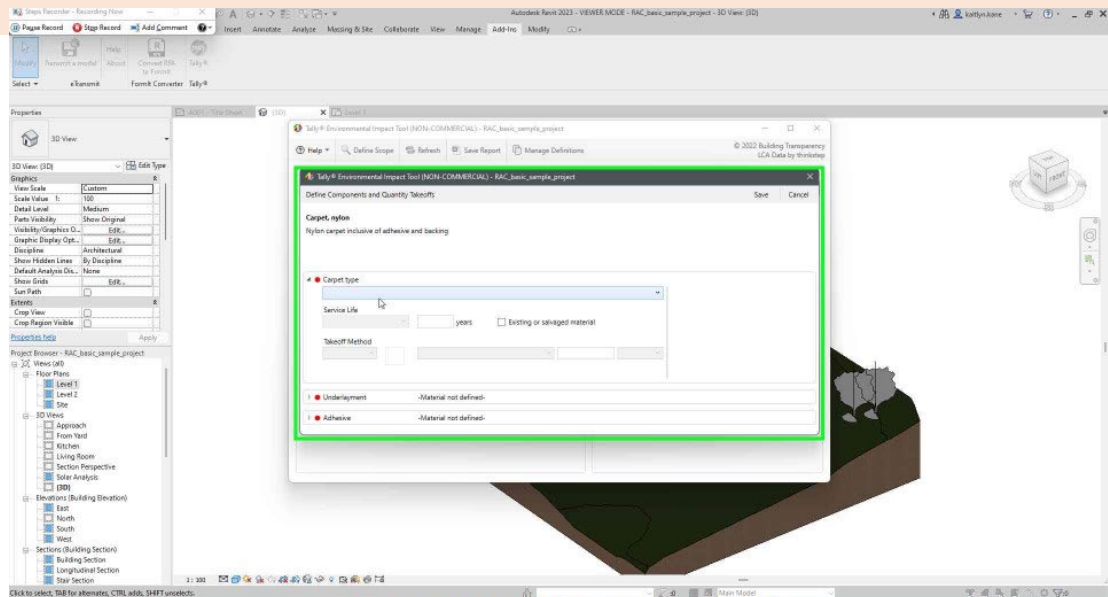
**Step 15:**  
User left click on "Apply"





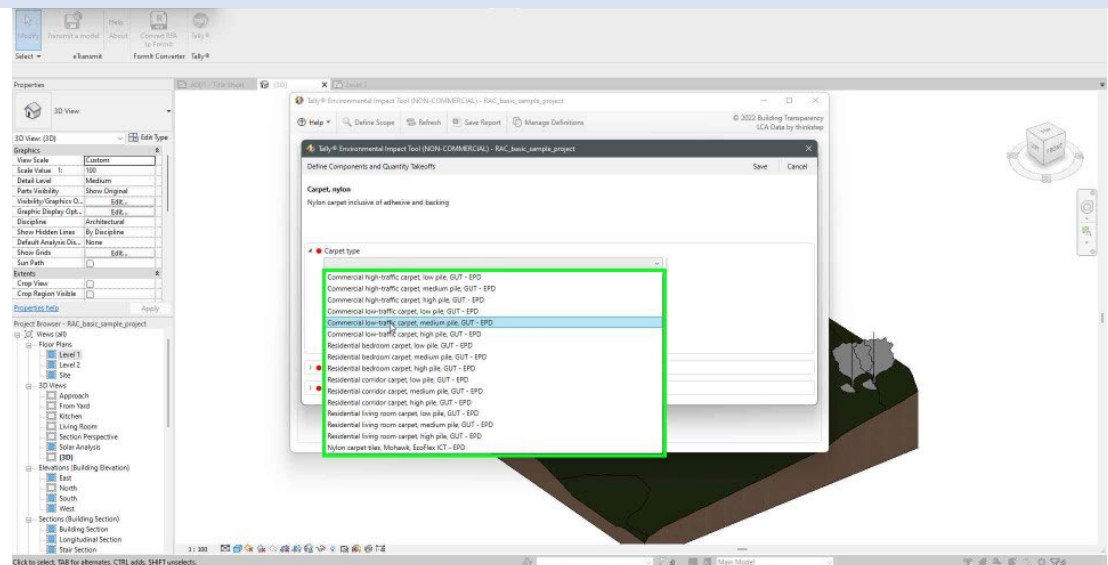
## Step 16:

User left click on the material definition drop down for "Carpet type"

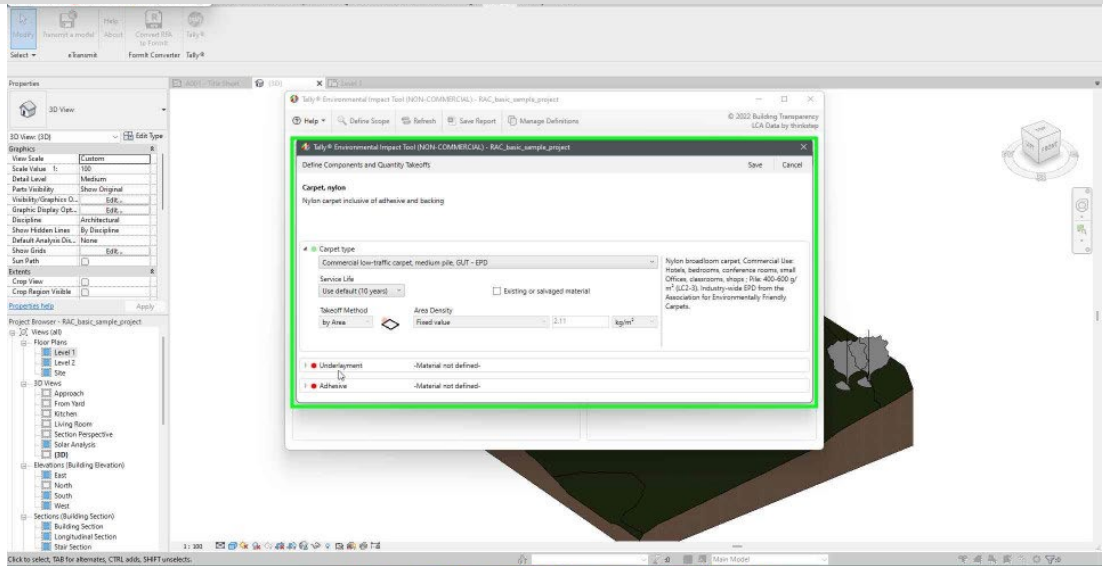


## Step 17:

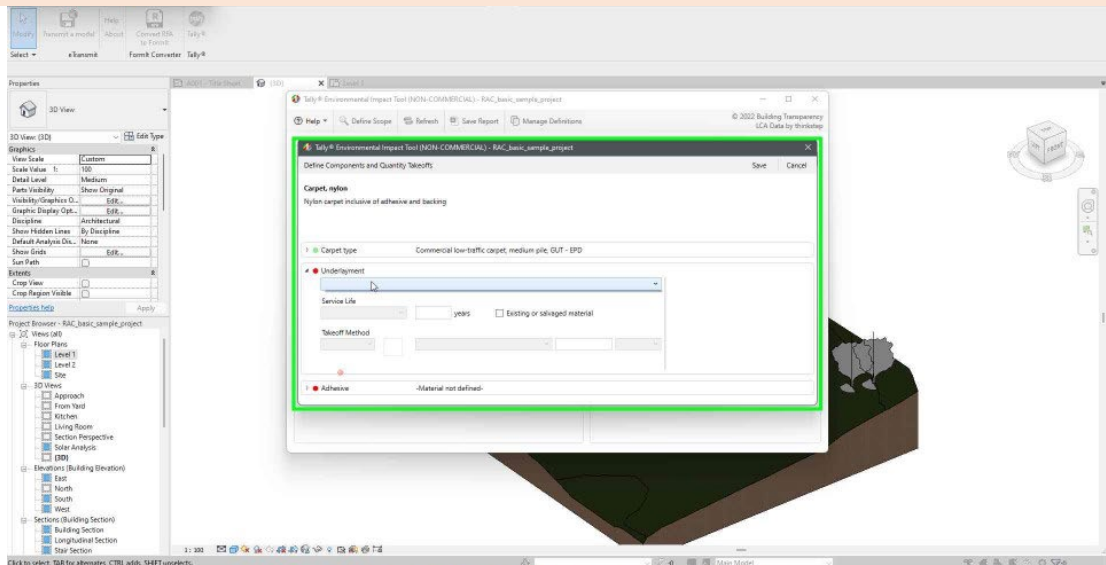
User left click on a specific material type



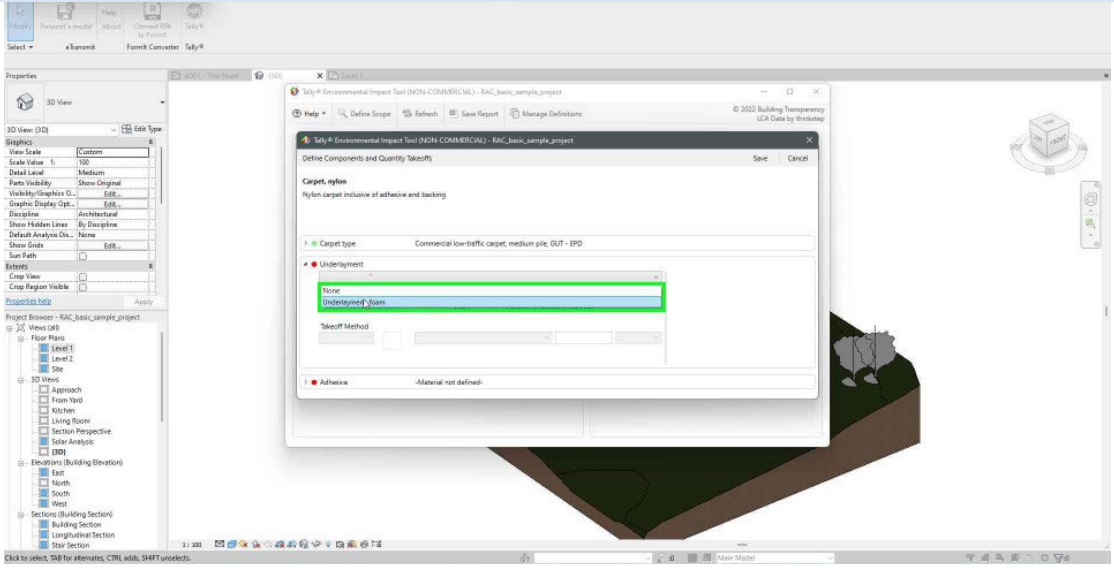
**Step 18:**  
User left click out to allow for default input



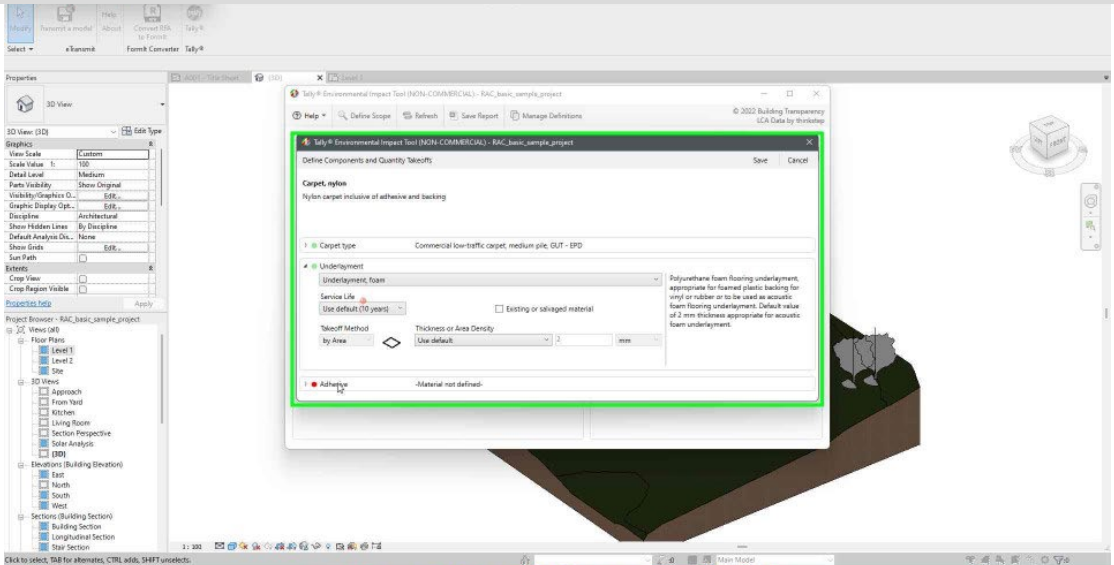
**Step 19:**  
User left click on the material definition drop down for "Underlayment"



**Step 20:**  
User left click on User left click on a specific material type

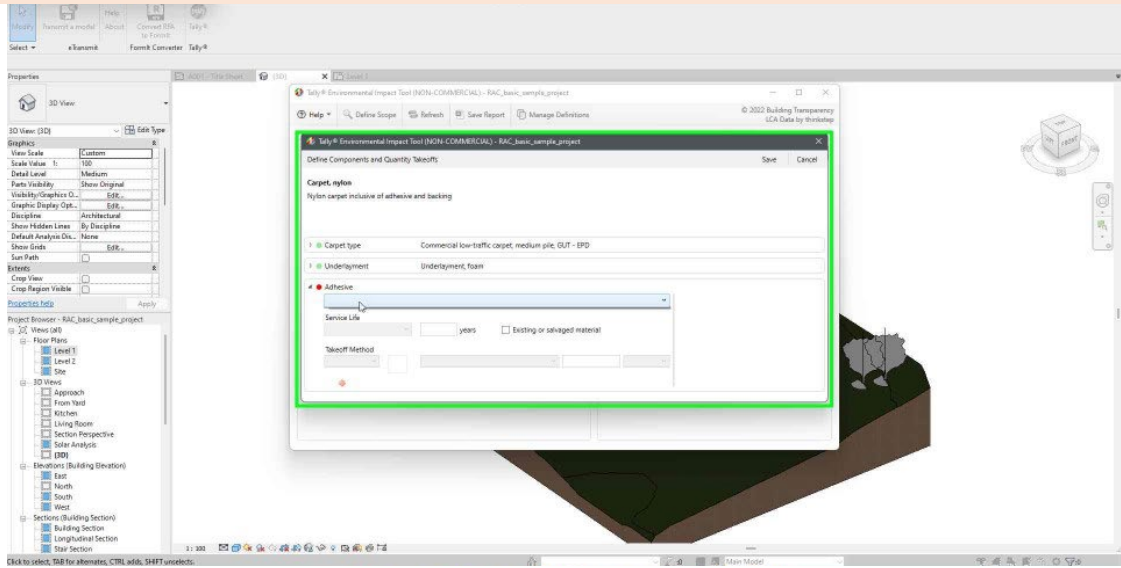


**Step 21:**  
User left click out to allow for default input



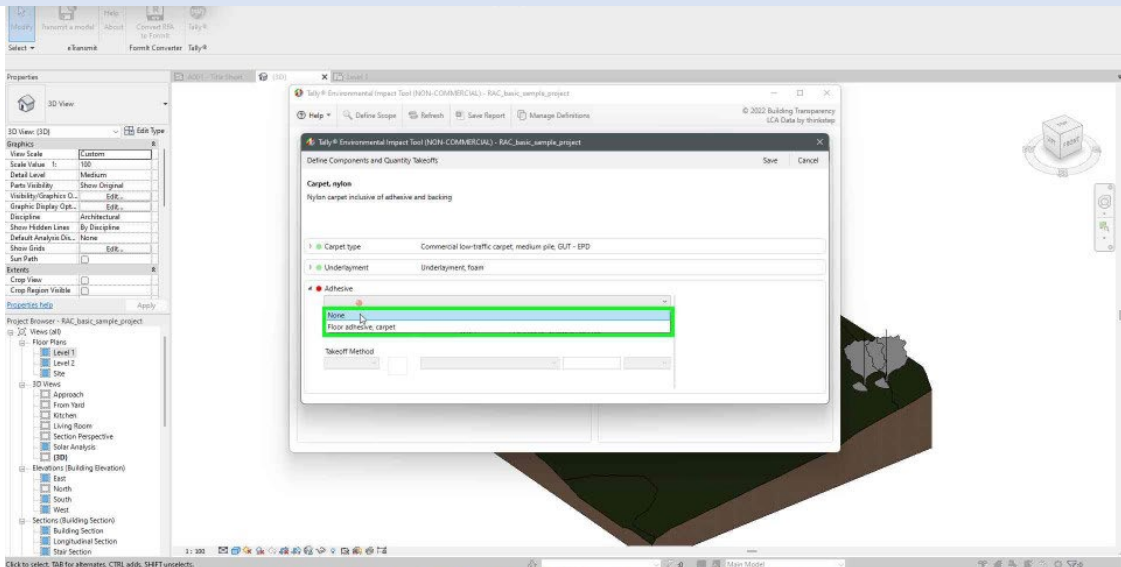
### Step 22:

User left click on the material definition drop down for "Adhesive"

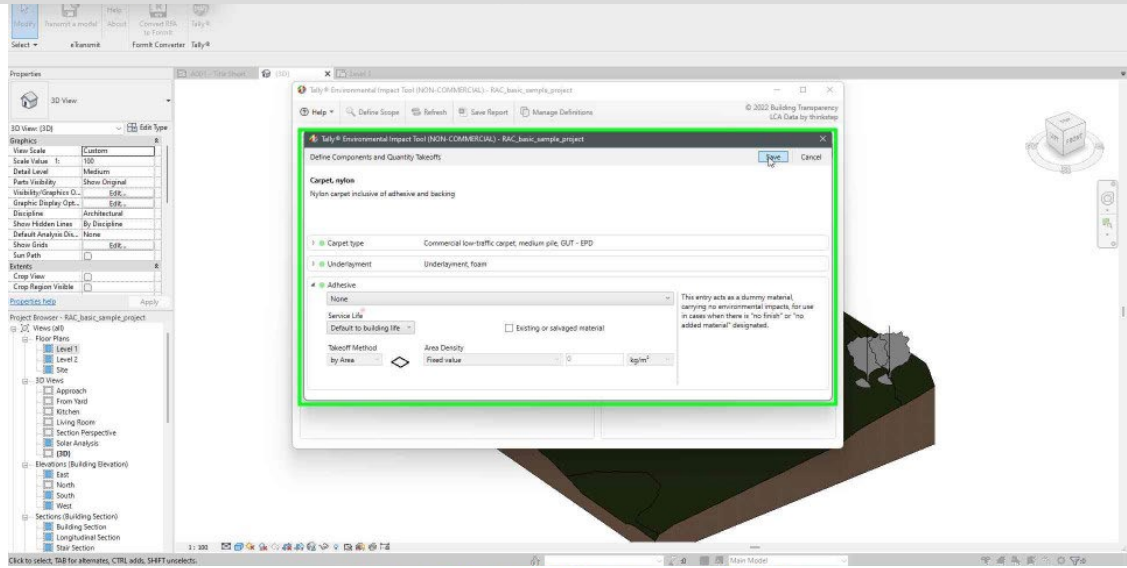


### Step 23:

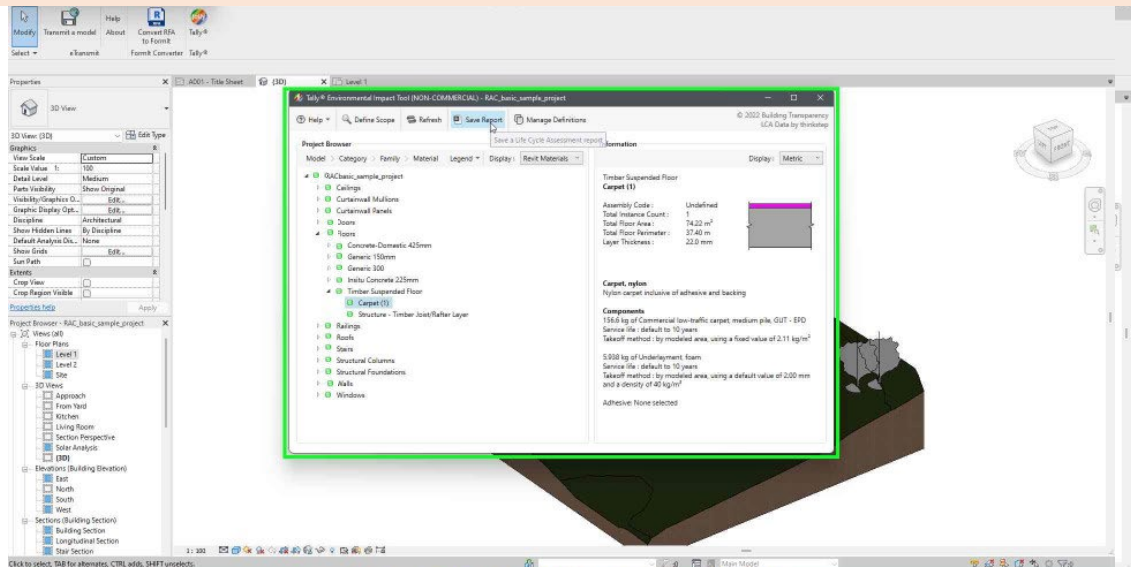
User left click on a specific material type



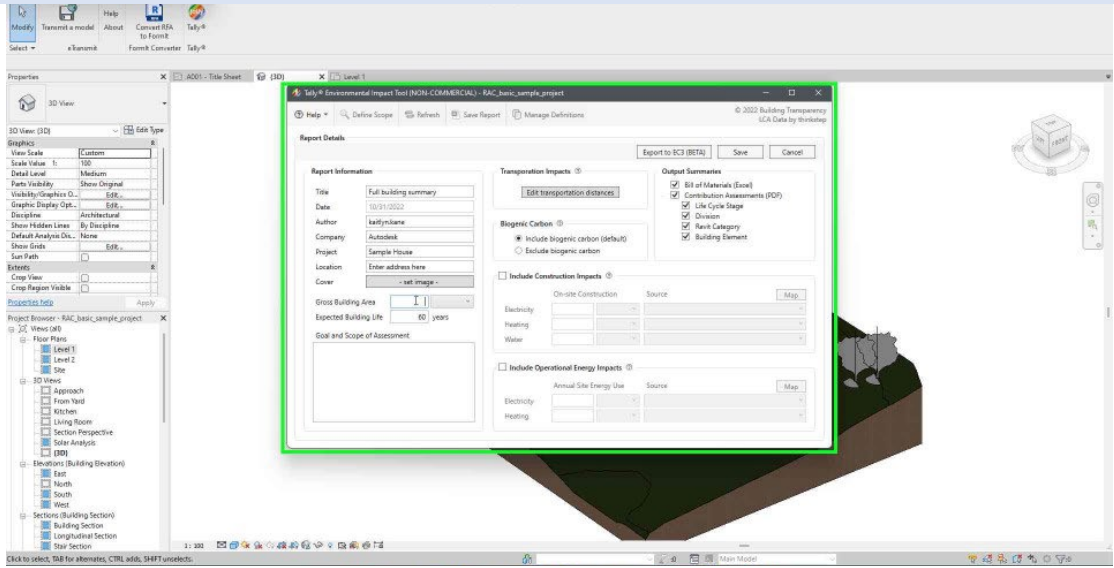
**Step 24:**  
User left click on "Save"



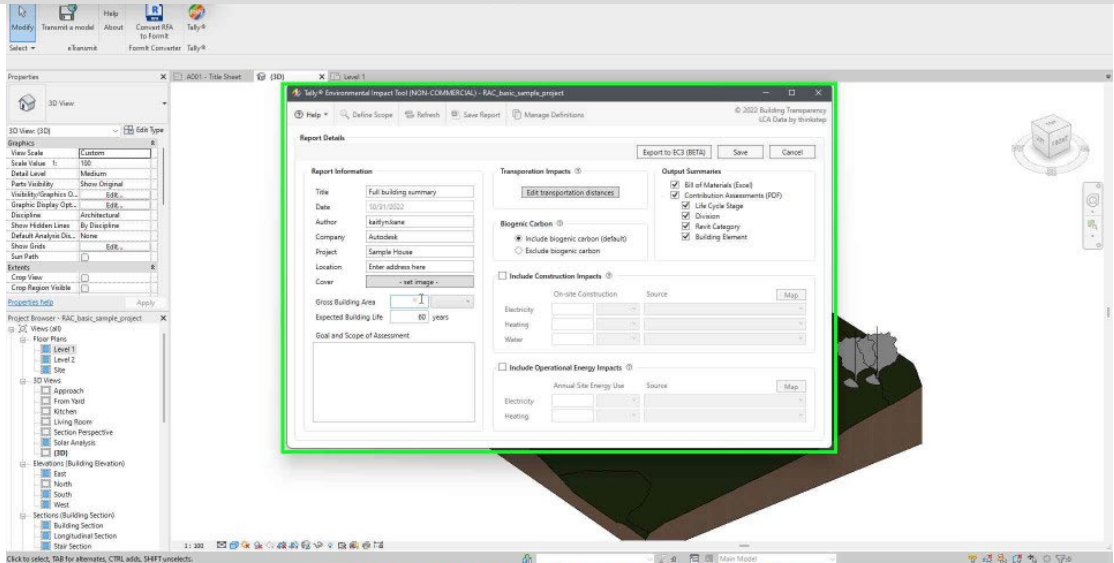
**Step 25:**  
User left click on "Save Report"



**Step 26:**  
User left click the box to the right of "Gross Building Area"

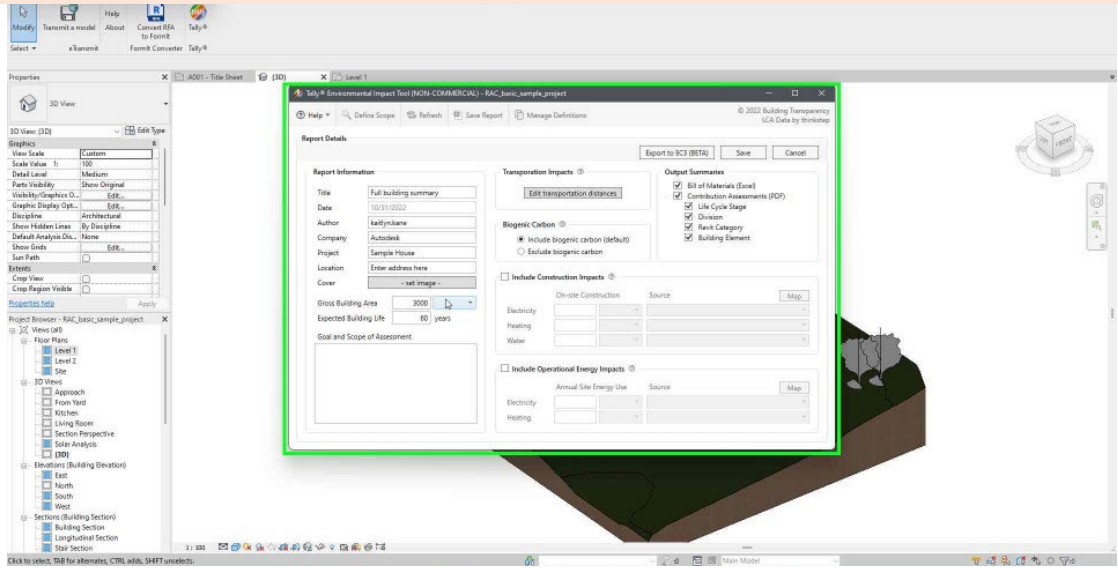


**Step 27:**  
Type the building area amount



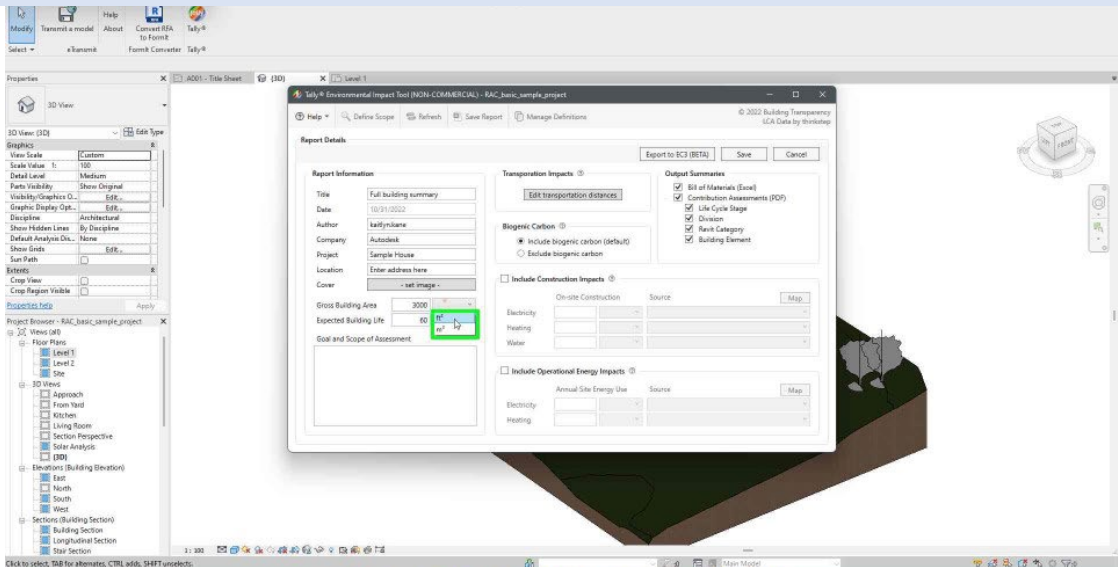
### Step 28:

User left click on the box to the right of the building area amount



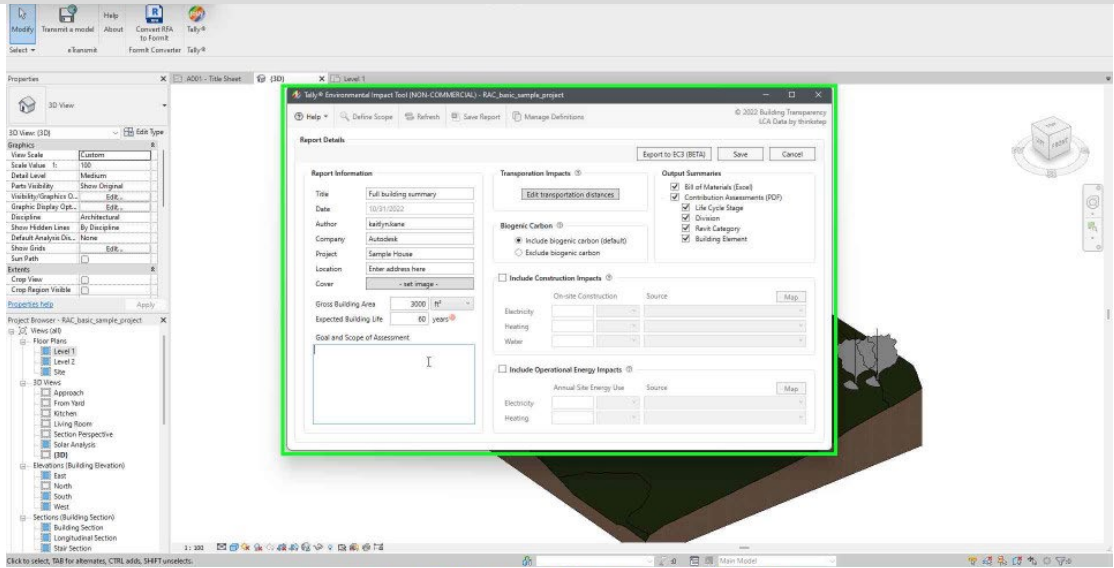
### Step 29:

User left click on the desired unit



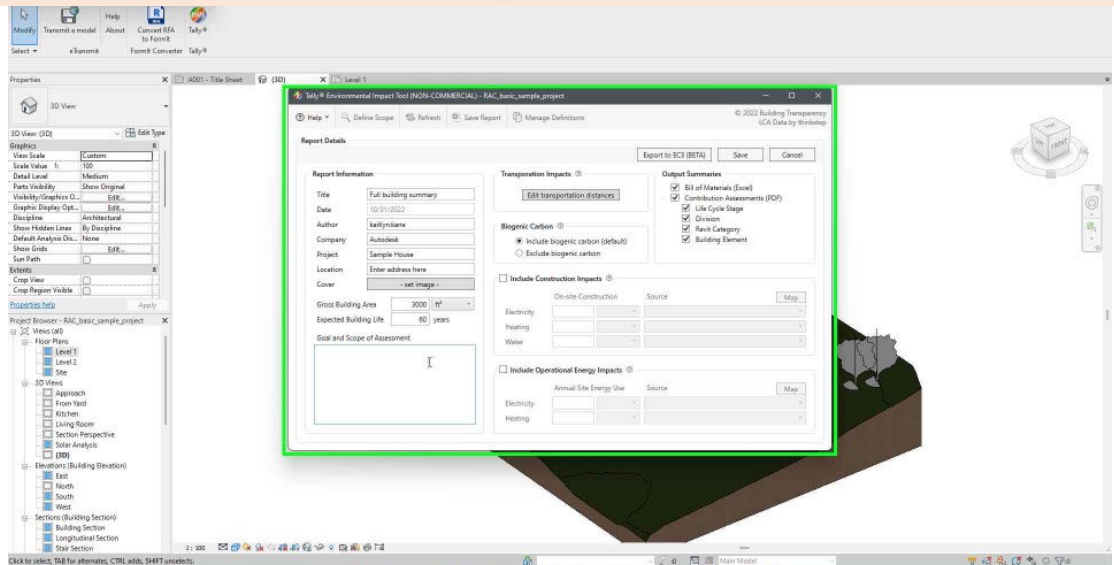
### Step 30:

User click on the box below "Goal and Scope of Assessment"



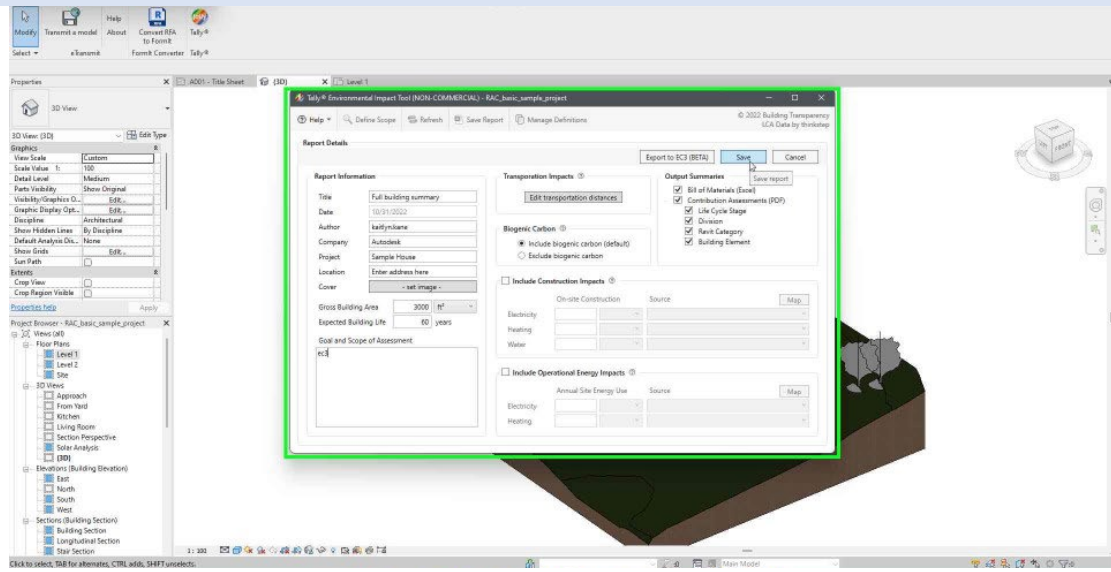
### Step 31:

Fill in "Goal and Scope of Assessment" box

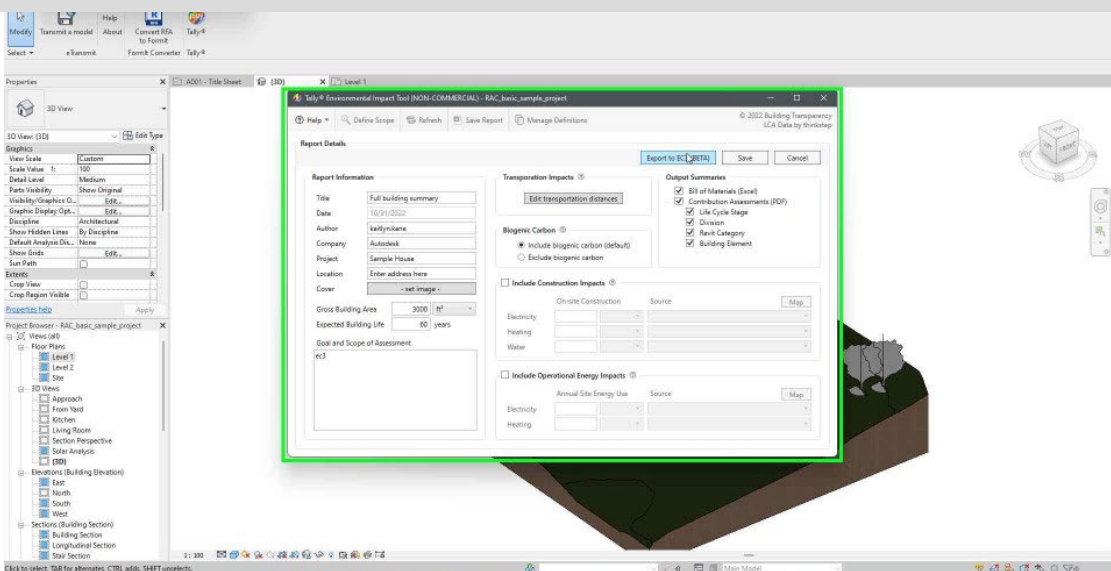




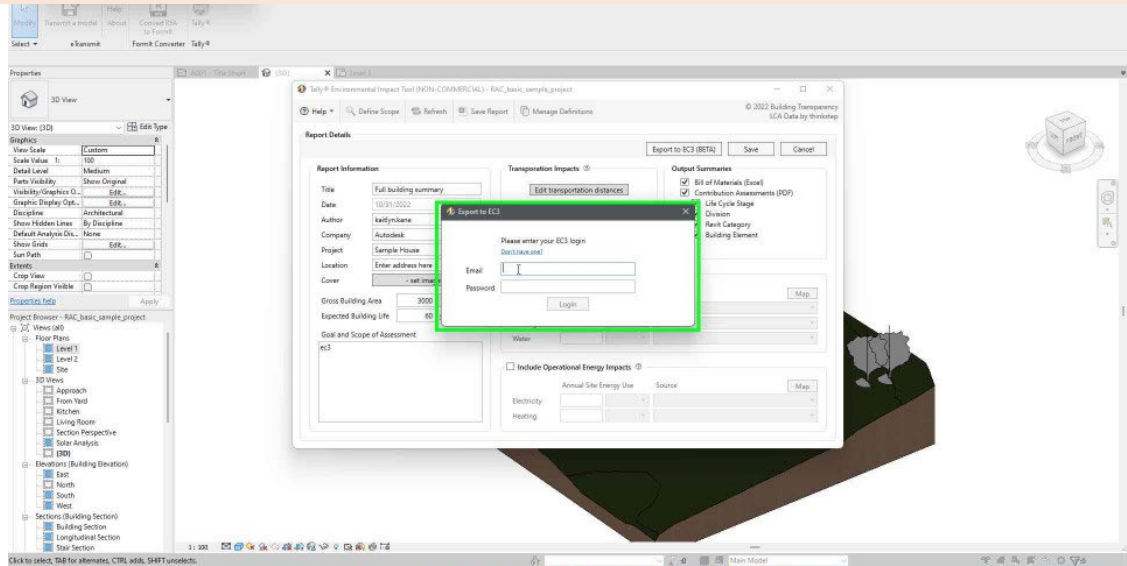
**Step 32:**  
Fill out any other information needed to define the project



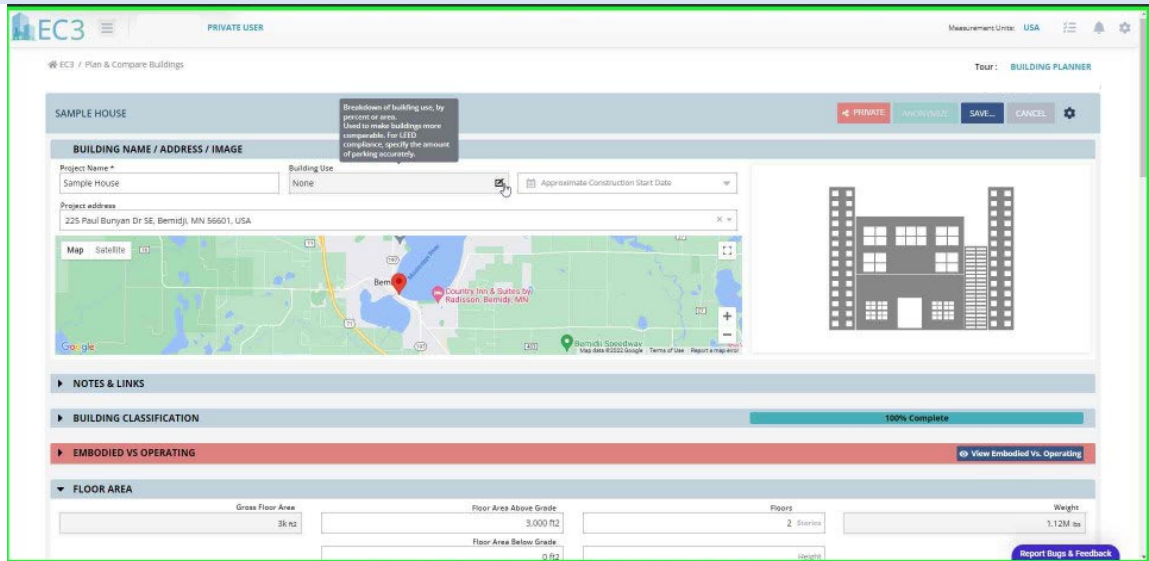
**Step 33:**  
User click on "Export to EC3 (BETA)"



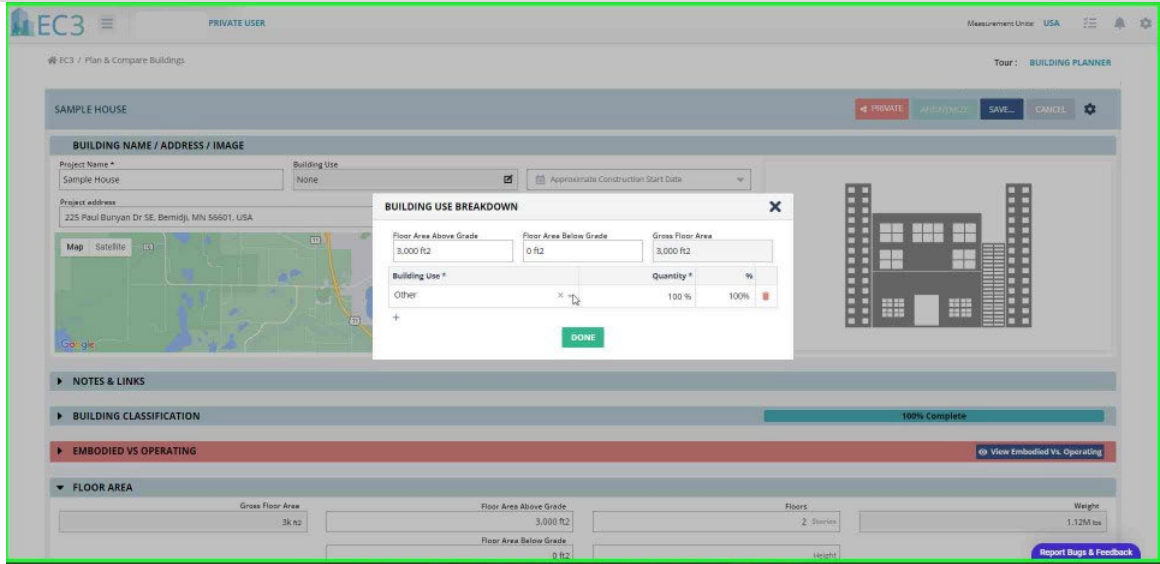
**Step 34:**  
Fill in EC3 account information



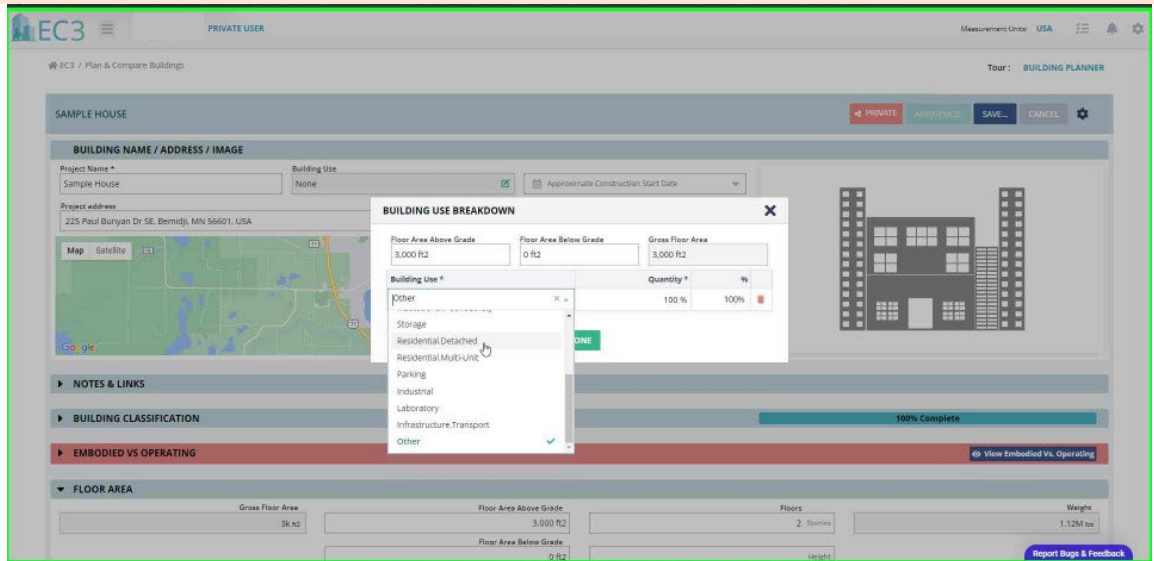
**Step 35:**  
User left click on "Building Use" drop down



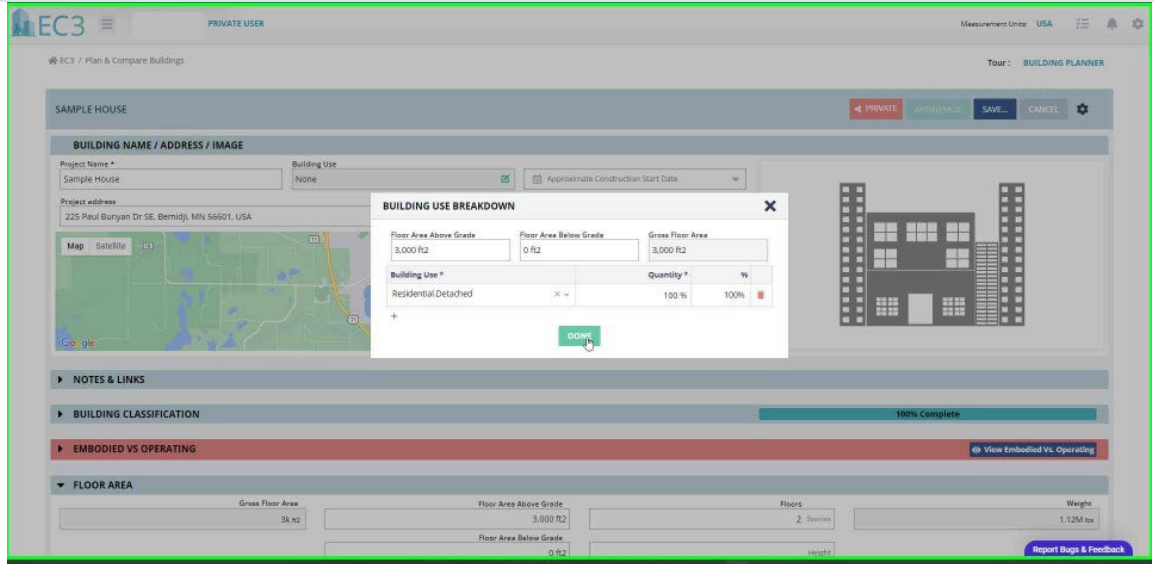
**Step 36:**  
User left click on "Building Use" drop down



**Step 37:**  
User left click on building use type



**Step 38:**  
User left click on "Done"

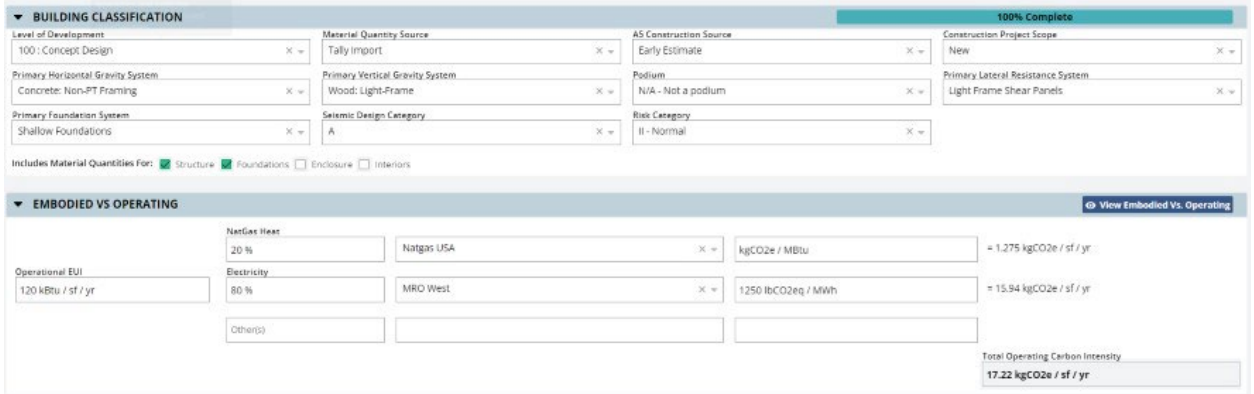


**Step 39:**

Select the drop down arrow for "Building Classification" and fill out additional building information

**Step 40:**

Select the drop down arrow for "Embodied vs Operating" and fill out information about the buildings EUI



**Step 41:**

Look at the bottom right of the "Embodied vs Operating" section to find the buildings Total Operating Carbon Intensity

**EMBODIED VS OPERATING** View Embodied Vs. Operating

Operational EUI 120 kBtu / sf / yr	NetGas Heat 20 %	Natgas USA	x	kgCO <sub>2</sub> e / MBtu	= 1.275 kgCO <sub>2</sub> e / sf / yr
	Electricity 80 %	MRO West	x	1250 lbCO <sub>2</sub> eq / MWh	= 15.94 kgCO <sub>2</sub> e / sf / yr
	Other(s)				

**Total Operating Carbon Intensity**  
**17.22 kgCO<sub>2</sub>e / sf / yr**

**Total Operating Carbon Intensity**  
**17.22 kgCO<sub>2</sub>e / sf / yr**

**Step 42:**

Select the drop down arrow for "Floor Area" and fill out additional building area information

**FLOOR AREA**

Gross Floor Area 3k ft <sup>2</sup>	Floor Area Above Grade 3,000 ft <sup>2</sup>	Floors 2 Stories	Weight 1.12M lbs
	Floor Area Below Grade 0 ft <sup>2</sup>	Height	

	Achievable	Realized	Conservative
<b>EC Building Intensity</b>	139 kgCO <sub>2</sub> e / ft <sup>2</sup>	369 kgCO <sub>2</sub> e / ft <sup>2</sup>	357 kgCO <sub>2</sub> e / ft <sup>2</sup>
<b>EC Building Total</b>	417k kgCO <sub>2</sub> e	1.11M kgCO <sub>2</sub> e	1.07M kgCO <sub>2</sub> e

### Step 43: Review emission outputs

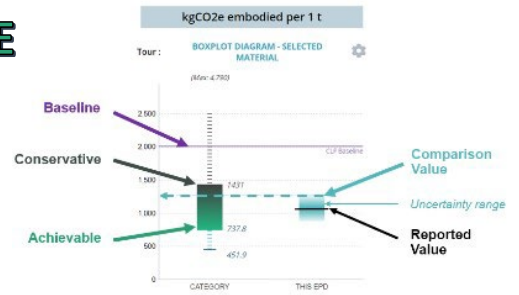
EC Building Intensity	Achievable	Realized	Conservative
	139 kgCO <sub>2</sub> e / ft <sup>2</sup>	369 kgCO <sub>2</sub> e / ft <sup>2</sup>	357 kgCO <sub>2</sub> e / ft <sup>2</sup>
EC Building Total	Achievable	Realized	Conservative
	417k kgCO <sub>2</sub> e	1.11M kgCO <sub>2</sub> e	1.07M kgCO <sub>2</sub> e

Achievable	139 kgCO <sub>2</sub> e / ft <sup>2</sup>
Achievable	417k kgCO <sub>2</sub> e
Realized	369 kgCO <sub>2</sub> e / ft <sup>2</sup>
Realized	1.11M kgCO <sub>2</sub> e
Conservative	357 kgCO <sub>2</sub> e / ft <sup>2</sup>
Conservative	1.07M kgCO <sub>2</sub> e

**ACHIEVABLE**

**REALIZED**

**CONSERVATIVE**

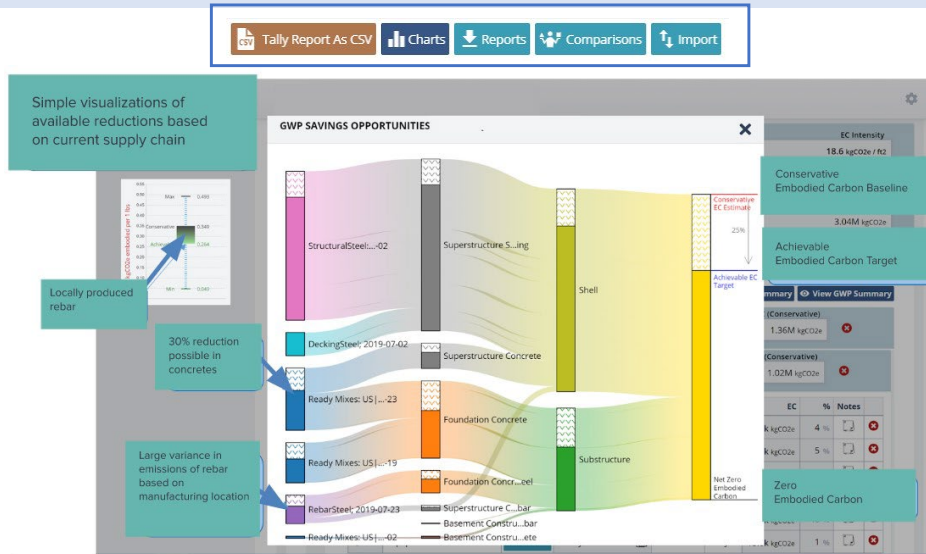


### Step 44: Scroll further down to review materials and their properties.

Material	Quantity	Unit	Collector	Detected	Realized	%
00 00 00 No Masterformat Code					2,814 kgCO <sub>2</sub> e	100%
Portland cement, PCA - EPD	2.2	t	Concrete Industry EPD		2,814 kgCO <sub>2</sub> e	100%
03 00 00 Concrete					1,004 kgCO <sub>2</sub> e	35%
22 21 00 Reinforcement Bars					1,004 kgCO <sub>2</sub> e	100%
Steel, reinforcing rod	304.1	t	RebarSteel		1,004 kgCO <sub>2</sub> e	100%
Steel, concrete reinforcing steel, CHC - EPD	0.22	t	RebarSteel		367 kgCO <sub>2</sub> e	36%
22 33 00 Cast-in-Place Concrete					14,114 kgCO <sub>2</sub> e	100%
Lightweight concrete, 2000 psi, 20% fly ash	88.7	m <sup>3</sup>	ReadyMix		14,114 kgCO <sub>2</sub> e	100%
Structural concrete, 4000 psi, 20% fly ash	16.6	m <sup>3</sup>	ReadyMix		11,236 kgCO <sub>2</sub> e	80%
Structural concrete, 6000 psi, 20% fly ash	4.5	m <sup>3</sup>	ReadyMix		2,744 kgCO <sub>2</sub> e	100%
04 00 00 METALS					115.8 kgCO <sub>2</sub> e	100%
Aluminum extrusion, painted, ACC - EPD	1.0	kg	Aluminum Industry EPD		115.8 kgCO <sub>2</sub> e	100%
06 00 00 Wood, Plastics & Composites					1,174 kgCO <sub>2</sub> e	100%
06 10 00 Rough Carpentry					1,174 kgCO <sub>2</sub> e	100%
06 11 00 Wood Framing					28.7 kgCO <sub>2</sub> e	2%
Domestic softwood, US, AWG - EPD	0.14	m <sup>3</sup>	WoodFraming Industry EPD		13.2 kgCO <sub>2</sub> e	46%
Walnut lumber, 2 inch	0.20	m <sup>3</sup>	WoodFraming		85 kgCO <sub>2</sub> e	100%
Walnut lumber, 1 inch	0.18	m <sup>3</sup>	WoodFraming		14.8 kgCO <sub>2</sub> e	100%
06 16 00 Sheathing					784 kgCO <sub>2</sub> e	100%
Oriented strandboard (OSB), AWG - EPD	2.4	m <sup>3</sup>	Sheathing/Fanels Industry EPD		784 kgCO <sub>2</sub> e	100%
06 17 00 Shop-Fabricated Structural Wood					262 kgCO <sub>2</sub> e	100%
26 17 33 Wood Joists					262 kgCO <sub>2</sub> e	100%
Composite wood joist, AWG - EPD	27.4	m	WoodJoist		262 kgCO <sub>2</sub> e	100%
07 00 00 Thermal and Moisture					1,276 kgCO <sub>2</sub> e	100%

### Step 45:

At the top of the materials list, click on the different colored tabs to access many different charts and report information



**Review and analyze EC3 data to find out individual material information and emissions along with total building emissions.**

**Use this information to obtain carbon emissions to set a new goal for improvement.**

**Visit**

**<https://www.buildingtransparency.org/ec3/resources/ec3-user-guide/> for more guidance in EC3 Tool**