SimulEICon Multi-Objective Decision-Support Tool for Autodesk Revit 2012

Table of Contents

[Aim of This Document 3](#_Toc373312477)

[Installation 3](#_Toc373312478)

[What’s Included? 3](#_Toc373312479)

[Locations 3](#_Toc373312480)

[Windows 7 3](#_Toc373312481)

[Windows XP 3](#_Toc373312482)

[Installing the Add-in 3](#_Toc373312483)

[Using the SimulEICon Add-In 4](#_Toc373312484)

[Startup 5](#_Toc373312485)

[Selecting the Database File 6](#_Toc373312486)

[Viewing Previous Results 6](#_Toc373312487)

[Defining Component and Precedence Files for Optimization 8](#_Toc373312488)

[Creating the Component File 8](#_Toc373312489)

[Selecting Components from the BIM Model 8](#_Toc373312490)

[Adding Components from the Model into the Component File 9](#_Toc373312491)

[Combining Components from the Model 10](#_Toc373312492)

[Adding a Component Not Available in the Model 11](#_Toc373312493)

[Removing a Defined Component 12](#_Toc373312494)

[Selecting Options for the Component File 12](#_Toc373312495)

[Removing Selected Options 14](#_Toc373312496)

[Creating a New Assembly Option 14](#_Toc373312497)

[Creating the Precedence File 14](#_Toc373312498)

[Ordering Components 15](#_Toc373312499)

[Components in Parallel 16](#_Toc373312500)

[Running NSGA-II Optimization 17](#_Toc373312501)

[Adding EnergyPlus Simulation Results 19](#_Toc373312502)

# Aim of This Document

This document contains information on the purpose and usage of the ***SimulEICon Multi-Objective Decision-Support Tool*** add-in for Autodesk Revit. This software is an active prototype, so it is likely to contain bugs. Changes in functionality are to be expected as well. For more information or contact info, please visit <http://web.eng.fiu.edu/~zhuy/BESI/Research/tcei.html>

# Installation

## What’s Included?

You can download a zip file from <http://web.eng.fiu.edu/~zhuy/BESI/Research/tcei.html>. It contains the following important files:

* Add-in manifest file
* Add-in DLL file
* NSGAII executable
* SimulEICon Access database file

## Locations

In order to use the add-in, you will need to move certain files into an appropriate location. Below, example Revit Add-in locations are given for different Windows versions.

### Windows 7

* “C:\ProgramData\Autodesk\Revit\Addins\2012\”

### Windows XP

* “C:\Documents and Settings\All Users\Application Data\Autodesk\Revit\Addins\2012\”

## Installing the Add-in

1. Extract the zip archive (downloadable at <http://web.eng.fiu.edu/~zhuy/BESI/Research/tcei.html>).
2. Place the Add-in DLL file in the desired directory (e.g. “C:\Program Files\Autodesk\”)
3. The “NSGA2” directory, which contains the NSGAII.exe and other necessary DLLs, should be in the same directory as the Add-in DLL (e.g. “C:\Program Files\Autodesk\NSGA2”).
4. Edit the Add-in manifest file to point to the Add-in DLL location. (See )
   1. Set the both **<Assembly>** tag values to the path to the DLL file chosen in the previous step.
5. Place the Add-in manifest file in the appropriate location. (See section)



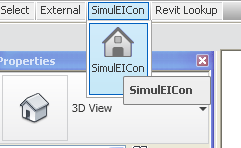
Figure

# Using the SimulEICon Add-In

Once installed, the SimulEICon add-in will be available from the Add-Ins tab of the ribbon. Figure 2 shows the tab within the ribbon. shows the SimulEICon button available within the Add-ins tab choices. **Note:** At this time, in order to select the SimulEICon button, a Revit model must be open. While viewing previous results does not require a model, using any other functionality does.

revit2012_ribbon.png

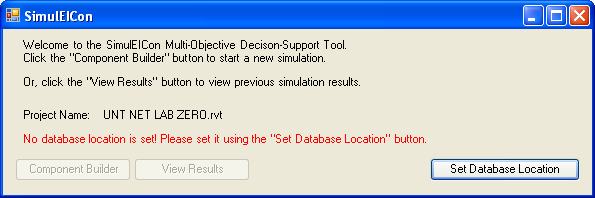
Figure



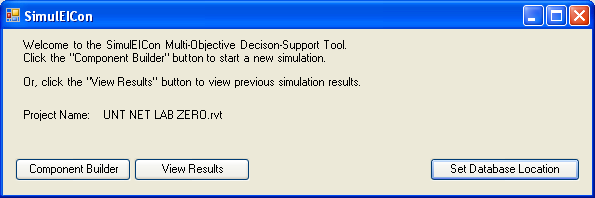
Figure

## Startup

The main window of the Add-in displays the current model name and allows users to view previous simulation results, or begin using the primary functionality. and show the main window.



Figure



Figure

## Selecting the Database File

In order to use SimulEICon, the user must specify the location of the database containing material and assembly information. This database is used in providing options and calculating the cost, environmental impact, and duration needed for different materials and assemblies.

When started, the SimulEICon add-in will search for a known database. If one is not found, the main functionality will be disabled until the user specifies a database file.

To specify a database file:

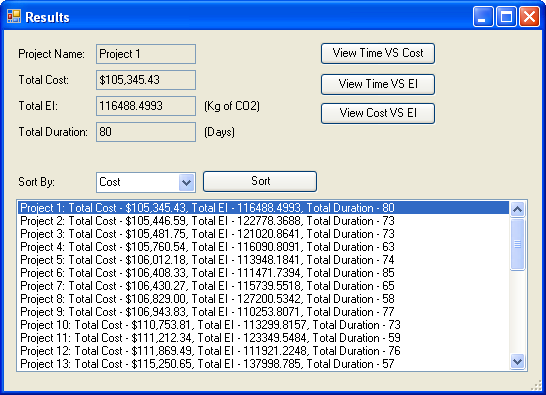
1. Open the SimulEICon add-in.
2. Select the “Set Database Location” button.
3. Choose an appropriate MS Access database file.

Once a database file has been chosen, it should persist throughout the use of the Add-in. It can be changed by using the “Set Database Location” button again.

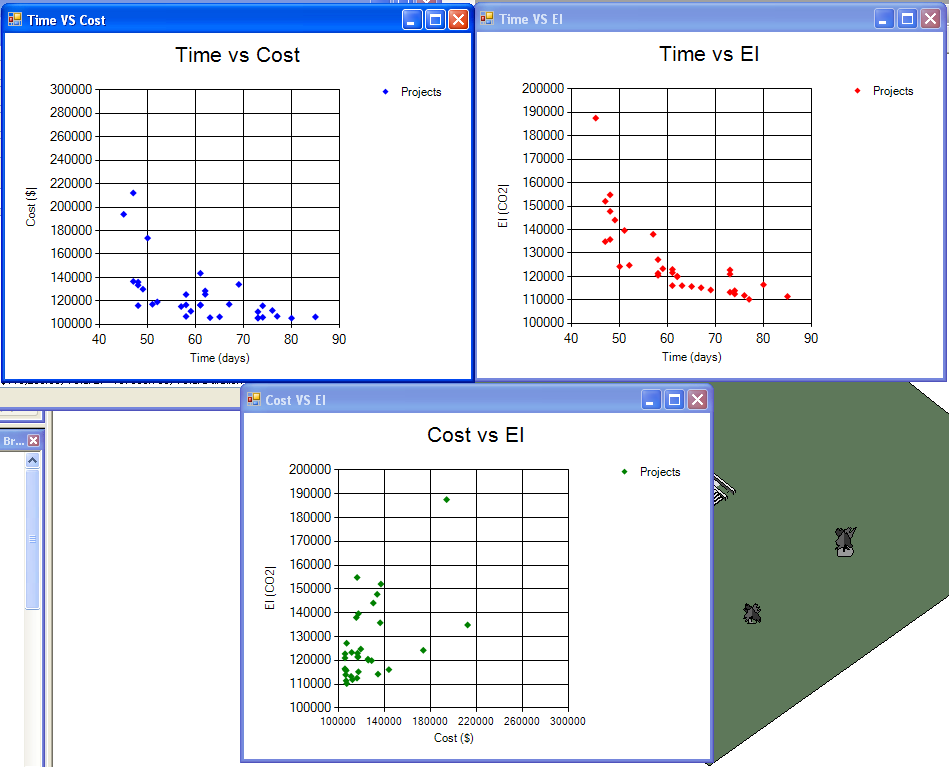
## Viewing Previous Results

To view previous simulation results, click on the “View Results” button in the main window. The user will be prompted for a results file, which is in the XML file format. Once selected, you may view the list of the resulting projects from the simulation. Figure # shows an example set of results.

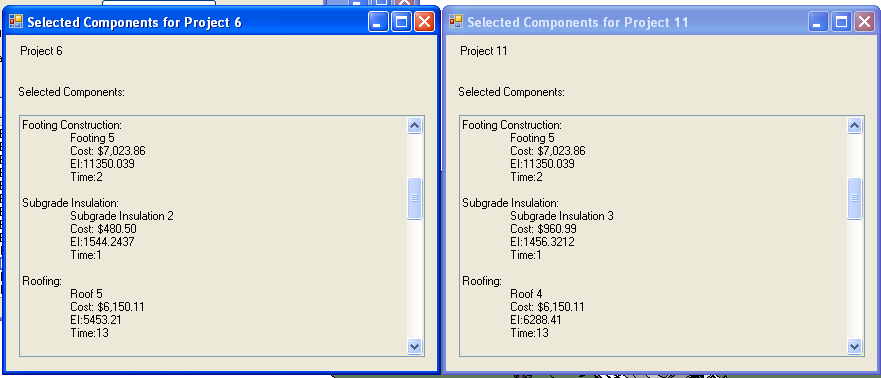
Selecting a single project will display basic information about it, including its name and estimated objective values. Listed projects can also be sorted in ascending order based on one of three objectives: time, cost, or environmental impact (EI). Users can also view scatter plot graphs comparing the different objectives. Figure # shows the different graphs available. Finally, users can open each project to see what components were selected for them, shown in Figure #.



Figure



Figure



Figure

## Defining Component and Precedence Files for Optimization

SimulEICon attempts to find a set of solutions that optimize three objectives: time, cost, and EI. Valid solutions are “balanced”, meaning that no one solution completely beats out another in all three objectives. The objectives in this case aim to be minimized. The lower the time, cost, and environmental impacts are, the more optimal the solution. The NSGA-II[[1]](#footnote-2) is currently used to solve this multi-objective optimization problem.

In order to use the NSGA-II algorithm, two primary files require definition by the user. The first contains a set of components (or activities) based on the selected BIM model. For each component, one or more options may be selected. Each option contains information about itself, including estimated time, cost and EI. The second file contains the precedence order of the defined components. This is similar to a project schedule. It is used to help calculate the total duration of a project (one of the objectives) based on the time needed for each individual component.

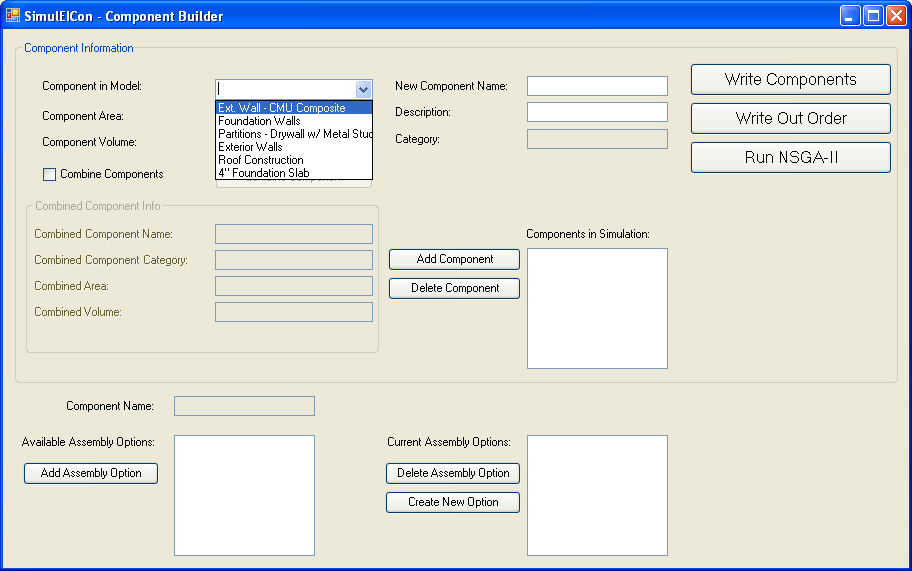
A third, optional file may also be specified by the user. This file is used to incorporate EnergyPlus[[2]](#footnote-3) energy simulation data into cost and EI calculations for projects. If this file is included, it is assumed that energy simulation data already exists and can be referenced.

The following sections give details on the functionalities available to help users define these files.

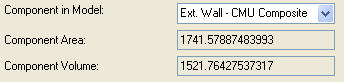
### Creating the Component File

#### Selecting Components from the BIM Model

From the main window, users can select the “Component Builder” button. This will bring up the Component Builder window. It is here that uses will be able to define component and precedence files using data retrieved from the underlying BIM model. As seen in Figure #, wall, flooring, and roofing data are extracted from the BIM model, and made available in a list of components from the model. Once a component is selected from the model, its area and volume are displayed, as seen in Figure #.



Figure



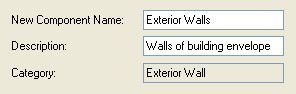
Figure

#### Adding Components from the Model into the Component File

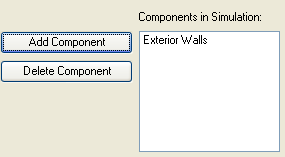
Once a user has decided a component from the model should be included in a simulation, he or she must include that component in a list of components that will be inserted into the Component File. When doing so, a name must be given to the component (see Figure #). It does not have to be the same as the name of the component from the Model. If a component is selected from the model, a category may appear. Many components within a BIM model have categories in Revit. These categories are currently used by the add-in to retrieve available options from an external data source. When completed, the new component will be listed as seen in Figure #.

To add a component from the model to the list of components used in the simulation:

1. Select a component from the model.
2. Enter a name that will be used for this component in the Component File.
3. Optionally enter a description.
4. Click the “Add Component” button.



Figure



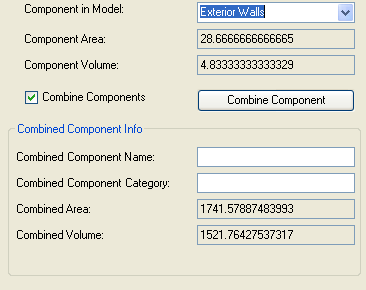
Figure

#### Combining Components from the Model

It is also possible to combine multiple components from the model into one component for use in the Component File. The combined area and volume is the sum of the individual component areas and volumes. Once combined, the new component can be named and given a category (see Figure #), and finally added to the list of components in the Component File.

To combine components from the model and then add them to the simulation:

1. Check the “Combine Components” checkbox.
2. Select a component from the model.
3. Click the “Combine Component” button.
4. Repeat 2 – 3 until desired components are combined.
5. Enter a component name for the combined components.
6. Enter a category for the combined components.
7. Click the “Add Component” button.

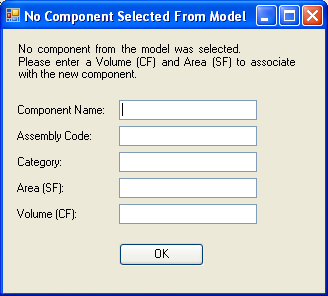


Figure

#### Adding a Component Not Available in the Model

Components that will exist in the Simulation are supposed to be functionally equivalent to activities in a project. However, certain activities may not have a representation in a BIM model. For example: site preparation work may need to be considered in a project, but has no component in the model to select as a reference. If, for whatever reason, a component in the model is not accurate, the user can define a correct version and use it as a reference instead. To handle this and other cases, users may define components that do not exist in the model for use in the simulation. Several pieces of information are required to define a new component (See Figure #).

A component name, assembly code, and category, along with the total area and volume must be given. This information is automatically extracted from components within the BIM model. The category is used to select alternative options for use in the simulation. The assembly code is used to merge individual elements in the BIM model into single components (**NOTE**: This may need to change to allow more flexible schedules.).



Figure

#### Removing a Defined Component

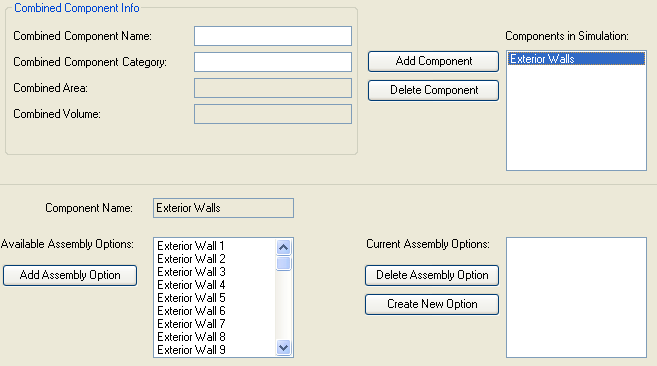
To delete a defined component (i.e. not include it in the component file creation):

1. Select the component from the “Components in Simulation” list.
2. Click the “Delete Component” button.

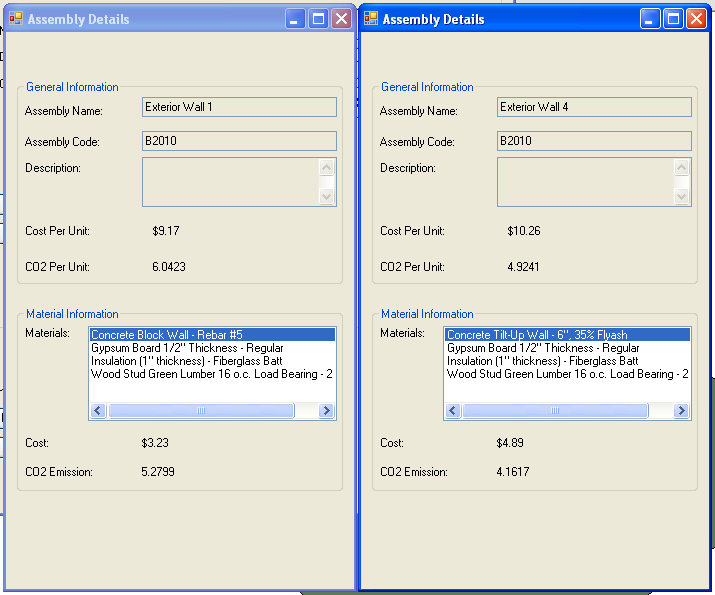
#### Selecting Options for the Component File

Once an item has been added to the list, “Components in Simulation”, it can have multiple options associated with it. These options are used during optimization as alternatives for the different the components. Currently, options for a selected component are retrieved based on the general category of the component. For example, in Figure #, the new component “Exterior Walls” has the category “Exterior Wall”. This means when that component is selected, options that have the same category will be retrieved from the database.

Available options are loaded into the “Available Assembly Option” list. Once there, any option can be double clicked to view details about it, including materials, costs, and EI (see Figure #). Users may select any desired options, and click the “Add Assembly Option” button to include the selected option in the lists of alternatives for the selected component shown in the “Component Name” text box (see Figure #). Once an option has been added, it will be visible in the “Current Assembly Options” list (see Figure #).



Figure

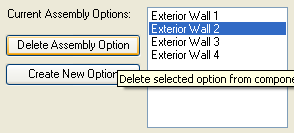


Figure

#### Removing Selected Options

Users may decide they no longer want associate an option with a component. Any options currently associated with a component can be removed. As with the available options list, more information can be viewed by double-clicking on an option. They can be removed by doing the following:

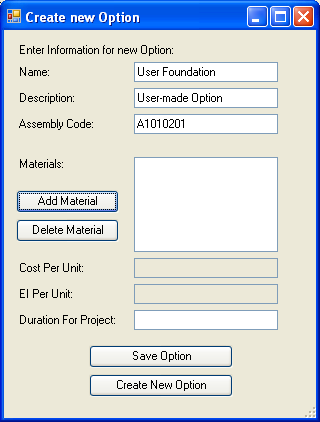
1. Select an option from the “Current Assembly Options” list.
2. Double click option for more information, if desired.
3. Click “Delete Assembly Option” button.



Figure

#### Creating a New Assembly Option

Due to the time constraint of this project, it is very possible options that are interesting to users will not be available in the current database. With this in mind, if users do not find the options they want to use for a component, they may make their own.

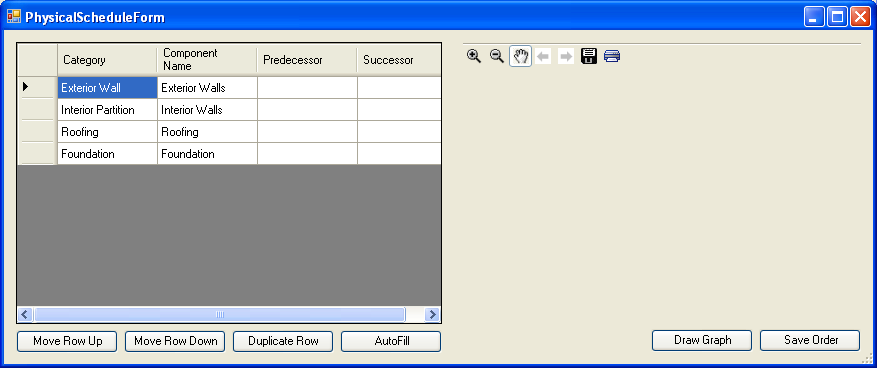


Figure

*MORE COMING SOON…*

### Creating the Precedence File

The precedence file represents the order in which components of the project are built. It is essentially the project schedule. In order to estimate the duration of an entire project, the order of construction must be known. Every component must know which component comes before it (predecessor) and after it (successor). Figure # shows the Precedence Order Definition Form in its initial state.

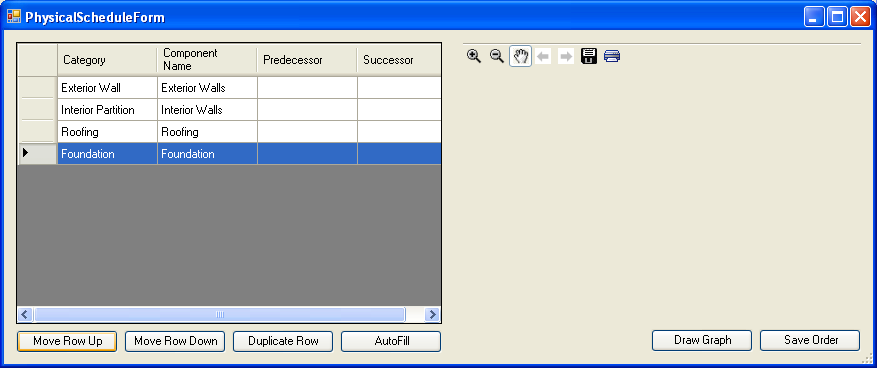


Figure

#### Ordering Components

The simplest ordering possible is a linear one. Each component is preceded by another (except the first), and followed by another (except the last). This may require a reordering of the components (see Figure #). To do this:

1. Select a row by clicking the side left side of the grid (beige cell)
2. Click the “Move Row Up” or “Move Row Down” button.
3. Continue to move follow 1 – 2 until rows are in desired order.

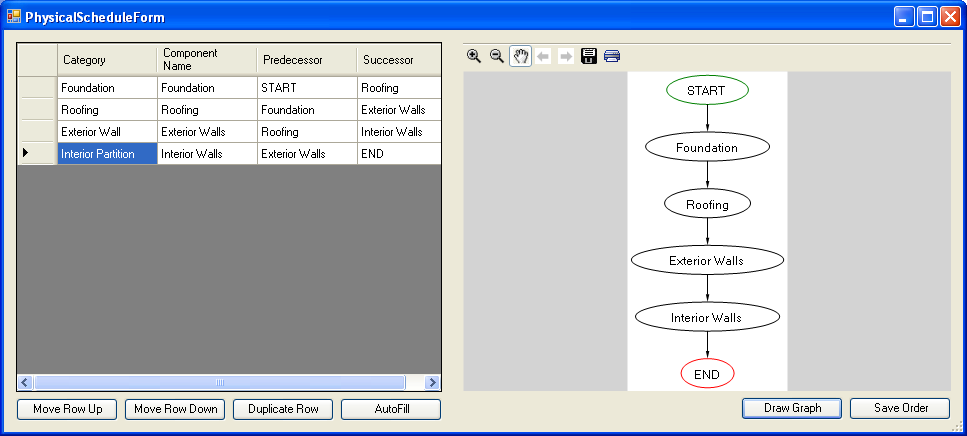


Figure

Once, the components are in a desired order, they must have their predecessors and successors defined. If the user clicks the “AutoFill” button, SimulEICon will attempt to correctly fill this information in. It can be changed by the user if it is not correct.

* The predecessor of the first component should be “START”.
* The successor of the last component should be “END”.

Finally, the user can view a graph representation of the order by clicking the “Draw Graph” button (see Figure #). When finished, the user can save the precedence order to a file for use in optimization.



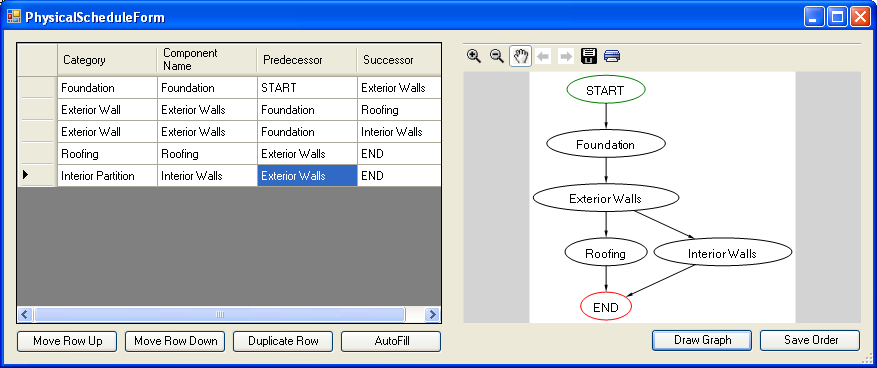
Figure

To save the precedence order:

1. Place components in desired order.
2. Define predecessors and successors.
3. Click “Save Order” button.

#### Components in Parallel

In many cases, components (or activities) may be worked on in parallel. In order to facilitate this, users may duplicate rows and adjust predecessors and successors. Figure # shows the results of duplicating a row and changing some predecessors and successors to create parallel components.



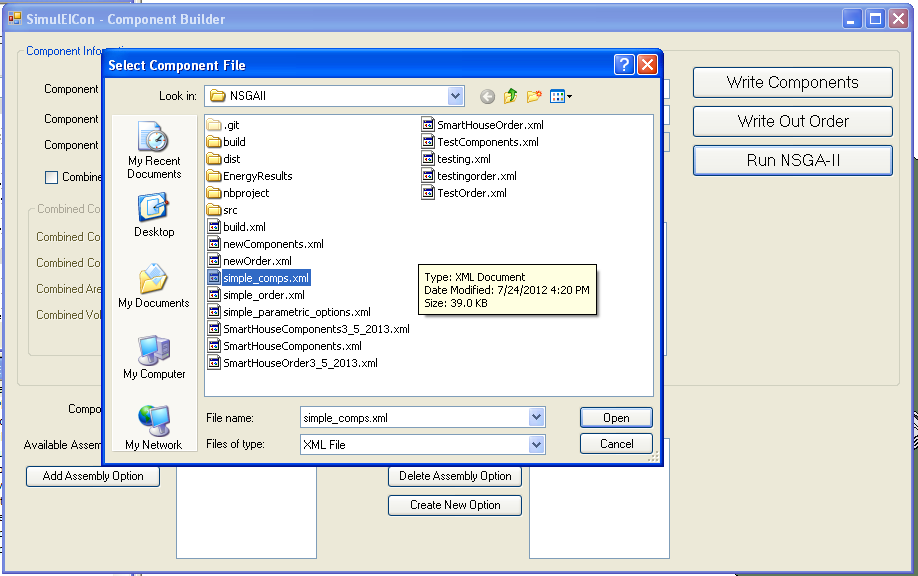
Figure

## Running NSGA-II Optimization

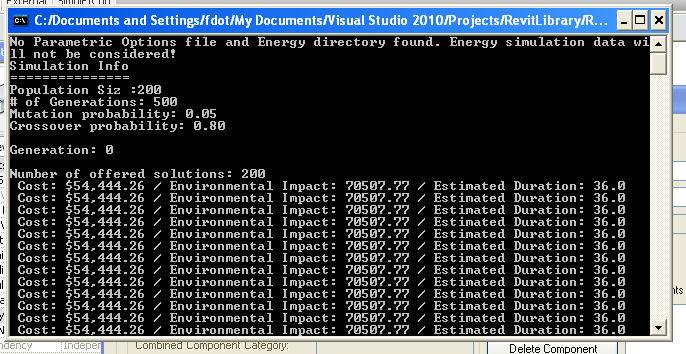
The NSGA-II optimization algorithm requires two primary input files: a component file and a precedence order file. Once these files have been defined, the user can run the optimization algorithm by:

1. Clicking “Run NSGA-II” button.
2. Selecting the desired component file.
3. Selecting the desired order file.
4. Selecting the desired output directory.

Once it has finished running, the results will be in the selected output location. To view the results see the section.



Figure



Figure

### Adding EnergyPlus Simulation Results

It is also possible to include EnergyPlus simulation data during the NSGA-II optimization. This means data from previously run energy simulations will be used during the calculation of the cost and environmental impact. To do this:

1. Click the “Run NSGA-II” button.
2. Select the desired component file.
3. Select the desired order file.
4. Select the desired Parametric Options files (for more info, see the *IDF Generator Manual*)
5. Select the directory containing the EnergyPlus simulation results.
6. Select the desired output directory.

1. For more information on NSGA-II, please see: <http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=996017> . [↑](#footnote-ref-2)
2. Visit [here](http://apps1.eere.energy.gov/buildings/energyplus/?utm_source=EnergyPlus&utm_medium=redirect&utm_campaign=EnergyPlus%2Bredirect%2B1) for information about EnergyPlus. [↑](#footnote-ref-3)