User's Manual for Optimizer Suite

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Overview

The NYSERDA Optimizer Suite is a planning tool designed to help hospitals select and schedule infrastructure projects to meet financial, environmental, and regulatory goals, especially Local Law 97 (LL97).

By inputting detailed project data (costs, durations, lifetimes, and emission impacts), the tool uses advanced optimization algorithms to recommend the best combination and sequencing of projects. It outputs which projects to start over a multi-year horizon and in what order, ensuring alignment with user-defined objectives and penalties (for emissions, risk, or other criteria). Users can also perform scenario analyses and evaluate financial metrics like net present value.

The suite offers three tool levels:

1. Tool 1 (Basic): Hospital Score Optimizer
2. Tool 2 (Decarb): Sustainable Project Scheduler
    a. LL97 Version: Minimize LL97 fines and cost
    b. Decarb Goal Version: Meet emission targets at minimal cost
3. Tool 3 (Advanced): General Criteria Optimizer

Optimization Suite Documentation

Basic Tool

Overview

The Basic Tool serves as a strategic planner that produces an optimal portfolio and project schedule, maximizing total project scores while satisfying relevant constraints. The score is defined by each hospital to reflect its unique priorities, combining multiple performance metrics, such as carbon reduction, resilience, financial impact, and other hospital-specific criteria (scoring details are discussed later). By selecting which projects to start and when, the tool ensures that annual capacity limits and budgets are respected, mandatory projects are completed on time, and prerequisites are considered (i.e. if project A must be completed before project B can be started). The result is a schedule that prioritizes the projects most beneficial to a hospital's own goals, and will be written on the corresponding spreadsheets.

Inputs

Before running the tool, make a copy of the empty (i.e. none of the input or output fields are populated by numbers) "NYSERDA_Tool_Basic-Master.xlsx" spreadsheet, and give it a unique file name (e.g. "`NYSERDA_Tool_Basic`"). Each time you run the tool, you should go back to the original master file, copy it, and give the copy a unique file name. Prepare the inputs in your copied spreadsheet by filling in all required fields on the **Planning** and **Projects Info** sheets. Optionally one can also add project names or notes in the **Projects Index** sheet. The following bullets list the required information for the spreadsheet:

- **Planning:**
  - **Interest Rate:** The rate used to account for the time value of money (default set to 3%).
  - **Number of Years**: The number of years over which projects are scheduled (up to a maximum of 25). By default, it's auto counted as the number of years with a non-empty budget in the **Annual Budget** row.
  - **Number of Projects:** The total count of projects available for selection, automatically set to the number of the projects with cost inputted in **Cost** column on **Projects Info**.
  - **Start Year:** The first year in the planning horizon.
  - **Note**: A free text field provided for adding any side notes or contextual comments about the scenario.
  - **Annual Project Capacity:** The maximum number of projects that can be undertaken in parallel each year within the planning horizon, reflecting hospital's real-world project-management bandwidth (for example, the total number of project managers or implementation teams available).
    - Simply leave any unused year columns blank.

- **Annual Budget:** The financial limit for each year within the planning period, specifying how much can be allocated annually.
    - Simply leave any unused year columns blank.



Interest Rate (%)	3.0	Number of Years	5	Number of Proje	40	Start Year	2025		Note	

Year	2025-2026	2026-2027	2027-2028	2028-2029	2029-2030	2030-2031	2031-2032	2032-2033	2033-2034	2034-2035	2035-2036	2036-2037	2037-2038	2038-2039
Annual Capacity of Projects to Take	5	5	5	5	5									
Annual Budget	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000									
Annual Number of Ongoing Projects														
Annual Total Cost														
Total Score of Selected Projects														
	Start in 2025	Start in 2026	Start in 2027	Start in 2028	Start in 2029	Start in 2030	Start in 2031	Start in 2032	Start in 2033	Start in 2034	Start in 2035	Start in 2036	Start in 2037	Start in 2038

- **Projects Info:**
    - **Cost:** The net upfront investment required for each project after subtracting any external funding.
        - *Example*: A project has a total implementation cost of $200,000 and receives a $150,000 grant. You would enter its cost as $50,000.
    - **Score:** Composite values representing each project's priority or benefit, by weighting a set of customized criteria and/or using the first decision-making matrix tool.
        - Users are free to define project scores however they choose; the tool will accept these scores as inputs and compute the schedule that maximizes the sum of scores over the planning horizon.
        - Please see details of calculation in Appendix (Score Calculation).
    - **Duration:** Years required to complete each project.
    - **Lifetime:** Years of expected useful lifespan of a completed project.
        - The period over which the project continues to deliver its intended benefits before major maintenance or replacement is required.
    - **Mandatory Deadline:** Indicates year by which a project must be completed (if there is such a requirement for that project).
        - A value of 0 means the project has no mandatory deadline.
            - If there is no mandatory deadline a 0 must be written or the tool will give an error.
        - Any positive value sets the latest allowed completion year for the project (e.g. 3 means by the end of third year in planning horizon).
        - Deadline values cannot exceed the total length of the planning horizon.
    - **Prerequisites:** The tool enforces that a project with prerequisites only starts after all listed parent projects are complete.
        - Prerequisites are entered as a comma-separated list under the Prerequisites column (e.g. "1,3,5").
        - Example: If Project 2 has "1,4" listed as its prerequisites, Project 2 cannot start until Projects 1 and 4 are both finished.
        - If a project has no prerequisites this field should be left blank
    - Values in **Scheduled** will be populated as an output after running the tool.

Project	Cost	Score	Duration	Lifetime	Mandatory Deadline	Pre-requisites	Scheduled
1	199,500	512	1	1	0		
2	204,200	294	1	2	0	1,4	
3	198,700	820	1	1	0		
4	202,100	172	1	1	1		
5	205,800	670	2	2	0		

- **Projects Index (Optional):**
  - **Name:** A descriptive title for each project.
  - **Note:** A free text field for any side notes or contextual comments about the project.

Project	Name	Note
1		
2		

Optimization Logic

The tool's objective is to maximize the total discounted score over the entire planning horizon (in each year summing the scores of all projects that have finished their implementation and are still within their useful life) over all possible construction schedules, while satisfying the necessary constraints.

- **Annual Score Calculation:** For each year in the horizon, the tool adds scores of all projects that have finished their implementation and are still within their useful life.
  - *Example*: If a project starts in the beginning of Year 2025, taking one year to complete and with 3-year lifetime, its score is counted for 2025-2026 (upon completion) and for each subsequent year (2026-2027, 2027-2028) until its useful life ends.
- **Discounting:** If an interest rate is specified, the tool can adjust future-year scores to present-value terms, giving higher weight to earlier benefits.
- **Total Score Maximization:** These annual scores are then summed across all years across the planning horizon to determine a plan's overall value. By comparing these cumulative, discounted scores across all feasible schedules, the solver picks the schedule that delivers the highest overall value.

Constraints

The tool enforces the following constraints to ensure the schedule remains feasible:

- **Budget:** Annual spending cannot exceed each year's budget.
- **Capacity:** Ensures the number of ongoing projects stays within capacity limits.
  - *Example*: A project that started in the beginning of 2025 with a duration of two years is counted as in progress in years 2025-2026 and 2026-2027.
- **Mandatory & Prerequisites:** Guarantee all required projects finish by deadlines and projects with dependencies only start after prerequisites are complete.

Outputs

The tool's outputs populate designated fields on the **Planning** and **Projects** Info sheets of your spreadsheet (namely the outputs are written onto the same spreadsheet as the inputs). This is part of why it is important to create a new blank copy each time you run the tool. The optimal construction schedule is presented in the **Planning** sheet and the **Projects Info** sheet of your copied spreadsheet**.** In the Planning sheet, the output is formatted by year, so it is easy to see in any given year which projects start. The Projects Info sheet output is formatted by project, so it is easy to see for any given project what year it was started (if that project was undertaken).

- **Planning:**
  - **Status:** Whether the solution is optimal, or infeasible.
    - No other outputs will be shown if infeasible**.**
    - Infeasible arises if the set of projects marked as mandatory (or their prerequisites) cannot all be funded or staffed with current inputs.
    - Adjust mandatory flags, budgets, or capacities to restore feasibility.
    - See Appendix (Resolving Infeasible Results) for further details.
  - **Annual Number of Ongoing projects:** The count of projects that have been started but not yet completed at the beginning of each year.
  - **Annual Total Cost:** The sum of all project expenditures incurred at the start of each year, based on the projects scheduled to begin in that year.
  - **Total Scores of selected:** The total score of every project that has been completed and remains within its useful lifetime at the end of each year, reflecting the benefit delivered by all "in-service" assets.
  - **Start in:** For each year, lists the projects that the tool recommends to start at the very beginning of that year under the optimized schedule.

Optimal

Interest Rate (%)	3.0	Number of Years	5	Number of Projs	40	Start Year	2025		Note	

Year	2025-2026	2026-2027	2027-2028	2028-2029	2029-2030	2030-2031	2031-2032	2032-2033	2033-2034	2034-2035	2035-2036	2036-2037	2037-2038	2038-2039
Annual Capacity of Projects to Take	5	5	5	5	5									
Annual Budget	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000									
Annual Number of Ongoing Projects	5	5	5	5	5									
Annual Total Cost	999,400	998,600	808,500	815,700	998,200									
Total Score of Selected Projects	3,020	6,200	9,546	12,819	13,076									
	Start in 2025	Start in 2026	Start in 2027	Start in 2028	Start in 2029	Start in 2030	Start in 2031	Start in 2032	Start in 2033	Start in 2034	Start in 2035	Start in 2036	Start in 2037	Start in 2038
	4	17	9	8	1									
	13	23	19	21	3									

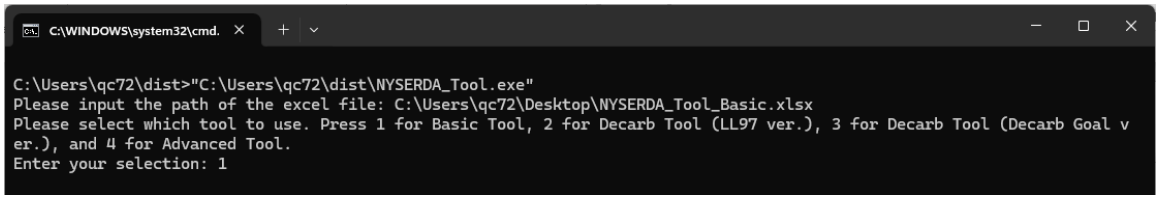
- **Projects Info:**
  - **Scheduled:** Each project's selected/start year is recorded, where 0 indicates the projected is not selected, any positive number means the project should be started **at the beginning** of the year indicated by the number.
    - *Example:* "2025" means Project 4 starts at the beginning of 2025, so its score will be gained by the end of Year 2025.

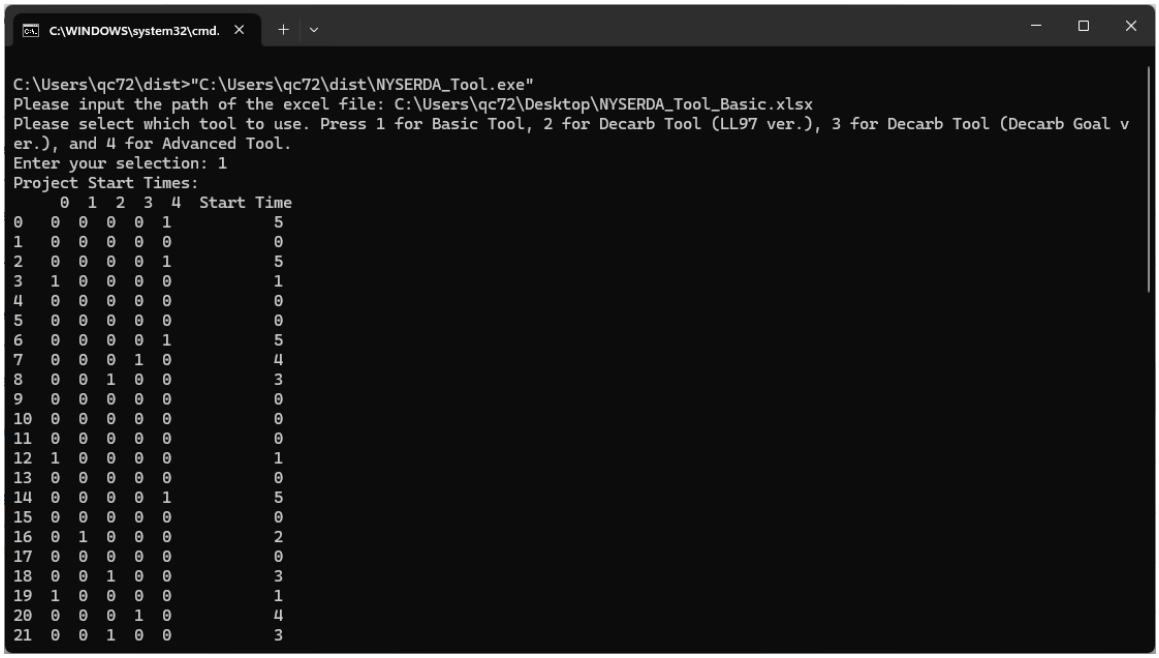
Project	Cost	Score	Duration	Lifetime	Mandatory Deadline	Pre-requisites	Scheduled
1	199,500	512	1	1	0		2029
2	204,200	294	1	2	0	1,4	0
3	198,700	820	1	1	0		2029
4	202,100	172	1	1	1		2025
5	205,800	670	2	2	0		0

Fast-Track Usage

The steps below show how to run the tool for a single scenario. It is very important to copy the original blank master sheet into a new saved file (with a unique file name) and populate it anew for each run of the tool (i.e. scenario). Please see Appendix (File Management) for a suggested file management workflow when running multiple scenarios.

1. Enter the input into your spreadsheet `NYSERDA_Tool_Basic.xlsx`:
    - Recall that `NYSERDA_Tool_Basic.xlsx` is what we are calling the copy of the blank master basic spreadsheet, in general the file name may be different if you have given your copy a different name.
    - Enter your scenario's annual budget, capacity, and any other required inputs in the **Planning** sheet.
    - Complete the **Projects Info** sheet with your project data. Optionally add project names or notes in the **Projects Index** sheet.
    - Leave any unused columns blank.
2. Close the Excel file, and double click `NYSERDA_Tool_Launcher.bat` to run the tool.
    - If asked by your operating system for permission or security confirmation, click "Allow" or "Keep Open" to grant access and proceed.
    - Ensure that `NYSERDA_Tool.exe` remains in the same directory as `NYSERDA_Tool_Launcher.bat` and is not renamed or moved.
3. When prompted, enter the full path of your edited spreadsheet **without** quotation marks, e.g.
    - Windows: `C:\…\NYSERDA_Tool_Basic.xlsx`
4. When asked for which tool to use, type **1** and hit enter to run the tool.
5. The screen will remain open and static while the tool is running its optimization.
6. Once the solver finishes (10 – 120 seconds for typical cases), a set of numbers will flash in the screen.
    - If an error occurs, console error messages will flash instead, please check the Troubleshooting Guide for possible issues and solutions.
7. Reopen your spreadsheet `NYSERDA_Tool_Basic.xlsx`. The **Planning** and **Projects Info** sheets will now display the solver outputs. From here, you're free to edit, apply filters, or format the results just like any other Excel file.




C:\WINDOWS\system32\cmd.
C:\Users\qc72\dist>"C:\Users\qc72\dist\NYSERDA_Tool.exe"
Please input the path of the excel file: C:\Users\qc72\Desktop\NYSERDA_Tool_Basic.xlsx
Please select which tool to use. Press 1 for Basic Tool, 2 for Decarb Tool (LL97 ver.), 3 for Decarb Tool (Decarb Goal ver.), and 4 for Advanced Tool.
Enter your selection: 1
Project Start Times:
0 1 2 3 4 Start Time
0 0 0 0 0 1 5
1 0 0 0 0 0 0
2 0 0 0 0 1 5
3 1 0 0 0 0 1
4 0 0 0 0 0 0
5 0 0 0 0 0 0
6 0 0 0 0 1 5
7 0 0 0 1 0 4
8 0 0 1 0 0 3
9 0 0 0 0 0 0
10 0 0 0 0 0 0
11 0 0 0 0 0 0
12 1 0 0 0 0 1
13 0 0 0 0 0 0
14 0 0 0 0 1 5
15 0 0 0 0 0 0
16 0 1 0 0 0 2
17 0 0 0 0 0 0
18 0 0 1 0 0 3
19 1 0 0 0 0 1
20 0 0 0 1 0 4
21 0 0 1 0 0 3

Decarb Tool (Local Law 97 Version)

Overview

The Decarb Tool (LL97 version) produces an optimal multi-year schedule of sustainability projects that minimizes total implementation costs and emission fines from Local Law 97 while maximizing the financial savings delivered by those projects. By balancing upfront investments, annual savings, and penalties for exceeding emission goals, it identifies the portfolio that minimizes net cash outflows. The result is cost-effective and aligns with capacity, budget, and project precedence requirements, and will be written on the corresponding spreadsheets.

Inputs

Before running the tool, make a copy of the empty (i.e. none of the input or output fields are populated by numbers) "NYSERDA_Tool_LL97-Master.xlsx" spreadsheet, and give it a unique file name (e.g. "`NYSERDA_Tool_LL97`"). Each time you run the tool, you should go back to the original master file, copy it, and give the copy a unique file name. Prepare the inputs in your copied spreadsheet by filling in all required fields on the **Planning**, **Projects Info**, **Carbon Emission Reduction** and **Savings** sheets. Optionally one can also add project names or notes in the **Projects Index** sheet. The following bullets list the required information for the spreadsheet:

- **Planning:**
  - **Interest Rate:** The rate used to account for the time value of money (default set to 3%).
  - **Number of Years**: The number of years over which projects are scheduled (up to a maximum of 25). By default, it's auto counted as the number of years with a non-empty budget in the **Annual Budget** row.
  - **Start Year:** The first year in the planning horizon.
  - **Note**: A free text field provided for adding any side notes or contextual comments about the scenario.
  - **Annual Project Capacity:** The maximum number of projects that can be undertaken in parallel each year within the planning horizon, reflecting hospital's real-world project-management bandwidth (for example, the total number of project managers or implementation teams available).
    - Simply leave any unused year columns blank.
  - **Annual Budget:** The financial limit for each year within the planning period, specifying how much can be allocated annually.
    - Simply leave any unused year columns blank.
  - **Current Annual Emissions:** The hospital's baseline annual carbon emissions if no new projects are implemented and operations stay the same. These inputs are required to determine the new Annual Carbon Emissions after implementing sustainability projects.
    - Specify a value for each year to reflect changes in grid upgrades or other external factors over time.
    - Provide these values based on your own assumptions about total annual emissions from all energy resources (electricity, gas, etc.).

        - The values can also be derived by multiplying the facility's estimated current energy usage from all energy resources by the appropriate GHG coefficients in that year.
        - Tailor inputs to your hospital's circumstances, for example using locally measured grid intensity, or known equipment performance.
        - Please check Appendix (Current Annual Emissions Calculation) for step-by-step calculation methodology.
        - If you have any in-flight projects, subtract their anticipated emission reductions from these baseline current annual emissions according to Appendix (In-flight Project Adjustment).
        - If your organization cannot reasonably project future emissions, set every year's value equal to your most recent annual emissions.
            - Also recall that the Basic tool can take environmental impact into consideration through the project scores, so that tool may also be appropriate in this case.
    - **LL97 Annual Limit:** The maximum allowable emissions each year under Local Law 97 (before fines are incurred).
        - Specify a value for each year to reflect LL97's changing requirements over time.
        - Provide these limits based on your chosen calculation method (e.g. intensity × GFA, percentage-of-2018 baseline for nonprofits) and any accommodations you qualify for.
        - Values may vary by hospital circumstance, such as nonprofit adjustments, portfolio-wide reductions for NYCHA, or other DOB-approved accommodations.
        - Please check Appendix (LL97 Limits Calculation) for a step-by-step calculation methodology.

Interest Rate (%)	3.0	Number of Years	25	Start Year	2025		Note	

Year	2025-2026	2026-2027	2027-2028	2028-2029	2029-2030	2030-2031	2031-2032	2032-2033	2033-2034	2034-2035	2035-2036	2036-2037	2037-2038
Annual Capacity of Projects to Take	5	5	5	5	5	5	5	5	5	5	5	5	5
Annual Budget	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
Current Annual Emissions	100,000	100,000	100,000	100,000	100,000	88,000	88,000	88,000	88,000	88,000	75,000	75,000	75,000
LL97 Annual Limit	85,000	85,000	85,000	85,000	85,000	70,000	70,000	70,000	70,000	70,000	50,000	50,000	50,000
Annual Number of Ongoing Projects													
Annual Total Cost													
Annual Total Savings													
Annual Carbon Reduction													
Annual LL97 Penalty													
	Start in 2025	Start in 2026	Start in 2027	Start in 2028	Start in 2029	Start in 2030	Start in 2031	Start in 2032	Start in 2033	Start in 2034	Start in 2035	Start in 2036	Start in 2037

- **Projects Info:**
    - **Number of Projects:** The total count of projects available for selection, automatically set to the number of the projects with cost inputted in **Cost**.
    - **Fine per Unit:** Penalty charged per unit of CO_2 exceeding the annual limit.
        - Default is set to $268 / ton to match with current LL97 regulations.
        - You may adjust this rate to reflect alternative penalty structures.
    - **Cost:** The net upfront investment required for each project after subtracting any external funding.

        - *Example*: A project has a total implementation cost of $200,000 and receives a $150,000 grant. You would enter its cost as $50,000.
    - **Duration:** Years required to complete each project.
    - **Lifetime:** Years of expected useful lifespan of a completed project.
        - The period over which the project continues to deliver its intended benefits before major maintenance or replacement is required.
    - **Mandatory Deadline:** Indicates year by which a project must be completed (if there is such a requirement for that project).
        - A value of 0 means the project has no mandatory deadline.
            - If there is no mandatory deadline a 0 must be written or the tool will give an error.
        - Any positive value sets the latest allowed completion year for the project (e.g. 3 means by the end of third year in planning horizon).
        - Deadline values cannot exceed the total length of the planning horizon.
    - **Prerequisites:** The tool enforces that a project with prerequisites only starts after all listed parent projects are complete.
        - Prerequisites are entered as a comma-separated list under the Prerequisites column (e.g. "1,3,5").
        - Example: If Project 2 has "1,4" listed as its prerequisites, Project 2 cannot start until Projects 1 and 4 are both finished.
        - If a project has no prerequisites this field should be left blank.
    - Values in **Scheduled** will be populated as an output after running the tool.
    - **Bundled Saving:** You may specify that certain pairs of projects are cheaper if started together than if undertaken separately.
        - Bundles are entered as a comma-separated pair (e.g. "1,5").
        - *Example:* Entering "1,5" with a paired cost of $300,000 means starting Projects 1 and 5 together costs $300,000 total, which is cheaper than the sum of their individual costs.

Number of Projs	40	Fine per Unit	268

Project	Cost	Duration	Lifetime	Mandatory Deadline	Prerequisites	Scheduled
1	199,500	1	25	0		
2	204,200	2	25	0		
3	198,700	1	25	0		
4	202,100	1	25	25	1,3	
5	205,800	2	25	0		

Number of Pairs	1

Bundled Saving	Cost
1,5	300,000

- **Carbon Emission Reduction:** Annual carbon reduction per year after completion; can vary over time (e.g. accounting for grid upgrade) or be constant.
    - Specify a value for each year to reflect changes in grid upgrades or other external factors over time.
    - Provide these reduction values based on your own assumptions about total reductions from the project across all fuels (electricity, gas, etc.).
    - The values can be derived by multiplying the project's estimated energy savings from all fuels by the appropriate GHG coefficients in that year.
    - Values can be tailored to each hospital's circumstance, for example, using locally measured grid coefficients or considering equipment performance.
    - Please check Appendix (Project Emission Reduction Calculation) for detailed calculation.

- *Example:* For a project with value 100 for Reduction in 2025-2026, it reduces 100 tons of CO_2 in that year if it is completed and still within its useful life in that year.

Project	Reduction in 2025-2026	Reduction in 2026-2027	Reduction in 2027-2028	Reduction in 2028-2029	Reduction in 2029-2030	Reduction in 2030-2031
1	1,112	1,112	1,112	1,112	1,112	668
2	2,759	2,759	2,759	2,759	2,759	2,039
3	2,076	2,076	2,076	2,076	2,076	1,928
4	2,439	2,439	2,439	2,439	2,439	1,709
5	1,122	1,122	1,122	1,122	1,122	1,073

- **Savings:** Annual financial savings per project-year after completion; can vary over time or be constant.
  - Specify a value for each year to reflect changes in grid upgrades or other external factors over time.
  - Provide these savings values based on your own assumptions about total cost reductions or revenue benefits from the project (e.g. lower utility bills, avoided maintenance, tax credits).
  - *Example:* For a project with value 100 for Saving in 2025-2026, it saves $100 in that year if it is completed and still within its useful life in that year.

Project	Saving in 2025-2026	Saving in 2026-2027	Saving in 2027-2028	Saving in 2028-2029	Saving in 2029-2030	Saving in 2030-2031
1	11,230	11,230	11,230	11,230	11,230	11,230
2	13,450	13,450	13,450	13,450	13,450	13,450
3	9,840	9,840	9,840	9,840	9,840	9,840
4	12,760	12,760	12,760	12,760	12,760	12,760
5	14,300	14,300	14,300	14,300	14,300	14,300

- **Projects Index (Optional):**
  - **Name:** A descriptive title for each project.
  - **Note:** A free text field for any side notes or contextual comments about the project.

Project	Name	Note
1		
2		

Optimization Logic

The tool's objective is to minimize the net present value of cash outflows over the planning horizon. The cashflow is calculated by taking the difference between outflows from project costs, and LL97 emission penalties and inflows from project savings. The optimization is over all possible construction schedules, while satisfying the necessary constraints.

- **Annual Emission Calculation:** The tool computes the hospital's potential emissions each year if the selected projects are implemented. Potential emissions are calculated by taking the current annual emissions and subtracting the total carbon

reductions from all projects that have completed implementation and remain within their useful life.
    - *Example:* A project that begins at the start of 2025, taking 1 year to complete and with 3-year lifetime, will reduce emissions by its specified amount in the 2025–2026 period, and again in 2026–2027 and 2027–2028, using the corresponding Carbon Emission Reduction values for each year.
- **Net Cashflows:** The tool then calculates the net cashflows for each year, including:
    - **Outflows:**
        - **Project Costs:** Cost of projects launched that year.
        - **Emission Fines:** Penalty for emissions above LL97 limits.
    - **Inflows:**
        - **Savings:** Annual savings from projects that have completed implementation and remain active.
- **Discounting:** If an interest rate is specified, the tool can adjust future-year cashflows to present-values, giving higher weight to earlier cashflows.
- **Total Net Outflow Minimization:** By comparing these cumulative, discounted net cash outflows across all feasible schedules, the solver picks the schedule that delivers the smallest total net cash outflows.

Constraints

The tool enforces the following constraints to ensure the schedule remains feasible:

- **Budget:** Annual spending cannot exceed each year's budget.
- **Capacity:** Ensures the number of ongoing projects stays within capacity limits.
    - *Example*: A project that started in the beginning of 2025 with a duration of two years is counted as in progress in years 2025-2026 and 2026-2027.
- **Mandatory & Prerequisites:** Guarantee all required projects finish by deadlines and projects with dependencies only start after prerequisites are complete.

Outputs

The tool's outputs populate designated fields on the **Planning** and **Projects** Info sheets of your spreadsheet (namely the outputs are written onto the same spreadsheet as the inputs). This is part of why it is important to create a new blank copy each time you run the tool. The optimal construction schedule is presented in the **Planning** sheet and the **Projects Info** sheet of your copied spreadsheet**.** In the Planning sheet, the output is formatted by year, so it is easy to see in any given year which projects start. The Projects Info sheet output is formatted by project, so it is easy to see for any given project what year it was started (if that project was undertaken).

- **Planning:**
    - **Status:** Whether the solution is optimal, or infeasible.
        - No other outputs will be shown if infeasible.

        - Infeasible arises if the set of projects marked as mandatory (or their prerequisites) cannot all be funded or staffed within current inputs.
        - Adjust mandatory flags, budgets, or capacities to restore feasibility according to Appendix (Resolving Infeasible Results).
    - **Annual Number of Ongoing projects:** The count of projects that have been started but not yet completed at the beginning of each year.
    - **Annual Total Cost:** The sum of all project expenditures incurred at the start of each year, based on the projects scheduled to begin in that year.
    - **Annual Total Savings:** The total financial savings of every project that has been completed and remains within its useful lifetime at the end of each year, such as reduced utility bills, and tax credits.
    - **Annual Carbon Reduction:** The total carbon reductions from all active projects at year's end (i.e., completed and still within useful lifespan).
    - **Annual LL97 Penalty:** The penalty charged for any remaining emissions above the LL97 limit after accounting for the year's carbon reductions.
    - **Start in:** For each year, lists the projects that the tool recommends to start at the very beginning of that year under the optimized schedule.

Optimal

Interest Rate (%)	3.0	Number of Years	25	Start Year	2025

Note	

Year	2025-2026	2026-2027	2027-2028	2028-2029	2029-2030	2030-2031	2031-2032	2032-2033	2033-2034	2034-2035	2035-2036	2036-2037
Annual Capacity of Projects to Take	5	5	5	5	5	5	5	5	5	5	5	5
Annual Budget	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
Current Annual Emissions	100,000	100,000	100,000	100,000	100,000	88,000	88,000	88,000	88,000	88,000	75,000	75,000
LL97 Annual Limit	85,000	85,000	85,000	85,000	85,000	70,000	70,000	70,000	70,000	70,000	50,000	50,000
Annual Number of Ongoing Projects	5	5	5	5	5	5	5	5	5	5	5	5
Annual Total Cost	997,000	816,200	814,900	0	817,000	201,200	803,700	0	397,900	199,000	402,400	400,400
Annual Total Savings	41,890	89,090	89,090	145,900	157,770	210,870	210,870	235,600	248,200	275,990	299,760	311,420
Annual Carbon Reduction	6,346	14,347	14,347	23,519	25,775	25,405	25,405	28,873	29,912	34,410	30,445	31,468
Annual LL97 Penalty	2,319,272	175,004	175,004	0	0	0	0	0	0	0	0	0
	Start in 2025	Start in 2026	Start in 2027	Start in 2028	Start in 2029	Start in 2030	Start in 2031	Start in 2032	Start in 2033	Start in 2034	Start in 2035	Start in 2036
	1	4	5		2	9	19		6	40	20	23
	3	21	11		8		30		29		24	36

- **Projects Info:**
    - **Scheduled:** Each project's selected/start year is recorded, where 0 indicates the projected is not selected, any positive number means the project should be started **at the beginning** of the year indicated by the number.
        - *Example:* "2025" means Project 1 starts at the beginning of Year 2025, so its carbon reductions and savings will be gained by the end of Year 2025.

Number of Projs	40	Fine per Unit	268

Project	Cost	Duration	Lifetime	Mandatory Deadline	Prerequisites	Scheduled
1	199,500	1	25	0		2025
2	204,200	2	25	0		2029
3	198,700	1	25	0		2025
4	202,100	1	25	25	1,3	2026
5	205,800	2	25	0		2027

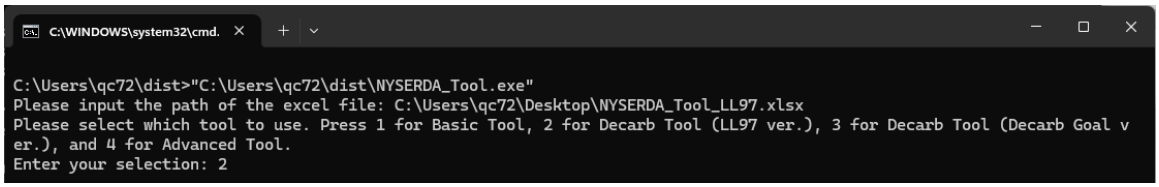
Number of Pairs	1

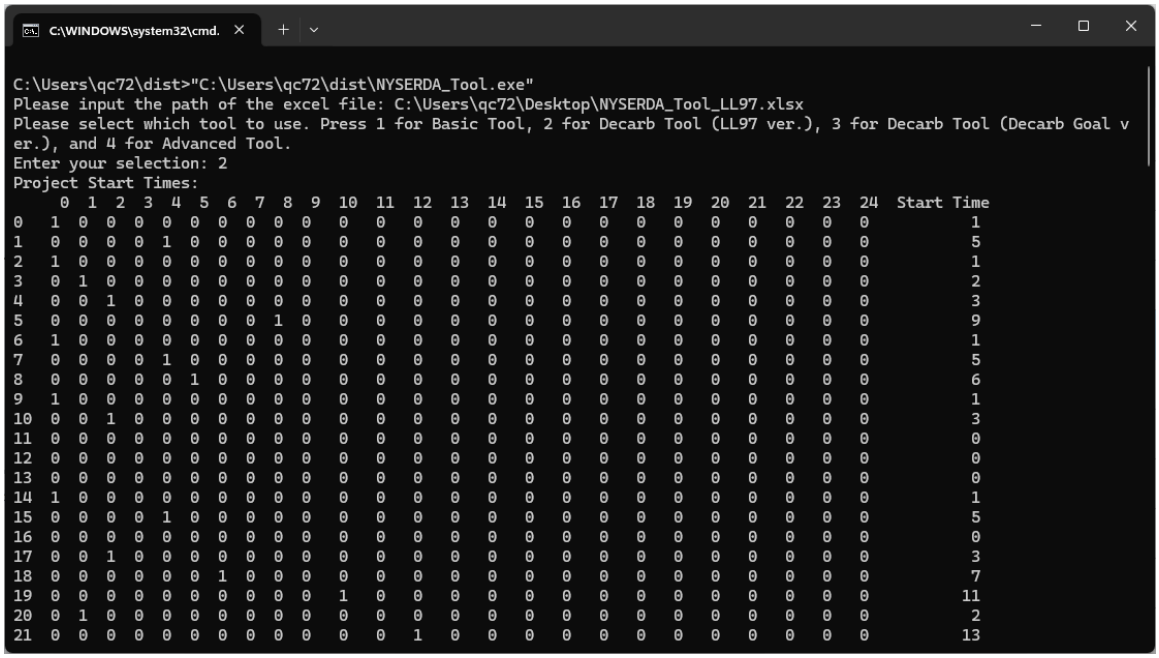
Bundled Saving	Cost
1,5	300,000

Fast-Track Usage

The steps below show how to run the tool for a single scenario. It is very important to copy the original blank master sheet into a new saved file (with a unique file name) and populate it anew for each run of the tool (i.e. scenario). Please see Appendix (File Management) for a suggested file management workflow when running multiple scenarios.

1. Enter the input into your spreadsheet `NYSERDA_Tool_LL97.xlsx`:
    - Recall that NYSERDA_Tool_LL97.xlsx is what we are calling the copy of the blank master LL97 spreadsheet, in general the file name may be different if you have given your copy a different name.
    - Enter your scenario's annual budget, capacity, and any other required inputs in the **Planning** sheet.
    - Complete the **Projects Info**, **Carbon Emission Reduction** and **Savings** sheets with your project data. Optionally add project names or notes in the **Projects Index** sheet.
    - Leave any unused columns blank.
2. Close the Excel file, and double click `NYSERDA_Tool_Launcher.bat` to run the tool.
    - If asked by your operating system for permission or security confirmation, click "Allow" or "Keep Open" to grant access and proceed.
    - Ensure that `NYSERDA_Tool.exe` remains in the same directory as `NYSERDA_Tool_Launcher.bat` and is not renamed or moved.
3. When prompted, enter the full path of your edited spreadsheet **without** quotation marks, e.g.
    - Windows: `C:\…\NYSERDA_Tool_LL97.xlsx`
4. When asked for which tool to use, type **2** and hit enter to run the tool.
5. The screen will remain open and static while the tool is running its optimization.
6. Once the solver finishes (10 – 120 seconds for typical cases), a set of numbers will flash in the screen.
    - If an error occurs, console error messages will flash instead, please check the Troubleshooting Guide for possible issues and solutions.
7. Reopen `NYSERDA_Tool_LL97.xlsx`. The **Planning** and **Projects Info** sheets will now display the solver outputs. From here, you're free to edit, apply filters, or format the results just like any other Excel file.




C:\WINDOWS\system32\cmd.
C:\Users\qc72\dist>"C:\Users\qc72\dist\NYSERDA_Tool.exe"
Please input the path of the excel file: C:\Users\qc72\Desktop\NYSERDA_Tool_LL97.xlsx
Please select which tool to use. Press 1 for Basic Tool, 2 for Decarb Tool (LL97 ver.), 3 for Decarb Tool (Decarb Goal ver.), and 4 for Advanced Tool.
Enter your selection: 2
Project Start Times:
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 Start Time
0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 5
2 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
3 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 2
4 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 3
5 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 9
6 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
7 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 5
8 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 6
9 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
10 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 3
11 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
12 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
13 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
14 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
15 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 5
16 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
17 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 3
18 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 7
19 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 11
20 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 2
21 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 13

Decarb Tool (Decarb Goal Version)

Overview

The Decarb Tool (Decarb Goal version) is not limited to LL97 compliance, any organization with a sustainability objective can use it to find the most cost-effective schedule of projects that strictly meets your defined emission targets. By balancing upfront investments and annual savings, the tool outputs the minimum cost (in the sense of net cash outflow) construction schedule that meets all your specified emission goals. The result aligns with capacity, budget, and project precedence requirements, and will be written on the corresponding spreadsheets.

Inputs

Before running the tool, make a copy of the empty (i.e. none of the input or output fields are populated by numbers) "NYSERDA_Tool_DecarbGoal-Master.xlsx" spreadsheet, and give it a unique file name (e.g. "`NYSERDA_Tool_DecarbGoal`"). Each time you run the tool, you should go back to the original master file, copy it, and give the copy a unique file name. Prepare the inputs in your copied spreadsheet by filling in all required fields on the **Planning**, **Projects Info**, **Carbon Emission Reduction** and **Savings** sheets. Optionally one can also add project names or notes in the **Projects Index** sheet. The following bullets list the required information for the spreadsheet:

- **Planning:**
  - **Interest Rate:** The rate used to account for the time value of money (default set to 3%).
  - **Number of Years**: The number of years over which projects are scheduled (up to a maximum of 25). By default, it's auto counted as the number of years with a non-empty budget in the **Annual Budget** row.
  - **Start Year:** The first year in the planning horizon.
  - **Note**: A free text field provided for adding any side notes or contextual comments about the scenario.
  - **Annual Project Capacity:** The maximum number of projects that can be undertaken in parallel each year within the planning horizon, reflecting hospital's real-world project-management bandwidth (for example, the total number of project managers or implementation teams available).
    - Simply leave any unused year columns blank.
  - **Annual Budget:** The financial limit for each year within the planning period, specifying how much can be allocated annually.
    - Simply leave any unused year columns blank.
  - **Current Annual Emissions:** The hospital's baseline annual carbon emissions if no new projects are implemented and operations stay the same. These inputs are required to determine the new Annual Carbon Emissions after implementing sustainability projects.
    - Specify a value for each year to reflect changes in grid upgrades or other external factors over time.

        - Provide these values based on your own assumptions about total annual emissions from all energy resources (electricity, gas, etc.).
        - The values can also be derived by multiplying the facility's estimated current energy usage from all energy resources by the appropriate GHG coefficients in that year.
        - Tailor inputs to your hospital's circumstances, for example using locally measured grid intensity, or known equipment performance.
        - Please check Appendix (Current Annual Emissions Calculation) for step-by-step calculation methodology.
        - If you have any in-flight projects, subtract their anticipated emission reductions from these baseline current annual emissions according to Appendix (In-flight Project Adjustment).
        - If your organization cannot reasonably project future emissions, set every year's value equal to your most recent annual emissions.
            - Also recall that the Basic tool can take environmental impact into consideration through the project scores, so that tool may also be appropriate in this case.
    - **Annual Emission Goals:** The facility's own target for maximum CO_2 emissions each year, which may align with LL97 or represent internal sustainability objectives.
        - Specify a value for each year to reflect each milestone targets.
        - For example, if LL97 limits don't apply or you have other goals, input your facility's self-set emission targets.
        - The optimizer will ensure that your carbon emission levels are below these targets in the given years (if it is feasible given the set of projects, budget, targets, etc.)

Interest Rate (%)	3.0	Number of Years	25	Start Year	2025		Note	

Year	2025-2026	2026-2027	2027-2028	2028-2029	2029-2030	2030-2031	2031-2032	2032-2033	2033-2034	2034-2035	2035-2036	2036-2037
Annual Capacity of Projects to Take	5	5	5	5	5	5	5	5	5	5	5	5
Annual Budget	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
Current Annual Emissions	100,000	100,000	100,000	100,000	100,000	88,000	88,000	88,000	88,000	88,000	75,000	75,000
Annual Emission Goal	98,000	97,000	96,000	95,000	94,000	84,000	83,000	82,000	81,000	80,000	73,000	72,000
Annual Number of Ongoing Projects												
Annual Total Cost												
Annual Total Saving												
Annual Carbon Emissions												
	Start in 2025	Start in 2026	Start in 2027	Start in 2028	Start in 2029	Start in 2030	Start in 2031	Start in 2032	Start in 2033	Start in 2034	Start in 2035	Start in 2036

- **Projects Info:**
    - **Number of Projects:** The total count of projects available for selection. It's auto counted as the number of projects with cost inputted in **Cost** column.
    - **Cost:** The net upfront investment required for each project after subtracting any external funding.
        - *Example*: A project has a total implementation cost of $200,000 and receives a $150,000 grant. You would enter its cost as $50,000.
    - **Duration:** Years required to complete each project.

- **Lifetime:** Years of expected useful lifespan of a completed project.
  - The period over which the project continues to deliver its intended benefits before major maintenance or replacement is required.
- **Mandatory Deadline:** Indicates year by which a project must be completed (if there is such a requirement for that project).
  - A value of 0 means the project has no mandatory deadline.
    - If there is no mandatory deadline a 0 must be written or the tool will give an error.
  - Any positive value sets the latest allowed completion year for the project (e.g. 3 means by the end of third year in planning horizon).
  - Deadline values cannot exceed the total length of the planning horizon.
- **Prerequisites:** The tool enforces that a project with prerequisites only starts after all listed parent projects are complete.
  - Prerequisites are entered as a comma-separated list under the Prerequisites column (e.g. "1,3,5").
  - Example: If Project 2 has "1,4" listed as its prerequisites, Project 2 cannot start until Projects 1 and 4 are both finished.
  - If a project has no prerequisites this field should be left blank.
- Values in **Scheduled** will be populated as an output after running the tool.
- **Bundled Saving:** You may specify that certain pairs of projects are cheaper if start together than if undertaken separately.
  - Bundles are entered as a comma-separated pair (e.g. "1,5").
  - *Example:* Entering "1,5" with a paired cost of $300,000 means starting Projects 1 and 5 together costs $300,000 total, which is cheaper than the sum of their individual costs.

Number of Projs	40

Project	Cost	Duration	Lifetime	Mandatory Deadline	Prerequisites	Scheduled
1	199,500	1	25	0		
2	204,200	2	25	0		
3	198,700	1	25	0		
4	202,100	1	25	25	3	
5	205,800	2	25	0		

Number of Pairs	1

Bundled Saving	Cost
1,5	300,000

- **Carbon Emission Reduction:** Annual carbon reduction per year after completion; can vary over time (e.g. accounting for grid upgrade) or be constant.
  - Specify a value for each year to reflect changes in grid upgrades or other external factors over time.
  - Provide these reduction values based on your own assumptions about total reductions from the project across all fuels (electricity, gas, etc.).
  - The values can be derived by multiplying the project's estimated energy savings from all fuels by the appropriate GHG coefficients in that year.
  - Values can be tailored to each hospital's circumstance, for example, using locally measured grid coefficients or considering equipment performance.
  - Please check Appendix (Project Emission Reduction Calculation) for detailed calculation.
  - *Example:* For a project with value 100 for Reduction in 2025-2026, it reduces 100 tons of CO_2 in that year if it is completed and still within its useful life in that year.

Project	Reduction in 2025-2026	Reduction in 2026-2027	Reduction in 2027-2028	Reduction in 2028-2029	Reduction in 2029-2030	Reduction in 2030-2031
1	1,112	1,112	1,112	1,112	1,112	668
2	2,759	2,759	2,759	2,759	2,759	2,039
3	2,076	2,076	2,076	2,076	2,076	1,928
4	2,439	2,439	2,439	2,439	2,439	1,709
5	1,122	1,122	1,122	1,122	1,122	1,073

- **Savings:** Annual financial savings per project-year after completion; can vary over time or be constant.
    - Specify a value for each year to reflect changes in grid upgrades or other external factors over time.
    - Provide these savings values based on your own assumptions about total cost reductions or revenue benefits from the project (e.g. lower utility bills, avoided maintenance, tax credits).
    - *Example:* For a project with value 100 for Saving in 2025-2026, it saves $100 in that year if it is completed and still within its useful life in that year.

Project	Saving in 2025-2026	Saving in 2026-2027	Saving in 2027-2028	Saving in 2028-2029	Saving in 2029-2030	Saving in 2030-2031
1	11,230	11,230	11,230	11,230	11,230	11,230
2	13,450	13,450	13,450	13,450	13,450	13,450
3	9,840	9,840	9,840	9,840	9,840	9,840
4	12,760	12,760	12,760	12,760	12,760	12,760
5	14,300	14,300	14,300	14,300	14,300	14,300

- **Projects Index (Optional):**
    - **Name:** A descriptive title for each project.
    - **Note:** A free text field for any side notes or contextual comments about the project.

Project	Name	Note
1		
2		

Optimization Logic

The tool enforces annual emission goals as a mandatory requirement, that each year's baseline emissions minus reductions from completed and active projects must not exceed the target. Among all schedules satisfying this constraint, it outputs the optimal one with minimal net cash outflows.

- **Annual Emission Calculation:** The tool computes the hospital's potential emissions each year if the selected projects are implemented. Potential emissions are calculated by taking the current annual emissions and subtracting the total carbon reductions from all projects that have completed implementation and remain within their useful life.
    - Example: A project that begins at the start of 2025, taking 1 year to complete and with 3-year lifetime, will reduce emissions by its specified amount in the

2025–2026 period and again in 2026–2027 and 2027–2028, using the corresponding Carbon Emission Reduction values for each year.

- **Net Cashflows:** The tool then calculates the net cashflows for each year, including:
  - **Outflows:**
    - **Project Costs:** Cost of projects launched that year.
  - **Inflows:**
    - **Savings:** Annual savings from projects that have completed implementation and remain active.
- **Discounting:** If an interest rate is specified, the tool can adjust future-year cashflows to present-values, giving higher weight to earlier cashflows.
- **Total Net Outflow Minimization:** By comparing these cumulative, discounted net cashflows across all feasible schedules, the solver picks the schedule that delivers the smallest total net cash outflows while satisfying the annual emission goals.

Constraints

The tool enforces the following constraints to ensure the schedule remains feasible:

- **Budget:** Annual spending cannot exceed each year's budget.
- **Capacity:** Ensures the number of ongoing projects stays within capacity limits.
  - *Example*: A project that started in the beginning of 2025 with a duration of two years is counted as in progress in years 2025-2026 and 2026-2027.
- **Mandatory & Prerequisites:** Guarantee all required projects finish by deadlines and projects with dependencies only start after prerequisites are complete.
- **Annual Emission Goals:** Emissions after reductions must not exceed annual goals.

Outputs

The tool's outputs populate designated fields on the **Planning** and **Projects** Info sheets of your spreadsheet (namely the outputs are written onto the same spreadsheet as the inputs). This is part of why it is important to create a new blank copy each time you run the tool. The optimal construction schedule is presented in the **Planning** sheet and the **Projects Info** sheet of your copied spreadsheet**.** In the Planning sheet, the output is formatted by year, so it is easy to see in any given year which projects start. The Projects Info sheet output is formatted by project, so it is easy to see for any given project what year it was started (if that project was undertaken).

- **Planning:**
  - **Status:** Whether the solution is optimal, or infeasible.
    - No other outputs will be shown if infeasible.
    - Infeasible arises if the set of projects marked as mandatory (or their prerequisites) cannot all be funded or staffed, or annual emission goals cannot be reached with the current inputs.

        - Adjust mandatory flags, budgets, capacities or annual emission goals to restore feasibility.
        - See Appendix (Resolving Infeasible Results) for further details.
    - **Annual Number of Ongoing projects:** The count of projects that have been started but not yet completed at the beginning of each year.
    - **Annual Total Cost:** The sum of all project expenditures incurred at the start of each year, based on the projects scheduled to begin in that year.
    - **Annual Total Savings:** The total financial savings of every project that has been completed and remains within its useful lifetime at the end of each year, such as reduced utility bills, and tax credits.
    - **Annual Carbon Emission:** The total carbon at year's end after accounting for the year's carbon reductions from all active projects (finished and within useful lifetime).
    - **Start in:** For each year, lists the projects that the tool recommends to start at the very beginning of that year under the optimized schedule.

Optimal

Interest Rate (%)	3.0	Number of Years	25	Start Year	2025

Note	

Year	2025-2026	2026-2027	2027-2028	2028-2029	2029-2030	2030-2031	2031-2032	2032-2033	2033-2034	2034-2035	2035-2036	2036-2037
Annual Capacity of Projects to Take	5	5	5	5	5	5	5	5	5	5	5	5
Annual Budget	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
Current Annual Emissions	100,000	100,000	100,000	100,000	100,000	88,000	88,000	88,000	88,000	88,000	75,000	75,000
Annual Emission Goal	98,000	97,000	96,000	95,000	94,000	84,000	83,000	82,000	81,000	80,000	73,000	72,000
Annual Number of Ongoing Projects	5	5	5	5	5	5	5	5	5	5	5	5
Annual Total Cost	904,400	605,900	806,900	205,600	817,000	201,200	802,900	0	402,900	598,300	0	0
Annual Total Savings	34,410	83,230	93,380	145,900	157,770	210,870	210,870	235,600	271,970	271,970	271,970	286,000
Annual Carbon Emissions	95,154	87,382	85,832	76,481	74,225	62,595	62,595	59,127	54,559	54,559	47,659	45,695
	Start in 2025	Start in 2026	Start in 2027	Start in 2028	Start in 2029	Start in 2030	Start in 2031	Start in 2032	Start in 2033	Start in 2034	Start in 2035	Start in 2036
	1	4	10	31	2	9	6		24	20		

- **Projects Info:**
    - **Scheduled:** Each project's selected/start year is recorded, where 0 indicates the projected is not selected, any positive number means the project should be started **at the beginning** of the year indicated by the number.
        - *Example:* "2025" means Project 1 starts at the beginning of Year 2025, so its carbon reductions and savings will be gained by the end of Year 2025.

Number of Projs	40

Project	Cost	Duration	Lifetime	Mandatory Deadline	Prerequisites	Scheduled
1	199,500	1	25	0		2025
2	204,200	2	25	0		2029
3	198,700	1	25	0		2025
4	202,100	1	25	25	3	2026
5	205,800	2	25	0		2025

Number of Pairs	1

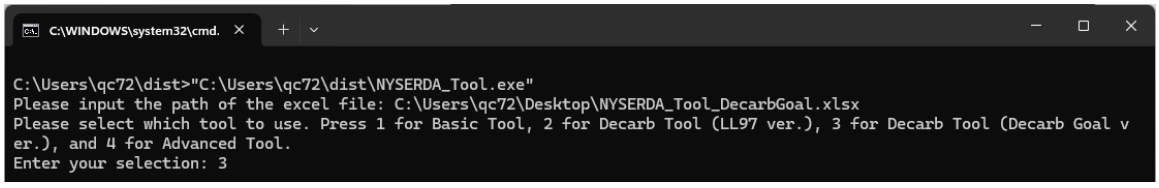
Bundled Saving	Cost
1,5	300,000

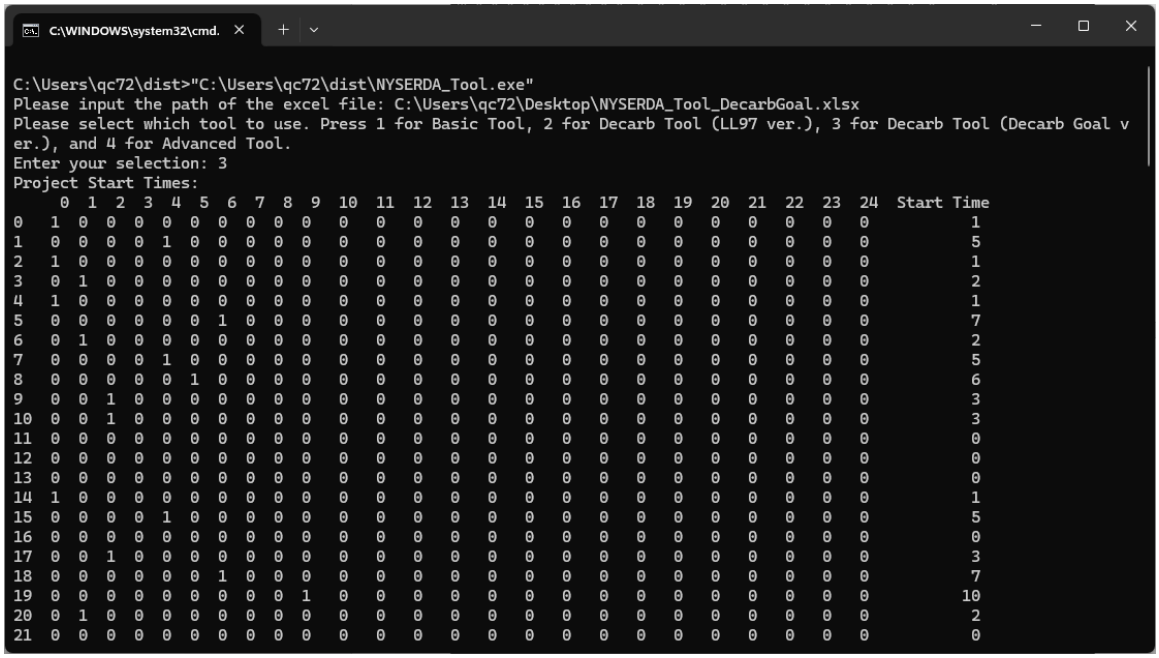
Fast-Track Usage

The steps below show how to run the tool for a single scenario. It is very important to copy the original blank master sheet into a new saved file (with a unique file name) and populate it anew for each run of the tool (i.e. scenario). Please see

Appendix (File Management) for a suggested file management workflow when running multiple scenarios.

1. Enter the input into your spreadsheet `NYSERDA_Tool_DecarbGooal.xlsx`:
    - Recall that NYSERDA_Tool_DecarbGoal.xlsx is what we are calling the copy of the blank master decarb goal spreadsheet, in general the file name may be different if you have given your copy a different name.
    - Enter your scenario's annual budget, capacity, and any other required inputs in the **Planning** sheet.
    - Complete the **Projects Info**, **Carbon Emission Reduction** and **Savings** sheets with your project data. Optionally add project names or notes in the **Projects Index** sheet.
    - Leave any unused columns blank.
2. Close the Excel file, and double click `NYSERDA_Tool_Launcher.bat` to run the tool.
    - If asked by your operating system for permission or security confirmation, click "Allow" or "Keep Open" to grant access and proceed.
    - Ensure that `NYSERDA_Tool.exe` remains in the same directory as `NYSERDA_Tool_Launcher.bat` and is not renamed or moved.
3. When prompted, enter the full path of your edited spreadsheet **without** quotation marks, e.g.
    - Windows: `C:\…\NYSERDA_Tool_DecarbGoal.xlsx`
4. When asked for which tool to use, type **3** and hit enter to run the tool.
5. The screen will remain open and static while the tool is running its optimization.
6. Once the solver finishes (10 – 120 seconds for typical cases), a set of numbers will flash in the screen.
    - If an error occurs, console error messages will flash instead, please check the Troubleshooting Guide for possible issues and solutions.
7. Reopen `NYSERDA_Tool_DecarbGoal.xlsx`. The **Planning** and **Projects Info** sheets will now display the solver outputs. From here, you're free to edit, apply filters, or format the results just like any other Excel file.




C:\WINDOWS\system32\cmd.
C:\Users\qc72\dist>"C:\Users\qc72\dist\NYSERDA_Tool.exe"
Please input the path of the excel file: C:\Users\qc72\Desktop\NYSERDA_Tool_DecarbGoal.xlsx
Please select which tool to use. Press 1 for Basic Tool, 2 for Decarb Tool (LL97 ver.), 3 for Decarb Tool (Decarb Goal ver.), and 4 for Advanced Tool.
Enter your selection: 3
Project Start Times:
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 Start Time
0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 5
2 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
3 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 2
4 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
5 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 7
6 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 2
7 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 5
8 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 6
9 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 3
10 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 3
11 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
12 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
13 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
14 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
15 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 5
16 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
17 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 3
18 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 7
19 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 10
20 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 2
21 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

Advanced Tool

Overview

The Advanced Tool builds on basic project planning by optimizing multiple, user-defined criteria in parallel. You can specify custom metrics (e.g. carbon reduction, risk mitigation, financial savings) and constraints (e.g. maximum allowable risk, minimum resilience thresholds) and the tool will generate a schedule that maximizes total net benefit across those metrics regarding to the constraints. Users define their own targets and penalty/reward structures, allowing the model to balance diverse priorities and deliver a customized optimal plan, and the plan will be written on the corresponding spreadsheets.

Inputs

Before running the tool, make a copy of the empty (i.e. none of the input or output fields are populated by numbers) "NYSERDA_Tool_Advanced-Master.xlsx" spreadsheet, and give it a unique file name (e.g. "`NYSERDA_Tool_Advanced`"). Each time you run the tool, you should go back to the original master file, copy it, and give the copy a unique file name. Prepare the inputs in your copied spreadsheet by filling in all required fields on the **Planning**, **Projects Info**, and **Criterion** sheets. Optionally one can also add project names or notes in the **Projects Index** sheet. The following bullets list the required information for the spreadsheet:

- **Criterion:**

In the Advanced tool, a criterion quantifies how well a proposed schedule meets a specific organizational objective, such as carbon reduction, resilience, operational risk, or financial savings. Each criterion carries a target value for each year, and a directional preference. Some goals you wish to drive upward hoping to exceed a lower bound (e.g. achieving at least a certain level of carbon reduction or generating more savings), while other metrics you intend to keep small hoping to stay below an upper bound (e.g. limiting annual emissions or capping operational risk). By framing these objectives as criteria, the tool can treat each objective uniformly within a single optimization problem, even when the underlying concepts differ markedly (e.g. tons of CO_2 versus dollars of savings) as long as you can provide the weights or convention of each objective. We also provided some example uses of criteria later.

Each project has a score for each criterion in each year. For each criterion, the total score of a given schedule in a given year (for that criterion) is the sum, over all projects completed and within their lifetime, of those projects' criterion scores.

To translate these abstract targets into optimization logic, each criterion can be classified into one of three categories (for each criterion you will specify the appropriate category).

- **Penalty:** A per-unit charge applied when the schedule falls below a specified lower bound or exceeds a specified upper bound for a criterion in a given year. In this

paradigm, such a gap increases the objective function's overall "cost", thereby disincentivizing schedules that differ too much from the goal.

- **Reward:** A per-unit reward applied when the schedule exceeds a specified lower bound or falls below a specified upper bound for a criterion in a given year. Reward-based criteria provide an incentive to beat your baseline expectations.

- **Mandatory:** impose hard, non-negotiable constraints that must be exactly satisfied (or lie within a specified relational bound) for a schedule to be considered feasible. If any mandatory requirement is violated, the entire schedule is viewed as invalid, regardless of how well it performs on other metrics.

By combining these elements, you give the Advanced tool a complete description of each objective and its trade-offs. The solver then balances all criteria, applying charges where goals are missed and credits where they are surpassed in each year, and combines the rewards and penalties of all criteria over all years to ensure that the final project plan not only performs well across multiple dimensions but also satisfies any critical non-negotiable requirements.

- For each of the criteria, use a separate sheet named "Criterion 1", "Criterion 2", etc. If you need more or fewer criteria than the preset number, simply add or remove the corresponding "Criterion" sheets in the workbook.
  - **Type of Goals:** Choose from the following options:
    - **Penalty**
    - **Reward**
    - **Mandatory**
  - **Relation to Goals:** Select how to compare actual vs. target:
    - **<=:** The goal will be understood as specifying an upper bound (e.g. risk levels).
    - **>=:** The goal will be understood as specifying a lower bound (e.g. emission reductions).
    - **=:** The goal must be met with equality. **Note:** the equality relation is only consistent with the mandatory goal, and should not be matched with either penalty or reward goals.
  - **Units**: The per-unit penalty or reward applied for each unit of deviation from the specified upper or lower bound (e.g. \$268 per ton of CO_2 or 1 point per savings unit). In all cases you should specify a positive number, whether it counts as a penalty or reward will be dictated by the type of goal specified.
    - **Note:** the objective combines the rewards and penalties in the units you specify and adds them together across criteria and time periods, so make sure units are compatible across different criteria.
  - **Name**: A descriptive label for the criterion (e.g. "Carbon Reduction").
  - **Score:** A table of project-by-year values for the criterion, can vary over time or be constant.
    - Simply leave unused columns blank.

Type of Goals	Reward	Relation to Goals	>=	Penalty/Reward Unit	1		Name	Savings

Project	Score in 2025-2026	Score in 2026-2027	Score in 2027-2028	Score in 2028-2029	Score in 2029-2030	Score in 2030-2031	Score in 2031-2032	Score in 2032-2033
1	11,230	11,230	11,230	11,230	11,230			
2	13,450	13,450	13,450	13,450	13,450			
3	9,840	9,840	9,840	9,840	9,840			
4	12,760	12,760	12,760	12,760	12,760			
5	14,300	14,300	14,300	14,300	14,300			

- **Planning:**
  - **Interest Rate:** The rate used to account for the time value of money (default set to 3%).
  - **Number of Years**: The number of years over which projects are scheduled (up to a maximum of 25). By default, it's auto counted as the number of years with a non-empty budget in the **Annual Budget** row.
  - **Number of Criteria:** Total number of criteria being considered in evaluation.
  - **Start Year:** The first year in the planning horizon.
  - **Note**: A free text field provided for adding any side notes or contextual comments about the scenario.
  - **Annual Project Capacity:** The maximum number of projects that can be undertaken in parallel each year within the planning horizon, reflecting hospital's real-world project-management bandwidth (for example, the total number of project managers or implementation teams available).
    - Simply leave any unused year columns blank.
  - **Annual Budget:** The financial limit for each year within the planning period, specifying how much can be allocated annually.
    - Simply leave any unused year columns blank.
  - **Target Score for Each Criterion:** The desired score for each criterion each year over the planning period.
    - If there is no specific target, you may set it to 0 and specify the goal type as "reward" to ensure that criterion is generically part of the maximization.
    - After the tool runs, row labels will update automatically based on the names you entered in the **Criterion** sheets. (e.g. Realized Total for Savings).

Interest Rate (%)	3.0	Number of Years	5	Number of Criteria	3	Start Year	2025		Note	

Year	2025-2026	2026-2027	2027-2028	2028-2029	2029-2030	2030-2031	2031-2032	2032-2033	2033-2034	2034-2035	2035-2036
Annual Capacity of Projects to Take	5	5	5	5	5						
Annual Budget	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000						
Target Total Score for Criterion 1	15,000	20,000	25,000	25,000	30,000						
Target Total Score for Criterion 2	1,000	2,000	3,000	4,000	5,000						
Target Total for Criterion 3	0	0	0	0	0						
Annual Number of Undergoing Projects											
Annual Total Cost											
Total Score of Selected for Criterion 1											
Total Score of Selected for Criterion 2											
Total Score of Selected for Criterion 3											
	Start in 2025	Start in 2026	Start in 2027	Start in 2028	Start in 2029	Start in 2030	Start in 2031	Start in 2032	Start in 2033	Start in 2034	Start in 2035

- **Projects Info:**
  - **Number of Projects:** The total count of projects available for selection. it's auto counted as the number of projects with cost inputted in **Cost** column.
  - **Cost:** The net upfront investment required for each project after subtracting any external funding.
    - *Example*: A project has a total implementation cost of $200,000 and receives a $150,000 grant. You would enter its cost as $50,000.
  - **Goal:** A custom name for the project's objective or target outcome (e.g. "Max Benefit"), used only for reference.
  - **Cost in objective:** Specify whether cost is a factor considered in the objective, or it's just a constraint that must stay within annual budget.
    - If cost is included in the objective, the tool will add a term penalizing these expenditures along with the rewards and penalties from the criteria. If specified, again please make sure all units are compatible, as these terms will simply be added together.
    - If cost is only a constraint, the tool will ensure annual spending stays within the budget but will not penalize higher costs in the objective function.
  - **Duration:** Years required to complete each project.
  - **Lifetime:** Years of expected useful lifespan of a completed project.
    - The period over which the project continues to deliver its intended benefits before major maintenance or replacement is required.
  - **Mandatory Deadline:** Indicates year by which a project must be completed (if there is such a requirement for that project).
    - A value of 0 means the project has no mandatory deadline.
      - If there is no mandatory deadline a 0 must be written or the tool will give an error.
    - Any positive value sets the latest allowed completion year for the project (e.g. 3 means by the end of third year in planning horizon).
    - Deadline values cannot exceed the total length of the planning horizon.
  - **Prerequisites:** The tool enforces that a project with prerequisites only starts after all listed parent projects are complete.
    - Prerequisites are entered as a comma-separated list under the Prerequisites column (e.g. "1,3,5").
    - Example: If Project 2 has "1,4" listed as its prerequisites, Project 2 cannot start until Projects 1 and 4 are both finished.
    - If a project has no prerequisites this field should be left blank.
  - Values in **Scheduled** will be populated as an output after running the tool.
  - **Bundled Saving:** You may specify that certain pairs of projects are cheaper if start together than if undertaken separately.
    - Bundles are entered as a comma-separated pair (e.g. "1,5").
    - *Example:* Entering "1,5" with a paired cost of $300,000 means starting Projects 1 and 5 together costs $300,000 total, which is cheaper than the sum of their individual costs.

Number of Projs	40	Goal	Max Benefit	Cost	Only need to be within budget

Project	Cost	Duration	Lifetime	Mandatory Deadline	Prerequisites	Scheduled
1	199,500	1	1	0		
2	204,200	1	2	0		
3	198,700	1	1	0		
4	202,100	1	1	4	1,3	
5	205,800	2	2	0		

Number of Pairs	1

Bundled Saving	Cost
1,5	300,000

Optimization Logic

The tool maximizes overall performance across all user-defined criteria throughout the planning horizon. It assesses each project's potential start years and compares the resulting annual performance scores, by including rewards for exceeding targets and penalties for shortfalls. Among all schedules that meet operational constraints and mandatory goals, the tool selects the one with the highest weighted sum of scores (adding the rewards and subtracting the penalties and, if specified, costs) in all criteria across the planning horizon.

- **Criterion Gap Calculation**: For each criterion and year, calculate the deviation from its target, then apply to the following types:
    - **Penalty Criteria:** Impose a penalty for the amount that actual performance falls short of or exceeds the target times the unit weight, according to the specified relation.
    - **Reward Criteria:** Award a credit for the amount that performance exceeds or stays below the target times the unit weight.
- **Overall Performance:**
    - **Penalties:** Aggregate all penalties for criteria deviations from target.
    - **Rewards:** Aggregate all rewards for exceeding (or staying within) targets.
    - **Costs and Discounts:** If cost also considered in objective, then project costs, acting as penalties, are incorporated into the same net performance framework.
- **Discounting:** If an interest rate is specified, the tool can adjust future-year performance to present-values, giving higher weight to earlier benefits.
- **Total Net Benefit Maximization:** By comparing the net benefit as difference between total discounted reward and total discounted penalties across all feasible schedules, the solver picks the schedule with the highest net benefit, guaranteeing all hard constraints and mandatory goals are met.

Constraints

The tool enforces the following constraints to ensure the schedule remains feasible:

- **Budget:** Annual spending cannot exceed each year's budget.
- **Capacity:** Ensures the number of ongoing projects stays within capacity limits.
    - *Example*: A project that started in the beginning of 2025 with a duration of two years is counted as in progress in years 2025-2026 and 2026-2027.
- **Mandatory & Prerequisites:** Guarantee all required projects finish by deadlines and projects with dependencies only start after prerequisites are complete.
- **Mandatory Goals:** Enforce that actual performance satisfies the exact relation to the target with no gap allowed for each mandatory criterion.

Outputs

The tool's outputs populate designated fields on the **Planning** and **Projects** Info sheets of your spreadsheet (namely the outputs are written onto the same spreadsheet as the inputs). This is part of why it is important to create a new blank copy each time you run the tool. The optimal construction schedule is presented in the **Planning** sheet and the **Projects Info** sheet of your copied spreadsheet**.** In the Planning sheet, the output is formatted by year, so it is easy to see in any given year which projects start. The Projects Info sheet output is formatted by project, so it is easy to see for any given project what year it was started (if that project was undertaken).

- **Planning:**
  - **Status:** Whether the solution is optimal, or infeasible.
    - No other outputs will be shown if infeasible**.**
    - Infeasible arises if the set of projects marked as mandatory (or their prerequisites) cannot all be funded or staffed, or target scores cannot be reached in some criteria with the current inputs.
    - Adjust mandatory flags, budgets, capacities or target scores to restore feasibility.
    - See Appendix (Resolving Infeasible Results) for further details.
  - **Annual Number of Ongoing projects:** The count of projects that have been started but not yet completed at the beginning of each year.
  - **Annual Total Cost:** The sum of all project expenditures incurred at the start of each year, based on the projects scheduled to begin in that year.
  - **Realized Total for Criterion:** The total score in this criterion of every project that has been completed and remains within its useful lifetime at the end of each year, reflecting the impact delivered by all "in-service" assets.
  - **Start in:** For each year, lists the projects that the tool recommends to start at the very beginning of that year under the optimized schedule.

Optimal

Interest Rate (%)	3.0	Number of Years	5	Number of Criteria	3	Start Year	2025	Note	

Year	2025-2026	2026-2027	2027-2028	2028-2029	2029-2030	2030-2031	2031-2032	2032-2033	2033-2034	2034-2035	2035-2036
Annual Capacity of Projects to Take	5	5	5	5	5						
Annual Budget	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000						
Target Total for Carbon Reduction	15,000	20,000	25,000	25,000	30,000						
Target Total for Score	1,000	2,000	3,000	4,000	5,000						
Target Total for Saving	0	0	0	0	0						
Annual Number of Undergoing Projects	5	5	5	5	5						
Annual Total Cost	999,900	998,200	910,200	815,500	999,700						
Realized Total for Carbon Reduction	12,427	21,272	25,886	26,718	29,967						
Realized Total for Score	2,410	5,802	7,870	8,468	9,223						
Realized Total for Saving	58,430	118,250	160,820	190,090	215,530						
	Start in 2025	Start in 2026	Start in 2027	Start in 2028	Start in 2029	Start in 2030	Start in 2031	Start in 2032	Start in 2033	Start in 2034	Start in 2035
	6	3	1	2	10						
	13	15	5	4	18						

- **Projects Info:**
  - **Scheduled:** Each project's selected/start year is recorded, where 0 indicates the projected is not selected, any positive number means the project should be started **at the beginning of** the year indicated by the number.
    - *Example:* "2028" means Project 4 starts at the beginning of Year 2028, so its score will be gained by the end of Year 2028.

Number of Projs	40	Goal	Max Benefit	Cost	Only need to be within budget

Project	Cost	Duration	Lifetime	Mandatory Deadline	Prerequisites	Scheduled
1	199,500	1	1	0		2027
2	204,200	1	2	0		2028
3	198,700	1	1	0		2026
4	202,100	1	1	4	1,3	2028
5	205,800	2	2	0		2027

Number of Pairs	1

Bundled Saving	Cost
1,5	300,000

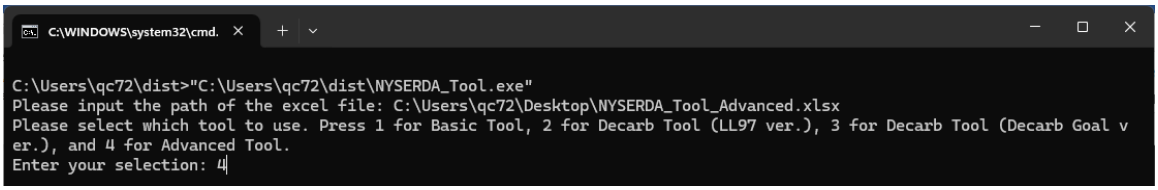
Fast-Track Usage

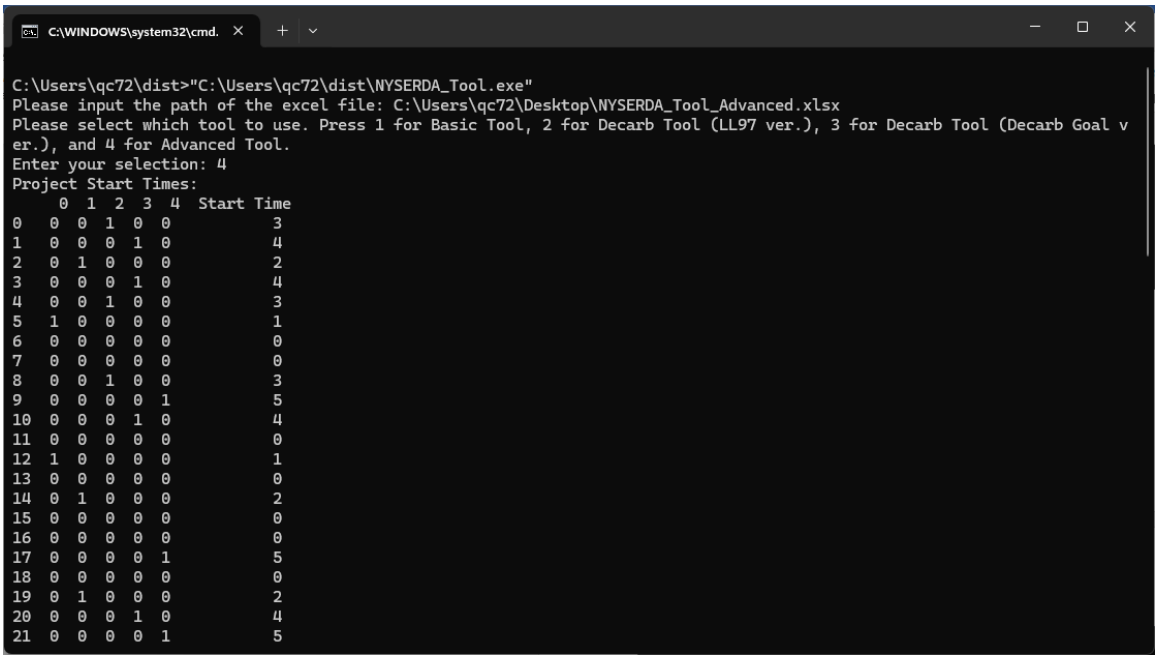
The steps below show how to run the tool for a single scenario. It is very important to copy the original blank master sheet into a new saved file (with a unique file name) and populate it anew for each run of the tool (i.e. scenario). Please see Appendix (File Management) for a suggested file management workflow when running multiple scenarios.

1. Enter the input into your spreadsheet `NYSERDA_Tool_Advanced.xlsx`:
   - Recall that NYSERDA_Tool_Advanced.xlsx is what we are calling the copy of the blank master advanced spreadsheet, in general the file name may be different if you have given your copy a different name.
   - Enter your scenario's annual budget, capacity, number of criteria and any other required inputs in the **Planning** sheet. If you have more or fewer criteria than the template, delete or insert the corresponding target and total score rows.
   - Complete the **Projects Info** sheet with your project data. Optionally add project names or notes in the **Projects Index** sheet.
   - Create **Criterion** sheet for each criterion. Enter the scores and select the types, relations, units to the goal. If you have more or fewer criteria than the template, delete or add the corresponding criterion sheet.
   - Leave any unused columns blank.
2. Close the Excel file, and double click `NYSERDA_Tool_Launcher.bat` to run the tool.
   - If asked by your operating system for permission or security confirmation, click "Allow" or "Keep Open" to grant access and proceed.
   - Ensure that `NYSERDA_Tool.exe` remains in the same directory as `NYSERDA_Tool_Launcher.bat` and is not renamed or moved.
3. When prompted, enter the full path of your edited spreadsheet **without** quotation marks, e.g.
   - Windows: `C:\…\NYSERDA_Tool_Advanced.xlsx`
4. When asked for which tool to use, type **4** and hit enter to run the tool.
5. The screen will remain open and static while the tool is running its optimization.
6. Once the solver finishes (10 – 120 seconds for typical cases), a set of numbers will flash in the screen.

- If an error occurs, console error messages will flash instead, please check the Troubleshooting Guide for possible issues and solutions.

7. Reopen `NYSERDA_Tool_Advanced.xlsx`. The **Planning** and **Projects Info** sheets will now display the solver outputs. From here, you're free to edit, apply filters, or format the results just like any other Excel file.





Example Uses of Criteria

Below we provide multiple demonstrations of the Advanced tool's core functionality, illustrating how to define multiple criteria, set targets, and generate an optimal project schedule. As we will see in some of these examples, through clever modeling one can encode quite sophisticated constraints and logic using the Advanced tool.

Minimize LL97 fines with Savings above given threshold

In this basic example, we optimize for LL97 fines while requiring the financial savings from implemented projects to exceed a certain amount for each year, also

under budget and capacity constraints. As it is simply meant to illustrate the advanced tool on a toy example, we do not detail all relevant LL97 calculations (as we did in the previous tool).

1. Define Criterion 1 for carbon reduction in the **Planning** sheet,
- Specify annual carbon reduction goals to reach no fines by entering the desired tonnage as the Target Total Score for Criterion 1 each year.
- *Example:* If the "Target Total Score for Criterion 1" in 2025–2026 is set to 15,000, then it means the hospital needs to reduce carbon emission by at least 15,000 t CO_2 for that year to achieve no LL97 fine. This number should account for both the changes in LL97 goals over time, as well as the increasing efficiency of the grid (e.g. regarding current usage statistics over time).
2. Define Criterion 2 for savings in the **Planning** sheet,
- Specify annual saving goals by entering the desired levels as the Target Total Score for Criterion 2 each year.
- *Example:* If the "Target Total Score for Criterion 2" in 2025–2026 is set to 8,000, then the required saving level for that year is at least $8,000.

Interest Rate (%)	3.0	Number of Years	5	Number of Criteria	2	Start Year	2025		Note	

Year	2025-2026	2026-2027	2027-2028	2028-2029	2029-2030	2030-2031	2031-2032	2032-2033	2033-2034	2034-2035	2035-2036	2036-2037	2037-2038	2038-2039	2039-2040
Annual Capacity of Projects to Take	5	5	5	5	5										
Annual Budget	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000										
Target Total Score for Criterion 1	15,000	20,000	25,000	25,000	30,000										
Target Total Score for Criterion 2	8,000	8,000	8,000	8,000	8,000										
Annual Number of Undergoing Projects															
Annual Total Cost															
Total Score of Selected for Criterion 1															
Total Score of Selected for Criterion 2															

3. Prepare its **Criterion 1** sheet for Carbon Reduction.
- Set **Type** = Penalty, **Relation** = "≥", **Penalty unit** = 268, and give it a descriptive name (e.g. "Carbon Reduction").
- Enter annual carbon emission amount as the scores in corresponding years.

Type of Goals	Penalty	Relation to Goals	>=	Penalty/Reward Unit	268		Name	Carbon Reduction

Project	Score in 2025-2026	Score in 2026-2027	Score in 2027-2028	Score in 2028-2029	Score in 2029-2030	Score in 2030-2031	Score in 2031-2032	Score in 2032-2033
1	1,112	1,112	1,112	668	668			
2	2,759	2,759	2,759	2,039	2,039			
3	2,076	2,076	2,076	1,928	1,928			
4	2,439	2,439	2,439	1,709	1,709			
5	1,122	1,122	1,122	1,073	1,073			

4. Prepare its **Criterion 2** sheet for Saving.
- Set **Type** = Mandatory, **Relation** = "≥", **Penalty unit** = 0, and give it a descriptive name (e.g. "Saving").
- Enter annual saving amount as the scores in corresponding years.

Type of Goals	Mandatory	Relation to Goals	>=	Penalty/Reward Unit	0		Name	Saving

Project	Score in 2025-2026	Score in 2026-2027	Score in 2027-2028	Score in 2028-2029	Score in 2029-2030	Score in 2030-2031	Score in 2031-2032	Score in 2032-2033
1	512	512	512	512	512			
2	294	294	294	294	294			
3	820	820	820	820	820			
4	172	172	172	172	172			
5	670	670	670	670	670			

Mutually Exclusive Choices

When you have alternative projects serving the same need, such as two competing equipment upgrades, you would want a constraint that you can only implement at most one of the projects. The Advanced tool supports this by grouping those alternatives into a single "Exclusive Option" set and enforcing an "at most one constraint". This can be achieved by creating a criterion for this feature, as we now explain. This ensures the solver selects no more than one project from the group, accurately reflecting real-world decision logic where only the best alternative is pursued.

1. Define a criterion for each exclusive option set in the **Planning** sheet,

- Enter a target score of **1** for every year under that criterion.

Interest Rate (%)	3.0	Number of Years	5	Number of Criteria	2	Note	

Year	2025-2026	2026-2027	2027-2028	2028-2029	2029-2030	2030-2031	2031-2032	2032-2033	2033-2034	2034-2035	2035-2036	2036-2037
Annual Capacity of Projects to Take	5	5	5	5	5							
Annual Budget	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000							
Target Total Score for Criterion 1	1	1	1	1	1							
Annual Number of Undergoing Projects												
Annual Total Cost												
Total Score of Selected for Criterion 1												
	Start in 2025	Start in 2026	Start in 2027	Start in 2028	Start in 2029	Start in 2030	Start in 2031	Start in 2032	Start in 2033	Start in 2034	Start in 2035	Start in 2036

2. For each "Exclusive Option" set, prepare its **Criterion** sheet.

- Set **Type** = Mandatory, **Relation** = "≤", **Penalty unit** = 0, and give it a descriptive name (e.g. "Set 1").
- For projects in the set: enter 1 for every year.
- For projects not in the set: enter 0 for every year.

Type of Goals	Mandatory	Relation to Goals	<=	Penalty/Reward Unit	0

Name	Set 1

Project	Score in 2025-2026	Score in 2026-2027	Score in 2027-2028	Score in 2028-2029	Score in 2029-2030
1	0	0	0	0	0
2	1	1	1	1	1
3	0	0	0	0	0
4	1	1	1	1	1
5	1	1	1	1	1

Minimize LL97 fines across different campuses

When multiple campuses draw from a shared budget, but each faces its own LL97 limits, the Advanced tool can aggregate their individual penalty calculations into a single objective. The solver allocates projects across all campuses while under the common budget and capacity constraints, to minimize the total fines, effectively directing investments where they yield the greatest penalty reductions.

1. Enter each campus's annual emission gap in the **Planning** sheet.

- For each campus and year, calculate **(current emissions – LL97 limit)**.
- Details of computing current emissions can be inferred from Appendix (Current Annual Emissions Calculation).
    - *Example:* If Campus 1 emits 35,000 t CO_2 in 2025–2026 and the LL97 limit is 20,000 t, then record 15,000 as the Criterion 1 target for 2025–2026.

Interest Rate (%)	3.0	Number of Years	5	Number of Criteria	2

Note	

Year	2025-2026	2026-2027	2027-2028	2028-2029	2029-2030	2030-2031	2031-2032	2032-2033	2033-2034	2034-2035	2035-2036	2036-2037
Annual Capacity of Projects to Take	5	5	5	5	5							
Annual Budget	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000							
Target Total Score for Criterion 1	15,000	20,000	25,000	25,000	30,000							
Target Total Score for Criterion 2	1,000	2,000	3,000	4,000	5,000							
Annual Number of Undergoing Projects												
Annual Total Cost												
Total Score of Selected for Criterion 1												
Total Score of Selected for Criterion 2												
	Start in 2025	Start in 2026	Start in 2027	Start in 2028	Start in 2029	Start in 2030	Start in 2031	Start in 2032	Start in 2033	Start in 2034	Start in 2035	Start in 2036

2. For each campus, prepare its **Criterion** sheet.

- Set **Type** = Penalty, **Relation** = "≥", **Penalty unit** = 268 (or your chosen rate), and name it (e.g. "Campus 1").
- For projects not located on that campus: enter 0 for all years.
- For projects located on that campus: enter each project's annual carbon reduction.
- See Appendix (Project Emission Reduction Calculation) for calculation details.

Type of Goals	Penalty	Relation to Goals	>=	Penalty/Reward Unit	268

Name	Campus 1

Project	Score in 2025-2026	Score in 2026-2027	Score in 2027-2028	Score in 2028-2029	Score in 2029-2030
1	0	0	0	0	0
2	2,759	2,759	2,759	2,039	2,039
3	0	0	0	0	0
4	2,439	2,439	2,439	1,709	1,709
5	1,122	1,122	1,122	1,073	1,073

Replacement of Mandatory Projects

It may be that a mandatory project must be replaced at the end of its useful life (and that this next version must itself be replaced at the end of its useful life, etc.) The Advanced tool can incorporate this mandatory scheduling of subsequent replacements (with realistic cash flows, e.g. only paying for the replacement at the end of the lifetime of the original version) as follows.

1. Create sequential replacement projects that each depend on the previous one in the **Planning** sheet.

    - *Example:* Suppose the initial Project 1 must finish by the end of Year 2 but itself only lasts one year.

- Create additional projects (e.g. Project 2, Project 3, Project 4) that each has the previous project as a prerequisite. These copies function as sequential replacements to cover the 5-year planning horizon from Year 2-5.

Project	Cost	Duration	Lifetime	Mandatory Deadline	Prerequisites	Scheduled
1	199,500	1	1	2		
2	199,500	1	1	0	1	
3	198,700	1	1	0	2	
4	202,100	1	1	0	3	

Intuitively, we will create a criterion with target one, assign the initial project and the replacements a score of one in this criterion, and force that we always hit the target of one (so exactly one copy will be in effect at any given time). However, this naïve formulation runs into the problem that we would be enforcing the initial project (or a replacement) to be in effect before the initial project is even completed, which would not make sense. Instead, we use a more sophisticated approach with two criteria and modified targets, which will allow us to ensure the "exactly one in effect" constraint is only enforced starting in the year the initial project must be completed by (i.e. its mandatory deadline).

2. Create **Criterion 1** sheet:

   - Set **Type** = Mandatory, **Relation** = "≥", **Penalty unit** = 0.
   - For the initial project and its replacement projects: enter 1 for every year.
   - For the other projects: enter 0 for every year.

Type of Goals	Mandatory	Relation to Goals	>=	Penalty/Reward Unit	0

Project	Score in 2025-2026	Score in 2026-2027	Score in 2027-2028	Score in 2028-2029	Score in 2029-2030
1	1	1	1	1	1
2	1	1	1	1	1
3	1	1	1	1	1
4	1	1	1	1	1
5	0	0	0	0	0

3. Create **Criterion 2** sheet:

   - Set **Type** = Mandatory, **Relation** = "≤", **Penalty unit** = 0.
   - For the initial project and its replacement projects: enter 1 for every year.
   - For the other projects: enter 0 for every year.

Type of Goals	Mandatory	Relation to Goals	<=	Penalty/Reward Unit	0

Project	Score in 2025-2026	Score in 2026-2027	Score in 2027-2028	Score in 2028-2029	Score in 2029-2030
1	1	1	1	1	1
2	1	1	1	1	1
3	1	1	1	1	1
4	1	1	1	1	1
5	0	0	0	0	0

4. Create target scores for both criteria: Crtierion1 guarantees the project or one of its replacements must be in effect from every year starting from the mandatory deadline of the initial project; Criterion 2 guarantees that you can never have a project and its replacement in effect at the same time.

- Set **Target Total Score for Criterion 1** to be 1 starting from the mandatory deadline of the initial project, and 0 in all years before that.
    - *Example:* Suppose Project 1 must finish by the end of Year 2, then you will input 0 for the first year, and 1 starting from second year.
- Set **Target Total Score for Criterion 2** to be 1 for all years.

Interest Rate (%)	3.0	Number of Years	5	Number of Criteria	3	Start Year	2025

Year	2025–2026	2026–2027	2027–2028	2028–2029	2029–2030	2030–2031	2031–2032	2032–2033
Annual Capacity of Projects to Take	5	5	5	5	5			
Annual Budget	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000			
Target Total Score for Criterion 1	0	1	1	1	1			
Target Total Score for Criterion 2	1	1	1	1	1			
Annual Number of Undergoing Projects								
Annual Total Cost								
Total Score of Selected for Criterion 1								
Total Score of Selected for Criterion 2								
	Start in 2025	Start in 2026	Start in 2027	Start in 2028	Start in 2029	Start in 2030	Start in 2031	Start in 2032

We present these examples to illustrate the tool's flexibility, feel free to explore possible criterions to your own requirements.

Troubleshooting Guide

Below is a list of potential error messages you may encounter when running the tool, along with recommended steps to resolve each issue:

- **"<path>" was not found or is a directory, please check again.**
  - Verify you entered the correct file path.
  - **Please do not** include quotation marks around the path.
- **Worksheet named "<sheet>" not found**
  - Ensure every required sheet uses the exact template name (e.g. `Projects Info`, `Planning`, `Criterion 1`, etc.).
  - If you added criteria, confirm you created matching sheets named `Criterion 2`, `Criterion 3`, etc., and that your "Number of Criteria" in **Planning** matches the number of Criterion sheets.
- **Defining usecols with out-of-bounds indices is not allowed. [..] are out-of-bounds. (sheet: Planning)**
  - Make sure you're using the correct template file for the chosen option:
    - Option 1 → `NYSERDA_Tool_Basic.xlsx`
    - Option 2 → `NYSERDA_Tool_LL97.xlsx`
    - Option 3 → `NYSERDA_Tool_DecarbGoal.xlsx`
    - Option 4 → `NYSERDA_Tool_Advanced.xlsx`
- **Index … is out of bounds for axis 0 with size …**
  - Check that your "Number of Years" and "Number of Projects" in the **Planning** sheet accurately reflect the years and the count of projects you provided.
- **Could not convert string to float: '…'**
  - One of the numeric inputs (e.g. cost, duration, or goal) contains the literal text "nan" or an invalid entry. Please remove any placeholder text and ensure all required numeric cells are truly blank or contain valid numbers.
- **KeyError or missing decision variable `(i, t)`**
  - Verify that your number of projects matches the rows in **Projects Info** and number of years match the data.
  - Verify that the durations and mandatory deadlines no larger than the length of planning horizon.
  - Please start with your first year in the first year-column, then add or remove year-columns as needed.

- **TypeError in looping over durations or lifetimes**

  - Check the **Projects Info** sheet to confirm every duration and lifetime cell is numeric, with no stray characters.

- **PermissionError when writing results**

  - Close the spreadsheet in any other program and ensure you have permission to write to the spreadsheet.

- **InvalidFileException: File is not a ZIP file**

  - Save your spreadsheet in `.xlsx` format, rather than `.xls` or others, and retry.

- **Outputs appear in the wrong rows**

  - Ensure that you have not shifted the output write-down rows.
  - Ensure any added Criterion sheets are accompanied by the correct header rows in **Planning** (two rows per criterion) when using Advanced tool. Use the original template's row structure as a guide.

Appendix

Resolving Infeasible Results

When the solver returns an "Infeasible" status, it means that no valid schedule exists under the current inputs and constraints. In the case of infeasibility, a user may proceed as follows.

The first step is to determine whether the infeasibility arises from overly strict mandatory deadline or project prerequisites. To do this, temporarily increase your annual budget and project capacity to an arbitrarily high value (e.g. 99,999,999), downgrade your decarb goals (e.g. 0) and re-run the model. If the solver now finds a feasible schedule, you know that at least one of your mandatory flags, prerequisite chains or decarb goals is impossible to satisfy under realistic resource limits.

Next, one can inspect the mandatory deadlines by confirming whether any deadlines requirements conflict with one another or exceed the planning horizon. For example, if there are 6 projects that must finish by Year 1 but you only have capacity for 5 projects in Year 1, the solver reports infeasible. Another possible case will be a project is mandatory to be finished by Year 6, but it takes at least 7 years to finish all prerequisites. In that case, consider loosening deadlines.

If mandatory constraints appear consistent, examine prerequisite dependencies. Ensure that no circular prerequisites exist (Project A → Project B → Project A) and that any prerequisite projects themselves are not infeasible to finish. You may need to reassign prerequisites for low-priority projects to break impossible chains.

If raising budgets and capacity does not resolve infeasibility, the issue likely lies in conflicting target scores or overly strict criteria. For example, when using the Decarb Goal tool, it could be that in later years of the horizon the goals are so stringent that even if you schedule all projects, and even considering that your current annual emission values will in general go down over time due to increased grid efficiency, it may be impossible to meet your goals. In this case, reduce the target (or, in the Advanced tool, convert it to a penalty criterion) so the solver can find a feasible solution.

Finally, if you still cannot locate the source of infeasibility:

1. Double-check that all numeric inputs (costs, lifetimes, reductions, capacity limits) are correctly formatted.
2. Consider creating a minimal test scenario with only a handful of projects and criteria and shorter planning horizon to confirm that the solver works on this smaller problem and gradually reintroduce projects, later years and constraints until infeasibility reappears.

File Management

Here we propose a file management approach if you would like to run the tool across multiple scenarios (although we note that using this approach is not necessary, as long as a new copy of the master file is created for each scenario). By isolating a Master template from your working Scenario files, the core template remains unchanged. For each new use case, simply duplicate the Master into a new Scenario workbook and adjust that copy's inputs. This keeps the original template safe from unintended edits, enables easy comparison across runs, and lets you add or archive scenarios without clutter.

1. **Find the three subfolders after unzipping Optimizer Suite:**
    - **Master** (empty templates ending in "–Master.xlsx")
    - **Scenarios** (directory for your working files)
    - **Demo Scenarios** (sample scenarios with inputs ending in "–Demo.xlsx" to help users understand the required inputs)
2. **Create a Scenario File:**
    - Copy the appropriate Master template (e.g. `NYSERDA_Tool_LL97-Master.xlsx`) from **Master** to **Scenarios**, and rename it (e.g. `Scenario1_LL97.xlsx`).
    - Always work from a **Scenario** spreadsheet and do **not** run the tool on any Master files.
3. **Populate Scenario Inputs:**
    - Fill in all required fields in the Scenario spreadsheet (e.g. **Planning, Projects Info** and etc.)
4. **Run the Tool and Review Results:**
    - Follow the standard execution steps (as described earlier) to solve the Scenario spreadsheet (e.g. `Scenario1_LL97.xlsx`) in **Scenarios** folder.
    - After solving, reopen the Scenario spreadsheet to view outputs on **Planning** and **Projects Info**.
5. **Repeat for Additional Scenarios:**
    - For each new scenario, duplicate the Master into **Scenarios**, rename it (e.g. `Scenario2_LL97.xlsx`), and repeat steps 3–5.

Score Calculation

The scoring method considers user-defined characteristics that matter most to the hospital, such as safety, resiliency, regulatory compliance, and carbon reduction. To translate these qualitative priorities into a single numeric score you first assign each characteristic a numerical rating on a common scale (e.g. 0–100) based on your evaluation of the project's performance in that area. Next, you apply a predefined weight to each characteristic, that reflects its relative importance to your organization. Finally, you sum the weighted values to obtain a composite score. This approach ensures that high-priority dimensions carry more influence in the final

ranking than lower-priority ones, while still capturing the project's overall strengths and weaknesses across all criteria.

Example
Suppose the following weights represent the relative importance of each user-defined characteristic for a project:

- Project Financial Data: 30%
- Institutional Financial Impact: 20%
- Organizational Business Objectives: 15%
- Facility Operation & Resiliency: 10%
- Facility Carbon Emissions Impact: 10%
- Regulatory Compliance Score: 10%
- Education & Training: 5%

We evaluate a single project across seven characteristics, each scored on a 0–100 scale, with the following weights:

- Project Financial Data = 90
- Institutional Financial Impact = 70
- Organizational Business Objectives = 85
- Facility Operation & Resiliency = 60
- Facility Carbon Emissions Impact = 75
- Regulatory Compliance Score = 95
- Education & Training = 80

We compute each weighted value:

- Project Financial Data: 90 × 0.30 = 27.0
- Institutional Financial Impact: 70 × 0.20 = 14.0
- Organizational Business Objectives: 85 × 0.15 = 12.75
- Facility Operation & Resiliency: 60 × 0.10 = 6.0
- Facility Carbon Emissions Impact: 75 × 0.10 = 7.5
- Regulatory Compliance Score: 95 × 0.10 = 9.5
- Education & Training: 80 × 0.05 = 4.0

Adding these gives a composite score of 80.75. This single number reflects the project's performance across all seven dimension and weighted according to your strategic priorities, allowing easy comparison against other projects.

To be clear, the computation of these scores is not part of the optimization tool, it is input to the tool. You can use a methodology of your choice (also the separate decision-making matrix tool) to compute these scores in advance based on your hospital's unique features and considerations.

Project Emission Reduction Calculation

To estimate a project's annual CO_2 reduction, first quantify the energy changes it delivers in each energy source (e.g. electricity, natural gas consumption or fuel-oil). Then multiply each unit of energy change by its GHG coefficient **in that year** (e.g. LL97 factors or your hospital's standard) to convert to tons of CO_2 avoided. Sum those products across all energy types to get the project's total annual reduction.

Example: if an HVAC upgrade saves 200,000 kWh and but increases 100,000 kBtu more gas, then in 2024-2029,

- **Electricity**: If the coefficient in 2024-2029 is 0.000288962 t CO_2/kWh, you'd calculate 200,000 kWh × 0.000288962 = 57.79 t CO_2.
- **Natural Gas**: If the coefficient in 2024-2029 is 0.00005311 t CO_2/kBTU, that yields -100,000 × 0.00005311 = -5.31 t CO_2.

  Total carbon reduction of the project is 57.79 - 5.31 = 52.48 t CO_2 in 2024-2029.

As the grid is expected to decarbonize in 2030–2034, the electricity GHG coefficient decreases as well, so the same kWh savings yield proportionally lower CO_2 reductions.

- **Electricity:** If the coefficient in 2030-2034is 0.000145 t CO_2/kWh, you'd calculate 200,000 kWh × 0.000145 = 29.00 t CO_2.
- **Natural Gas**: If the coefficient in 2030-2034 is still 0.00005311 t CO_2/kBTU, that yields -100,000 × 0.00005311 = -5.31 t CO_2.

  Total carbon reduction of the project is 29.00 - 5.31 = 23.69 t CO_2 in 2030-2034.

Current Annual Emissions Calculation

To compute your facility's current annual CO_2 emissions, start by gathering usage data for each energy source, including electricity, natural gas, fuel oils, and any other on-site fuels. Then:

1. **Calculate Baseline emissions**: Multiply each annual usage by your chosen GHG coefficient (e.g. LL97 factors or your hospital's standard).
2. **Annual Emission:** Sum all results to get total metric tons of CO_2 for the year.

Example: If your campus currently consumes 1,000,000 kWh Electricity, 12,000,000 kBTU Natural gas and 3,000,000 kBTU Fuel Oil #2, then in 2024-2029,

- **Electricity**: If the coefficient in 2024-2029 is 0.000288962 t CO_2/kWh, you'd calculate 1,000,000 kWh × 0.000288962 = 288.96 t CO_2.
- **Natural Gas**: If the coefficient in 2024-2029 is 0.00005311 t CO_2/kBTU, that yields 120,000 × 0.00005311 = 637.32 t CO_2.

- **Fuel Oil #2**: If the coefficient in 2024-2029 is 0.00007421 t CO_2/kBTU, you calculate 3,000,000 × 0.00007421 = 222.63 t CO_2.

  Adding 288.96 + 637.32 + 222.63 gives your campus's current annual emissions 1148.91 tons in 2024-2029.

As the grid is expected to further decarbonize over time, in 2030–2034, the electricity GHG coefficient decreases, so the same kWh savings yield proportionally lower CO_2 emission.

- **Electricity**: If the coefficient in 2030–2034 is 0.000145 t CO_2/kWh, you'd calculate 1,000,000 kWh × 0.000145 = 145 t CO_2.
- **Natural Gas**: If the coefficient in 2030–2034 is still 0.00005311 t CO_2/kBTU, that yields 120,000 × 0.00005311 = 637.32 t CO_2.
- **Fuel Oil #2**: If the coefficient in 2030–2034 is still 0.00007421 t CO_2/kBTU, you calculate 3,000,000 × 0.00007421 = 222.63 t CO_2.

  Adding 145 + 637.32 + 222.63 gives your campus's current annual emissions 1004.85 tons in 2030-2034.

In-flight Project Adjustment

If your organization currently has in-flight projects which may have a significant impact on your annual emissions but are not yet reflected in your current annual emissions, you should use the previous methodology to adjust your current annual emissions appropriately (over time) to account for the corresponding emission reductions.

Example: Assume the carbon reduction value and current emission are pre-calculated using previous methodology.

- In-Flight Project A finishes in 2028, has a useful lifetime of 3 years.
- Using the previous methodology, we find that it reduces emissions by 52.48 t CO_2 in 2028-2029 and 2029-2030, and 23.69 t CO_2 in 2030-2031.
- The current annual emission without considering this project A is 1148.91 t CO_2 in 2028-2029 and 2029-2030, and 1004.85 t CO_2 in 2030-2031.

Then we adjust the current annual emission according to the reduction value that project A brings after completion:

- No change in 2025-2027 and 2031-2050.
- Current annual emission in 2028-2029 and 2029-2030 are now 1148.91-52.48 = 1096.43 t CO_2.
- Current annual emission in 2030-2031 is now 1004.85-23.69 = 981.16 t CO_2.

Local Law 97 Limits Calculation

To determine your hospital's annual LL97 emissions limit, follow these steps for each five-year compliance block:

1. Lookup the intensity-based cap
    - Find the prescribed emissions intensity (tCO_2/ ft^2/ year) for your hospital category and compliance period.
    - Multiply that rate by your total gross floor area (GFA).
    - *Example*: If the intensity is 0.04 tCO_2/ ft^2 in 2025 and GFA is 500,000 ft^2 then compute LL97 cap 0.04 × 500,000 = 20, 000 t CO_2 in 2025.
2. Apply the nonprofit hospital alternative baseline if applicable:
    - 2025–2029: Nonprofits may elect an accommodation equal to 85% of their CY 2018 actual emissions, instead of the intensity cap, whichever yields the higher limit.
    - 2030–2034: Nonprofits may elect an accommodation equal to 70% of their CY 2018 actual emissions, instead of the intensity cap, whichever yields the higher limit.
3. Calculate the LL97 annual limits
    - For nonprofits in 2025–2029: max(intensity × GFA, 0.85 × 2018 emissions).
    - For nonprofits in 2030–2034: max(intensity × GFA, 0.70 × 2018 emissions).
    - For all hospitals (profit or nonprofit) in 2035–2050: intensity × GFA.

For NYCHA properties, annual emissions limits aren't set by a per-square-foot intensity but by portfolio-wide percentage reductions from baseline emissions:

1. Baseline calculation
    - Determine total annual GHG emissions in the baseline year (typically CY 2018) by same fuel-use × coefficient method described earlier.
2. 2025–2030 Block
    - No LL97 Limits (999,999,999 as input)
3. 2030–2034 Block
    - LL97 Limit = 60% of baseline emissions.
    - *Example*: If your NYCHA portfolio emitted 100,000 t CO_2 in 2018, your 2030–2034 LL97 limit is 100,000 × 0.60 = 60000 t CO_2 per year.
4. 2035–2050 Block
    - LL97 Limit = 20% of your baseline emissions.
    - *Example*: If your NYCHA portfolio emitted 100,000 t CO_2 in 2018, your 2035–2050 LL97 limit is 100,000 × 0.20 = 20,000 t CO_2 per year.

If your facility qualifies for any additional accommodations or exemptions, simply subtract those allowances from the LL97 limits above to arrive at your adjusted annual limits.

Integer Programming Formulations

In this section we provide the explicit mathematical models used in each of the optimization tools, written as integer programming optimization problems. Each model has a set of decision variables (to be optimized over), objective function, and constraints. Reading this section is not at all necessary for using the tool, it is only for users interested in understanding precisely what is going on "under the hood", and does assume a familiarity with such optimization models.

Integer Programming Formulation for Basic Tool

Decision Variables

For each project i and each year t in the planning horizon, define a binary variable

$$X_{i,t} = \begin{cases} 1 & \text{if project } i \text{ is started in year } t \\ 0 & \text{otherwise} \end{cases}$$

Objective

Maximize the total discounted performance score of all selected projects. Each project i, with duration D_i and lifetime L_i, contributes its score S_i in its useful lifetime after it finishes. Formally:

$$max \sum_{i=1}^{N} \sum_{t=1}^{T} \frac{S_i}{(1+r)^t} \sum_{\tau=max(0,t+1-D_i-L_i,)}^{t-D_i} X_{i,\tau}$$

where the last sum indicates whether project i finishes and within lifetime in year t.

Constraints

- **Budget Limits**: In each year t, the sum of net costs C_i of all projects started cannot exceed the annual budget B_t ,

$$\sum_{i=1}^{N} C_i X_{i,t} \leq B_t$$

- **Parallel Capacity:** At any year t, the number of projects still under implementation must not exceed the capacity K_t:

$$\sum_{i=1}^{N} \sum_{\tau=max(0,t-D_i+1)}^{t} X_{i,\tau} \leq K_t$$

- **Unique Selection:** Each project may be initiated at most once over the entire horizon:

$$\sum_{t=0}^{T-1} X_{i,t} \leq 1$$

- **Mandatory Deadlines**: For any project i with a positive deadline M_i, exactly one start time must be chosen that guarantees completion by year :

$$\sum_{t=0}^{M_i - D_i} X_{i,t} = 1$$

- **Precedence:** If project j has project i as prerequisite, then no start time for j may be chosen before i finishes. Equivalently, for each prerequisite pair (i, j), the model force $X_{j,t} = 0$ for all $t < D_i$; and for $t \geq D_i$,

$$X_{j,t} \leq \sum_{\tau=0}^{t-D_i} X_{i,\tau}$$

Outputs

When solved by PuLP (open-source Python library for modeling and solving linear optimization problems), this model produces a binary start-time schedule $X_{i,t}$ that maximizes the discounted sum of project scores, respects annual budgets and capacity limits, enforces mandatory deadlines, and honors all prerequisite relationships.

Integer Programming Formulation for Decarb Tool (LL97 ver.)

Decision Variables

- $X_{i,t} \in \{0,1\}$: 1 if project i starts in year t, 0 otherwise, for all $i = 1 \dots N, t = 0 \dots T-1$.
- $Z_{i,j} \in \{0,1\}$: 1 if the bundled savings "pair" pairing (i,j) is used, 0 otherwise, for each pair in the bundled savings list.
- $W_{i,j,t} \in [0,1]$: linearization variable that equals 1 if both projects i and j start together in year t and the pair (i,j) is chosen; 0 otherwise.
- $F_t \geq 0$: the emission-gap variable in year t, capturing any excess emissions over the Local Law 97 limit.

Objective

Minimize the net present value of all cashflows, accounting for outflows from project costs and LL97 penalties, and inflows from bundle cost savings and financial savings from implemented and still active projects:

$$min \underbrace{\sum_{i,t} \frac{C_i}{(1+r)^t} X_{i,t}}_{\text{project costs}} + \underbrace{\sum_{t} \frac{268}{(1+r)^t} F_t}_{\text{fines for excess emission}} - \underbrace{\sum_{(i,j),t} \frac{c_{i,j}^{\text{pair}}}{(1+r)^t} W_{i,j,t}}_{\text{pair savings}} - \underbrace{\sum_{i,t} \frac{S_i}{(1+r)^t} \sum_{\tau=max(0,t+1-D_i-L_{i,})}^{t-D_i} X_{i,\tau}}_{\text{annual financial savings}}$$

where the last sum indicates whether project i finishes and within lifetime in year t.

Constraints

- **Budget Limits**: In each year t, the sum of net costs C_i of all projects started, after subtracting their applicable pair savings $c_{i,j}^{\text{pair}}$, cannot exceed annual budget B_t:

$$\sum_{i=1}^{N} C_i X_{i,t} \leq B_t$$

- **Parallel Capacity:** At any year t, the number of projects still under implementation must not exceed the capacity K_t:

$$\sum_{i=1}^{N} \sum_{\tau=max(0,t-D_i+1)}^{t} X_{i,\tau} \leq K_t$$

- **Unique Selection:** Each project may be initiated at most once over the entire horizon:

$$\sum_{t=0}^{T-1} X_{i,t} \leq 1$$

- **Mandatory Deadlines**: For any project i with a positive deadline M_i, exactly one start time must be chosen that guarantees completion by year :

$$\sum_{t=0}^{M_i - D_i} X_{i,t} = 1$$

- **Precedence:** If project j has project i as prerequisite, then no start time for j may be chosen before i finishes. Equivalently, for each prerequisite pair (i, j), the model force $X_{j,t} = 0$ for all $t < D_i$; and for $t \geq D_i$,

$$X_{j,t} \leq \sum_{\tau=0}^{t-D_i} X_{i,\tau}$$

- **Largest Saving:** Each project involved in any pair will be paired once with the one giving the largest saving if selected,

$$\sum_{j:(i,j)\in \text{ pairs}} Z_{i,j} = 1, \forall i \in \text{paired set.}$$

- **Linearization of Pairs**: For each pair (i, j) and year t,

$$W_{i,j,t} \geq Z_{i,j} + X_{i,t} + X_{j,t} - 2$$
$$W_{i,j,t} \leq Z_{i,j}, W_{i,j,t} \leq X_{i,t}, W_{i,j,t} \leq X_{j,t}$$

  such that $W_{i,j,t} = Z_{i,j} X_{i,t} X_{j,t}$.

- **Gap from Actual Emission and LL97 Limits:** The gap variable F_t shows the shortfall between the required reduction G_t(difference between current emissions and the LL97 limit) and the total emissions reduction delivered by the chosen projects. In other words,

$$F_t = max(0, -G_t + \sum_i E_{i,t} \sum_{\tau=max(0,t-D_i-L_i+1)}^{t-D_i} X_{i,\tau})$$

  where the double sum represents the sum of reduction $E_{i,t}$ provided by each project i that is active in year t.

Outputs

When solved by PuLP (open-source Python library for modeling and solving linear optimization problems), this model produces a binary start-time schedule $X_{i,t}$ that minimizes the net present cashflows. It balances project costs and Local Law 97 penalties with bundle savings and annual financial savings, while respecting budgets, capacities, deadlines, and prerequisites.

Integer Programming Formulation for Decarb Tool (Decarb Goal ver.)

Decision Variables

- $X_{i,t} \in \{0,1\}$: 1 if project i starts in year t, 0 otherwise, for all $i = 1 \dots N, t = 0 \dots T-1$.
- $Z_{i,j} \in \{0,1\}$: 1 if the bundled saving "pair" pairing (i,j) is used, 0 otherwise, for each pair in the bundled saving pairs list.
- $W_{i,j,t} \in [0,1]$: linearization variable that equals 1 if both projects i and j start together in year t and the pair (i,j) is chosen; 0 otherwise.

Objective

Minimize the net present value of all cashflows, accounting for outflows from project costs, and inflows from bundle cost savings and financial savings from implemented and still active projects:

$$min \underbrace{\sum_{i,t} \frac{C_i}{(1+r)^t} X_{i,t}}_{\text{project costs}} - \underbrace{\sum_{(i,j),t} \frac{c_{i,j}^{\text{pair}}}{(1+r)^t} W_{i,j,t}}_{\text{pair savings}} - \underbrace{\sum_{i,t} \frac{S_i}{(1+r)^t} \sum_{\tau=max(0,t+1-D_i-L_i,)}^{t-D_i} X_{i,\tau}}_{\text{annual financial savings}}$$

where the last sum indicates whether project i finishes and within lifetime in year t.

Constraints

- **Budget Limits**: In each year t, the sum of net costs C_i of all projects started, after subtracting their applicable pair savings $c_{i,j}^{\text{pair}}$, cannot exceed annual budget B_t:

$$\sum_i C_i X_{i,t} - \sum_{(i,j)} c_{i,j}^{\text{pair}} W_{i,j,t} \leq B_t$$

- **Parallel Capacity:** At any year t, the number of projects still under implementation must not exceed the capacity K_t:

$$\sum_{i=1}^{N} \sum_{\tau=max(0,t-D_i+1)}^{t} X_{i,\tau} \leq K_t$$

- **Unique Selection:** Each project may be initiated at most once over the entire horizon:

$$\sum_{t=0}^{T-1} X_{i,t} \leq 1$$

- **Mandatory Deadlines**: For any project i with a positive deadline M_i, exactly one start time must be chosen that guarantees completion by year :

$$\sum_{t=0}^{M_i - D_i} X_{i,t} = 1$$

- **Precedence:** If project j has project i as prerequisite, then no start time for j may be chosen before i finishes. Equivalently, for each prerequisite pair (i, j), the model force $X_{j,t} = 0$ for all $t < D_i$; and for $t \geq D_i$,

$$X_{j,t} \leq \sum_{\tau=0}^{t-D_i} X_{i,\tau}$$

- **Largest Saving:** Each project involved in any pair will be paired once with the one giving the largest saving if selected,

$$\sum_{j:(i,j)\in \text{ pairs}} Z_{i,j} = 1, \forall i \in \text{paired set.}$$

- **Linearization of Pairs**: For each pair (i, j) and year t,

$$W_{i,j,t} \geq Z_{i,j} + X_{i,t} + X_{j,t} - 2$$
$$W_{i,j,t} \leq Z_{i,j}, W_{i,j,t} \leq X_{i,t}, W_{i,j,t} \leq X_{j,t}$$

  such that $W_{i,j,t} = Z_{i,j} X_{i,t} X_{j,t}$.

- **Reduction Goals:** The total emissions reduction delivered by the chosen projects must be greater than the required reduction G_t(difference between current emissions and target emission levels).

$$\sum_i E_{i,t} \sum_{\tau=max(0,t-D_i-L_i+1)}^{t-D_i} X_{i,\tau} \geq G_t$$

  where the double sum represents the sum of reduction $E_{i,t}$ provided by each project i that is active in year t.

Outputs

When solved by PuLP (open-source Python library for modeling and solving linear optimization problems), this model produces a binary start-time schedule $X_{i,t}$ that minimizes the net present cashflows while ensuring all emission targets are met. It balances project costs with bundle savings and annual financial savings, while respecting budgets, capacities, deadlines, prerequisites and emission goals.

Integer Programming Formulation for Decarb Tool (Advanced ver.)

Decision Variables

- $X_{i,t} \in \{0,1\}$: 1 if project i starts in year t, 0 otherwise, for all $i = 1 \dots N, t = 0 \dots T-1$.
- $Z_{i,j} \in \{0,1\}$: 1 if the bundled saving "pair" pairing (i,j) is used, 0 otherwise, for each pair in the bundled saving pairs list.
- $W_{i,j,t} \in [0,1]$: linearization variable that equals 1 if both projects i and j start together in year t and the pair (i,j) is chosen; 0 otherwise.
- $F_{m,t} \geq 0$: the gap variable for criterion m in year t, capturing any shortfall or over-achievement relative to its target.

Objective

Maximize the net benefit of all criteria, accounting for resulting rewards and penalties of deviation from specified targets.

$$max \quad \underbrace{\sum_{m,t} \frac{u_{m,t}}{(1+r)^t} F_{m,t}}_{\text{net benefit from criterion m}}$$

If cost is also considered in the objective, then the project costs and bundle cost savings are also incorporated:

$$max \quad \underbrace{\sum_{m,t} \frac{u_{m,t}}{(1+r)^t} F_{m,t}}_{\text{net benefit from criterion m}} - \underbrace{\sum_{i,t} \frac{C_i}{(1+r)^t} X_{i,t}}_{\text{project costs}} + \underbrace{\sum_{(i,j),t} \frac{c_{i,j}^{\text{pair}}}{(1+r)^t} W_{i,j,t}}_{\text{pair savings}}$$

Constraints

- **Budget Limits**: In each year t, the sum of net costs C_i of all projects started, after subtracting their applicable pair savings $c_{i,j}^{\text{pair}}$, cannot exceed annual budget B_t:

$$\sum_i C_i X_{i,t} - \sum_{(i,j)} c_{i,j}^{\text{pair}} W_{i,j,t} \leq B_t$$

- **Parallel Capacity:** At any year t, the number of projects still under implementation must not exceed the capacity K_t:

$$\sum_{i=1}^{N} \sum_{\tau=max(0,t-D_i+1)}^{t} X_{i,\tau} \leq K_t$$

- **Unique Selection:** Each project may be initiated at most once over the entire horizon:

$$\sum_{t=0}^{T-1} X_{i,t} \leq 1$$

- **Mandatory Deadlines**: For any project i with a positive deadline M_i, exactly one start time must be chosen that guarantees completion by year :

$$\sum_{t=0}^{M_i - D_i} X_{i,t} = 1$$

- **Precedence:** If project j has project i as prerequisite, then no start time for j may be chosen before i finishes. Equivalently, for each prerequisite pair (i, j), the model force $X_{j,t} = 0$ for all $t < D_i$; and for $t \geq D_i$,

$$X_{j,t} \leq \sum_{\tau=0}^{t-D_i} X_{i,\tau}$$

- **Largest Saving:** Each project involved in any pair will be paired once with the one giving the largest saving if selected,

$$\sum_{j:(i,j)\in \text{ pairs}} Z_{i,j} = 1, \forall i \in \text{paired set.}$$

- **Linearization of Pairs**: For each pair (i, j) and year t,

$$W_{i,j,t} \geq Z_{i,j} + X_{i,t} + X_{j,t} - 2$$
$$W_{i,j,t} \leq Z_{i,j}, W_{i,j,t} \leq X_{i,t}, W_{i,j,t} \leq X_{j,t}$$

  such that $W_{i,j,t} = Z_{i,j} X_{i,t} X_{j,t}$.

- **Gap of Each Criteria:** First, for criterion m at year t, compute the total realized score

$$S_{m,t} = \sum_i S_{i,m,t} \sum_{\tau=max(0,t-D_i-L_i+1)}^{t-D_i} X_{i,\tau},$$

  where $S_{i,\boldsymbol{m},t}$ is contribution of project i in criterion m in year t if it is active.

  Then compare $S_{\boldsymbol{m},t}$ with targets $G_{\boldsymbol{m},t}$ of criterion m in year t, and define the gap variable $F_{\boldsymbol{m},t}$ according to the specified types (if is "Penalty" or "Reward") and relations to goals (if is "<=" or ">=").

  - Penalty Type, "<=" Goal: $F_{m,t} = min(0, G_{m,t} - S_{m,t})$,

so $F_{m,t}$ is negative if the total score $S_{m,t}$ exceeds the target $G_{m,t}$, yielding a penalty.

- Penalty Type, ">=" Goal: $F_{\boldsymbol{m},t} = min(0, S_{\boldsymbol{m},t} - G_{\boldsymbol{m},t})$,

  so $F_{m,t}$ is negative if the total score $S_{m,t}$ falls short of the target $G_{m,t}$.

- Reward Type, "<=" Goal: $F_{\boldsymbol{m},t} = max(0, G_{\boldsymbol{m},t} - S_{\boldsymbol{m},t})$,

  so $F_{m,t}$ is positive if the total score $S_{m,t}$ is within the target $G_{m,t}$, yielding a reward.

- Reward Type, ">=" Goal: $F_{\boldsymbol{m},t} = max(0, S_{\boldsymbol{m},t} - G_{\boldsymbol{m},t})$,

  so $F_{m,t}$ is positive if the total score $S_{m,t}$ exceeds the target $G_{m,t}$.

- **Mandatory Targets:** For each "mandatory" type criterion $\boldsymbol{m}$ in year t, the total score $S_{\boldsymbol{m},t}$ is calculated as before. Then, depending on the user's chosen relation to the target $G_{m,t}$, enforce one of the constraints.
  - If the relation is "=", impose $S_{\boldsymbol{m},t} = G_{\boldsymbol{m},t}$.
  - If the relation is ">=", impose $S_{\boldsymbol{m},t} \geq G_{\boldsymbol{m},t}$.
  - If the relation is "<=", impose $S_{\boldsymbol{m},t} \leq G_{\boldsymbol{m},t}$.

  These hard constraints guarantee that each mandatory criterion exactly meets (or does not exceed/fall below) its specified target.

Outputs

When solved by PuLP (open-source Python library for modeling and solving linear optimization problems), this model produces a binary start-time schedule $X_{i,t}$ that maximizes the total performance. It balances project costs with bundle savings if finance is also considered as part of performance evaluation, while respecting budgets, capacities, deadlines, prerequisites, and mandatory targets.