2026 ICM
Problem E: Passive Solar Shading

Background

Passive solar shading has become a common addition to both housing and commercial buildings as a part of a retrofit or in new construction. It is relatively inexpensive and creates cost savings in heating and cooling. The shades are designed to block summer sun from entering a building, while allowing winter sun to not only enter the building but to warm a thermal mass that can reradiate for many hours after. Strategies such as overhangs, vegetative shading, brise-soleil systems, and high-performance glazing can reduce heat gain in buildings during higher temperatures.

Passive solar shading is different depending on building orientation, window area distribution between the different faces of the building, and climate. It also requires the presence of an internal thermal mass that can be heated by the direct sun. This thermal mass can be concrete, stone, water, or other material that can store heat. The thermal mass not only stores heat but reduces temperature swings throughout the day.

These techniques use the predictable path of the sun (determined through the use of solar position calculators), materials, geometry, and natural environmental conditions to maintain comfort and reduce energy consumption. However, the typical calculations make use of the angle of the sun at **solar noon** on the **Summer** and **Winter Solstices** to calculate the optimal extension of a shade over a window as shown in **Figure 1**. This is a simplistic view of the problem, and future metrics must do better to account for change.

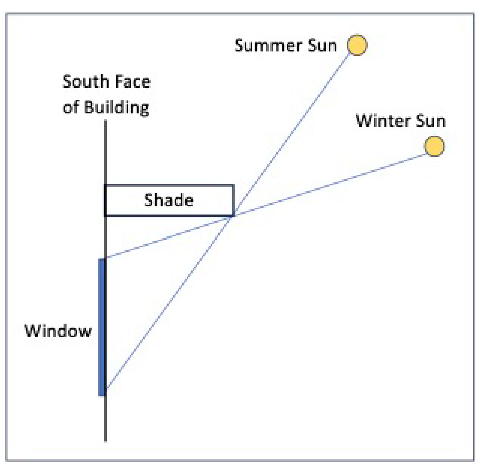

Figure 1: Passive Solar Shading – Winter and Summer Sun on Solstices

Scenario

You have been hired by the Collective Organizations Making Astrophysical Protections (COMAP) to innovate the next generation of solar shading strategies to be implemented at the **notional** Sungrove University and notional Borealis University.

The notional Sungrove University, located in a warm, low-latitude region with high solar exposure and increasingly frequent heat waves, is planning a major transformation of its main academic quad. The campus currently suffers from excessive cooling costs and glare in the classrooms. The university leadership has decided to pursue a **net-zero cooling** initiative by 2040.

Notably, Sungrove University is planning to retrofit its Academic Hall North. It is a two-story classroom and office building. The interior layout combines perimeter offices and classrooms with interior corridors. The building has a rectangular footprint (60m × 24m) with its long side aligned east-west as shown in **Figure 2**. The facade consists of double glazing and a brick veneer with an average window-to-wall ratio of 45% on the south facing side and 30% on the remaining sides. The building relies on mechanical cooling in the summer and hydronic heating in the winter with limited passive strategies in place. Additional features of this notional building are yours to imagine. Ensure you communicate these features in your writing to COMAP.

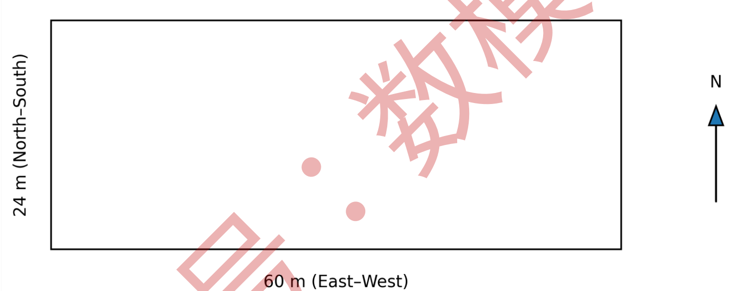

Figure 2: Academic Hall North footprint

Additionally, COMAP has been hired by the notional Borealis University, located at a high latitude where winter temperatures remain below freezing for months, sunlight hours are limited, and buildings experience heavy heating demands.

Sungrove University and Borealis University are also both planning a new student union that will serve as the hub of university activities. They have each mandated that their new student union building relies heavily on passive solar shading rather than mechanical cooling systems. The Universities want their student union building to serve as a prototype for future developments, meaning that their passive solar strategy design must perform well not only today, but under projected climate conditions well into the future.

Beyond the standard approach to shading as outlined in the Background, to assist these notional universities, you should extend your ideas to include:

- Shading needs throughout the day rather than just at solar noon.
- Windows of different sizes and shapes.
- Windows that do not face exactly south/north (depending on the hemisphere).
- Shades of different styles and materials that would match the architecture of the building.

As with any new strategy or model, you will not only need to describe your approach but also explain the advantages that your proposal holds over the previous standard. COMAP needs to know how your passive solar shading strategies can more effectively reduce heat gain in campus buildings during the summer while still admitting beneficial winter sun.

Requirements

Your team has been asked by COMAP to provide a model-based feasibility analysis that determines how Sungrove University can reduce its academic year cooling load with passive solar design in the retrofit of buildings on campus. To do so, design a retrofit for Sungrove University's Academic Hall North that optimizes heating and cooling throughout the academic year. What passive solar strategies and building features would you use, and how would you evaluate their performance?

Borealis University has a building with a similar design to Sungrove University's Academic Hall North. How can extending your work for Sungrove University to include the crucial importance of the effective use of a thermal mass provide Borealis University with a plan to use passive solar shading? You may want to consider building geometry, material selection, glazing positioning, internal thermal mass, or other aspects to maximize winter heat gain while avoiding overheating in the warmer months.

The retrofit design models at both Sungrove and Borealis Universities are helpful for only those notional sites. Adapt your model and discuss the design considerations for other locations including the different heating and cooling needs at places that might have similar latitudes.

Design a passive solar shading strategy for the new student union building at either Sungrove University or Borealis University that keeps the building temperate. Describe the strategies, building features, and modeling approaches you would use to evaluate performance over time. You may wish to address some of the following in your analysis:

- Predicting solar heat gain
- Estimating heating and/or cooling load reductions
- Accounting for seasonal variations
- Evaluating the tradeoffs between daylighting needs and shading effectiveness

Write a one-to-two-page letter to either Sungrove University or Borealis University (not both) outlining the steps they should take to include passive solar shading in both their retrofit and new building plans.

Your PDF solution of no more than 25 total pages should include:

- One-page Summary Sheet.
- Table of Contents.
- Your complete solution.
- One-to-Two-Page Letter.
- References List.
- AI Use Report (If used does not count toward the 25-page limit.)

Note: There is no specific required minimum page length for a complete ICM submission. You may use up to 25 total pages for all your solution work and any additional information you want to include (for example: drawings, diagrams, calculations, tables). Partial solutions are accepted. We permit the careful use of AI such as ChatGPT, although it is not necessary to create a solution to this problem. If you choose to utilize a generative AI, you must follow the COMAP AI use policy. This will result in an additional AI use report that you must add to the end of your PDF solution file and does not count toward the 25 total page limit for your solution.

Glossary

Solar noon is the moment during the day when the Sun is at its highest point in the sky for a given location.

Winter Solstice is the day with the least daylight of the year, caused by Earth's tilt.

Summer Solstice is the day with the most daylight of the year, caused by Earth's tilt.

Notional means theoretical or fictitious. The universities in this problem are not real, but only theoretical case studies.

Net-zero cooling means providing cooling without adding greenhouse gases to the atmosphere.