2026 HiMCM
Problem B: Air Conditioning the Environment: Modeling Energy Waste in Public Cooling



Image Credit: Adobe Express

Background

Everyone knows it is wasteful to leave the door of the freezer open. As cold air escapes and warm air enters, the freezer must use additional energy to maintain the desired temperature. Yet many modern public spaces do not follow this principle, as they intentionally expend energy to cool areas that are not fully enclosed. ***Open-air venues***, like stadium concourses or concert amphitheaters, and, ***semi-open public spaces***, like transit stations, airport terminals, and public waiting areas, use cooling systems to keep customers comfortable and safe, despite constant exposure to the surrounding environment. In these settings, some of the cooling reaches its intended audience, while some dissipates into the atmosphere.

As cities become warmer, energy costs increase, and extreme heat events become more frequent, venue operators face a difficult challenge trying to provide comfortable and safe environments while using energy responsibly. Determining whether a cooling strategy is effective requires more than measuring temperature alone. Factors such as facility design, crowd size, weather conditions, airflow, operating costs, and visitor comfort and safety all play a role.

The Heat impact Mitigation through Cooling Management (HiMCM) team that manages both open-air venues and semi-open public spaces is reevaluating its cooling practices and wants to understand how efficiently its systems deliver useful cooling to visitors. Because conditions vary across facilities and climates, the company seeks a general framework that can be used to compare different cooling approaches and identify opportunities for improvement.

Your team has been hired by HiMCM to investigate the problem. Develop a mathematical model to evaluate the effectiveness of cooling systems in both open-air venues and semi-open public spaces and provide recommendations for balancing comfort, safety, energy consumption, and cost.

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Requirements.

1. **Understand the Problem.** ***Open freezer cases*** in grocery stores continuously use energy to remove heat from food and the surrounding air. What aspects of a freezer case should be considered when measuring cooling efficiency? Should efficiency depend only on energy use? Justify the quantities that should be included in a measure of cooling efficiency. Use your response to motivate the design of your cooling efficiency models below.

2. **Create Your Model.** A city is looking for ways to keep people comfortable while they wait for public transportation by bus or rail on hot summer days.

a. For the bus, one proposal is to install a cooling system in an open-sided **bus stop** shelter. City planners want to determine which system is the most efficient, but at this time, only know the following:

Cooling System	Effect on Shelter	Energy Use
A. Fan System	Makes space feel up to 3°C cooler	0.25 kW
B. ***Evaporative Cooler***	Lowers air temperature up to 5°C	1.2 kW
C. Large Evaporative Cooler	Lowers air temperature up to 8°C	2.5 kW

Develop a measure of cooling efficiency for the bus stop. You may want to consider factors, including, but not limited to, the size of the cooled area, ***climate conditions***, energy use, and the number of people benefiting from the cooling.

b. For a semi-open rail-station waiting area, revise and improve your model as necessary to measure cooling efficiency. Clearly explaining what changed, why the change was necessary, and how the revision improved the model's usefulness or accuracy.

3. **Apply Your Model.** Does your cooling efficiency model scale? Apply your model to at least two specific venues. Ensure these venues are in different climates or that they use different types of cooling systems to demonstrate the robustness of your model. Possible case studies include:
    - Stadium concourses,
    - Concert amphitheaters,
    - Outdoor restaurant patios,
    - Open-air airport terminals in warm climates,
    - Open walkways in outdoor malls, or
    - Other open-air venues or semi-open public spaces.

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You may use real-world data or reasonable estimates with assumptions when real-world data is not available. Use your model to compare the efficiency of cooling strategies across venues and identify the characteristics that contribute most to efficient cooling.

4. **Expand Your Model and Reflect on Your Analysis.** A cooling solution that is highly efficient may not be the most effective overall. Extend your model to evaluate cooling effectiveness by balancing cooling performance, visitor experience, energy consumption and cost. Clearly describe how your model accounts for these competing objectives.

5. **Share Your Model and its Results.** Propose guidelines for the use of cooling systems in your venues. Discuss strategies for how operators can balance visitor comfort, sustainability, and cost while maintaining safe and effective environments during periods of extreme heat.

    a. Prepare a one-to-two-page memorandum to the Chief Operations Officer of HiMCM about one of your chosen venues. In your memorandum, summarize your major findings and provide actionable recommendations regarding the use of cooling systems for that venue. Your recommendations should address balancing the trade-offs of cooling effectiveness.

    b. Create a **blog post** that HiMCM can use to explain these results to the public. HiMCM wants to educate the public surrounding the question of "How much cooling are we getting for the energy we use in these open-air venue or semi-open public spaces?".

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 memorandum to the Chief Operations Officer.
- References list.
- Report on Use of AI Tools (If used does not count toward the 25-page limit.).

Glossary:

Open-air venue – a place where events are held primarily outdoors and are exposed to the surrounding environment rather than being enclosed by walls and a roof.

Semi-open public space – a publicly accessible area that is partially enclosed by roofs, walls or other structures while still allowing for a significant air exchange with the outdoors.

Open freezer case – a refrigerated display used in grocery or convenient stores that keeps products cold while remaining open to the surrounding air, allowing customers to easily view and access items without opening a door.

Bus Stop – A designated roadside location where a bus briefly halts to let passengers get on or off.

Evaporative cooler – cooling device that lowers air temperature by passing warm air through water-soaked pads. As the water evaporates, it absorbs heat for the air, producing cooler air that is then circulated by a fan, using less energy than traditional air conditioners.

Climate conditions – could include latitude or location, temperature, humidity, solar exposure or wind.

Blog post – an article or piece of written content published on a website.

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