MathWorks Math Modeling Challenge 2025
A program of SIAM

Hot Button Issue: *Staying Cool as the World Heats Up*

The world is steadily warming, and as temperatures rise, new high-temperature records are regularly being set. In 2024 alone, all-time temperature highs were reached in many parts of the world[1]. While individual hot days are concerning, they become even more dangerous when they are part of a larger, more extreme weather event called a heat wave. Unfortunately, heat waves are not only occurring more frequently, but they are growing more intense, lasting longer, and spreading across broader periods of the year—an alarming trend that has persisted for more than 50 years[2].

One of the major risks of heat waves is power outages. Despite advancements in technology, such as more efficient air conditioning and better home insulation, the high energy demand during heat waves can put significant strain on the electrical grid, often resulting in widespread loss of electricity[3]. Without electric power, homes and businesses lose the ability to stay cool, while critical infrastructure—like communication networks, hospitals, and transportation systems—struggle to function[4].

Socioeconomically vulnerable urban populations are often disproportionately affected by heat-induced power outages[5, 6, 7]. These communities rely more heavily on public transportation, which exposes them to higher levels of heat, and have limited access to green spaces and cooling areas. Rural populations also face heat-related challenges, including greater exposure to heat from outdoor work, fewer healthcare resources, and limited access to cooling centers[8].

Local authorities in two cities—Memphis, Tennessee, and Birmingham, England—have requested your team's assistance. They need insights into residential temperature trends and energy demands to help inform emergency plans and social services for their residents. Choose one of these locations to focus on as you answer the three questions below.

- **Q1: Hot to Go**—During a heat wave rising temperatures lead to increased air conditioning and electricity use. As the day goes on, the temperature inside a building also rises, particularly in homes without air conditioning. Develop a model to predict the indoor temperature of any non-air-conditioned dwelling during a heat wave over a 24-hour period in one of the cities mentioned above. A data set containing sample dwellings and specific heat wave data for your chosen city is provided. Test your model against this data and clearly explain the choices you made in creating your model.
- **Q2: Power Hungry**—Develop a model that predicts the peak demand that your city's power grid should be prepared to handle during the summer months. Do you foresee any changes in the maximum demand 20 years from now?
- **Q3: Beat the Heat**—Power system outages pose serious risks, potentially exposing people to extreme heat without relief, and these impacts are often felt disproportionately by different segments of the population. City officials have asked your team to develop a vulnerability score for various neighborhoods to help them equitably allocate resources for minimizing the effects of a heat wave or a power grid failure. Justify all factors you choose to include in your vulnerability scores. In addition, propose a single approach for how your chosen city can incorporate these vulnerability scores into their management of heat waves.

The first page of your submission should be an executive summary of your findings, which may be written in the form of a brief to your chosen city's authorities. This should be followed by your solution paper, which should include clear explanations—understandable to city authorities—of why you chose the mathematical approaches used in your model(s). We recommend that your solution paper not exceed 20 pages in length. **Remember to cite your sources**, including the provided data file, if you use it. If you choose to write code as part of your work to be eligible for the technical computing prize, please include it either in the body of your paper or in a separate appendix and check the technical computing box when you upload your paper. Appendices and references/citations do not count toward the recommended 20-page limit.

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1 https://www.noaa.gov/news/2024-was-worlds-warmest-year-on-record (National Oceanic and Atmospheric Administration)

2 https://www.epa.gov/climate-indicators/climate-change-indicators-heat-waves (United States Environmental Protection Agency)

3 https://www.climatecentral.org/climate-matters/weather-related-power-outages-rising (Climate Central)

4 https://fas.org/publication/grid-failure-extreme-heat/ (Federation of American Scientists)

5 https://19january2021snapshot.epa.gov/heatislands/heat-islands-and-equity_.html (United States Environmental Protection Agency)

6 https://iopscience.iop.org/article/10.1088/1748-9326/ab3b99 (T. Chakraborty, et al)

7 https://www.npr.org/2019/09/03/754044732/as-rising-heat-bakes-u-s-cities-the-poor-often-feel-it-most (NPR)

8 https://www.ruralhealthinfo.org/rural-monitor/heat (Rural Health Information Hub

Data Statement:

Various organizations and agencies collect all kinds of data that may be relevant to this problem. A small amount of data has been compiled and a link to a Google spreadsheet with five worksheets of data is provided. The data is available at https://m3challenge.siam.org/897bjhb54cgfc/ (password: KLwGH45P09xnyy5).

Except for question 1, you are not required to use this data; that is, you may choose to use none, some, or all of this data and/or any additional data sources you may identify while working on this problem. If you use this data, please cite it as follows: Hot Button Issue, MathWorks Math Modeling Challenge 2025, curated data, https://m3challenge.siam.org/897bjhb54cgfc/.

MATLAB Users:

If you use Excel or any other spreadsheet data in MATLAB, you can import the data by double-clicking the files in MATLAB's "Current Folder" browser or use the Import Data Button **(**https://www.mathworks.com/help/matlab/spreadsheets.html?ue**)** at the top of the Toolstrip.

Watch this quick MATLAB video tutorial **(**https://www.youtube.com/watch?v=0hArv-UBKQQ&list=PLn8PRpmsu08oBSjfGe8WIMN-2_rwWFSgr&index=14**)** about importing spreadsheet data.

This problem was written by M3 Challenge Problem Development Committee members Dr. Jen Gorman, Lake Superior State University; Dr. Chris Musco, New York University; and Dr. Neil Nicholson, University of Notre Dame.