



SYS 660 Decision and Risk Analysis  
Midterm Exam

New Jersey Governor Phil Murphy signed an [executive order](#) on February 15, 2023, committing the state to 100% clean energy by 2035. This commitment will position New Jersey as one of the first states in the country to fully transition to renewable energy sources. The Governor also presented six fundamental elements that will establish the basis for a more sustainable, eco-friendly, and stronger New Jersey, such as installing zero-carbon-emission heating and cooling systems in 400,000 homes and 20,000 commercial properties.

According to the World Economic Forum, buildings account for nearly 40% of the world's energy consumption and about one-third of the total greenhouse gas emissions. Much of that is due to inefficient heating and cooling systems. One study says nearly 10% of US emissions come from fossil fuel consumption from water heaters, furnaces, and other heating sources. As a compelling solution, the decarbonization [heat pumps](#) move heat between the air inside and outside a home to recover and repurpose heat, delivering up to three times more heat energy to a home than the electrical energy it consumes.

The state's environmental community strongly supports the switch to renewable energy. Doug O'Malley, director of Environment New Jersey, called the order "a necessary step toward reducing emissions from our buildings, the second-highest polluting sector in the state while delivering clean air and healthier homes." Financial incentives have been provided at the federal and state levels to promote the transition. For example, households can receive a federal tax credit to cover up to 10% of the cost of insulation materials and other energy-efficient improvements, like energy-saving windows and doors, in 2022. They can also receive a \$300 tax credit for purchasing efficient heating and cooling equipment, like a heat pump or central air conditioner. Low-income households in NJ would qualify for additional financial assistance to purchase and install them.

In contrast, the opponents argue that New Jersey does not have the infrastructure to support such rapid and radical changes and are concerned with the installation cost – "Governor Murphy doesn't care how many tens of thousands of dollars it will cost New Jersey families to convert their gas stoves, water heaters, and furnaces to fully electric appliances." In addition to high installation costs, greater space and insulation requirements may further hinder the transition.

Imagine that you are advising that decision-making body on their response to the heat pump (or other zero-carbon-emission heating and cooling solutions) adoption. Choose between organization (e.g., country, state or county governor, local business owner, homeowner association, etc.), company (HVAC manufacturer, hardware supplier, house builder, etc.), or household. Apply the techniques you have learned in this class to develop a recommendation and justify any assumptions you make. Your analysis and the report detailing the full context and analysis should include the following steps:

Choose a decision-making body and research how heat pump adoption impacts them and their constituents/stakeholders. Briefly describe the decision-making body and its current situation, citing all sources and avoiding plagiarism (150-300 words). [10pts]



1. Identify the fundamental/ends and means objectives for that decision-making body. Construct objectives diagrams—either (a) a fundamental objectives hierarchy plus a means objectives network or (b) a hybrid diagram—to illustrate the relationships among the objectives. [15pts]
2. Identify alternatives. Be creative, and use existing proposals (citing your sources). Develop a consequence table with four mutually exclusive, non-dominated alternatives and four attributes (attributes should be consistent with objectives in Parts 1 & 2). At least three attributes should be represented as continuous variables on an interval or ratio scale (i.e., not nominal or ordinal attributes). [15pts]
3. Identify uncertainty in at least two attributes and present justified uncertainty distributions of those attributes for all alternatives. You may use objective data or (more likely) generate your own subjective probability distributions (using techniques from Week 5) based on your interpretation of the situation. Explain your process and cite/justify any assumptions. [10pts]
4. Develop a multi-attribute utility model to evaluate your alternatives, using the appropriate methods we learned in class. You may assume an additive utility function, but you should use methods from Week 6 to find the univariate utility functions (CE, PE, or TO) and the weights (swing or lottery weights). [25pts]
5. Evaluate the utility model for each alternative from your consequence table, accounting for uncertainty (e.g., using a Monte Carlo simulation). Provide information about the utility distribution for each alternative (e.g., means, histograms). [10pts]
6. Perform sensitivity analyses over at least two factors to assess the robustness of the results and briefly explain the meaning of each of those analyses for decision-making. [10pts]
7. Make a clear recommendation based on the results and describe any limitations/caveats that the decision-making body should be aware of. [5pts]

**This is an individual, take-home exam.** You may not discuss the exam with your peers. You may use any generally available research sources such as news articles and journal papers (cite your sources) but be aware that some websites and organizations are biased and may provide misinformation.

You should submit on Canvas **a typed and stand-alone pdf document** detailing your analysis, including all necessary contextual information and explanations of your assessment procedures. You should also attach an Excel or code file as a supplement so I can check your calculations if needed. Screenshots of Excel work sheets will not receive credits.

Grading criteria include:

- Completeness of analysis
- Consistency and clarity



- Correct application of decision analysis tools
- Justification of models and assumptions

Plagiarism (such as copying and pasting others' words without properly quoting and citing them or using others' ideas without citing them) will result in severe grading penalties, which may include earning a zero on the exam and academic disciplinary action. If you do not know the rules of plagiarism, you can read more about them here:

<https://www.plagiarism.org/article/what-is-plagiarism>

[http://thevisualcommunicationguy.com/wp-content/uploads/2014/09/Infographic\\_Did-I-Plagiarize1.jpg](http://thevisualcommunicationguy.com/wp-content/uploads/2014/09/Infographic_Did-I-Plagiarize1.jpg)

