2023 HiMCM
Problem B: Charging Ahead with E-buses

The proliferation of **electronic buses (e-buses)** in cities across the globe represents a significant stride toward sustainable urban transport. With the mounting concerns over air pollution and climate change, many cities have been prompted to reconsider their reliance on traditional diesel buses. According to a recent report by Bloomberg New Energy Finance[1], e-buses are set to dominate the public transit sector, becoming the majority of all buses on the road globally by 2032. China has been particularly noteworthy in this transition, as it is home to most of the world's e-buses, driven in large part by government policies that prioritize electric vehicles and stringent emission standards. Cities throughout the world (e.g., Bogota, Colombia, New York, USA, and Berlin, Germany) are also making concerted efforts to incorporate e-buses into their fleets, albeit at a more gradual pace.

E-buses aren't only environmentally appealing but are also anticipated to be cost-effective in the long run due to falling battery prices and lower operational expenses. Governmental incentives, such as the $1.7 billion allocation from the 2023 Bipartisan Infrastructure Law for e-bus projects in the U.S.[2], further bolster e-bus adoption. However, challenges include high initial costs, charging infrastructure development, lengthy charging times, and potential range limitations.

1. Construct a model to aid cities in understanding the ecological consequences of transitioning to an all-electric bus fleet.

   Identify a **metropolitan area** with a population of (at least) 500,000 people that does not currently have a fully electric bus fleet. Apply your model to your chosen location.

2. Money matters. Construct a model that focuses on the financial implications associated with a conversion to e-buses. Your model should factor in potential external funding covering up to 50% of the transition costs.

   Apply your financial model to the same metropolitan area you used in the previous question.

3. Transportation officials in metropolitan areas are exploring approaches in which they gradually change their fleet from combustion engines buses to electric. Assuming the goal is to have a fully electric fleet no later than 2033, utilize your previously developed models to craft a 10-year roadmap that urban transport authorities can leverage to plan their e-bus fleet updates.

   Apply your models (or new model) to the same metropolitan area you used in the previous question and also apply it to two additional metropolitan areas of your choosing.

4. Write a one-page letter to the transportation officials of one of your chosen metropolitan areas in which you detail your recommendation for their transition to e-buses.

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

- One-page Summary Sheet.
- Table of Contents.
- Your complete solution.
- One-page letter to the transportation officials.
- 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 HiMCM 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

An **Electric Bus (e-bus)** is any bus whose propulsion and accessory systems are powered exclusively by a zero-emissions electricity source.

Metropolitan Area: a core area containing a large population nucleus, together with adjacent communities that have a high degree of economic and social integration with that core.

References

[1] https://about.bnef.com/electric-vehicle-outlook/

[2] https://www.transit.dot.gov/about/news/biden-harris-administration-announces-nearly-17-billion-help-put-better-cleaner-buses

Use of Large Language Models and Generative AI Tools in COMAP Contests

This policy is motivated by the rise of large language models (LLMs) and generative AI assisted technologies. The policy aims to provide greater transparency and guidance to teams, advisors, and judges. This policy applies to all aspects of student work, from research and development of models (including code creation) to the written report. Since these emerging technologies are quickly evolving, COMAP will refine this policy as appropriate.

Teams must be open and honest about all their uses of AI tools. The more transparent a team and its submission are, the more likely it is that their work can be fully trusted, appreciated, and correctly used by others. These disclosures aid in understanding the development of intellectual work and in the proper acknowledgement of contributions. Without open and clear citations and references of the role of AI tools, it is more likely that questionable passages and work could be identified as plagiarism and disqualified.

Solving the problems does not require the use of AI tools, although their responsible use is permitted. COMAP recognizes the value of LLMs and generative AI as productivity tools that can help teams in preparing their submission; to generate initial ideas for a structure, for example, or when summarizing, paraphrasing, language polishing etc. There are many tasks in model development where human creativity and teamwork is essential, and where a reliance on AI tools introduces risks. Therefore, we advise caution when using these technologies for tasks such as model selection and building, assisting in the creation of code, interpreting data and results of models, and drawing scientific conclusions.

It is important to note that LLMs and generative AI have limitations and are unable to replace human creativity and critical thinking. COMAP advises teams to be aware of these risks if they choose to use LLMs:

- Objectivity: Previously published content containing racist, sexist, or other biases can arise in LLM-generated text, and some important viewpoints may not be represented.
- Accuracy: LLMs can ‘hallucinate’ i.e. generate false content, especially when used outside of their domain or when dealing with complex or ambiguous topics. They can generate content that is linguistically but not scientifically plausible, they can get facts wrong, and they have been shown to generate citations that don’t exist. Some LLMs are only trained on content published before a particular date and therefore present an incomplete picture.
- Contextual understanding: LLMs cannot apply human understanding to the context of a piece of text, especially when dealing with idiomatic expressions, sarcasm, humor, or metaphorical language. This can lead to errors or misinterpretations in the generated content.
- Training data: LLMs require a large amount of high-quality training data to achieve optimal performance. In some domains or languages, however, such data may not be readily available, thus limiting the usefulness of any output.

Guidance for teams

Teams are required to:

1. **Clearly indicate the use of LLMs or other AI tools in their report,** including which model was used and for what purpose. Please use inline citations and the reference section. Also append the Report on Use of AI (described below) after your 25-page solution.
2. **Verify the accuracy, validity, and appropriateness** of the content and any citations generated by language models and correct any errors or inconsistencies.
3. **Provide citation and references, following guidance provided here.** Double-check citations to ensure they are accurate and are properly referenced.
4. **Be conscious of the potential for plagiarism** since LLMs may reproduce substantial text from other sources. Check the original sources to be sure you are not plagiarizing someone else's work.

COMAP will take appropriate action when we identify submissions likely prepared with undisclosed use of such tools.

Citation and Referencing Directions

Think carefully about how to document and reference whatever tools the team may choose to use. A variety of style guides are beginning to incorporate policies for the citation and referencing of AI tools. Use inline citations and list all AI tools used in the reference section of your 25-page solution.

Whether or not a team chooses to use AI tools, the main solution report is still limited to 25 pages. If a team chooses to utilize AI, following the end of your report, add a new section titled Report on Use of AI. This new section has no page limit and will not be counted as part of the 25-page solution.

Examples (this is *not* exhaustive – adapt these examples to your situation):

Report on Use of AI

1. OpenAI *ChatGPT* (Nov 5, 2023 version, ChatGPT-4,)
   Query1: *<insert the exact wording you input into the AI tool>*
   Output: *<insert the complete output from the AI tool>*

2. OpenAI *Ernie* (Nov 5, 2023 version, Ernie 4.0)
   Query1: *<insert the exact wording of any subsequent input into the AI tool>*
   Output: *<insert the complete output from the second query>*

3. Github *CoPilot* (Feb 3, 2024 version)
   Query1: *<insert the exact wording you input into the AI tool>*
   Output: *<insert the complete output from the AI tool>*

4. Google *Bard* (Feb 2, 2024 version)
   Query: *<insert the exact wording of your query>*
   Output: *<insert the complete output from the AI tool>*