The Carbon Footprint of Large Language Models:
The Case of ChatGPT

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Abstract

The rapid growth of Large Language Models (LLMs), including ChatGPT (a Generative Pre-trained Transformer), has raised significant concerns about their energy consumption and the resulting carbon footprint. This research employs System Dynamics Modelling (SDM) to examine and project the carbon emissions associated with the adoption and utilization of Large Language Models (LLMs). This research models ChatGPT as a case study to simulate future trends in AI usage, energy consumption, emissions, and carbon footprints. It employs reinforcing and balancing feedback loops to capture the dynamics of AI adoption, user behaviour, energy efficiency improvements, and renewable energy integration. The baseline scenario suggests that, without intervention, the energy consumption and carbon emissions of LLMs will increase unsustainably due to the exponential growth in adoption and usage. However, simulations also indicate that modest technological advancements and the gradual implementation of carbon-free energy can stabilize emissions.

In contrast, more stringent policy measures, such as ambitious energy efficiency targets and investments in renewable energy, result in substantial long-term reductions. The findings underscore the need for proactive strategies, including enhancing AI energy efficiency, expanding renewable energy infrastructure, and establishing dynamic regulatory frameworks to manage AI-related emissions. This study emphasizes the need to align technological innovation with environmental sustainability for the responsible implementation of AI systems. This study provides valuable insights for policymakers, AI developers, and environmental planners, aligning

with the primary objectives of the Sustainable Development Goals (SDGs) regarding responsible consumption, production, and climate action.