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Thinking AI models emit 50x more CO2—and often for nothing

Researchers found some LLMs create four times the amount of CO2 emissions than other models with comparable accuracy. Their findings allow users to make informed decisions about their own LLM use

Date: June 19, 2025

Source: Frontiers

Summary: Every query typed into a large language model (LLM), such as ChatGPT, requires energy and produces CO2 emissions. Emissions, however, depend on the model, the subject matter, and the user. Researchers have now compared 14 models and found that complex answers cause more emissions than simple answers, and that models that provide more accurate answers produce more emissions. Users can, however, to an extent, control the amount of CO2 emissions caused by AI by adjusting their personal use of the technology, the researchers said.

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FULL STORY



The more an AI thinks, the more carbon it emits. Reasoning-heavy models can produce 50x more emissions than concise ones, often without much gain in accuracy. Credit: Shutterstock

No matter which questions we ask an AI, the model will come up with an answer. To produce this information - regardless of whether the answer is correct or not - the model uses tokens. Tokens are words or parts of words that are converted into a string of numbers that can be processed by the LLM.

This conversion, as well as other computing processes, produce CO₂ emissions. Many users, however, are unaware of the substantial carbon footprint associated with these technologies. Now, researchers in Germany measured and compared CO₂ emissions of different, already trained, LLMs using a set of standardized questions.

"The environmental impact of questioning trained LLMs is strongly determined by their reasoning approach, with explicit reasoning processes significantly driving up energy consumption and carbon emissions," said first author Maximilian Dauner, a researcher at Hochschule München University of Applied Sciences and first author of the *Frontiers in Communication* study. "We found that reasoning-enabled models produced up to 50 times more CO₂ emissions than concise response models."

'Thinking' AI causes most emissions

The researchers evaluated 14 LLMs ranging from seven to 72 billion parameters on 1,000 benchmark questions across diverse subjects. Parameters determine how LLMs learn and process information.

Reasoning models, on average, created 543.5 'thinking' tokens per questions, whereas concise models required just 37.7 tokens per question. Thinking tokens are additional tokens that reasoning LLMs generate before producing an answer. A higher token footprint always means higher CO₂ emissions. It doesn't, however, necessarily mean the resulting answers are more correct, as elaborate detail that is not always essential for correctness.

The most accurate model was the reasoning-enabled Cogito model with 70 billion parameters, reaching 84.9% accuracy. The model produced three times more CO₂ emissions than similar sized models that generated concise answers. "Currently, we see a clear accuracy-sustainability trade-off inherent in LLM technologies," said Dauner. "None of the models that kept emissions below 500 grams of CO₂ equivalent achieved higher than 80% accuracy on answering the 1,000 questions correctly." CO₂ equivalent is the unit used to measure the climate impact of various greenhouse gases.

Subject matter also resulted in significantly different levels of CO₂ emissions. Questions that required lengthy reasoning processes, for example abstract algebra or philosophy, led to up to six times higher emissions than more straightforward subjects, like high school history.

Practicing thoughtful use

The researchers said they hope their work will cause people to make more informed decisions about their own AI use. "Users can significantly reduce emissions by prompting AI to generate concise answers or limiting the use of high-capacity models to tasks that genuinely require that power," Dauner pointed out.

Choice of model, for instance, can make a significant difference in CO₂ emissions. For example, having DeepSeek R1 (70 billion parameters) answer 600,000 questions would create CO₂ emissions equal to a round-trip flight from London to New York. Meanwhile, Qwen 2.5 (72 billion parameters) can answer more than three times as many questions (about 1.9 million) with similar accuracy rates while generating the same emissions.

The researchers said that their results may be impacted by the choice of hardware used in the study, an emission factor that may vary regionally depending on local energy grid mixes, and the examined models. These factors may limit the generalizability of the results.

"If users know the exact CO₂ cost of their AI-generated outputs, such as casually turning themselves into an action figure, they might be more selective and thoughtful about when and how they use these technologies," Dauner concluded.

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Materials provided by **Frontiers**. *Note: Content may be edited for style and length.*

Journal Reference:

1. Maximilian Dauner, Gudrun Socher. **Energy costs of communicating with AI**. *Frontiers in Communication*, 2025; 10 DOI: [10.3389/fcomm.2025.1572947](https://doi.org/10.3389/fcomm.2025.1572947)
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Frontiers. "Thinking AI models emit 50x more CO2—and often for nothing." ScienceDaily. ScienceDaily, 19 June 2025. <www.sciencedaily.com/releases/2025/06/250619035520.htm>.

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