Environmental Impact of Training LLMs

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1 Calculator Verification

We first use the Machine Learning Emissions Calculator [1] to calculate carbon emissions of training LLMs that have publicly available data on actual emissions. See the results below:

Model	Hardware	GPU Hours	Estimated CO_2eq	Actual CO_2eq
BLOOM	384 A100 80GB	1,082,990	31.6 tonnes	25.0 tonnes
OPT-175B	992 A100 80GB	785,664	75.4 tonnes	70.0 tonnes
GPT-3	10,000 V100 32GB	3,552,000	447 tonnes	502 tonnes

Table 1: Calculator-estimated carbon emissions vs. actual reported carbon emissions

There are a couple of important things to note:

- BLOOM was trained on the Jean Zay supercomputer, located in France. It is recognized as one of Europe's most eco-efficient machines. However, it is private infrastructure and we must estimate the carbon efficiency of the machine. To do so, note that Jean Zay features a Power Usage Effectiveness (PUE) of 1.28. We also assume that the researchers use the higher end of the reported range, 57 gCO_2e/kWh. Then, carbon emissions is calculated as Carbon Emissions = Total Energy Consumption $\times$ Carbon Intensity $\rightarrow$ 1.28kWh $\times$ 57 gCO_2e/kWh = 72.96 gCO_2e. We get our estimate plugging in this number into the calculator.
- While we are able to verify that BLOOM used the Jean Zay supercomputer, OPT-175B used Azure as their provider, and CoreWeave agreed to train a GPT-3 equivalent model, it is difficult to determine in which the datacenters were located in. This leads to slight inaccuracies in the estimated carbon emissions.
- GOPHER did not publicly release information about the hardware they used to train the model. The lack of information makes it difficult to estimate the CO_2eq emissions.

2 Estimates for Recently Released Models

Given that we have observed decent accuracy in using the calculator to predict carbon emissions, we estimate the carbon emissions of recently released models in this section.

Model	Hardware	GPU Hours	Estimated CO_2eq

Table 2: Calculator-estimated carbon emissions for recently released models

References

[1] A. Lacoste, A. Luccioni, V. Schmidt, and T. Dandres. Quantifying the carbon emissions of machine learning. *arXiv preprint arXiv:1910.09700*, 2019.