



# The Green Mile : A Multi-Layered Quest to Reveal, Measure, and Slash Carbon Emissions in AI Training & Inference



Subramanyam Sahoo<sup>1</sup> Sonal Singh<sup>2</sup> Joel Jojo<sup>2</sup>

<sup>1</sup>NIT Hamirpur

<sup>2</sup>Liverpool John Moores University

"THE GREATEST THREAT TO OUR PLANET IS THE BELIEF THAT SOMEONE ELSE WILL SAVE IT." – ROBERT SWAN

## Introduction

AI model  $\xrightarrow{\text{computation}}$  energy usage  $\xrightarrow{\text{greenhouse gas emissions}}$  environmental impact (1)

- The **neural scaling law** enhances model efficiency, but higher energy demands during training raise power usage and carbon emissions, emphasizing sustainable AI practices.
- The ICT industry accounts for **1.4%** of global greenhouse gas emissions.

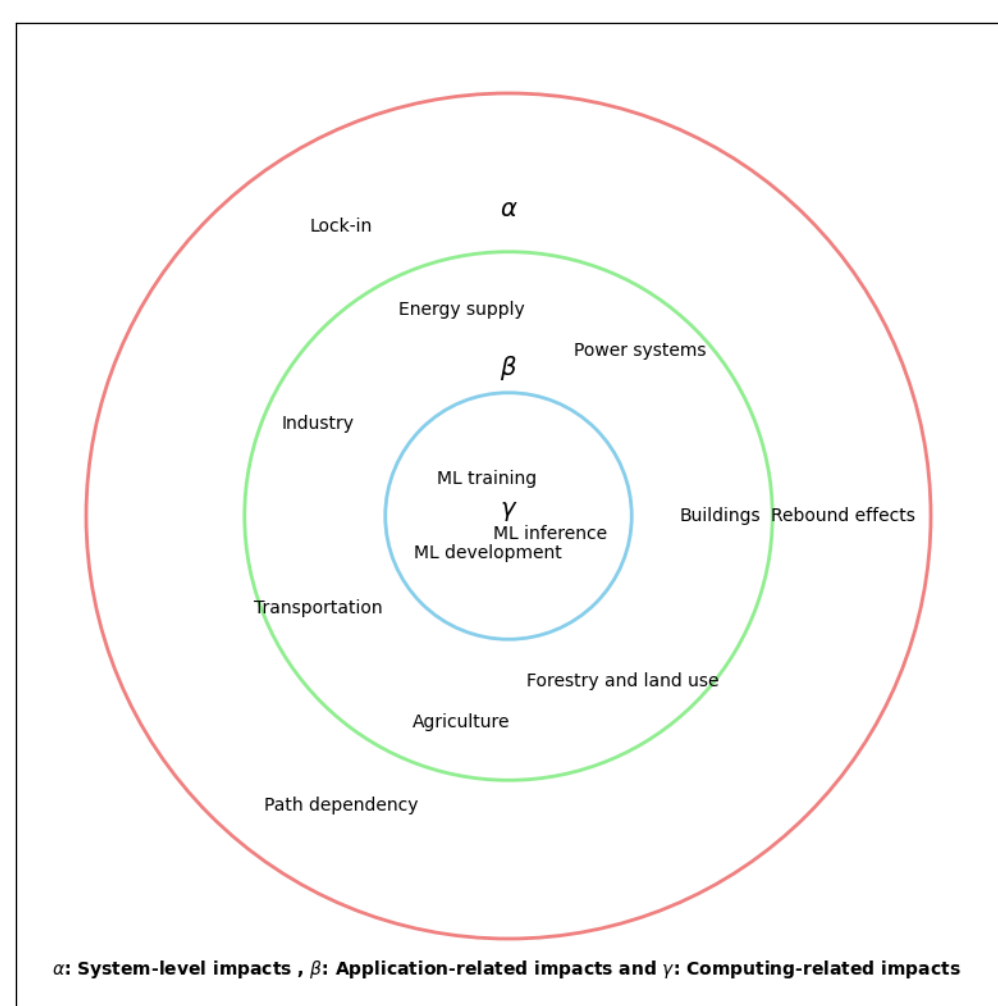


Figure 1. 3 levels of impact on emission

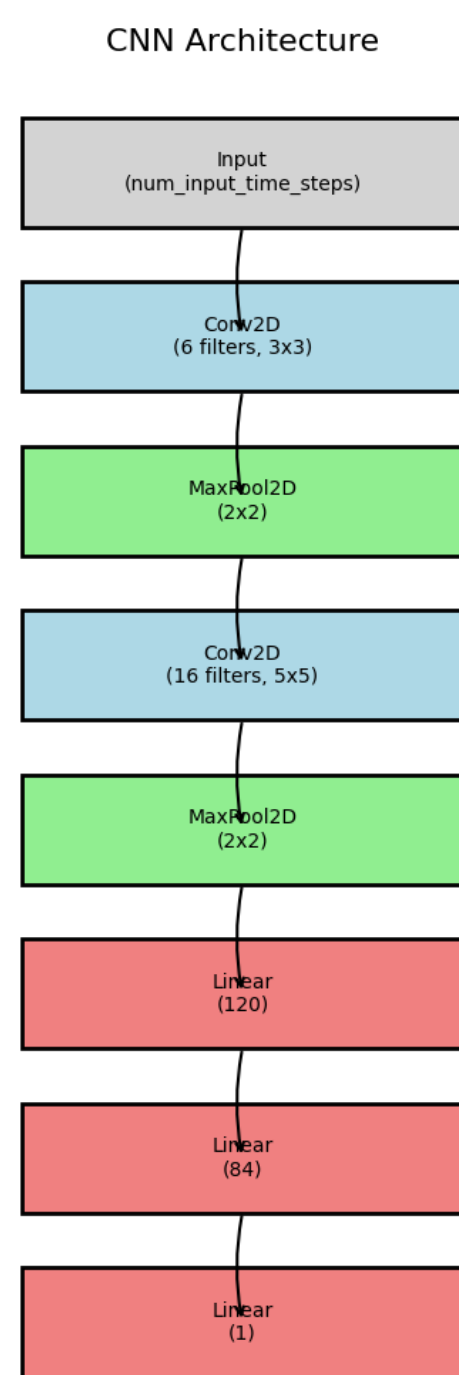


Figure 2. CNN with 6.99 Million Parameters

## Measuring Carbon Intensity

"CodeCarbon" uses the following formula :-

$$\text{Energy Consumption(kWh)} = \sum_{i=1}^n \left( \text{Power Usage}_i(\text{W}) \times \text{Runtime}_i(\text{hours}) \times \frac{1}{1000} \right) \quad (2)$$

$$\text{Total Carbon Emissions(gCO}_2\text{)} = \text{Energy Consumption(kWh)} \times \text{Carbon Intensity(gCO}_2\text{/kWh)} \quad (3)$$

## Experiments & Results

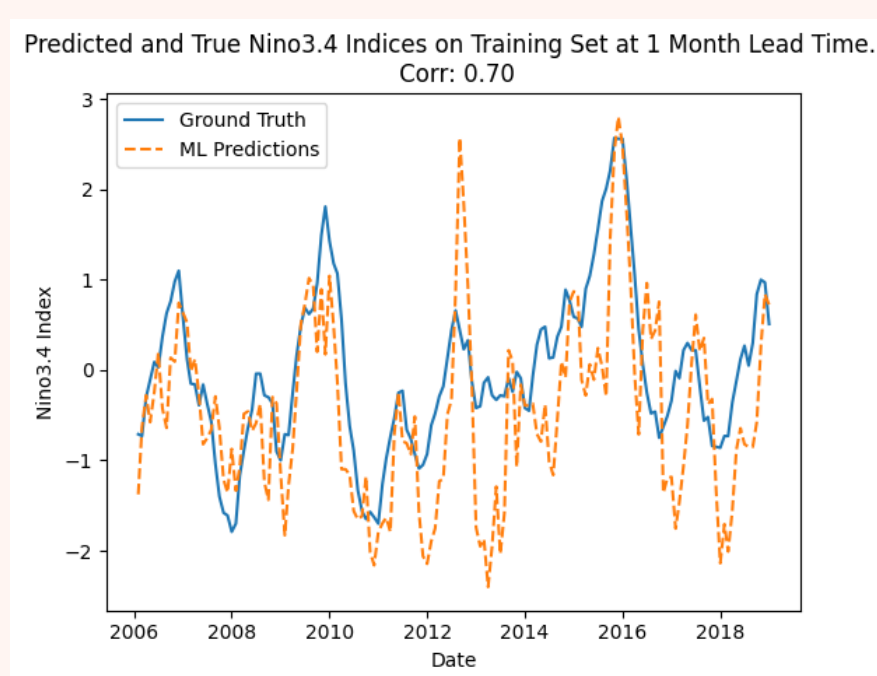


Figure 3. Linear regression correlation coefficient

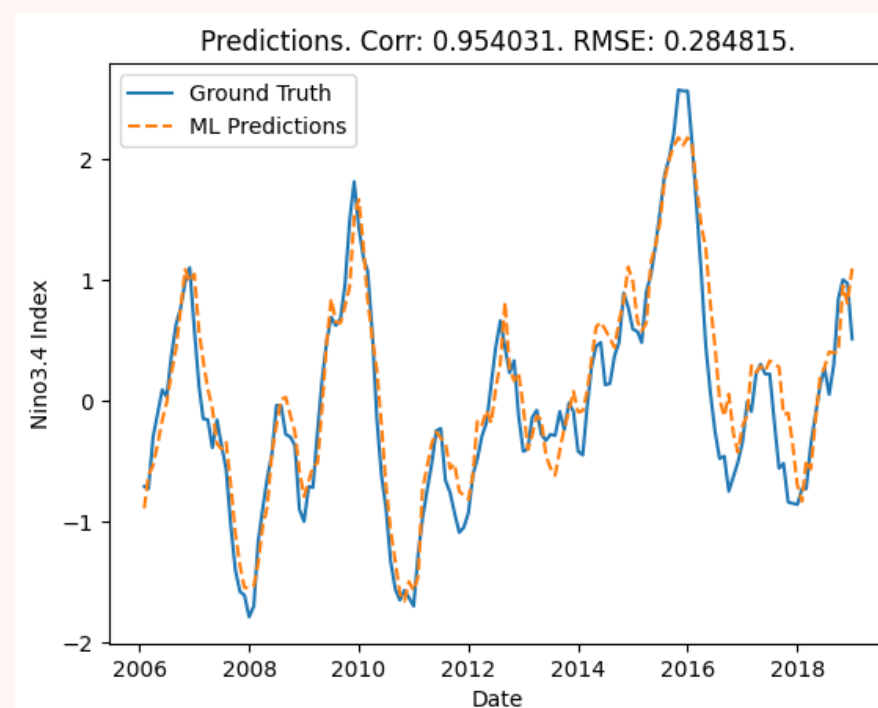


Figure 4. CNN correlation coefficient

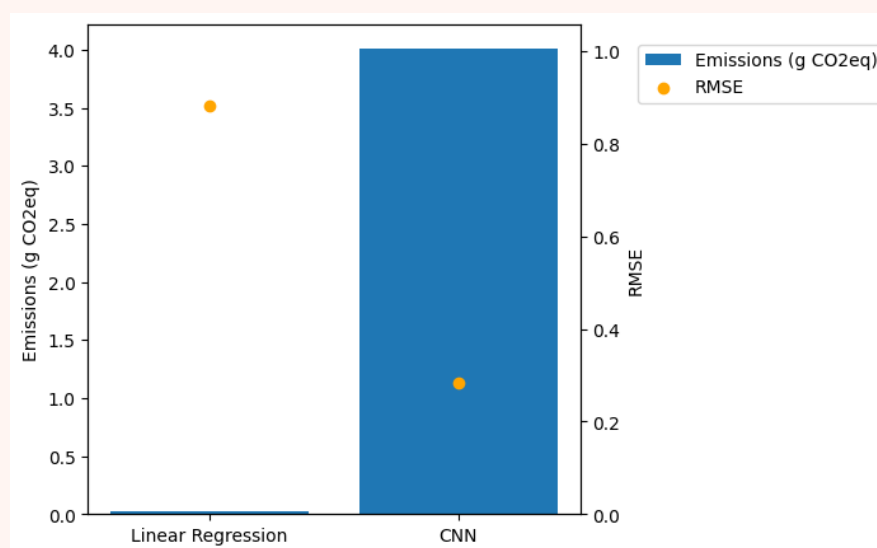


Figure 5. LR vs CNN Trade off

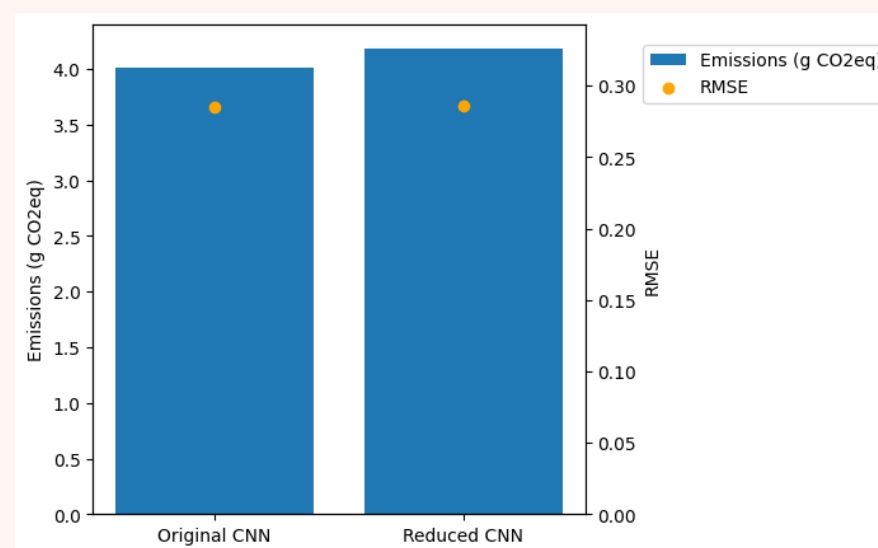


Figure 6. CNN Variants Trade off

- Training was conducted using the Adam optimizer with a learning rate of 0.0001, batch size of 10, over 50 epochs.

## Hyperparameter Tuning

- Tree-structured Parzen Estimator (TPE) is used

Parameter	Value
Number of Input Time Steps	1
Learning Rate	0.0046
Optimizer	SGD

Table 1. Optimal Hyperparameters

## Hyperparameter Pruning

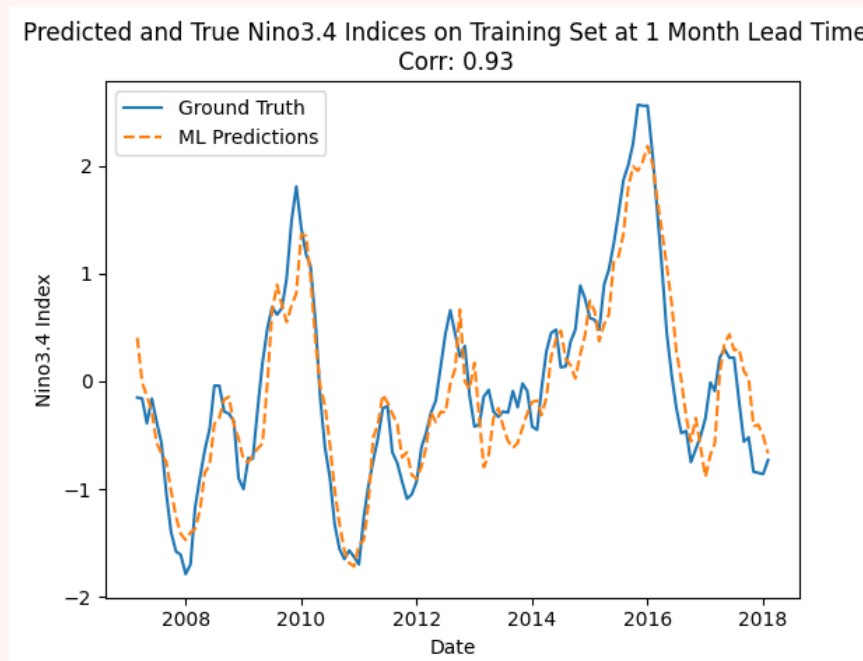


Figure 7. CNN with TPE search

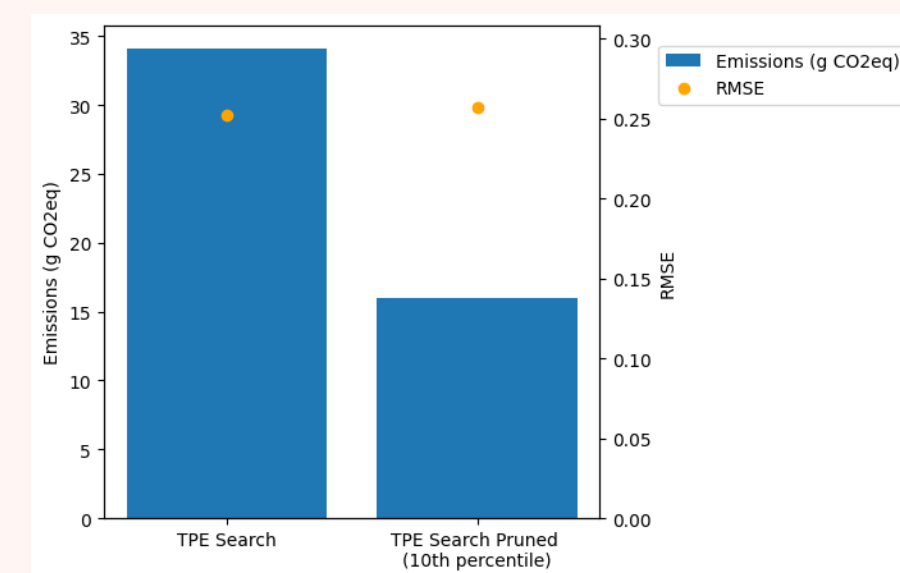


Figure 8. CNN with 10th percentile TPE pruner

Strategy	Num Input Time Steps	Learning Rate	Optimizer	RMSE
Not pruned	1	0.004626	SGD	0.252572
Pruned	1	0.004626	SGD	0.256914

Table 2. Comparison of RMSE for pruned vs. not pruned strategies

## Tracking Emissions from Model Training

Model	Emission Rate (in Kg CO <sub>2</sub> eq)	RMSE Score
Linear Regression model	0.00003	0.284815
CNN Model	0.004014	0.285503
Pruned CNN Model	0.004188	0.285000
CNN Model + Early Stopping	0.002287	0.298000
CNN Model + Hyperparameter Tuning	0.03407	0.252572
CNN Model + Hyperparameter Pruning	0.01600	0.256914

Table 3. Tracking Emissions and RMSE from Model Training

## Tracking Emissions from Model Inference

- Linear Regression model** –  $7.5714 \times 10^{-8}$  kg CO<sub>2</sub>eq
- CNN Model** –  $9.8744 \times 10^{-6}$  kg CO<sub>2</sub>eq

## Related Works

Model	Energy Use	Greenhouse Gas Emissions
T5	86	47
GShard	24	4.3
Switch Transformer	179	59
GPT-3	1287	552

Table 4. Estimates of models by Patterson et al., 2021

Unit for Energy Use & Greenhouse Gas Emissions is (MWh) and (tCO<sub>2</sub>eq) respectively.

## Conclusion

WHAT IF IT WERE A STANDARD PROCEDURE FOR ALL RESEARCH PAPERS TO DISCLOSE EMISSIONS !!!

## Recommendation

- Work on Open Problems
- Socio-technical approach > > > Techno-solutionist approach

