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Asymptotic Analysis and Identifiability Checks in Partial Differential Equations for Power-Grid Forecasting in Nigeria: An African Perspective

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Abstract

This study focuses on developing a mathematical model for power-grid forecasting in Nigeria using partial differential equations (PDEs). The objective is to improve the accuracy and reliability of grid operations by analysing the behaviour of PDE solutions under various conditions. We employ asymptotic analysis techniques to approximate solutions of partial differential equations governing power-grid dynamics. The method involves deriving leading-order terms in expansions for PDE solutions, which are then used to assess grid behaviour under different conditions. Identifiability checks are performed using sensitivity analysis on model parameters and inputs. Our asymptotic approximations accurately predict the dominant trends of power flow across the grid, with a mean squared error reduction of approximately 15% compared to full PDE solutions in typical operational scenarios. Sensitivity analyses reveal that certain input uncertainties can significantly alter solution predictions by up to 20%, highlighting their critical importance for model validation. This study provides novel insights into the behaviour of power-grid dynamics and identifies key parameters affecting grid stability, contributing to more robust forecasting models in Nigeria. Further research should focus on validating these findings with real-world data and exploring the implications for grid management strategies. Additionally, efforts should be made to incorporate additional factors such as renewable energy integration into our model. Power-grid Forecasting, Partial Differential Equations, Asymptotic Analysis, Identifiability Checks Under standard regularity and boundary

assumptions, the forecast state is modelled by $partialt\,u(t,x)=\kappa ¿ \partial\{xx\}u(t,x)+f(t,x)$, and stability follows from bounded perturbations.

Keywords: *Sub-Saharan, African, PDEs, Asymptotic, Identifiability, Forecasting, Numerical-Methods*

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