

**MATHEMATICAL MODELING FOR GENERATING
SYNTHETIC VALUES TO BE USED IN
NON-CONVENTIONAL ENERGY SYSTEMS**

BY

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**DEPARTMENT OF MATHEMATICS
UNIVERSITY OF BALOCHISTAN
QUETTA
2001**

**MATHEMATICAL MODELING FOR GENERATING
SYNTHETIC VALUES TO BE USED IN NON-
CONVENTIONAL ENERGY SYSTEMS**

BEING A THESIS PRESENTED

BY

LALARUKH KAMAL



TO THE

UNIVERSITY OF BALOCHISTAN

QUETTA

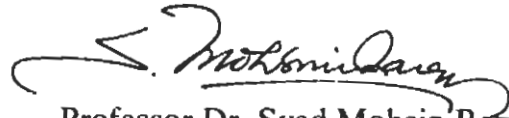
IN APPLICATION FOR THE DEGREE OF

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2001

CERTIFICATE

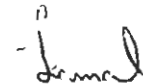
This is to certify that Mrs. Lalarukh Kamal has worked under my supervision for the degree of Doctor of Philosophy. Her research work is original. She has an excellent aptitude for carrying an independent research in diverse disciplines of mathematical sciences. She fulfils all the requirements to submit the thesis for the degree of Doctor of Philosophy.



Professor Dr. Syed Mohsin Raza,

Research Supervisor

and Dean, Faculty of Physical Sciences.



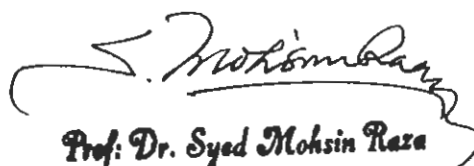
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DECLARATION BY THE APPLICANT

I, Lalarukh Kamal, do solemnly declare that the research work under title "MATHEMATICAL MODELING FOR GENERATING SYNTHETIC VALUES TO BE USED IN NON-CONVENTIONAL ENERGY SYSTEMS" is hereby submitted for the degree of Doctor of Philosophy and has not been submitted elsewhere for any degree. The said research work was carried out by the undersigned under the guidance of supervisor approved by the University of Balochistan.



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Dedicated
TO MY
PARENTS



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ABSTRACT

After having reviewed, all the existing deterministic and stochastic models, being used currently, all over the world, to generate data for non-conventional energy systems, a need was felt for appropriate mathematical models to generate solar radiation and wind speed for realistic operating conditions for energy systems, by mathematical equations characterizing the deterministic and the stochastic components of the long term measured records, specially from the point of view of our country, Pakistan.

Stochastic modeling of hourly global solar radiation; Markov transition matrix (MTM) model; triangulation method (modified Angstrom model) for mean monthly daily global solar radiations; autoregressive moving average (ARMA) and autoregressive integrated moving average (ARIMA) models for wind; discrete state stochastic simulation of daily averaged wind speed; simulation of wind energy for different wind turbines are the models, which we fitted and tested their validity for solar and wind data of different cities of Pakistan. The generation of synthetic sequences using these models was also done and the results obtained by these models were compared.

Using stochastic modeling of hourly global solar radiation, AR(1) models give the best results showing good agreement between generated and observed solar data. MTM approach to generate hourly averaged global radiation led to a reliable simulator. The method of triangulation was found better than any single regression equation methods. For generation of wind data, ARMA(2, 0); ARMA(2, 2); ARMA(1, 0) and ARMA(2, 0) are the best fitted models for winter, spring, summer and autumn respectively. The time series model, which we used to generate wind power for different turbines suggested MOD2 turbines, the best suited for the coastal area considered.