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MODELING OF METEOROLOGICAL PARAMETERS FOR UNITED ARAB EMIRATES

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By

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Chairman: Professor Hj. Mohd Yusof Sulaiman, Ph.D.

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There has been an increasing world interest in clean renewable energies (mainly solar radiation and wind energies) due to the minimal environmental problems resulting from their uses. The continuous depletion of traditional and conventional energy resources and the growing world concern about the environment have led to an extensive research and development efforts in order to improve the energy conversion efficiencies and economics of utilization solar energy devices. However, it is important to identify the potential of available energy resources on the site where renewable energy is to be utilized.

Meteorological information is critical to the assessment of the energy resources available and to the performance of many different types of renewable energy systems. Potential of the renewable energy available is strongly influenced by climatic factors such as air temperature, relative humidity, sunshine duration and natural energy supply. Solar radiation is strongly weather dependent. In the United Arab Emirates weather conditions are monitored by meteorological stations across

the country and weather data are collected by various meteorological agencies . But unfortunately, not all of these data are dependable, because most of them are taken on recording tapes from unattended instruments with the lack of maintenance and calibration. Therefore, in this research we depended on meteorological data taken at aeronautical with on-site observers and regular maintenance and calibration. In the present study, it was found that UAE receives about 5.96 $kWh/m^2/day$ on average. The available data of solar radiation were statistically analyzed and they were compared to the theoretical prediction of solar radiation using various models. Alnaser`s model gave the best agreement with the available data. It was found that the least difference between the measured and the theoretically computed total radiation for Abu-Dhabi airport for the period 1982-1999, when Alnaser`s model was used . Therefore, it is used to predict the global and diffuse radiation for other studied stations. Solar map of the total radiation over the United Arab Emirates was produced using the values obtained by Alnasr`s model. It is concluded that solar radiation energy, as a clean energy source is abundant in the United Arab Emirates with excellent prospects for the future use (photovoltaic and solar thermal applications especially in remote areas).

Regarding wind energy in UAE, it is not encouraging or propitious as much as solar energy, much research must be carried out before jumping to any indecisive results, because wind speed is highly affected by the geographical local site features. But this energy should be utilized. especially, in Al Ain and along the coastline in spite of this may spoil the fascinating scenery of the coastline of the UAE, hourly Abu-Dhabi wind data were collected for the period from 1990-1999. The wind data for Sharjah, Al-Ain, Abu Dhabi and RAS-Alkhaimah, airports were

also collected for the year 1996. These data have been analyzed for maximum wind power with different sweep area of the turbine blades at 10 and 50 meters height above the ground surface.

Weibull distribution has been applied to fit the probability nature of wind speed distribution; all sites data can be modeled using this distribution. It was found that the month of March has the highest mean wind speed for all locations for long-term data (10 years). For the climatic parameters (wind speed, sunshine duration, relative humidity and solar energy) of UAE time series of daily data are analyzed using Box-Jenkins method. It was found that the sequence of the parameters in all studied locations of the study are not stationary. Transformation technique (differencing) has been applied to get stationary time series. Seasonal or. non- seasonal auto- regressive models are adequate to describe the residuals ,time plot of the residuals .The statistical tests of the time series :Ljung Box statistics(1978) Mcleod and Li test (1983), the turning point test , the difference-sign test and the rank test indicate satisfactory choice of the model .

Abstrak tesis yang dikemukakan kepada Senat Unversiti Putra Malaysia sebagai memennuhi keperluan untuk memperolehi ijazah Master Sains

MODEL PARAMETER KAJICUACA UNTUK UNITED ARAB EMIRATES

Oleh

RIAD MOHAMED Al SHEIKH

September 2002

Pengerusi : Profesor Hj. Mohd. Yusof Sulaiman , Ph.D.

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UAE adalah sebuah negara membangun dengan sumber semulajadi yang kebanyakan sumber tenaga untuk pemanasan, penjanakuasa elektrik, dan lain-lain penggunaan adalah diimport. Sumber tenaga yang terhad ini telah memaksa kami untuk menimbangan penggunaan tenaga terbaharu seperti tenaga suria, angin, dan kuasahidro.

Untuk menjayakan penyelidikan tenaga serta untuk kegunaanya, parameter cuaca UAE (laju angin, tempoh sinaran matahari, kelembapan, suhu, dan sinaran suria global) perlu dimodelkan.

Untuk penggunaan tenga suria, malkumat berkenaan sinaran suria global bagi kawasan tertenu di mana tiada rekod tentang data cuaca didapati adalah diperlukan. Model berdasarkan formula Page, Alnaser , Gopinthan,Glover and Rietveld menggunakan data cuaca seperti sinaran matahari, suhu dan Kelembapan untuk empat stesyen diterangankan. Angin adalah sumber tenaga

penting dan manusia telah lama meneroka untuk menggunakannya.

Pengiraan keluaran bagi kincir angin memerlukan pengetahuan tentang taburan kelajuan angin. Taburan Weibull telah dipadakan kepada taburan kebarangkalian kelajuan angin. Kami telah mendapati bahawa untuk semua lokasi, data berkenaan boleh dimodelkan dengan taburan Weibull. Analisis siri masa ke atas parameter cuaca telah dilakukan.

Untuk menggunakan proses auto regrasi, teknik transformasi (perbezaan) telah digunakan untuk menjana siri masa pegun. Model auto regrasi bermusim dan tidak-bermusim ini telah dapat menerangkan data-data untuk semua stesyen.

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I certify that an Examination Committee met on 18th September 2002 to conduct the final examination of Riad Mohamed Al Sheikh on his Master of Science thesis entitled "Modeling of Meteorological Parameters for United Arab Emirates" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions

Riad Mohamed Alsheikh

Date :

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LIST OF SYMBOLS AND ABBREVIATION

Solar Radiation

a,b	Regression coefficients.
G_{sc}	A solar constant (1376 W/sq. m).
Hd	Monthly mean of daily diffuse radiation (kWh/m^2).
H	Monthly mean of daily measured total radiation (kWh/m^2).
H0	Monthly mean daily extraterrestrial radiation (when n and δ taken for the average day).
H_d/H	Fraction of radiation which is diffused.
K_T	Clearness index ($K_T = H/H_o$).
n	Is the day of the year, starting from 1 January and February is taken to contain 28 days ($1<n<365$) (radiation calculation).
RH	Monthly mean daily relative humidity in percentage (%)(RH).
S/S_o	Maximum possible sunshine hours in percentage.
S_o	Monthly mean of daily maximum daylight hours(hour).
S	Monthly mean daily measured sunshine duration (hours).
T	Monthly mean daily maximum temperature (degrees Celsius).
W	Monthly mean correction factor.
W_N	White noise
X(t)	Observations of stationary time series.

Y(t)	Original data of time series.
$\chi 2$ test	Chi-square test.
ω_s	Sunset hour angle in degrees.
δ	Declination angle in degrees.
θ_z	Zenith angle in degrees.
ω	Hours angle in degrees.

Wind

A	Rotor swept area, exposed to the wind (m^2), $A = \pi \times D^2/4$.
GMT	Greenwich mean time (local time in UAE =GMT + 4 hours).
n	A coefficient varying from 0.10 to 0.40. (Wind power calculation)
P	Power in Watts.
V_{sp}	Wind speed (m/s).
V_o	Observed wind speed at height Ho above the ground. 10meters is the usual height given to Ho.
V_{sa}	Wind speed at altitude H (m/s).
ρ	Air density, which at the sea level = 1.225 kg/m^3.

SUBSCRIPTS

N	Alnaser's model.
P*	Page's model.
R	Rieveld's model or equation.
GM	Glover and McCulloch's model.
G	Gopinathan,s model or equation.

GLOSSARY

Air pressure The pressure exerted by the weight of air above a given point. Usually expressed in millibars (mb) or inches (centimeters or millimeters) of mercury

Anemometer An instrument designed to measure wind speed (m/s) or knot.

Atmosphere The envelope of gases that surround a planet and is held to it by the planets gravitational attraction. The earth's atmosphere is mainly nitrogen and oxygen, it extends up to 30 km above the earth` surface .

Beam radiation Also known as direct radiation and it is the solar radiation received from the sun without having beam scattered by the atmosphere (kWh/m^2).

Diffuse radiation : The solar radiation received from the sun after its direction has been changed by scattering by the atmosphere particles (kWh/m^2).

Climate The accumulation of daily and seasonal weather events over a long period of time.

Declination (δ) That is, the angular position of the sun at solar noon with respect to the plain of the equator, north positive $23.45° < \delta < 23.45°$

Divergence An atmospheric condition that exists when the winds cause a horizontal net outflow of air from

specific region.

Front The transition zone between two distinct air masses.

Fog A cloud with its base at the earth's surface. It reduces visibility to below 1 km.

Haze Fine dry or wet dust or salt particles dispersed through a portion of the atmosphere. Individually these are not visible but cumulatively they will diminish visibility.

Hour Angle (ω) That is, the angular displacement of the sun east or west of the local meridian due to the rotation of the earth on its axes at 15^0 per hour, morning negative, afternoon positive.

Inter Tropical Convergence Zone (ITCZ) That is, boundary zone

Separating the northeast trade winds of the Northern Hemisphere from the southeast trade winds of the Southern Hemisphere.

Knot A unit of speed which is equal to 0.515 m/s.

Latitude That is , the angular location north or south of the equator , north positive, $-90^\circ < \Phi < 90^\circ$.

Meteorology The science that deals with phenomena of the atmosphere, especially weather & weather conditions.

Mansoon Depression Weak low-pressure areas that tend to form in response to divergence in the upper-level jet stream . The circulation around the low strengthens the mansoon wind system and enhances precipitation during the summer.

Mansoon Wind System Wind system that reverse direction between winter and summer . Usually the wind blows from land to sea in winter and from sea to land in summer .

Mean (Average) Day That is the day which has the extraterrestrial radiation closest to the average for the month.

Solar constant The energy from the sun , per unit time , received on a unite area of surface perpendicular to the direction of propagation of the radiation at the earth's mean distance from the sun, outside the atmosphere its mean value equals 1376 W/sq.m .

Weather The condition of the atmosphere at any particular time and place.

Wet-Bulb Temperature The lowest temperature that can be obtained by evaporating water into the air (Celsius or Fahrenheit).

Total Solar Radiation The sum of the beam and the diffuse radiation on a surface. (The most common measurement of solar radiation is total radiation on a horizontal surface,often referred as global radiation) (kWh/sq.m).

Zenith Angle (θz) The angle subtended by a vertical line to the zenith (the point directly overhead and the line of sight to the sun .