Poster 1

FEASIBILITY OF RDF PRODUCTION FROM SHIRAZ MUNICIPAL SOLID WASTE AND ITS UTILIZATION IN FARS CEMENT FACTORY AS AN ALTERNATIVE FUEL

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Processed municipal solid waste (MSW) and industrial waste are being used both in dedicated energy-to-waste plants and as fuel substitutes in industrial processes. RDF co-incineration in industrial processes has several advantages such as saving non-renewable resources by substituting fossil fuels in high-demand energy processes. In this research, feasibility of RDF production from municipal solid waste of Shiraz and its utility in Fars cement Factory (located 80 km far from Shiraz) as an alternative fuel was studied. Shiraz with the population of 1.5 million is the fifth populated city of Iran and generated 1200 tons of MSW daily. In 2008, waste sampling was carried out seasonally in order to characterize the waste composition. The composition (on a weight basis) of the municipal solid waste of shiraz in this year is as follow: putrescible 67.7%, plastic 8%, paper and cardboard 4.6%, glass 2.2% metal 1.3%, and non recoverable material 14.4%. Regarding to waste composition, different alternatives of RDF production were investigated and the best option was chosen considering economic, environmental and technical aspects. Then economic analysis was carried out to find the effectiveness of RDF replacement with portion of conventional fuel in cement factory. The results show that in the case of RDF producing from putrescible and plastic wastes and replacing it with 10% of consumed heavy crude oil, the daily expenditure of cement production in Fars cement factory decreases about 7500$. In Addition the rate of transferred waste to landfill also reduces by 240 tons per day.

Poster 2

SYNOPTIC INFLUENCES ON LARGE-SCALE RENEWABLE ENERGY OUTPUT FOR AUSTRALIA

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With increasing installation of renewable energy technologies across Australia the question as to whether or not technologies such as wind and solar are able to provide stable and reliable energy at large amounts of penetration is quickly becoming a question that needs addressing. To date, most of the research (often undertaken by the wind/solar farm operators themselves) has focused on the local conditions that affect single wind farms or solar stations. Yet the processes in the atmosphere that drive variability on the large-scale are quite different from those that drive the small scale, and will determine the optimal mix and geographical placement of wind and solar farms to meet Australia's electrical energy needs. For the domain of Australia, this study uses the ECMWF reanalysis data ERA-interim from 1989-2010 to investigate the variability of both wind and solar power. Modes of variability of power output that link with the currently known synoptic modes of variability for this region will be examined. The implications on power output from various synoptic conditions such as the position of the Sub-Tropical Ridge, blocking high pressure systems, cut-off low pressure systems and the availability of systems from the southern hemisphere storm track will also be investigated.

Poster 3

PRELIMINARY RESULTS OF AN ANALYSIS-FORECASTING SYSTEM FOR THE SHORT-TERM PREDICTION OF ENERGY RELEVANT ATMOSPHERIC PARAMETERS

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A data assimilation system combines all available information on the atmospheric state in a given time-window to produce an estimate of atmospheric conditions valid at a prescribed analysis time. Sources of information used to produce the analysis include observations, previous forecasts (the background or first-guess state), their respective errors and the laws of physics.

Nowadays, increased computing power coupled with greater access to real-time asynoptic data is paving the way toward a new generation of high-resolution (i.e., on the order of 10 km or less) operational mesoscale analyses and forecast systems. Moreover, better initial conditions are increasingly considered vital for a range of NWP applications, in particular at the short range.

Here, we present preliminary results of the CRAMS (Calabria Regional Atmospheric Modelling System) analysis-forecasting system focused on the assimilation of wind profiler data. CRAMS is composed by two main components: a univariate analysis package and a forecasting model. Both components are based on the RAMS (Regional Atmospheric Modelling System) model and the analysis package employs the method of successive corrections.

In this method, two equations are iteratively solved for each analyzed variable ø (i. e., zonal and meridional wind components, temperature, relative humidity, geopotential height, surface temperature and surface relative humidity). The first equation is the estimate of the correction for the grid-point variable $ø_x$, the second equation is an updated observation estimate $ø_0$.

The CRAMS is applied to a poor forecast case study (16 September 2008), for which the misplacing of the cyclone centre played a crucial role. For this case study, pseudo-observations were generated from a simulation using ECMWF (European Centre for Medium Range Weather Forecast) analysis as initial and boundary conditions, which performed much better than the forecast.

In addition to the ECMWF analysis "soundings" the wind profile measured by the Lamezia Terme wind profiler is assimilated. The radar wind profiler, located on the west coast of the central Calabria, has operated since 1 June 2008. The radar sounds the lower troposphere, usually up to 3 km, and measures the horizontal and vertical wind components using one vertical and two oblique beams slanted at an off-zenith angle of 15.5°. The operating frequency is 1290 MHz (about 23 cm wavelength). Returned echoes are due to air masses refractive index fluctuation advected by the wind. Data consist of the three wind components (zonal, meridional and vertical) every 30 min. The vertical resolution is 100 m, the minimum range gate is 150 m, and the vertical range is 2 to 5 km depending on atmospheric conditions. Accuracy of the wind measurements is 1 ms^{-1} for the horizontal wind components, 0.5 ms^{-1} for the vertical component, and less than 10° for the direction.

We show the impact of the data assimilation on both directly assimilated and non-assimilated variables. Results show the ability of CRAMS to correct the first-guess field. Moreover, the results of this case study highlight the potential of CRAMS to improve the short-range forecast (0-6 hours).

Poster 4

BARRIERS TO THE ADOPTION OF DECENTRALISED RENEWABLE ENERGY SYSTEMS IN DEVELOPING COUNTRIES: THE MINDANAO GRID CASE

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Most of the economic mobilizations in both developed and developing countries are driven by fossil fuel-based energy. With the threats of climate change and diminishing supply of fossil materials, renewable energy sources are seen as the best alternatives to produce energy for sustainable development. While renewable energy technologies have a promising role for energy generation, their potential to the development of rural communities in developing countries is yet to be demonstrated.

In the Philippines, twenty-two dispersed rural communities in Mindanao, utilizing six solar and sixteen hydro technologies, were considered in the study to identify factors affecting the operation of renewable energy systems. Deficient managerial and technical capabilities, very limited financial support, inappropriate business models, and unsuitable development mechanisms were found to be the major barriers to the adoption of renewable energy technologies in rural communities. Reviews of the Philippine energy laws and energy development plans showed stratified intervention at various levels, for the successful implementation and adoption of renewable energy technologies, as mitigating measures to combat climate change and ensure sustained supply of energy.

In the long term, it is expected that some small-scale renewable energy systems operated by the small rural communities could be entrenched by national electric grids which may lead to its failure or success. Its operation may fail if the members of the communities discontinue supporting their renewable energy systems; however, it is contended that connections to the national grid will help in sustaining the operation of decentralized renewable energy systems in Mindanao, the Philippines.

Poster 5

A COSCINODISCUS SPECIES FROM A MARICULTURE SITE IN THE PHILIPPINES AS POTENTIAL SOURCE OF BIODESEL

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Isolation of a marine diatom, Coscinodiscus, collected at Bolinao, Pangasinan, Northern Philippines was done for culture purposes. Partial identification of the species through morphological analysis using light microscope revealed the characteristics similar to Coscinodiscus centralis. Lipids of sample from culture were quantified using Soxhlet mehod. The lipid content obtained for the three replicates was 16.85%, 17.38%, and 17.51%. Biochemical approach to increase the lipid content of the diatom was explored. Silicate starvation for 8 hours before lipid extraction was done to increase the lipid content and an average of 23.84% was obtained. Initial results showed that longer silicate starvation time could possibly increase the lipid content, together with, the manipulation of other factors such as temperature, light intensity, salinity, and precursor nutrients.

Poster 6

ENHANCED SOLAR ULTRA VIOLET RADIATION INDUCED ERYTHROCYTES MEMBRANE DAMAGE WITH PHOTOSENSITIZERS

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Solar light is the primary source of UV radiation for all living systems. Ozone depletion leads to an increase in the ultraviolet-B component (290-320 nm) of solar ultraviolet radiation (UVR) reaching the surface of the earth. Photohaemolysis of erythrocytes was studied under natural and artificial ultraviolet-B light wavelength 312 nm. Photohaemolysis study was carried out on human erythrocytes by exposing them with different intensity and dose of natural solar light and artificial UV-B with chloroquine and tetracycline. Monitoring of solar ultraviolet radiation shows seasonal and altitudinal variations. Chloroquine was found more phototoxic than tetracycline at different dose and intensity of artificial UV-B. Maximum haemolysis was observed in presence of chloroquine with high intensity of artificial UV-B while natural and artificial UV-B alone was found less toxic. Peroxidation of fatty acids by free radicals initiates a chain reaction which,enhances oxidative damage and reduces the antioxidative potential leading to cell injury. UV-B dose dependent lysis of erythrocytes was observed by recording malondialdehyde in the form of an increased amount of thiobarbituric acid-reactive substance and significant decrease in GSH content. Phototoxicity of chloroquine and tetracyclne is due to photooxidation, which generates free radicals and responsible for oxidative stress and damage to cell membrane. A difference in phototoxicity was observed in natural solar and artificial ultraviolet radiation of same intensity.

Poster 7

ENERGY & METEOROLOGY

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Meteorology is a science which studies about the weather conditions in the atmosphere. As a science, meteorology faces many challenges since it deals with nature. There are also many challenges of weather and climate especially when using energy.

- Energy production and use are sensitive to changes in the climate. For example, the energy supply and demand will depend not only on climatic factors, but also on patterns of economic growth, land use, population growth and distribution, technological change and social and cultural trends that shape individual and institutional actions. Greater energy efficiency and new technologies hold promise for reducing green house gases and solving this global challenge. Changes in temperature due to climate change could affect our demand for energy.
- There may also be changes in energy consumption for other climate-sensitive processes. For example, rising air temperatures will likely lead to substantial increases in energy demand for air conditioning and it is also associated with an increase in evaporation which increases energy needs for irrigation such as pumping water for agriculture, particularly in dry regions. Increasing temperature will reduce consumption of energy for heating but increases the necessity of the energy used for cooling buildings.
- Other energies which are affected by climate are hydropower generation energy source, which is likely to be most directly affected and sensitive to the amount, timing and geographical pattern of precipitation and temperature. Buildings and Infrastructure for energy production, transmission and distribution could be affected by climate.
- By increased cloudiness, solar energy production could be reduced. Wind energy production would be reduced if wind speeds increase above or fall below the acceptable operating range of the technology. Unlike others, nuclear energy represents a source of energy with low carbon levels and relatively stable costs, which makes it attractive from the point of view of security of supply and fighting climate change.

Poster 8

APPLICATION OF WEATHER AND CLIMATE FORECASTS AND ADVICE IN THE ENERGY INDUSTRY

Rob Harrison

Head of Utilities, MET Office, UK

This poster is presented by D. de Gusmão, *Met Office Hadley Centre, Exeter, UK*

The UK Met office has been supplying specialist services to the UK energy industry for over 20 years. These services are used by our customers to inform:

- Energy supply and demand forecasting and planning
- Infrastructure planning and design
- Network management, operational planning and optimisation
- Investments and business strategy

This presentation will describe the challenges posed by weather and climate to the energy industry and the services the Met Office has developed, working with our customers, to help meet those challenges. In particular we will focus on recent developments in weather and climate models, and post processing techniques and will present case studies of their application. Modelling developments include high resolution numerical weather prediction, nowcasting, regional climate model ensembles and decadal forecasting. Post processing techniques we have developed recently include methods to investigate rare, but high impact events and use of observations to bias correct forecasts and increase accuracy. We will describe the use of high resolution modelling and observations to generate highly accurate site specific forecasts. We will also present techniques we have developed to support the use of longer terms forecasts and climate simulations in business planning and strategy decisions.

Poster 9

SHORT-TERM WIND POWER FORECAST BASED ON NUMERICAL WEATHER PREDICTIONS AND A NEURAL NETWORK APPROACH FOR NORTHEASTERN BRAZIL

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The installed wind power capacity is increasing significantly worldwide and since it is a relatively new energy source, its technology development has been occurring along with wind industry expansion. Due to wind high variability in space and time, one of the main challenges is to forecast the available wind power in the time frame from hours to days, in order to facilitate scheduled maintenance, prevent from extreme wind conditions and optimize the energy dispatch by electrical managing institutions, increasing wind energy competitiveness in the energy market. Despite several studies carried abroad, there are few advances in this subject in Brazil, where the installed wind power capacity is achieving relevant thresholds, predominantly in the northeastern region. This study introduces a methodology for development of a short-term wind power forecast model from the outputs of CPTEC/INPE Eta-20km numerical weather predictions, using an artificial neural network approach. It is presented a discussion over the impact of current forecast accuracy on the available wind power, as well the steps in developing the neural network model, involving data assimilation, treatment and validation, predictors selection criteria, network architectures and training techniques. A total of 8 test sites were used for model evaluation and results indicate a significant improvement on forecast performance when compared to other traditional statistical techniques like multiple linear regressions.

Poster 10

FEASIBILITY STUDIES OF BIOGAS PRODUCTION IN DEVELOPING COUNTRIES (CASE STUDY: MAKURDI, NIGERIA)

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Developing countries are faced with the challenge of meeting the energy demands of their people, whilst they possess unexploited renewable energy resources. In developing countries, energy production and utilization is an index to economic development and the quality of life. Makurdi is a growing urban city in the north- central region of Nigeria which comprises of the town central and satellite rural areas. This is representative of rural and urban areas in developing countries, which are currently faced with environmental problems associated with landfill waste disposal as well as urban rural drift settlements.

This study evaluates the implementation of biogas production in Makurdi with data available from previous studies on waste generation identifying the most sustainable form of biomass. Literature on anaerobic digestion technology and fermentation process with respect to biomass selection and the capacity of biogas generated as it relates to the size of the co-generator or gas turbine were also reviewed. The Installed system and running costs of the digesters and co-generators are also projected for economic viability.

The production of biogas as an alternative source is viable due to its simplicity, economic benefits as well as the small and large scale operational capacity. It can thus be utilized by emerging urban and rural cities in developing countries. Its adoption would contribute immensely to the energy demands of people.

Poster 11

ANALOG METHOD FOR COLLABORATIVE SHORT-TERM FORECASTING OF POWER GENERATION FROM PHOTOVOLTAIC SYSTEMS

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There is an increasing interest in exploiting renewable energy resources, such as solar power harnessed by photovoltaic (PV) systems. However, the variability of power production from PV systems poses a challenge for the adoption and management of this resource. The ability to adequately predict the production of PV systems could allow to take advantage of moments of high production and to respond in a timely manner at moments of low production.

We propose a method to generate short-term forecasts (10 minutes to 3 hours) of power generation from individual PV systems.

The method is based on the search of local analogs -or k nearest neighbours- whose predictive power is further judged by collaboration with other nearby PV systems. In contrast to most PV prediction approaches which part from weather forecasts, the input data is the history of local power production, which is accessed only by the PV system generating the data. Once a PV system has identified the moments in the past similar to its current local production, the timestamps and the weights of these analogs are exchanged with other systems. By using the information of analogs from other systems global analogs are identified, allowing to discard local analogs that do not make part of the regional trend.

The method is tested with data from 11 PV systems and accuracy is compared to two standard reference models. Results show that the method is adequate for short-term predictions, with improvements in certain horizons when collaboration among sites is employed.

Poster 12

WEATHER FORECASTING RESEARCH - ITS REALISTIC AND VISIONARY APPLICATIONS ON THE GENERATION OF 3C ENERGY

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The world energy consumption has been skyrocketing in the past few decades as the result of overpopulation and the rapid industrialization of the developing world. What accompanies the increase in the demand on energy is the depletion of traditional fuel resources. Uranium, biomass, and other renewable environmental resources, such as wind, have been nominated as potential clean alternatives to petroleum, coal, and natural gas. However, the Fukushima nuclear crisis in March showed the world just how environmentally damaging nuclear energy can be, despite the fact that it releases low carbon dioxide. Of the remaining choices on the list, which one is going to provide the current and future generations with the most sustainable outcome, or namely, energy that is clean, cheap, and consistent? With the advancement of weather forecasting technologies, bioenergy crops will be grown efficiently so as wind and other renewable resources are expected to be utilized by even the least developed countries (LDC) at an affordable rate. What weather forecasting cannot tell us, perhaps, is when exactly an earthquake or tsunami will hit a nuclear power plant.

Poster 13

THE EFFICIENCY LEVEL OF A VERTICAL KINETIC TURBINE AT VARIABLE TIDE LEVELS

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Tidal turbines are subjected to a variable water level during a day period. In shallow waters during the low tide, it is valid to assume that water level covers only part of the turbine and the rest of the turbine remains out of the water. In this study we test a model vertical kinetic turbine in a water tunnel at various water depths. Results for the power coefficient are presented for a range of tip speed ratio. The results of this investigation provide an insight into the operation of a vertical turbine in a range of tide levels especially when the water level is lower than the turbine top. Power coefficient of the turbine increases by reducing the water level while the turbine is fully submerged in the water. Power coefficient gain is due to the blockage effect of the water surface. The results match the trend in the one dimensional theory. When the water level drops lower than the turbine top the power coefficient declines dramatically. In this condition air gets in to the water and separates water from the blade surface. A high speed camera is employed to visualize the flow separation process while a torque transducer measures the instantaneous torque and rotational speed of the turbine.

Poster 14

SMART MICRO GRID WITH RENEWABLE ENERGY AND PHEV

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From the beginning of this century, there has been a great concern about Carbone dioxide emission from various sectors. Power and energy is such a sector from where, co2 emission is increasing day by day. Renewable energy is a solution for the situation with lots of economic benefits. Future power grid is going to be smarter with renewable energy sources and smart grid technologies. For a variety of reasons researchers and power engineers are interested to divide the large grid into small grids with renewable generation called micro grid. It has some interesting features like, capability of islanding operation, small scale generation, control and opportunity to join as a part of smart grid. PHEVs are one of the load types which are going to be an important factor in designing and planning micro grids as it is going to be a spinning reserve of energy as well as major load for micro grid. Using V2G technology PHEVs can be used to improve a microgrid in such a way as to be called as Smart Micro Grid. Utilization of PHEVs is demonstrated in this research

by designing following features: 1. An active filter for solar generation, 2. Use as a reactive power supply unit for wind generator. 3. Its use as a power reserve for smooth islanding operation. 4. Its use as a virtual STATCOM. All these activities have been demonstrated in software environment using PHEVs to improve power quality, stability and establish the micro grid as a smart micro grid.

Poster 15

INTENSITY OF SUMMER AND POST MONSOON PHASE OF SOUTH ASIAN MOSOON: ROLE OF EQUINOO VERSUS ENSO

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Positive EQUINOO (EQUATORIAL INDIAN OCEAN OSCILLATION) is defined as the presence of increased easterlies in equatorial Indian Ocean. Similarly EQUINOO the atmospheric component of IOD can lead to a negative effect on the AISMR if the deepening in the cloud formation is taking place on Bay of Bengal side of Indian Ocean. The upper hand of EQUINOO over the El Nino Southern Oscillation in deciding the course and the amount of Indian Summer Monsoon Rainfall (AISMR) is verified by studying both cloud data as well as satellite OLR data for last sixty years. The enhancement in the cloud formation over the Arabian Sea has an edge on the increased amount of ISMR than a similar accumulation of cloud formation over the Bay of Bengal. Due to the positive phase of Indian Ocean Dipole if there is an increase in SST on the Western side of the Indian Ocean, naturally it is transferred to the atmosphere as a decrease in SLP with a lag during the southwest monsoon period. This will promote cross equatorial moisture flux in the Indian Ocean and is allied by increased convective activity and is accompanied by additional cloud formation on the western side. The arrival of low-level jet stream during the monsoon period eventually carries the additional cloud towards peninsular India and to Central India giving surplus rain to these regions. On the other hand negative phase of EQUINOO the clouds may move further eastward avoiding India by the increased effect of westerly component of zonal wind in addition to the temperature shoot up in the western Pacific Ocean. This oscillation between the cloud formations in the either side of Indian Ocean can play a more direct and significant role in deciding the strength of Monsoon over India than the El Nino oscillation taking place in Pacific Ocean.

Poster 16

RENEWABLE ENERGY POTENTIAL AND ENVIRONMENTAL ISSUES IN NEPAL

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Energy is must for all the living things in the nature for their existence including human beings as its types and sources are different. As the global population is increasing, the use of energy is also increasing. It may results the lack of sources of energy in the future. The present energy demand of Nepal has been fulfilled, partly from hydropower, Bio-gas, fossil fuels and traditional energy sources. The use of renewable energy (such as solar and wind) is negligible. Conventional energy sources such as fire- wood, cow dung, coal, and fossil fuels (petroleum products) release more CO2 into the atmosphere, causing environmental problems that are directly related to the survival of human beings and contribute to the regional and global climate change.

In order to address various problems, both shortages of energy, environmental and climatic problems, the present study is carried out. The emphasis is given to renewable energy sources that can contribute to reduce energy related problems. Also, the considerable use of renewable energies, such as solar energy, wind energy and biogas in the urban areas can significantly support energy demand. A case study of Kathmandu valley presented here illustrates the energy related problems and possible solution with renewable energy.

Energy production through biogas increased significantly with the increase of number of biogas plants installed in Nepal; from less than 500 GJ during 1992-1994 to 4500 GJ during 1992-2005.

Pre-monsoon and post monsoon seasons have higher mean monthly sunshine duration (about 8 hours/day) than summer (about 5 hours/day) and winter (about 7 hours/day) seasons over Kathmandu. Pre-monsoon and monsoon seasons receive solar energy of about 250 W/m2 and 200 W/m2 respectively. The winter season receives the least amount of solar radiation (about 150 W/m2). In the present context, approximately 150 MW of solar electricity can be produced in Kathmandu (assumption: 10% roof area of each house of Kathmandu is used for solar panel with 20% efficiency) that will substantially fulfill energy demand and reduce environmental pollution.

Generally, wind power (at Kathmandu airport) is higher during pre-monsoon season (about 1.5 W/m2) than the monsoon season (about 1 W/m2).

Clean energy and clean environment are the ones we desire for our society, our country and our planet earth. Therefore, in order to solve energy shortage problem and environmental pollution problem, application of clean energy, such as solar and wind energies is urgent and should think about for necessary clean energy policy.

Poster 17

THE POTENTIAL FOR SEASONAL FORECASTING OF SOLAR POWER IN AUSTRALIA

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Electricity generated from solar power introduces uncertainty into the commitment of thermal generation units. Forecasting of solar energy is required at all time scales to ensure stable operation of the electricity grid. This work examines the issue of seasonal solar power forecasting. The El Nino Southern Oscillation (ENSO) phenomenon is one of the largest influences on seasonal climate in Australia and can be predicted several months in advance. Here we conduct an analysis of gridded ERA-Interim reanalysis data spanning 20 years. The results indicate that ENSO affects solar radiation in certain regions of the Australian continent, particularly in winter. These results are applied to solar panel yield using a simple model for solar photovoltaic conversion. A bootstrap test has been used to generate regions of statistical significance. Our results show that seasonal forecasting of the solar energy resource will assist with planning the operation of the electricity grid.

Poster 18

CHARACTERIZING WIND TURBINE INFLOW AND WAKES THROUGH COMPARISON OF SODAR AND MET TOWER OBSERVATIONS—A PART OF TWICS: THE TURBINE WAKE INFLOW CHARACTERIZATION STUDY

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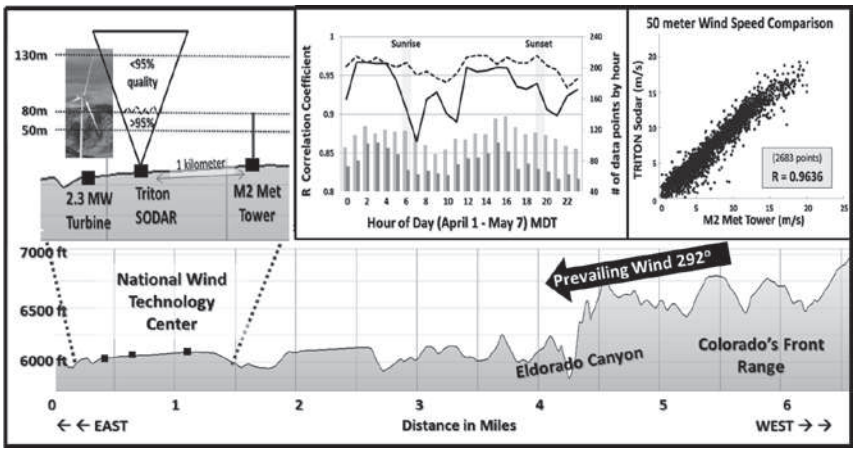
Wind offers an inexhaustible domestic energy source with minimal greenhouse gas emissions. To maximize energy generation from wind turbines it is essential to understand the influence of inflow conditions and wakes on wind turbine energy production. In accordance with this goal, the TWICS field campaign was conducted in April and May 2011 at the National Renewable Energy Lab's (NREL) National Wind Technology Center (NWTC) in the complex terrain downwind of Colorado's Front Range mountains. TWICS employed meteorological monitoring towers and remote sensing systems to provide a three dimensional spatio-temporal illustration of the inflow to and wake from a 2.3 MW turbine with a 100 meter rotor diameter. An important step in analyzing the TWICS data was quantifying the performance of the different measurement devices that were used. This research compares simultaneous measurements taken during TWICS by a Second Wind Triton Sodar and from the NREL M2 80 meter meteorological tower, which were located one kilometer apart.

During the TWICS campaign, we found strong linear correlations between wind speed measurements at 50 and 80 meters from the sodar and met tower. The high correlation suggests that flow is usually homogenous across the NWTC at time scales of ten minutes, but that there are also occasional periods of inhomogeneous flow. Wind speed correlations were also found to vary with time of day. This diurnal variation could represent different conditions at the sodar and tower site because of localized heating and turbulent mixing, but may also be due to changes in sodar performance as atmospheric stability changes during the course of the day. Results from this research will feed into future analysis of data collected during TWICS and help improve our understanding of turbine performance in the atmospheric boundary layer.

The National Renewable Energy Laboratory's National Wind Technology Center is located downwind of Colorado's Front Range near Boulder. The magnified cross section of the site (top left) shows the location of a Triton Sodar and 80m M2 Met Tower relative to a 2.3 MW Wind Turbine. Correlations between the SODAR and met tower (top right) over 37 days in 2011 were R > 0.93 at both 50 and 80 meter elevation. Correlations and data returns show a slight diurnal variation (top center, 50m- dotted lines and light bars, 80m -solid lines and dark bars).



Poster 19

MODELS FOR THE PREDICTION OF MONTHLY AVERAGE DAILY GLOBAL SOLAR RADIATION FOR KEBBI STATE, NIGERIA, USING SUNSHINE HOUR AND MAXIMUM TEMPERATURE

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Solar radiation is a function of several climatic variables and may be estimated from data of sunshine duration, cloud cover and air temperature. In this work, regression equations have been developed from sunshine hour duration and maximum temperature data to predict the monthly average daily global solar radiation for Kebbi State in Nigeria, located at latitude 12°N and longitude 4.3°E and with no known previous record of such data. The results show good agreement with Angstrom and Hargreave models.