Wind Power Density Program Requirements, Phase 2
Honors Math 3199

Overview

In an earlier lab, you wrote code which produced one to three output files, each showing wind speed averages and wind power density. Wind power density was calculated as follows:

$$\frac{P}{A} = \frac{1}{2}\rho v^2 \quad \text{Equation 1}$$

where

P = Power (Watts)

A = swept area of blades = πr^2, r = blade radius

ρ = atmospheric density (notice that this is listed in the input file, you may use a single value for the entire month(s)

v = calculated average wind speed

Notice that Equation 1 is a normalized value; it is available wind power. For your earlier calculations, you did not need to know a turbine blade radius. Rather you were calculating the value of the ratio, which is the right hand side of Equation 1.

Actual power delivered by a wind farm depends upon

- efficiency of the wind turbines used at the farm
- size of the wind turbines (swept area)

Actual wind power delivered by a turbine is a modification of Equation 1:

$$P = \frac{1}{2}cA\rho v^2 = \frac{1}{2}c\pi r^2 \rho v^2 \quad \text{Equation 2}$$

where

A = swept area of blades = πr^2, r = blade radius

c = efficiency of specific turbine

For this second lab activity, you will choose turbines for a wind farm at your wind location, and a number of turbines. For these turbines, you will need to know their blade size (radius in Equation 2) and the efficiency of the turbine.

You will add a fourth column to your output file, which lists wind power for each row value (hour of day or day of month).

Again, output will be written to a text file (see later section "Output File Structure" for details). You will read the text file into Excel, and use Excel graphing utility to show the data.

Your system must consider wind variations across a three-month span; i.e. run your program with three consecutive months of wind data, consolidate output files into a single large file.

The output file will be read into Excel, where you will display averages graphically.

Overview: Enrichment\Challenge

Enable your program to read three (or more) months of data, storing in a larger array. Process the data as per paragraph.

Grouping

You will work in groups of three for this effort. The group activity will involve selection of turbines, number of turbines, and estimating cost. The three members should be using different wind sites, your goal is to purchase a common turbine for all three sites. If group members happened to have chosen the same wind site during Phase I, one or more of them should be able to easily change their program(s) to use a different site's wind data.

Research: Phase 2, Turbines

Review wind manufacturer turbine data, and existing wind installations (to see which turbines they used). Select a turbine manufacturer and size that is suitable for all three wind sites. Using a common turbine lowers ownership costs (maintenance, spare parts, training). Be prepared to describe your rationale, and the turbine selected as part of the grade for this lab activity.

You will estimate or obtain costs per Kilowatt hour for electricity in the region of the wind farm, and use this value plus your expected wind power (also in kilowatt hours) to calculate an expected cost savings for your wind farm. Assume a value for turbine maintenance, consider that value in your projected cost savings.

Requirements: Phase 2, Expected Wind Power

Supplement your Phase I program so that it

- Writes additional header line(s) to the output file, these lines identify the turbine type, size, number and locations
- Use turbine values and last column entry of Phase I table, to calculate and write as a new last column, expected wind power at that hour\day

NOTE: See section "Output File Structure" for more details.

Output File Structure

Output file structure will include the following. Note that additions to earlier output file are italicized and in red font:

- Header line (title)
- *Additional header line(s) which describe number and type (manufacturer part number is sufficient) of turbines used on the wind farm, and their locations*
- Column titles
- (hourly averages) 24 rows, each with the average speed for that hour, and wind power density for that speed (*4 columns*; hour number, average speed, power density, *wind power*)
- (daily average) 30 or 31 rows, each with the average speed for that day and wind power density for that speed (*4 columns*; day number, average speed, power density, *wind power*)

You may run your program with three separate input files (month files), and manually consolidate output files into a single file, or generate a single output file from three input files.

You will read your C-output file into Excel, and then create a graph that shows the data.

Add comments to your code as necessary, update user guide as necessary.

Because a wind farm is expected to operate year-round, you must analyze one year of data for each site of group members. You may do this by operating your modified Lab 1 program 12 times, and then combining outputs into a single Excel file.

Extra Credit

You will receive extra credit if your programs operate on 12 input files, and generates a single large output file. Note that this output file will be a 3D array; [month][day][hour]. You can choose instead to store in a 2D array, permitting day to range from 1 – 365.

Assessment

Since this program is a small modification of the earlier one, assessment will focus on design of the wind farm.

Each individual will modify their Lab1 code to calculate output values. Power point presentation must show output files, and Excel graphs, for each individual in the group.

As a group, you will prepare a power point presentation that describes

- Locations
- Summary of wind power density
- Trends that you see in wind (i.e. night time vs day time, time of month, time of year).
- Choice of turbine for the farms, and characteristics of the turbine

Each member of the group will receive a 100 point grade for this project. Points will be collected as follows:

- Explanation of turbine selection, reason it was selected, and its characteristics — 20%
- Observations on wind trends; seasonal, annual, time of day for each site — 20%
- Power point distinctives (video?, photos?, manufacturer diagrams?) — 20%
- Accompanying verbal description of power point — 20%
- Explanation of turbine site choices — 15%
- Excel diagram of expected wind power: — 5%
- Extra credit: 3D array or large 2D array, with analysis — 10%