Wind Turbine Generator Assignment

Essential Question: How can Energy be transformed into useful forms?

Assignment #3: Describe the mechanical power generated by your turbine, both by direct drive and by electrical energy conversion to mechanical power, evaluate efficiency of energy transformations. *Note: we will only use fan speed 3 for this part.*

Electrical power is calculated by multiplying volts times amps, but mechanical power is determined by how much mass is lifted how high in how much time.

Calculation of Mechanical Power in Watts:
Watts = (Mass in grams/1000) (9.8 m/s^2) (Height Lifted in cm/100) / (Avg Time in sec)

Direct Drive Performance

Direct Drive will be determined by attaching a string directly to the shaft at the back side of the turbine *with the generator removed*. Use different amounts mass on the hanger and time how long it takes to lift that mass a measured height. Use the photogate to measure tip speed. Find the maximum mass that your turbine can lift at a steady rate. Take data on that mass, repeat each weight trial three times and take the average time to calculate power. Reduce the mass in 5 steps with the last step being about 1/5 the highest mass.

Direct Drive	Trial #1	Trial #2	Trial #3	Trial #4	Trial #5
Mass in grams					
Height Lifted in centimeters					
Time to lift in seconds #1 #2 #3					
Average Time in seconds					
Tip Speed in m/s #1 #2 #3					
Average Tip Speed in m/s					
Power in Watts					

Electrical Conversion to Mechanical Power Calculation

This will be determined by connecting your turbine to a generator, then wiring your generator to an electric motor that drives a shaft that will lift mass on a hanger. You will take similar data to the direct drive method. Find the maximum mass that your turbine can lift at a steady rate. Take data on that mass, repeat each weight trial three times and take the average time to calculate power. Reduce the mass in 5 steps with the last step being about 1/5 the highest mass.

Electrical Conversion to Mechanical Power	Trial #1	Trial #2	Trial #3	Trial #4	Trial #5
Mass in grams					
Distance Lifted in centimeters					
Time to lift in seconds #1 #2 #3					
Average Time in seconds					
Tip Speed in m/s #1 #2 #3					
Average Tip Speed in m/s					
Power in Watts					

Wind Turbine System Performance Graph

Make a graph showing how Power in watts depends on Tip Speed in m/s. Power should be on the Y axis, and Tip Speed should be on the X axis. Show performance for the Direct Drive (part 3), Electricity Generated (part 2), and the Mechanical Power (part 3).

Most turbines will have a small range of speeds that they are most efficient at. This should show up in your graph by having all three lines (Direct Drive, Electricity, and Mechanical) have their highest power at similar speeds.

Calculation of Efficiency: The Direct Drive Power calculated in Part Three is the base power that efficiencies are calculated from. This is the power that your wind turbine blades extracted from the moving air without any of the losses of turning a motor, a gear, or generating electricity. Use your Direct Drive Power as the base to compare efficiencies of energy transformation.

Efficiency in Generating Electricity
This is the efficiency of converting rotational mechanical energy into electricity by turning a set of gears that turn a coil of wire inside of a magnetic field creating a flow of electrons (current) in the coil.

Efficiency in Using Electricity

This is the efficiency of converting electricity into mechanical power. The generated electricity flows through the coil in the motor creating a magnetic field that reacts to the magnetic field in the motor housing, causing the motor shaft to turn. The shaft then turns a series of gears that turn a drive shaft supported by bearings. The string wraps around the drive shaft and lifts the mass on the hanger.

Overall Efficiency

This is the overall efficiency of converting rotational mechanical energy into electricity, then converting that electricity back into mechanical energy. This includes all of the losses of turning gears, generating electricity, using electricity to turn a shaft, turning more gears, and turning a drive shaft that lifts loads.

Table of Powers and Efficiencies

Maximum Direct Drive Power (Part Three) in watts	
Maximum Electrical Power Generated (Part Two, fan speed 3) in watts	
Maximum Electrical Conversion to Mechanical Power (Part Three) in watts	

Calculation of Efficiencies

Efficiency of Generating Electricity in Percent Electric Power / Direct Drive *100%	
Efficiency in Using Electricity in Percent Electrical Conversion to Mechanical Power / Electric Power * 100%	
Overall Efficiency in Percent Electrical Conversion to Mechanical Power / Direct Drive * 100%	

Written Assignment #3:

Your report needs to include your data tables for Direct Drive, your data from Part Two for fan speed three's Electricity Power, and the data table for Electrical Conversion to Mechanical Power. Include a graph showing the power performance of your wind turbine system with each of the above listed power data sets plotted against tip speed. Include the calculated efficiencies for each energy transformation and for the overall system.

Your written report should explain how the power flows through your wind turbine system and where the apparent losses go for each transformation.

Part 3 Grade	Rubric Description
A	Wind Turbine System is critically evaluated as a whole, and losses and efficiencies are evaluated for each transformation.
B	Wind Turbine System performance is analyzed and losses and efficiencies are explained
C	Data tables, graph and efficiencies are included, Where the apparent losses of power go is explained.
C-	Data tables, graph and efficiencies are included. Efficiency and loss of power are discussed.

Your report can be presented in any deliverable format that you choose including hand written paper copy, digital text files and multimedia or video. Performance data should be graphed.