ENGR290: Renewable Energy

Final Exam Review

Dec 17, 2013

If you can answer these questions, then you will do fine on the final:

Problem 1: Power, Energy and Time Value of Money (Easy)

My very old refrigerator consumes a constant $\$250/W$ of electricity all day every day. PNM charges $\$0.13/kWh$.

1. How much does it cost to run the fridge for a year ($)? _____
   (a) Draw a cash flow diagram (10 year, 8%) of the cost of the energy consumed by the fridge.
   (b) What is the Present Value of that cost? _____
2. I can buy a fancy new fridge for $1200 that will last 10 years. This new fridge will draw an average of $150W$ continuously.
   (a) How much will the new fridge cost to run each year ($/year)? _____
   _____
   (b) Draw a cash flow diagram (10 year, 8%) of the cost of the new fridge and the energy for 10 years.
   (c) What is the Present Value of that cost? _____
3. Is it worth buying the new fridge based on just the difference in energy costs? _____

Problem 2: Deferrable Loads and Storage (Medium)

PNM has different rates for daytime and nighttime power consumption. They charge \$0.20/kWh from 6AM to 8PM and \$0.10/kWh the rest of the time. You have to provide water to a neighborhood. If you pump water directly from the well as needed, you have the average daily load profile shown in Figure 1.

1. Using the power profile in Figure 1 and the variable power rate:
   (a) How much does your energy cost each year? (\$) _____
   (b) What is the Present Value of the utility cost (10 yr, 8%)?(\$)_____
2. To avoid the high price during the day, you decide to shift your well pumping to night and just provide water from the tank during the day. You find that you are able to shift $2kW$ each hour from 6AM to 8PM into the night to give the power profile shown in Figure 2.
   (a) How much does your deferred energy cost each year? (\$)? _____
   (b) What is the Present Value of the deferred utility cost (10 yr, 8%)?_____
3. You are still unhappy about paying those high daytime rates, so you decide to store energy in batteries during the night to use during the day so that you never pay the daytime rate again!
   (a) Using the deferred load power profile in Figure 2, how much energy must you store to consume no power between 6AM and 8PM? (kWh)? _____
   (b) What would that energy cost per year (\$)? _____
   (c) If you can buy a $400Ah$ battery for \$300.
      i. How many of these batteries would you need? _____
      ii. How much would those batteries cost?(\$)_____
   (d) Draw a cash flow diagram of the battery system and utility cost .
   (e) What is the Present Value of the battery and utility cost (10 yr, 8%)?(\$)_____
   (f) Is it a good investment to buy the batteries?_____

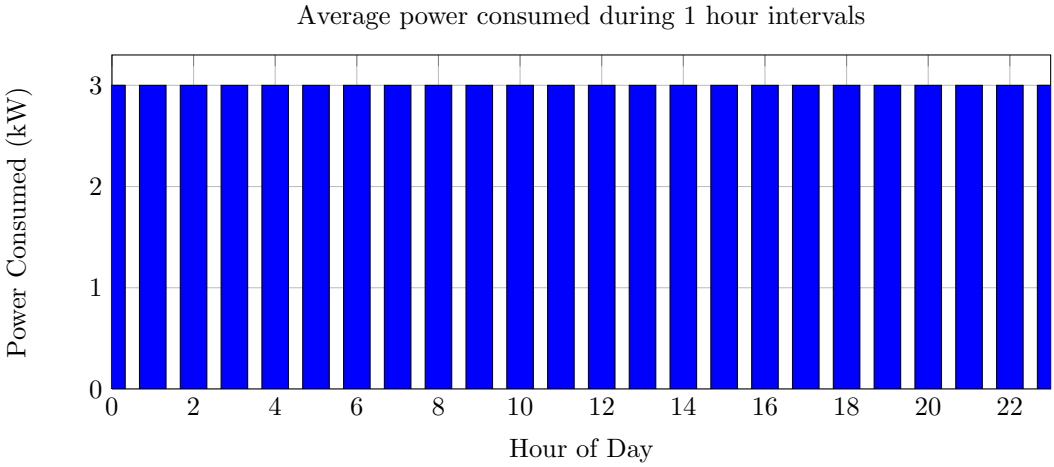

Figure 1: Power Load

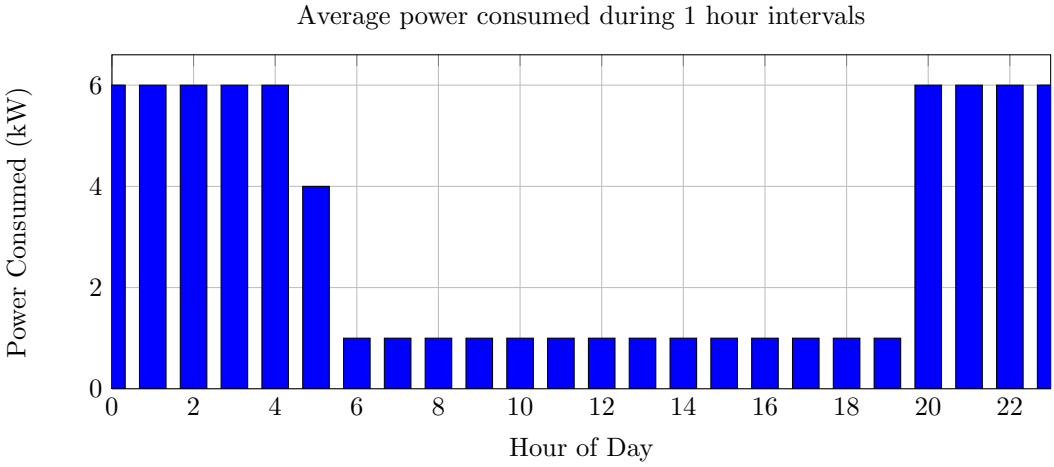

Figure 2: Deferred Power Load

Problem 3: Energy system design (Hard)

A security lighting system needs to light the entrance to my ranch every night to make sure no one sneaks in a steals all of the cows you killed on your last quiz. You need to design a stand-alone system that can power the lights without fail. The lights consume $3kW$ and run an average of 8 hours every day of the year.

I have done some research and found that I can get:

- Solar panels: 32VDC, 120W for $200 each.
- Solar charge controller 150VDC input, up to 4kWfor $500.
- Two axis tracking mount that can hold 8 of the above panels for $1000.
- Inverter: 1.2kW (24VDC in, 120VAC out) for $1500.
- Batteries: $400Ah$, 6VDC for $300.
- Windturbine: $900W$, 24VDC output for $3000.

1. (a) Draw a block diagram of the system using all of the above components.

   (b) What is my average power load (kW)? _____

   (c) What is my daily energy consumption (kWh)? _____

2. First you try do it all with only solar power. Since this is a life critical application you want plenty of margin, so design the system for 3 times the average daily consumption. Using Albuquerque's solar data:

   (a) What is the minimum wattage for my solar array to provide 3x the daily energy from (1c)? (kW)_____ (hint: 2 axis tracking in Albuquerque sunshine!)

   (b) How many panels should I wire in Series to feed my charge controller with the correct voltage? _____

   (c) How many series strings should I wire in parallel to get the power calculated in 2a?_____

3. Of course your solar system needs batteries for night time.

   (a) How much energy do I need to store to keep the lights on for 3 days without sun? (kWh)?
   _____

(b) How many batteries would that require? _____

(c) How much would those batteries cost? _____

4. I don't like depending only on the sun, and there is a enough wind on my site to provide an average of 300W of continuous power from one turbine.

   (a) How much average energy will the wind turbine provide each day(kWh)? _____

   (b) If I start with all of the batteries in 3b charged and my solar charge controller breaks so that I am depending only on the the batteries and wind, how many days will my lights stay on before the system looses power? _____

5. What does the PV, battery and wind system cost? _____