Physics and Mathematics of Sustainable Energy

Finance Exercises

College of the Atlantic

Due Tuesday, November 9, 2021

Guidelines

- You can work on this with a partner and hand in only one writeup. If you opt for this route, I strongly recommend that you each write one of the spreadsheet models. Don't have the same person in the duo write both of the models.
- This should be typed up (not handwritten) and should be reasonably well explained. In particular, but be sure to clearly enumerate the various assumptions that you make in your models.
- Please use google docs for your spreadsheets and include a link to your spreadsheets in the submission you upload on google classroom.
- Your spreadsheets should use the techniques that I demonstrated last week. Namely, all the parameters (system cost, capacity factor, discount rate, etc.) in your model should be in their own cells—nothing should be hidden in a formula. This way you can easily adjust these parameters and see what happens. Also, anything that is a dollar amount should be indicated as such with a "$", and you should round everything to the nearest dollar or perhaps the nearest ten dollars.

The Situations

Below are three situations for you to analyze and compare: purchasing solar cells, replacing an oil furnace with a heat pump system, and insulating your attic. The basics of each are described below.

If there are one or two people in your group, chose two of the situations to analyze. If there are three people in your group, you should compare all three situations.

Option A: Solar PV

- 20 solar panels, 360 Watts (nameplate) each.
- Capacity factor is 0.14.
- Installation cost: $3/Watt.
- The electricity you generate is worth 17 cents per kWh.
- You may (or may not) get a 30% tax credit on the installation costs. (This is like a 30% rebate it's just that you would be paying less taxes, rather than directly paying less money for the solar panels.)
- Assume that the solar panels last for 25 years.

Option B: Insulating Cottage

- Insulating the attic and air sealing Cottage will cost $15,000.

- Doing so will reduce heat loss by between 25 and 35%.
- Cottage uses 875 gallons of fuel oil a year.
- Oil prices in Maine for the last 12 years can be found at `https://www.maine.gov/energy/heating-fuel-prices`.
- Assume that the insulation and air sealing will last for 25 years.

Option C: Installing Heat Pumps in Cottage

- Cottage uses 875 gallons of fuel oil a year. The efficiency of the furnace is around 70%.
- You will use the heat pumps to generate as much heat as the oil furnace delivered to Cottage. (I.e., the caloric value of 70% of 850 gallons.)
- The cost of electricity is 17 cents per kWh.
- The heat pump, installed, will cost $10,000.
- Oil prices in Maine for the last 12 years can be found at `https://www.maine.gov/energy/heating-fuel-prices`.
- Assume the heat pump lasts for 15 years.
- Assume that the COP of the heat pump is 3.

Things to do and Figure Out

Once you have the spreadsheet set up, use it to answer the following questions.

1. For each of the investments, build a spreadsheet model that you can use to to analyze it.
2. For each investment, calculate the payback time, ROI, NPV, and IRR for the solar cells. Determine the NPV for discount rates of 5 and 10 %.
3. For the solar panels, calculate the above quantities with and without factoring in the 30% tax credit.

Your Report

Suppose that COA is trying to decide among the scenarios you analyzed. There is only funding to do one of these projects. Write a report that will help inform this decision. Assume that your reader understands ROI, NPV, and IRR.

Your report should be structured as follows:

1. Analysis of solar PV. Write a few paragraphs summarizing your analysis of this project. This summary should include not only your values for IRR, payback, NPV, and IRR, but the assumptions that went into these calculations. Include some assessment of risk. How confident are you of your analysis? What are some ranges or bounds for the quantities you calculated? Your analysis should include analysis both with and without the 30% rebate.

2. Analysis of attic insulation and air sealing. Repeat the above analysis but for the insulation. Be sure to include a discussion of how you handled the uncertainty around the price of heating oil.

3. Analysis of the heat pump. Repeat the above analysis but for the insulation. Be sure to include a discussion of how you handled the uncertainty around the price of heating oil.

4. **Your approach of uncertainty should involve more than simply taking an average of oil prices. Consider a few different scenarios and get a sense of the range of possible outcomes.**

5. Recommendation. Which investment do you recommend, and why?

Your report should be typed/word-processed (i.e., not handwritten) and will probably be around two pages.

Other, Optional things to Consider

If you have time and the inclination, there are some other considerations you could add to your analysis.

- What happens if the cost of electricity increases by 1% a year?
- What happens if the capacity factor of the solar installation is slightly different?
- What happens if the solar panels only last 20 years? Or if they last 30 years?
- What happens if there is a 2000 state rebate for solar PV? For the attic insulation?
- How does your analysis change if the cost of electricity was 11.3 cents per kWh, as it is in New Mexico?
- How does your analysis change if the cost of electricity was 20.7 cents, as it is in Connecticut?
- A more difficult thing to do would be to compare the two investments in terms of CO_2 saved instead of money.