Physics and Mathematics of Sustainable Energy

Finance Exercises

College of the Atlantic

Due: November 7, 2025

The Set-up

Bear Paul is College of the Atlantic's Administrative Dean and CFO (Chief Financial Officer). He has determined that in next year's budget there will be around $15,000 that can be used to invest in energy efficiency. He is considering three options, each of which is described below.

Bear does not know which option to choose, and he has reached out to your consulting business for guidance. He would like you to prepare a comparative analysis of the three options and make a recommendation for which one the college should pursue.

Some important details about Bear and what he has hired your business to do.

- Bear knows what IRR, NPV, etc are. He's a CFO, after all. So you don't need to explain these terms to him.
- Bear understands the importance of reducing carbon emissions, so you don't need to convince him of this.
- Bear is busy. He wants to see as simple a comparison as possible. Bear does not want to read a long narrative piece.

Timeline

- By the end of lab **today (Tuesday 24 October)**, get a good start on your spreadsheet models.
- The target date for your report: **Tuesday 7 November**.

Logistical Guidelines

- You can work on this with a partner and hand in only one report. If you opt for this route, I strongly recommend that one of you write the spreadsheet for scenario B and the other of you write the spreadsheet for scenario C. (Scenario A we will basically do in class today.) Don't have the same person in the duo write both of the models.
- Please use google docs for your spreadsheets and include a link to your spreadsheets in the submission you upload on google classroom.

Technical Specifications for the Report

- For each option
  - Build a spreadsheet model that you can use to to analyze it.
  - State the assumptions you used when building your model (capacity factor, cost of fuel, etc.).
  - Calculate the ROI, NPV (using a discount rate of 5%), the payback time, and the IRR.
  - Do the above calculations for three scenarios:
    * The most reasonable/likely scenario.
    * A bad[1] but plausible scenario.
    * A good but plausible scenario.
  - Estimate the total emissions saved due to each investment. Assume a carbon intensity of 0.35 kg per kWh of electricity from the grid, and a carbon intensity of 0.04 kg per kWh of electricity generated from the solar panels you install.
- After you present your results, make a recommendation to Bear stating which option you think the college should pursue, and why. Your recommendation should account for your financial analysis but does not need to be purely financial.
- 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. (It is possible that Bear gets curious and wants to explore your models. So the spreadsheets should be understandable to him.)

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 and air sealing a house. The basics of each are described below.

Option A: Solar PV

- 16 solar panels, 450 Watts (nameplate) each.
- Capacity factor is 0.13.
- Installation cost: $3/Watt.
- However, there is a 30% rebate thanks to the US Inflation Reduction Act (IRA). So subtract 30% from the total cost.
- The electricity you generate is worth 0.32$ per kWh.
- Assume that the solar panels last for 25 years.

[1] For example, the capacity factor is a little on the low side, costs of fuel and electricity are a little worse than you expect, etc. Note: What "bad" costs mean depends on the investment. Expensive electricity might be good for some investments but bad for others.

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 twentyish 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 875 gallons.)
- The cost of electricity is 32 cents per kWh.
- The heat pump, installed, will cost $11,000.
- Oil prices in Maine for the last twentish 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 3.5.

Notes on the Scenarios

The numbers given above are all based on real systems. The solar installation numbers are those for a system we installed at our home in the summer of 2022. I think the installation costs are likely higher now, due to inflation. Also, we needed to upgrade our electrical panel in order to tie our system in to the grid. I didn't include this cost in the scenario.

The Inflation Reduction Act reinstated the 30% tax credit for the next 10 years, and made it available as an upfront rebate for non-profits, schools, and municipalities.

The costs for the heat pumps and insulation/air sealing are approximate actual costs for work that was done in the last 3–4 years.

In general, a lot is in flux economically, to say the least. So some of the numbers in the scenarios will likely soon be out of date. But they're pretty close to the current reality, maybe. And the spreadsheet models you built can be easily updated as numbers change.