Chapter 15. Supply and Costs

Homework 15.1. Convert the formula $P = 5.9HF$ to H measured in feet and F measured in cubic feet per second.

Homework 15.2.

15.2a. Set up an excel program to compute unit costs for the scenario below. Now compute costs for the following scenarios.

15.2b. Interest rate is 15%.

15.2c. Base case scenario with interest rate 10% but you install your generator at a windier location, where you run at 35% of capacity.

15.2d. Base case scenario except you buy a more durable generator that lasts 25 instead of 20 years.

15.2e. Base case scenario but you have to do some repairs to your turbine which cost $50,000 at year 10.

Homework 15.3. In a bit more realistic example, the wind patterns might follow some probability distribution over time at varying wind speeds. Suppose that the generated amount of electricity is proportional to the wind speed and that at 20 mph it generates at 600 kw, at 15 mph it generates at 450 kw, at 10 mph is generates at 300 kw, at 5 mph it generates at 150 kw, and with no wind it generates no power. Assuming only five possible wind speeds, let the probability distribution of wind speed be:

x = wind speed (mph)	**P(x) = percent of time**
0	**0.35**
5	**0.25**
10	**0.15**
15	**0.15**
20	**0.10**

15.3a. What is the expected or average value of wind speed per year? Remember the expected value of a discrete random variable is E(x) = $\Sigma_{i=1}^{n} x_i P(x_i)$.

15.3b. What is the expected amount of power generated each year, if power is generated according to the function g(x), which is electricity generated as a function of wind speed, with g(x) = 30x. Remember the expected value of a function of a discrete random variable is $E(g(x)) = \Sigma_0^n g(x_i) * P(x_i)$.

15.3c. In the case of a linear function, we can compute the expected value of the function directly from the expected value of the original variable. For example, let

$g(x_i) = a + bx_i$

then

$$E(g(x)) = \sum_{i=1}^{n} (a + bx_i)*P(x_i)$$

$$= \sum_{i=1}^{n} a*P(x_i) + \sum_{i=1}^{n} bx_i *P(x_i)$$

$$= a* \sum_{i=1}^{n} P(x_i) + b \sum_{i=1}^{n} x_i*P(x_i)$$

But we know that probabilities must sum to one or $\sum_{i=1}^{n} P(x_i)$ and $\sum_{i=1}^{n} x*P(x_i) = E(x)$.

So we can simplify the above expression to

$$= a*1 + b*E(x) = a + b*E(x).$$

The mathematics tells us that the expected value of a linear combination of random variables is the same linear combination of the expected value of the variable. Although this sentence is quite a mouthful, it is easy to apply in practise.

When speed is x, expected wind speed is E(x), and power production is 30x, then expected power production is E(30x) = 30*E(x). Verify this formula using your results in a and b.

15.3d. Using the expected power production compute the expected levilized cost of power per kilowatt hour?

Homework 15.4. Suppose the wind follows a continuous probability function f(x) from 0 to 20 miles per hour. You have found a probability density function for wind speed of f(x) = 0.005*(20 - x).

15.4a. Is this a bonafide density function? (i.e. Does $\int_0^{20} f(x)dx = 1$?). If it is not, fix it to integrate to 1.

15.4b. What is the expected wind speed in this case? Remember that expected value in the continuous case is $\int_0^{20} xf(x)\,dx$.

15.4c. Assume that power generated = (wind speed)/20*600 for x between 0 and 20. What is the expected electricity generated per year?

15.4d. What is the expected capital cost per kilowatt hour?

15.4e. What is the probability that wind speed is between 0 and 10 miles per hour. Remember that this probability is the integral of the probability function from 0 to 10

Homework 15.5. The Nuclear Energy Agency computed the costs in Table 15.6. Does a discount rate of 5% seem high or low to you? For a comparison find a bond rate for an electrical utility, preferably one with nuclear power plants. Would costs be higher or lower if the bond rate you found were used instead? Why?

Homework 15.6. Show that the formula for $\$_o$ and $\$_t$ for the discrete case can be written as

$$\$_o = \frac{K}{Q} / \Sigma_{t=1}^{n} \frac{(1-\alpha)^t}{(1+r)^t} \; and \; \$_t = \frac{K}{Q} / \Sigma_{0}^{n} \frac{1}{(1+r)^t}.$$

Homework 15.7.

15.7a. What are unit costs for a pipeline that will be used to transport 300 million barrels of oil a year for 25 years? Its initial cost is $500 million and your discount rate is 11%.

15.7b. Now suppose that you don’t know the cost of the pipeline. You know it will be 1000 miles long and you know how much crude you will have to transport from part a. Cookenboo has calculated the throughput of a pipeline as:

$$T^{2.735} = H * (D)^{4.735/0.01046}$$

Where T = throughput in thousands of a barrels per day. D = inside diameter, which is 1/2 inch less than the outside diameter of the pipe. H is the pumping station horsepower in thousands. The *Oil and Gas Journal* reports pipeline costs for the U.S. in the Annual Pipeline Economics Report, which is published in September every year. You have chosen a pipeline with a 20" outside diameter. What size pumping station would you need to pump 300 million barrels a year. (Round to the nearest horsepower). Find the per mile cost of a 20" pipeline from the latest Pipeline Economics report. Add 15% to this cost to account for pumping station costs. What is your best unit transport cost estimates for your pipeline?

Homework 15.8. Values for the denominator of our continuous and discrete case are

$$Continuous\colon \int_0^n e^{(-\alpha-r)t}\,dt, Discrete\colon \Sigma_{i=0}^{n} \frac{(1-\alpha)^t}{(1+r)^t}.$$

These are computed in Table 15.8 below for various interest rates, decline rates, and project lives. Fill in the missing values and verify the values in Table 15.8. Give an intuitive explanation of what happens to costs as interest rates increase and as project life lengthens for both the continuous and discrete case.

15.8. Denominators for Computing Capital Costs in the Continuous and Discrete Cases for Various Interest Rates

Decline Rate = →	**0%**	**5%**	**10%**	**15%**
Discrete Discounting at IIR(r) =5%				
Project life ↓				
20 years	13.46	9.22	6.73	5.19
25 years	15.09	9.72	6.87	5.23
30 years	16.37	10.03	6.94	5.24
infinity				
Discrete Discounting at IIR(r) = 10%				
20 years	9.51	7.00	5.42	4.38
25 years	10.08	7.17	5.47	4.39
30 years	10.43	7.26	5.49	4.40
Infinity				
Continuous Discounting at IIR(r) = 5%				
20 years	12.64	8.65	6.33	4.91
25 years	14.27	9.18	6.51	4.97
30 years	15.54	9.50	6.59	4.99
infinity	20.00	10.00	6.67	5.00
Continuous Discounting at IIR(r) = 10%				
20 years	12.64	8.65	6.33	4.91
25 years	14.27	9.18	6.51	4.97
30 years	15.54	9.50	6.59	4.99
Infinity(∞)	10.00	6.67	5.00	4.00

Homework 15.9. Go to energy trade journals and find a project for which capital costs are reported. Compute unit costs for this project. For example if you choose an electricity generation plant compute cost per kilowatt hour, if you chose a refinery compute cost per barrel, if it's an LNG tanker compute costs of transporting a metric ton, it it's the cost of

developing a gas field compute costs per cf. Use an interest rate of 15%. State any assumptions you are making about the life of the project. Reference your cost source and note if it's a journal that we should add to the following list. Examples of Trade Journals include

American Gas Association Monthly

American Gas

Coal

Coal Age

Coal Outlook

Electrical World

Energy Daily

Energy Developments

Energy World

Independent Energy

Independent Power

Marathon World Review

Mining Magazine

National Coal Voice

Offshore

Offshore Incorporating the Oil Man

Oil and Energy Trends

Oil and Gas Investor

Oil and Gas Journal

Oil Investors Journal

Oil Week

Pacific World Oil

Petroleum Economist

Petroleum Independent

Petroleum Intelligence Weekly

Petroleum News

Petroleum Review

Petroleum Times

Southwest Oil World

Western Energy Update

Western Oil World

World Coal

World Oil

Homework 15.10. Page through some recent Oil and Gas Journals.

15.10a. What seems to be a current hot spot for drilling?

15.10b. Find a recent field where they give reserve information and development costs and compute approximate above ground costs with an interest rate of 9% and a decline rate of 10%.

15.10c. Do the same computation assuming that the field lasts for 20 years and see how much difference it makes on the costs.

Homework 15.11.

15.11a. What are unit costs for a pipeline that will be used to transport 300 million barrels of oil a year for 25 years? Its initial cost is $500 million and your discount rate is 11%.

15.11b. What are the costs if you use the infinite approximation?

15.11c. Now suppose that you don't know the cost of the pipeline. You know it will be 1000 miles long and you know how much crude you will have to transport from part a. Cookenboo has calculated the throughput of a pipeline as:

$$T^{2.735} = H*(D^{4.735})/0.01046$$

Where T = throughput in thousands of a barrels per day. D = inside diameter, which is ½ inch less than the outside diameter of the pipe. H is the pumping station horsepower in thousands. The *Oil and Gas Journal* reports pipeline costs for the U.S. in the Annual Pipeline Economics Report, which is published in September every year. You have chosen a pipeline with a 20" outside diameter. What size pumping station would you need to pump 300 million barrels a year. (Round to the nearest horsepower). Find the per mile cost of a 20" pipeline from the latest Pipeline Economics report. Add 15% to this cost to account for pumping station costs. What is your best unit transport cost estimates for your pipeline?

Homework 15.12. Go to an energy trade journal and find a project that interests you for which capital costs are reported. Compute unit costs for this project. For example if you chose an electricity generation plant compute cost per kilowatt hour, if you chose a refinery compute cost per barrel, if it's an LNG tanker compute costs of transporting a metric ton, it it's the cost of developing a gas field compute costs per cf. Use an interest rate of 15%. State any assumptions you are making about the life of the project. Reference your cost source and note if it's a journal that we should add to the following list.