PBL-4 Problem Statement: Photovoltaic Expansion in Logan, Utah

Learning Objectives:

a. *Demonstrate critical analysis skills and capabilities expected of practicing water resources engineers, including to identify, evaluate, and recommend alternatives.*
b. *Apply engineering economic principles and methods to evaluate alternatives.*
c. *Apply multiple criteria in project evaluation*
d. *Gather, analyze, and synthesize data*
e. *Include risk and uncertainty in engineering economic analysis*
f. *Coherently and concisely present engineering analysis in written form*
g. *Apply tools to your own and communicty financial and investment decisions*

The Situation:

You are a practicing engineer employed at EngineeringEcon Pros, an engineering firm located in Logan, Utah. The City of Logan is forecasting a 25% increase in energy consumption from the current 400,000 MW-hr/year by its customers over the next 15 years. The city has hired your firm to recommend how the city should meet the expected increase in electricity demand. Should the city encourage residential customers to install photovoltaic systems on their residences, build a utility-operated solar farm, buy electricity off the wholesale market, or use multiple sources? The city will use attributes of present value of costs ($/MW), ease to implement, and long-term sustainability as decision criteria ranked in that order. More information on the options:

Encourage residential customers to install photovoltaic (PV) systems

- The typical Logan residential customer uses 375 kW-hr/month. Assume this use varies among customers according to a skewed lognormal distribution with mean and standard deviation parameters of 5.8 and 0.5 (see Excel functions LOGNORM.DIST and LOGNORM.INV to calculate the probability density, cumulative density, and inverse).
- Residential energy demand increases by 25% in peak summer months (May to September) and falls by 25% in all other months.
- PV systems will be sized (power in KW) to meet 90% of household peak demand.
- Residential panels have a capacity factor between 15% and 22% (hours generating / total hours in the year). The capacity factor depends on latitude, cloud cover, tree shading, panel orientation, etc. (Feldman et. al, 2016).
- Logan City currently charges $0.10/kW-hr. The city also has a net-metering program where the city will credit all additional electricity the residential customer generates but does not use at the same $0.10/kW-hr rate. Residential prices may vary in the future according to average retail rates in the nearby states of Nevada, Arizona, New Mexico, Colorado, Wyoming, and Idaho (EIA, 2017a) and recent time trends (EIA, 2017b)
- A PV system has an expected life between 20 and 30 years.
- The City does not know when homeowners will install PV systems.
- A homeowner can offset part of the cost of a rooftop system with a 30% federal tax credit and 25% (up to $2,000) state tax credit.

- Based on initial costs (solar panels, inverter, writing, and net-metering), energy usage, and tax credits, only some households will find it economically beneficial to install PV panels. 300 Logan residential customers already have home PV systems.
- For each 1 kW of PV capacity installed, the City must nonetheless have available 0.4 kW of additional reliable supply (to ensure electricity supply in case of clouds, snow, inversion, or other conditions that limit solar generation).

Build a utility-operated solar farm

- The farm would be constructed in or near Logan
- Panels will use single-axis tracking (i.e., motorized and track the sun) and have a capacity factor of 25% (Feldman et. al, 2016).
- New panels can be added over time as demand increases.
- For each 1 kW of PV capacity installed, the City must nonetheless have available 0.4 kW of additional reliable supply (to ensure electricity supply in case of clouds, snow, inversion, or other conditions that limit solar generation).

Buy Electricity off the Wholesale Market

- Logan City purchases electricity off the wholesale market at rates described in EIA (2017c).
- The City then marks up the price to $0.10/kW-hr to sell to customers but the mark-up only partially covers the City's cost to deliver electricity and maintain the system.
- The source of wholesale supplies is a mix of coal- and natural gas- fired plants.

Additional sources of information provided by the instructor and contributed by students are available on the Canvas page for PBL-4 (https://usu.instructure.com/courses/469212/pages/pbl-4-additional-sources-of-information).

In your analysis:

1. Cite unattributed assumptions listed in this document as Rosenberg (2017). "PBL-4 Problem Statement: Photovoltaic Expansion in Logan, Utah." Utah State University.
2. Explicitly consider the uncertainties associated with each option.
3. Express costs for each option as the present value $ per MW of installed capacity.
4. State the expected fraction of Logan households that will have an economic incentive to install a PV system.
5. Describe costs associated with each option that Logan Utility will externalize (other entities will pay).
6. Explain how results will change if demand increases by 50% or the wholesale energy price continues to rise.
7. Recommend which option(s) the City should pursue to meet the expected increase in electricity demand.

This is a group PBL. Students can work in groups of up to 4 persons. To submit:

1. Create a group in Canvas for PBL-4.
2. One member submits the report for the group.
3. Each group member individually completes the Group/Self Rating Form (on main page) and submits on Canvas

You are responsible to obtain all additional data you need!! However, we will spend part of class on Nov 27 to answer questions.

References

Feldman, D., Boff. D., and Margolis, R. (2016). "Q3/Q 2016 Solar Industry Update". U.S. Department of Energy, National Renewable Energy Lab. December 21, 2016. https://www.nrel.gov/docs/fy17osti/67639.pdf

U.S. Energy Information Administration (EIA) (2017a). "State Electricity Profiles." https://www.eia.gov/electricity/state/. Accessed [November 14, 2017].

U.S. Energy Information Administration (EIA) (2017cb). "Real Prices Viewer." http://www.eia.gov/outlooks/steo/realprices/. Accessed [November 14, 2017].

U.S. Energy Information Administration (EIA) (2017c). "Wholesale Electricity and Natural Gas Market Data." https://www.eia.gov/electricity/wholesale/. Accessed [November 14, 2017].

See also information sources of information contributed by the instructor and students at https://usu.instructure.com/courses/469212/pages/pbl-4-additional-sources-of-information.

CEE 4200, PBL-3 Grading Rubric Students: _____

Category (Max. Score)	No Evidence	Far Below Standard	Below Standard	Meets Standard	Exceeds Standard	Self-Score	Instructor Score
Title Page (3)	Absent 0	Evidence of two or fewer title page elements 0	Unclear title, or only 3 of 5 title page elements present. 1	Separate title page. Title, Name, Instructor, Course, Date present 2	Separate title page. Can assess main point from title alone. Name, Instructor, Course, Date, Neat 3		
Introduction (7)	Absent, no evidence 0	There is no clear introduction, main topic, or description of the report's contribution. 1 - 2	Introduction states the main topic but either: 1. Does not give a full overview, or 2. Too detailed, leads to repetition later. 3 - 4	The introduction states the main topic and previews the structure of the report. 5 - 6	Introduction states the main problem, describes report contribution, and previews report structure. Overviews solution strategy. Makes reader want to continue reading. 7		
Organization and report structure (10)	No content provided. 0	Paragraphs fail to develop the main idea. No section headers or guide to help the reader understand how material is organized. 1 – 4	Organization of ideas not fully developed. Paragraphs lack supporting detail sentences. No transitions or section headers. Main report exceeds 3 pages. Appendices exceed 3 pages. 5 - 6	Paragraph development present but not perfected. Each paragraph has sufficient supporting sentences. Section headers. Few transitions. 3-page main report. 7 -8	Writer demonstrates logic and sequencing of ideas through well-developed section headers, paragraphs, and transitions. The first sentence of each paragraph is the summary sentence. Main report is 3 page or less. Appendices, if present, do not exceed 3 pages. 9 - 10		
Engineering Economic Analysis (60)	Engineering economic analysis point(s) not addressed. 3 – 42%	The writer has no clue what they are talking about. 45 – 58%	Sketchy: left out required points. Did not work on this as much as you should have, and it shows. Several important answers are incorrect. 61 – 79%	Necessary points are covered. Most answers are correct. Adequate explanation of methods. 82 – 88%	Provides what was explicitly asked for. The function of each piece is demonstrated to the reader in adequate, but not overwhelming, detail. Answers are correct and reasonable. 91 – 100%	[redacted]	[redacted]
	a) Present value cost/MW, ease of implementation, and sustainability for each option (15)						
	b) Description of uncertainties (5)						
	c) Expected fraction of Logan households that will implement a PV system (10)						
	d) Externalities (10)						
	e) Effect of increased demand, wholesale price (10)						
	f) Recommendation(s) (10)						

CEE 4200, PBL-3 Grading Rubric Students: _____

Category (Max. Score)	No Evidence	Far Below Standard	Below Standard	Meets Standard	Exceeds Standard	Self-Score	Instructor Score
Word Usage and Format (10)	Not applicable	Numerous and distracting errors in punctuation, capitalization, spelling, sentence structure, word usage, significant figures, tables, and figures. Data vomited onto page(s). Unacceptable / unprofessional at the graduate level. 1 – 5	Misspelled words, poor English grammar and word choice. Main body of report is either longer or significantly less than one page. Figures are too small and/or under-labeled, although they are usually of acceptable quality and focus. Tables incoherent or not cohesive. Bad font sizes. Too much or too little data in appendices. Could be improved by being more meticulous. 6 – 7	Almost no errors in punctuation, capitalization, spelling, sentence structure, word usage, significant figures, and presentation of figures, tables, and appendices. 8	Punctuation, capitalization, spelling, sentence structure, word usage, and significant figures all correct. Clear, consistent fonts. Good word processing skills. Figures have adequate contrast. Informative figure and table titles with numbers. Figures have appropriate axis tick spacing, labels, units, and legends. Table columns cohesive, labeled, and specify units. Equations are numbered. Appendices, if provided, are separated by topic, and each have a title, discussion, and proper formatting and display of information. 9 - 10		
Conclusion (7)	Absent 0	Incomplete and/or not focused. 1-2	The conclusion does not adequately restate the main results. 3-4	The conclusion restates the main results. 5	The conclusion restates the main results, and is an effective summary. 7		
References (3)	Absent 0	Many errors, off-the-wall sources used, and/or few sources cited 0	Some prior work, data, and sources cited. A few references formatted correctly. 1	Most prior work, data, and sources cited. Formatting generally correct. 2	All prior work, data, and sources cited and referenced in correct format. References section is at end of report. 3		
Group Participation (10)	Not applicable.	Project appears to be the work of one person. 1 - 3	Project appears to be the work of only a few group members. 4 - 6	All group members contribute. 7 - 8	All group members significantly and equitably contribute. 9 - 10		
TOTAL (110)							