To LED or not LED: a real-world approach to capital budgeting

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ABSTRACT

We take an actual case involving a small, mid-western commercial real estate business and modify the case to make it applicable to a decision that a typical undergraduate or graduate student might face. This case examines the choice to replace a compact fluorescent lamp (CFL) light bulb with a more energy-efficient, but more expensive light-emitting diode (LED) light bulb. Using this case provides the opportunity to give students a real-world application of a wide-variety of capital budgeting concepts including sunk costs, forecasting risk, scenario analysis, sensitivity analysis, net present value, internal rate of return, capital rationing, externalities, and using the replacement chain method to evaluate projects with unequal lives.

Keywords: undergraduate teaching, graduate teaching, capital budgeting, budget model, real-world

Capital budgeting is an important topic in most introductory-level business finance courses. Most business finance courses focus on applying capital budgeting techniques, such as cash flow estimation, and risk assessment, in a corporate setting. It can be difficult for a student between the ages of 18 and 22 with no corporate experience to truly appreciate the challenges of estimating the cash flows from a project or finding a discount rate that reflects the risk of a project's cash flows. Although one can make the argument that a corporate finance course should include cases geared towards a corporate finance setting, we introduce a case that can easily be applied to a corporate finance setting yet is also very easily applicable to a "traditional" college student with no corporate finance experience. In fact, this case was adopted from a real-world case facing a small, mid-western commercial real estate business and examines the return earned by adopting a form of “green energy” light emitting diode (LED) lightbulbs.

In most undergraduate corporate finance courses, students are taught that the appropriate discount rate to use for a project is the firm’s weighted-average cost of capital (WACC), assuming the project in question is comparable in risk to the firm. If the project is less risky than the firm itself, a downward adjustment must be made to the firm’s WACC to generate an appropriate discount rate for the project. While this practice is simple in theory, it is difficult to figure out the exact adjustment needed in practice.

Since the case was used in an introductory-level course, students were split into groups of four or five to work together and some simplifying assumptions were made. For instance, it is assumed that the cash flows from the energy savings of the light emitting diode (LED) bulbs occur at the end of each year. Instructors in upper-level finance courses could incorporate the more realistic assumption that cash flows occur at the end of each month. This adds an additional layer of complexity to the case and gives the instructor the opportunity to assess more advanced concepts, such as having students take a monthly internal rate of return (IRR) and converting it into an annual rate and an effective annual rate.

It was also assumed that the energy cost inflation rate would be zero. It could be modified for upper-level courses to include an inflation rate for energy costs, which students could easily incorporate using spreadsheet software. In addition, it was assumed that the price of LED bulbs and CFL bulbs would remain constant in the future. According to the United States Department of Energy, CFL bulbs were more than $25 each when they first became available on the market in the mid-1980s. Since then, the price of CFL bulbs has decreased by more than a factor of six. It is possible that the price of CFL bulbs will continue to decline in price in the future. Alternatively, it is possible that the price of CFL bulbs will increase with inflation over the next two decades. These possibilities could easily be factored into the case to make it more challenging for advanced students.

Lastly, the opportunity cost of one’s time spent replacing CFL bulbs more frequently than LED bulbs was ignored in order to simplify the case.

Useful Background

Since lightbulbs were first invented, they have and continue to change and improve to meet user and government standards and needs. According to the Department of Energy, the first electric lightbulb was invented by Humphry Davy, an English chemist, in 1809. His crude invention consisted of an arc lamp that hooked to a battery on one side, and a charcoal strip on the other, which connected by wiring[1]. The next breakthrough in lighting did not come for over 60 years, when in 1875 Thomas Edison patented the incandescent lightbulb.

The practicality of the lightbulb in modern history led many scientists and engineers to explore the use of different materials and configurations to improve the usefulness and efficiency of lightbulbs. In 1962, Nick Holonyak, Jr., an American engineer for General Electric, developed the first light-emitting diode (LED) light. The next major advancement in the development of lightbulbs occurred as a result of the 1973 oil crisis, which motivated researchers at Sylvania to develop miniaturized ballasts to improve the efficiency of the bulbs, but their design was cost prohibitive. According to the Department of Energy, the first CFL bulb, or compact fluorescent light, was developed at General Electric in 1976, but they were unable to mass-produce CFLs due the prohibitive cost of the required machinery.

The movement away from less efficient incandescent bulbs was spearheaded by the Energy Independence and Security Act, which Congress passed in 2007. This legislation did not ban incandescent lightbulbs, but effectively phased them out because of the requirement that incandescent bulbs become 25 percent more efficient. While it is possible to have the less efficient bulbs meet this requirement, manufacturers would have to decrease the brightness of the bulb to comply, which has led manufacturers to shift to producing CFLs and LED bulbs. Consumers initially choose CFL bulbs over LED bulbs due to the high cost of LED bulbs. However, the recent decline in the price of LED bulbs has made them a more attractive investment relative to CFL bulbs. Between 2008 and 2013, the price of LED bulbs has dropped more than 85%[2]. (Matukla & Wood, 2013)

The Scenario

Lisa, a junior accounting major, lives in an apartment in the Chicago land area. She is taking an introductory finance course and is intrigued by the possibility of applying some of the important concepts that she has learned. She notices a light bulb in her kitchen has burnt out and needs to be replaced. Out of curiosity, she decides to conduct some research to analyze if she is better off continuing to use CFL bulbs in her apartment, or if she should upgrade to an even more energy efficient bulb, an LED light bulb. Conveniently, she notices that there is a "Lighting Facts" label on both light bulb packages (see Figure 1). Lisa also notices that the 75-watt equivalent LED bulbs are expensive relative to the 75-watt equivalent CFL bulbs: the CFL bulbs are only $3.50 per bulb while the LED bulbs are $16.00.

Using the two Lighting Facts tables for the CFL bulb and the LED bulb, answer the following questions. For simplicity, round the life of the LED bulb down to 22 years and round all annual cost savings figures to the nearest cent. In addition, although LED bulbs will generate a daily cost savings, assume that all cost savings are realized at the end of the year.

Before you begin, a few conversion tips are in order. Looking at the Lighting Facts for the CFL bulb, notice that the annual estimated usage is calculated as $2.41 per year based on 3 hours of use per day for 365 days per year at a price of $0.11 per Kw/h. Note that this CFL bulb is 20 watts and that 1 watt is equal to 0.001 kilowatts. The annual cost of running a light bulb is equal to the kilowatt hours consumed per year times the price per kilowatt hour times the number of kilowatts of the light bulb. In the case of the CFL bulb, the annual cost of $2.41 is equal to 3 hours per day × 365 days× 0.001 × 20 watts × $0.11 = $2.409, which is $2.41 – when rounded to the nearest cent.

Lisa decides that replacing her CFL bulbs with the more energy-efficient LED bulbs is a risk-free proposition, since her cost savings will be guaranteed. Based on this belief, Lisa decides that an appropriate discount rate to use is the rate on 10-year Treasury notes, which is 2.20

percent at the time of her analysis. She decides to use base her analysis on the Lighting Facts and assumes that the price per kWh will equal $0.11 and that she will use the bulb for three hours per day. She decides to assume that the usage per day, the cost of the LED and CFL bulbs, and the cost per kWh will be constant over the next 22 years.

Based on this information, find the net present value of replacing the burnt light with an LED bulb instead of a CFL bulb [Question 1]. What is the internal rate of return of replacing the CFL bulb with an LED bulb [Question 2]? Based on this information, should Lisa purchase a CFL bulb or an LED bulb [Question 3]? Why or why not [Question 4]? Be sure to show your work by submitting the Microsoft Excel worksheet with the formulas shown.

Lisa decides to share her findings with her friend Emily, who is an electrical engineer. Upon hearing Lisa's analysis, Emily responds, "$0.11 per kWh? Don't you know the national average in the United States is $0.13 for a residential customer, according to the U.S. Energy Information Association?"

What is the net present value [Question 5] and internal rate of return [Question 6] of replacing the CFL bulb with an LED, assuming that Lisa continues to use the bulbs for three hours per day, but pays $0.13 per kWh? By examining the sensitivity of this project's net present value when only one variable is changed, what type of analysis is Lisa conducting [Question 7]?

Lisa also shares her analysis with her friend Jacob, who tells Lisa "$0.13 is the average in the United States, but Chicago is an expensive city. According to the Bureau of Labor Statistics, the price per kWh in Chicago is $0.16. Besides, you work 60 hours per week and are rarely home. I bet you will only use the light bulb in your kitchen an hour and a half per day."

Assuming that Lisa will only use the light bulb for 1.5 hours per day and that is the cost per kWh is $0.16, what is the net present value [Question 8] and internal rate of return [Question 9] of replacing the CFL bulb with an LED bulb? By examining the sensitivity of this project's net present value when multiple factors are changed, what type of analysis is Lisa conducting [Question 10]?

Lisa has always been a big believer of living within her means, is proud that she has no debt, and never plans to own a credit card. Therefore, she must rely solely on savings for her purchases. Even if Lisa decides the LED bulbs are a good investment, she will likely not replace all of her light bulbs at once. What is the term used to describe the decision to forgo a profitable investment due to lack of funds [Question 11]?

Based on your answers to the previous questions, do you think it is appropriate for Lisa to discount the cash flows associated with replacing the CFL bulb with the LED bulb at the risk free rate of return [Question 12]? Why or why not [Question 13]? Based on your answers in the previous questions, what is the primary type of risk that Lisa faces if she replaces her CFL bulb with an LED bulb [Question 14]?

List and describe two non-financial issues that Lisa should also consider when deciding to replace the CFL bulb with an LED bulb [Question 15]. What is another name for the impact an investment project has on other areas, such as the firm or the environment [Question 16]?

Lisa wakes up the day after analyzing the impact of replacing her CFL bulb with an LED bulb and decides to purchase the LED bulb. She reasons, “I have put a lot of time into this analysis, and that time will have been wasted if I don’t buy the LED bulb.” Is it rational for Lisa to make her decision based on the time and effort she spent analyzing the decision yesterday [Question 17]? Why or why not [Question 18]? The time that Lisa spent analyzing the cash flows in the past is an example of what type of cost [Question 19]?

Case Solution

Solution for Questions 1 – 4:

The purchase of an LED bulb in lieu of a CFL bulb will cost an additional $12.50. This is equal to the $16.00 cost of the LED bulb less the $3.50 cost of the CFL bulb. The annual cost to operate the CFL bulb will equal 3 hours per day × 365 days× 0.001 × 20 watts × $0.11 = $2.409, or $2.41 when rounded to the nearest cent. For the LED bulb, the annual cost would be equal to 3 hours per day × 365 days× 0.001 × 13 watts × $0.11 = $1.56585, or $1.57 when rounded to the nearest cent. Therefore, purchasing the LED bulb will generate an annual cost savings of $0.84, which is equal to the $2.41 annual cost to operate the CFL bulb less the $1.57 annual cost to operate the LED bulb. Using the replacement chain approach, also known as the common life approach, the purchase of an LED bulb saves an additional $3.50 at the end of year 11 because the LED bulb will not need to be replaced for 22 years while the CFL bulb would have needed to be replaced at the end of year 11. Therefore, the cash flow in year 0 would be ($12.50) and the cash flow in years 1-10 and years 12-22 would be the annual cost savings of the LED bulb over the CFL bulb, which is $0.84. The cost savings in year 11 is the annual cost savings of $0.84 plus the $3.50 savings from not having to replace the CFL bulb in year 11. Thus, the total cash flow in year 11 is $4.34. Using an annual discount rate of 2.20%, the net present value of using an LED bulb instead of a CFL bulb is $4.78 (answer to Question 1). The internal rate of return from replacing the CFL bulb with an LED bulb is 5.51% (answer to Question 2). Lisa should purchase the LED bulb (answer to Question 3) since it will increase her wealth by $4.78 (answer to Question 4). Another acceptable response to Question 4 would be for a student to point out that replacing the LED bulb with a CFL bulb generates a positive net present value.

Solution for Questions 5– 7:

If the energy cost per kWh is $0.13 instead of $0.11, the annual cost of the CFL bulb will equal 3 hours per day × 365 days× 0.001 × 20 watts × $0.13 = $2.847, or $2.85 when rounded to the nearest cent. The annual cost to run the LED bulb will equal 3 hours per day × 365 days× 0.001 × 13 watts × $0.13, which is $1.85055, or $1.85 when rounded to the nearest cent. An increase in the cost of energy increases the return earned by purchasing the LED bulb. The net present value increases from $4.78 to $7.55 (answer to question 5) and the internal rate of return increases from 5.51% to 7.21% (answer to question 6). By looking at how her NPV estimates change with changes in a single input, Lisa is conducting sensitivity analysis (answer to question 7).

Solution for Questions 8– 10:

If Lisa only uses the lightbulb in her kitchen 1.5 hours per day and if the cost of energy is $0.16 kWh, the annual cost of the CFL bulb will equal $1.752, or $1.75 when rounded. The annual cost of the LED bulb will be $1.1388, or $1.14 when rounded. One important adjustment that students often fail to make is to double the life of each bulb. If a CFL bulb lasts 11 years when used 3 hours per day, it should last 22 years if it is only used 1.5 hours per day. Likewise, the LED bulb should last for 44 years if it is only used for 1.5 hours per day. Since the LED bulb saves $0.61 in annual costs in this scenario, the cash flow for years 1-21 and 23-44 would be

$0.61. There would be an additional cost savings in year 22 of $3.50 from not needed to purchase another CFL bulb, making the cash flow in year 22 $4.11. The net present value in this case is $6.73 (answer to question 8) and the internal rate of return is 4.72% (answer to question 9). By changing multiple inputs at once, Lisa is conducting scenario analysis (answer to question 10).

Solution for Question 11:

The decision to forgo a profitable capital budgeting project due to a lack of funds is known as capital rationing.

Solution for Questions 12– 14:

It is not appropriate for Lisa to discount the cash flows associated with replacing the CFL bulb with an LED bulb at the risk-free rate of return (answer to Question 12) because the cash savings that Lisa will realize from using an LED bulb are not known with certainty (answer to Question 13). Unlike traditional capital budgeting projects where the profitability is determined by sales volume and per-unit sales price, Questions 1 through 10 illustrated the profitability of replacing a CFL bulb with an LED bulb is determined by the amount of hours the bulbs will be used and energy costs. Spending the additional $12.50 on an LED bulb instead of a CFL bulb will prove to be a mistake if there is a drastic decline in energy prices. Thus, the primary risk that Lisa faces when deciding to replace her CFL bulb with an LED bulb is forecasting risk (answer to Question 14).

Solution for Questions 15 and 16:

There are several non-financial issues that Lisa should consider when deciding to replace the CFL bulb with an LED bulb. The most obvious is the positive impact that the LED bulbs will have on the environment because they save energy. Another non-financial issue is safety. Unlike CFL bulbs, LED bulbs do not contain mercury, which is a toxic substance. This issue would be of significant importance to families with small children who may worry about harm to their children resulting from mercury released in their home as the result of a broken CFL bulb. Thus, two major non-financial issues for Lisa to consider would be the positive impact the LED bulbs would have on the environment and added safety of the LED bulb (answer to Question 15). The impacts that an investment project has on other areas are known as externalities (answer to Question 16).

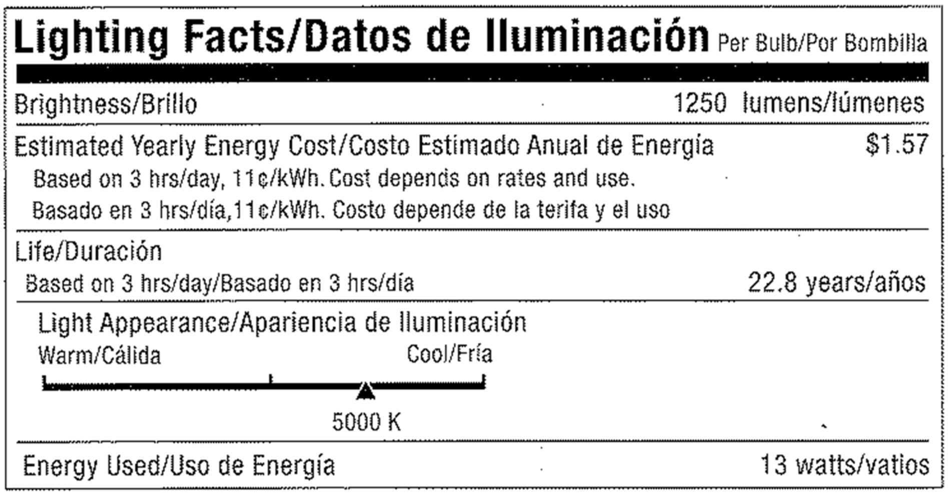
Solution for Questions 17– 19:

It is not rational for Lisa to make her decision based on the time and effort she spent analyzing the purchase of the LED bulb (answer to Question 17) because she cannot recover the time and effort that she has already spent (answer to Question 18). The time that Lisa spent analyzing the cash flows of this project is an example of a sunk cost (answer to Question 19).

Figure 1: Lighting Facts

Panel A presents the lighting facts for the LED light bulb and the lighting facts for the CFL light bulb are presented in Panel B.

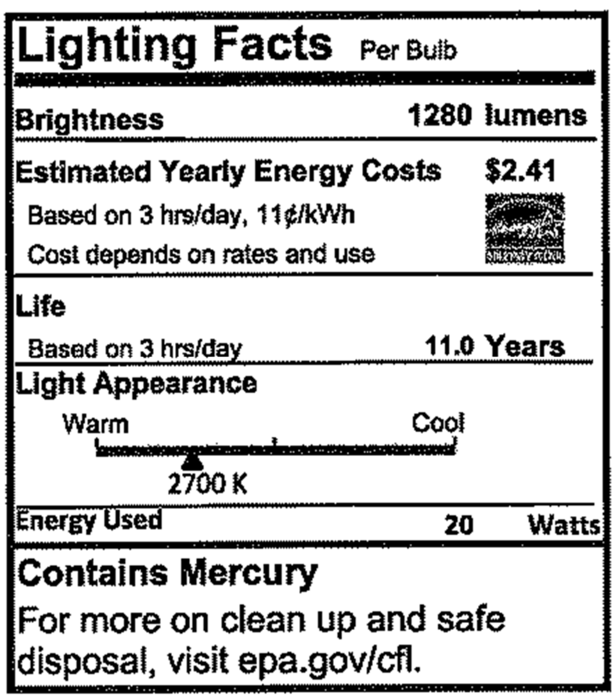
Panel A:



Lighting Facts/Datos de Iluminación Per Bulb/Por Bombilla

Brightness/Brillo	1250 lumens/lúmenes
Estimated Yearly Energy Cost/Costo Estimado Anual de Energía Based on 3 hrs/day, 11¢/kWh. Cost depends on rates and use. Basado en 3 hrs/día,11¢/kWh. Costo depende de la terifa y el uso	$1.57
Life/Duración Based on 3 hrs/day/Basado en 3 hrs/día	22.8 years/años
Light Appearance/Apariencia de Iluminación Warm/Cálida Cool/Fría 5000 K	
Energy Used/Uso de Energía	13 watts/vatios

Panel B:



Lighting Facts Per Bulb

Brightness	1280 lumens
Estimated Yearly Energy Costs Based on 3 hrs/day, 11¢/kWh Cost depends on rates and use	$2.41
Life Based on 3 hrs/day	11.0 Years
Light Appearance Warm Cool 2700 K	
Energy Used	20 Watts

Contains Mercury
For more on clean up and safe disposal, visit epa.gov/cfl.

REFERENCES

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