# Course on Innovation and Entrepreneurship: Light Bulb Life Extender Project

Raj L. Desai
The University of Texas of the Permian Basin
desai_r@utpb.edu

M. David Papendick
Cape Girardeau Career and Technology Center
papendickd@cape.k12.mo.us

## Abstract

The best way to equip students with the skills to survive and thrive in a global economy is to teach innovation and entrepreneurship. Students can develop the skills to identify new business opportunities and develop the tools to capitalize on these observations.

The main objective of this project was to research available literature on energy rectification in prolonging the life of normal incandescent light bulbs and to determine the need and/or desire among consumers for such a device. We utilized an interest survey to determine the demand for such a product. Results of the interest survey were analyzed and, upon demand, a light bulb life extender was designed. A prototype was developed and tested to ensure its safe and proper working condition for energy rectification in prolonging the life of normal incandescent light bulbs.

## Introduction

Innovation is the exploitation of change as an opportunity for a business or service. Innovation can be taught and learned [1]. On the average about sixty percent of all jobs in the U.S. are generated by firms with twenty or fewer employees. Large firms with over five hundred employees generate less than fifteen percent of all new jobs [2]. Students can also work for large companies as intrapreneurs within the large company, but must see small business as a viable option. The Engineering Design/Analysis course at the University of Nevada at Reno provides an example of what one course in entrepreneurship can accomplish [3]. Student teams work during one semester to design and build an electronic device of some sort. Several of the designs were turned into real products that were sold to existing companies or formed the basis for new startups. Engineering students have to learn to engineer in a way that is ethical, socially conscious, environmentally sound, and globally aware [4]. Engineering education must make active learning the predominant engineering student learning mode [5].

One instance of product innovation is the use of energy rectification in prolonging the life of normal incandescent light bulbs. The original light bulb functions much like light bulbs created in the early 1900's; they use tungsten filaments energized in a vacuum to produce light. Much to

the interest of the consumer, modern incandescent light bulbs also have one other important similarity to bulbs created early last century in that they can all work on either alternating or direct current. The use of direct current over alternating has many beneficial factors for the light bulb. The most important of these factors is the reduced heat caused by direct current usage. This reduction of heat increases the life of the bulb making already bought bulbs and bulbs which will be purchased in the future more cost effective for the consumer. What has not been tried is the use of fully rectified direct current as an energy source for incandescent light bulbs.

**The Concept**

Students can develop entrepreneurial skills by working in small teams to generate, evaluate, develop, and market their innovation. Faculty members should be encouraged to participate as student team mentors. At the beginning of the semester students in the innovation course will generate ideas for a large number of potential products. The product ideas will then be presented to the class and their peers will rate the ideas based on various factors given by the faculty. The product has to be prototyped by the end of the semester, so it has to be a project that is doable by the end of the semester. The project has to be at the skill level of the students. Students can imagine great projects, but they have to be able to make a prototype. The project cannot be too expensive, as it has to fit the budget of the school. Several other criteria can be added, depending on the limitations of the school. Students will then form teams based on product interest, compatibility, skills, and other factors. The teams will work together to generate marketable product concepts. Each student team will then perform a preliminary market analysis and patent search. Within a few weeks, the team must persuasively present their product concepts to their peers. As part of this presentation, each team must specify objectives to be met by the end of the semester. These objectives will be used as grading criteria for the project. The objective of every team and every project will be to create, prototype, and market a new product. Once the team has decided on a project concept and objectives, they will work on developing their product. This will involve product specific development using engineering and business concepts. Product protection and marketing will depend on the schools existing policies and procedures.

The majority of existing research for extending the life of incandescent light bulbs focuses on the use of half wave energy conversion to produce a situation of extended light bulb life. This leads a loss in luminosity and lessens the function of the bulb. Our goal was to produce a product that utilizes full wave rectification technology to extend bulb life without the loss of luminosity.

Our proposed study included:

1. Investigation of the marketability of a product, through a consumer survey, that extends the life of an incandescent light bulb by using direct current as an energy source.
2. Investigation of the feasibility of a system that changes the energy type used by an incandescent light bulb to direct current to extend the life of the bulb.

Our assumptions were:

1. All who took part in the survey process were legitimate in their answers.

2. The full-wave bridge rectifier is of such reliability that it can be used multiple times giving the impression that the device will “last a life time.”

Our delimitations were:

1. This study would not test light bulbs using a full-wave rectified power source to failure.
2. This study would establish that incandescent light bulbs using full-wave rectified direct current outlast the industry standard of 1,000 hours for the said bulb type.

Definition of terms [6]:

1. Rectification: to make (an alternating current) unidirectional
2. Rectifier: a device for converting alternating current into direct current
3. Direct current: an electric current flowing in one direction only and substantially constant in value - abbreviation *DC*
4. Alternating current: an electric current that reverses its direction at regularly recurring intervals -- abbreviation *AC*

**Product Development**

The process of taking an idea from initial conception to market is called product development. It includes idea generation, market research, product evaluation and selection, design and development, product protection and commercialization [7].

Idea Generation

Idea generation refers to generation or identification of potentially marketable product ideas. Highly motivated enterprising students are an ideal source of potentially marketable, creative product concepts. Students will be motivated to pursue their ideas, especially when the potential for recognition exists. The opportunity to learn real business and engineering skills while working on one’s own idea should appeal to many students. Even if student’s concepts fail due to weak market analysis, existing products, or for any other reason, failure can often teach much more than success. The process most often used for idea generation is brainstorming [8]. This involves students who suggest anything that comes to their mind, and feed off one another’s ideas, and seeks to create a large list of potential products in an environment free of criticism. Students will then form teams based on product interests, personal relationships, skills, or other factors. These teams will then work together to generate potentially marketable product concepts. Surveys or interviews with potential customers could be useful in generating relevant product concepts. Students must also be taught to keep an accurate log book and document their work carefully to protect their intellectual property rights. Once the list of potential products is developed, each product or concept should be evaluated, considering student interest in the project, strengths and weaknesses of the concept, feasibility of execution, etc. By the end of this process each team should have a potentially workable project. Once this process has been completed, the student teams can begin their market and product research, preparation of prototype, and preparing to present and defend their ideas before their peers.

The first light bulbs were invented using direct current as its main energy source [9]. These bulbs used energized carbon filaments to produce light inside a controlled vacuum. This type of light bulb was very inefficient and costly for production. It was only until the discovery of ductile tungsten did the light bulb become a viable instrument for light production [10]. The first bulbs that utilized tungsten filaments were produced by General Electric in 1907. Tungsten was found to be a good conductor of electricity while also having a high melting point and low evaporation rate which helped the filament withstand the heat created by light production. Later, inert gasses were used to reduce filament evaporation by transporting heat away from the filament and it was discovered that winding the filament helped reduce convective heat loss. This was all necessary because direct current had not become the energy of choice, alternating current had, and alternating current produces more heat in an incandescent light bulb than direct current resulting in faster filament loss [10]. The main reason current incandescent light bulbs use alternating current is its availability; even though direct current can still be utilized by an incandescent light bulb to produce light. Currently, many organizations produce products that utilize this principle for the conservation of light bulbs by the consumers who own their product. The only problem is that the type of energy conversion used by the organizations is not fully rectified. They use what is referred as a half wave rectification to reduce heat and lengthen the life of the bulb they are trying to protect [11]. This type of system reduces the luminosity of the bulb which makes it less functional even though the life-span of the bulb is lengthened a reported 27% to 93% [12].

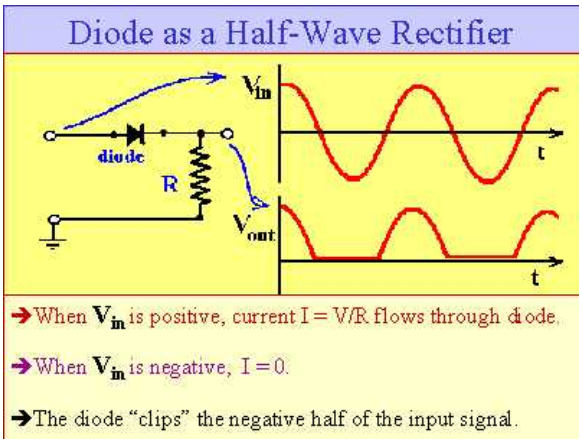


Figure 1: Half-Wave Rectifier

Energy rectification from alternating current to direct current is relatively simple. Through the use of a half wave or full wave rectifier diode alternating current comes into the system and direct current comes out [13]. Ron Stoner [14] displays these processes in Figures 1 and 2 from his physics PowerPoint lecture of the winter 1999. What has not been done is the use of full rectification of alternating current to produce a light bulb that still has the same luminosity of its alternating counterpart but a reduced heat production extending the life of the bulb.

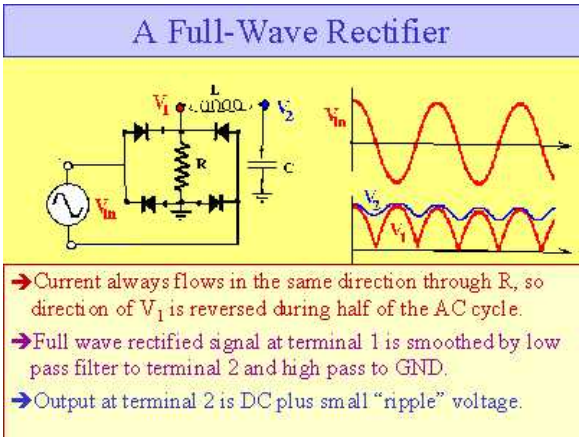


Figure 2: Full-Wave Rectifier

Market Research

During this phase students will perform searches to make sure they are not duplicating products already on the market. They should also consider demographic factors, identify competing products, establish timelines, and get a better estimate of the resources needed to complete their project.

Currently all efforts to provide rectified power for incandescent light bulbs are based on half wave rectification of alternating current to direct current. Our objective is to provide research on the viability of a product utilizing full wave technology in the rectification of power for said systems of light production. This is to be conducted through testing of a prototype system and a marketability survey of potential consumers for a product using said technology.

Our market research would:

1. Through a consumer survey, investigate the marketability of a product that extends the life of an incandescent light bulb by using direct current as an energy source.

2. Through performance testing, establish that an incandescent lighting system that uses a fully rectified energy source can surpass industry standards set for current lighting schemes using alternating current.

The survey used in this study consisted of various questions designed to retrieve feedback from possible consumers about the marketability of our product. The survey also collected information about these consumers and is designed to help the researchers forecast possible retail pricing and target populations. The survey used in this study and the results are displayed in Appendix A.

## Product Evaluation and Selection

Once potentially feasible ideas have been generated and market analysis has been performed student teams must present their concepts to their peers. Their peers will evaluate their concepts according to some established criteria. The evaluation criteria should include consideration of the product such as manufacturability, manufacturing costs, raw material availability, size, shape, material, color, price, projected sales volume, profitability, market strategy, adaptability to customer needs, and estimated cost of marketing. External factors to consider are market size, potential customers, competition, and demand. Internal factors include resources available, financial, equipment, time, and fit to program. This step is a filtering process in which only the ideas with greatest potential are allowed to proceed.

The data provided by the research showed the researchers that a product meeting the designed criteria is viable and marketable. The product is able to meet the criteria of extending the life of a normal incandescent light bulb. The research also shows that these attributes are in relatively high demand by the consumer. The product marketability survey was designed to identify the demographic segment most likely to purchase product that extends the life of an incandescent light bulb by using direct current as an energy source. This survey was also designed to allow the potential consumer to target the possible retail price of the product. The product marketability survey of potential consumers revealed that married individuals and females would be the ideal target demographic for a product that extends the life of an incandescent light bulb by using direct current as an energy source. Both of these groups were not only more inclined to purchase such a product, but were also more willing to purchased said product for a larger retail price.

## Product Design and Development

The details related to the design and development of a particular product depends on the nature of the product. Students should develop a timeline to guide the development of the product against which the team can be evaluated and graded at the end of the semester. This will also satisfy ABET (Accreditation Board for Engineering and Technology) Criteria 2000 [15]. Developing product prototypes will require the use of discretionary funds to cover the cost of materials, parts, and equipment usage.

The design for this experiment is that of a test of longevity of our rectification system verses the industry standard, for the utilized light bulb [16]. This test against time will show that our system allows a normal incandescent light bulb to outlast the industry standard and due to the time constraints of time allow the researchers to assume that the system increases bulb life. The tested bulb will be energized by a fully rectified system and not turned on or off until either the industry standard has been surpassed or the bulb life has expired. Figure 3 shows the prototype mould. Figure 4 shows the prototype components, and Figure 5 shows the final prototype. The product testing, shown in Figure 6, concluded that the system we implemented met our expectations. The light bulb used, which was rated at 1000 hours, surpassed the industry standard utilizing full wave rectification. The system succeeded in lengthening the life of the tested light bulb past its expected life span. The light bulb used was not tested to failure so

generalizations could not be established about how much our system lengthened the life of the light bulb only that it had lengthened it past the industry standard.

Figure 3: Prototype Mould

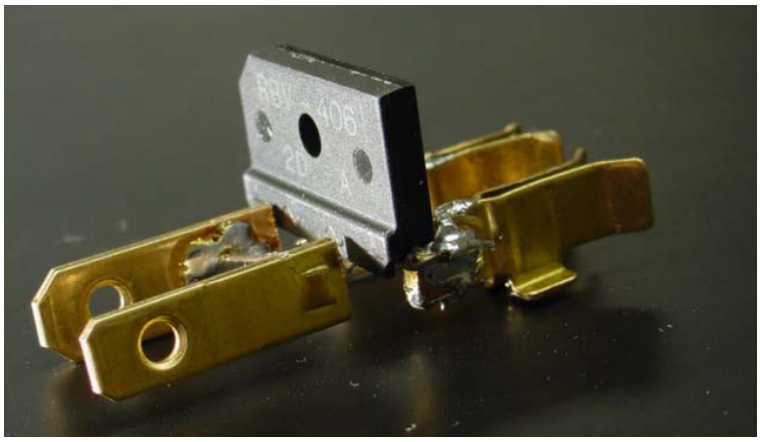

Figure 4: Prototype Components

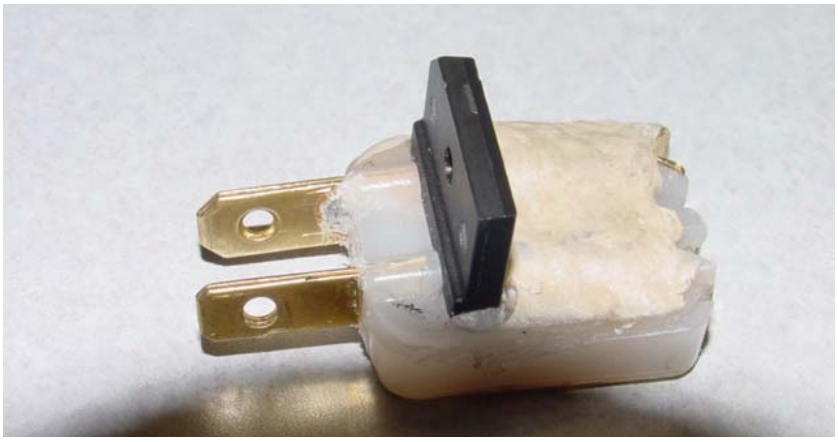

Figure 5: Final Prototype

Figure 6: Product Testing

Product Protection

Protection of products and intellectual properties by patenting or copywriting of new products are essential for long term survival and growth. However securing a patent can take up to two years and cost up to $10,000 in legal fees. Intellectual property policy protects the rights of all co-inventors. All participants must keep careful records of their activities in the form of engineering log books. Our product could easily be duplicated and we did not see the advantage of patenting the product.

Commercialization

Once products have been conceived, selected, developed and protected, they must be successfully commercialized. We are looking into commercialization options.

**Evaluation**

As each of the above steps is accomplished, every team should submit a brief informative report summarizing their activities for the current step, as well as laying out the goals for the next step. The report should be a flexible document, varying greatly from team to team, because it ultimately depends on the product. The key element in each report must be a summary of the work done to complete each step, broken down by team member, and a brief explanation of work to be done in the coming step. A formal presentation must be done at the end of the semester to develop their oral communication skills. Each team must also submit a final report outlining the development of their product and ideas for future development of the product. Another component of the final work is the product prototype. At the end of the semester, all groups should submit peer evaluations. This will allow students to comment on the behavior, contribution, and people skills of their teammates.

The evaluation of our research leads us to two major assumptions. The first assumption is that a product enlisting fully rectified energy in light production by an incandescent light bulb is marketable. Our market research shows that most individuals questioned, felt that this product is viable and necessary to their lifestyle. This shows that individuals would be interested in a product utilizing energy rectification in light production.

Secondly, an assumption can be made that our system of energy rectification in light production by an incandescent light bulb can out last industry standards for the same bulb that uses alternating current. Our testing shows that a system using full rectification along with an incandescent light bulb can help said bulb expand its life span. This can be inferred to our research which states that this type of system can increase life span by up to 93%. Further research is needed to validate these findings by our initial research shows that this idea is promising.

Other possible products brought up by this research involve this system being utilized in a wall mount switch for in home wiring, a breaker for commercial use to be installed in the electrical panel, and building the system within an electrical lamp. These possible products were not researched within the study for marketability but could be viable applications of the researched technology.

## Conclusion

The project will satisfy most of the skills of ABET essential summary of critical skills for engineering graduates in Criteria 2000 [16]. Motivated students from any department should be permitted to participate. Having a wide diversity of students participate broadens the perspective of students by exposing them to think differently. It develops development of communication and interpersonal skills.

Through our example, we have shown how a project can be taken from an idea to the design, prototype development and commercialization of the product. We hope the background information and example will be useful to other schools in development of a course in innovation and entrepreneurship.

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**Biographies**

RAJ DESAI is the Coordinator and founding faculty member of the new Industrial Technology Program and Engineering Transfer Program in the School of Business at the University of Texas of the Permian Basin in Odessa, Texas. His interests are in the areas of innovation, and new technologies.

DAVE PAPENDICK is the Director of the Electronic Program at the Cape Girardeau Career and Technology Center in Cape Girardeau, Missouri. His professional interest is in innovation.

## Appendix A
## Product Survey Results (n=25)

Please circle the letter that corresponds to your answer.

1) When was the last time someone in your household bought light bulbs?
   a) In the last month 36%
   b) One to two months 32%
   c) Two to six months 24%
   d) More than six months 8%

2) How often does someone in your household buy light bulbs?
   a) Once a month 8%
   b) Once every two months 28%
   c) Once every six months 44%
   d) Once a year 20%

3) What characteristic most influenced your purchase of light bulbs?
   a) Price 72%
   b) Brand name 4%
   c) Appearance 4%
   d) Advertising 4%
   e) Bulb life 16%

4) What price, per bulb, did you pay?
   a) Less than $1 48%
   b) $1.01 to $2 36%
   c) $2.01 to $5 16%
   d) More than $5 0%

5) Did you know the average bulb life for standard incandescent bulbs is only 750 hours?
   a) Yes 32%
   b) No 68%

6) Have you every purchased a “long life” or “extended life” bulb?
   a) Yes -- what was the cost 44% Avg cost - $5.89

b) No -- skip to question 8. 56%

7) How satisfied were you with the performance of the bulb when compared to the price?

| Dissatisfied | | Somewhat dissatisfied | | Neutral | | Somewhat satisfied | | Satisfied | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 18% | 9% | 9% | 0% | 18% | 36% | 9% | 0% | 0% | 0% |

8) Would you purchase a device that could extend the life of a light bulb by up to 10 times the normal 750 hours?
   a) Yes 84%
   b) No 16%

9) What would you be willing to spend on such a device?
   a) $1 to $5 56%
   b) $5 to $10 28%
   c) More than $10 16%

10) Would you buy more than one such device for your household?
   a) Yes – if yes, how many? 92% Avg # - 6 to 7 bulbs
   b) No – 8%

For demographic purposes, please answer the following:

Sex:

| female | male |
|---|---|
| 40% | 60% |

Marital status:

| single | married |
|---|---|
| 40% | 60% |

Age:

| <25 | 26 – 35 | 36 – 45 |
|---|---|---|
| 32% | 28% | 24% |

| 46 – 55 | 56 – 65 | >65 |
|---|---|---|
| 4% | 12% | 0% |

Household annual combined income:

| <$20,000 | $20,000 - $50,000 | |
|---|---|---|
| 20% | 36% | |

| $50,000 - $100,000 | >$100,000 | No answer – 4% |
|---|---|---|
| 32% | 8% | |