# Net Present Value Economic Analysis Model for Adoption of Photoperiod Manipulation in Lactating Cow Barns

by

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## Introduction

Photoperiod manipulation or long-day lighting (LDL), the practice of using a designed lighting system to artificially extend daylight hours to increase milk production in lactating dairy cows, started in the late 1970's and gained acceptance in the late 1990's. The increased light period decreases the secretion of melatonin and triggers the liver to increase production of insulin-like growth factor (IGF-1), which increases milk yield (Dahl, 2000). Supplementing lactating cows with 16 to 18 hours of light increases milk yield from 5 to 16% above cows exposed to less than 13.5 hours of light (Peters et al., 1978, 1981; Marcek and Swanson, 1984; Stanisiewski et al., 1985; Bilodeau et al., 1989; Phillips and Schofield, 1989). These increases are similar to increases realized from other management practices used in the dairy industry to increase milk production from lactating cows – for example, milking three times a day and the use of rbST. Recent research reported that extended light period, rbST, and three times a day milking were additive and produced 9.0 lbs per cow (Dahl, 2001).

Numerous trials have looked at the animal response, but few studies have examined the economic worth associated with LDL technology. The first to address the economic aspects of this technology were Dahl and his colleagues (Dahl 1999 & 2001). Their economic model and analysis determines the payback period for the technology. Their work is an application of the payback period method. This analysis method does not address the economic worth of the investment over its expected useful life, or time value of money considerations associated with investments in capital items (Casler, Anderson, and Aplin, 1993). The work described here adopts net present value (NPV), discounted cash flow, to examine the economic worth of this technology, avoiding the limitations of other measures of investment worth.

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The NPV method serves as the framework for an electronic spreadsheet that can be used by farm managers and their advisors for decision making. Differences in initial capital investment required due to design requirements, potential response in milk production, ration costs, and electricity prices among other key independent variables pointed to the need for a tool that could be applied using information specific to individual farms. In addition, the potential for variability in key variables on an individual farm pointed to the need for a model that could be readily used by the decision maker for the purposes of conducting sensitivity analyses. Sensitivity analysis measures the impact of changing one or more key input values about which there is uncertainty (Marshall, 1999). The purposes of this paper are as follows: 1) to describe the NPV electronic spreadsheet model developed to evaluate the adoption of LDL technology, and 2) to illustrate its application using farm data obtained from two commercial dairy farm businesses.

## Materials and Methods

*Net Present Value Method*

The NPV or discounted cash flow method is a preferred method for evaluating the economic worth of an investment, because the method considers the time value of the entire stream of net cash flows over the life of the investment (Casler, Anderson, and Aplin, 1993). NPV analysis is based on the concept that a dollar received today is preferred to a dollar received at some future date. The NPV of an investment is the sum of the present values for each year's net cash flow less the initial costs of the investment. Use of the NPV method requires estimating expected changes in net cash flow for each year of useful life using marginal approaches such as partial budgeting (Kay, 1981). Management should strongly consider implementing the investment to the farm business when the investment has a positive NPV. An NPV greater than zero implies an actual rate of return on the investment that is greater than the discount rate used, the minimum acceptable rate of return that must be earned by a capital expenditure. We use the weighted average cost of capital as the discount rate. The weighted average cost of capital considers the cost of capital funds from each source employed by the business, and the relative proportion of each source of capital given a firm's desired capital structure (Casler, Anderson, and Aplin, 1993).

*NPV Electronic Spreadsheet for Evaluating Long-Day Lighting*

An electronic spreadsheet incorporating NPV methods requires users to input a variety of data for the purpose of tailoring analyses to a farm. Users provide the initial capital investment required, type of system including numbers of fixtures by type, milk price, expected change in milk production per cow with implementation of LDL, cost of hauling, feed cost, and expected hours of use among others. The spreadsheet calculates the NPV associated with proposed investment in LDL technology based upon a partial budget analysis that calculates changes in cash flows. A free copy of this electronic spreadsheet can be downloaded at http://www.cce.cornell.edu/programs/nw-ny-dairy-fieldcrops/RobertasDairyUpdate.htm.

The NPV model assumes that added cash inflows and outflows are the same for each year of the ten-year expected economic life of the lighting system except for year one when added outflows include the initial capital cost associated with the investment. In addition, fixture ballasts use energy in amounts that are approximately 5 to 15 percent of the energy used by the bulbs alone. Therefore, since watts per bulb are the input in the model, energy use for the entire fixture, bulbs and ballasts included, equals the energy use for the bulbs plus 10 percent.

The partial budget analysis within the electronic spreadsheet considers added cash inflows and added cash outflows associated with the adoption of LDL technology. Based upon current knowledge of the technology, the analysis does not consider reduced cash inflows and reduced cash outflows, although the capacity is present to do so. Added cash inflows from additional milk receipts due to expected increases in milk production per cow characterize the analysis. The analysis considers added cash outflows due to the initial capital cost of the system (including installation), feed costs, promotion cost, hauling costs, milk handling costs (cooling and labor on farm), electricity cost, and maintenance costs associated with the lighting system.

*Farm Data*

To demonstrate the NPV model, owners of two commercial dairy farm businesses where the LDL technology has been adopted shared milk response, cost and other data with us. (For further information see ASAE Paper #024205, Lighting System Considerations and Design Options for Application of Photoperiod Manipulation Management for Freestall and Tie Stall Barns). Table 1 highlights the variables used in the NPV spreadsheet model and individual input values from the two farms. The total system costs including installation for Farm 1, an 80-cow tie stall facility, and Farm 2, a 210-cow freestall facility, were $3,559.80 and $14,878.00 respectively.

**Table 1. Variables Used in the NPV Model With Values.**

| Variable Costs | Farm 1 Data | Farm 2 Data |
|---|---|---|
| Average Number of Lactating Cows | 80 | 210 |
| Months/Year of Supplemental Lighting | 12 | 12 |
| Milk Response (lbs per day per cow) | 5 | 5 |
| Milk Price per cwt | $12.81 | $13.01 |
| Cost of Hauling per cwt | $0.39 | $0.35 |
| Cost of Promotion per cwt | $0.15 | $0.15 |
| Ration Cost - $ per pound of feed | $0.055 | $0.0786 |
| Hours/day of Operation | 18 | 18 |
| Average Energy Cost - $ per kW-hr | $0.082 | $0.115 |
| Weighted Average Cost of Capital, discount rate | 7.0% | 7.0% |

## Results and Discussion

Net present values for the ten-year expected economic life of the LDL technology for Farm 1 and Farm 2 were $56,990 and $28,915, respectively. Applying the decision-making criterion described above suggests that investment in the LDL technology would be attractive to owners of both dairy farm businesses given the initial data and assumptions.

Due to expected greater variability in milk response and electricity costs per unit, a sensitivity analyses was conducted using the model. Results of sensitivity analyses for Farm 1, (reported in Table 2) suggest that LDL becomes an undesirable investment for that farm only when expected milk response decreases to one pound per cow per day and electricity costs rise to $0.12 per kW-hr or higher.

Results from sensitivity analyses for Farm 2 (reported in Table 3) suggest that LDL becomes an undesirable investment over a wider range of milk response and electricity costs per unit when compared to Farm 1. For example, at current electricity costs per unit of $0.115 per kW-hr, Farm 2 must make about four pounds of milk per cow per day for the investment to be desirable. If milk response falls to 3 pounds per cow per day, then NPV is negative and the investment is undesirable given the discount rate and other inputs.

Differences in the values of key variables between the two farms help to explain relative differences in results between each. Farms differed with respect to milk price, hauling costs, ration costs, and energy costs. Farm 2 had higher values for three of these four variables when compared to Farm 1. At initial values, investment in LDL technology produced a NPV of $56,990 or $712 per cow for Farm 1. In contrast, although Farm 2 earned approximately $0.20 more per hundredweight of milk, adoption of the technology resulted in a net present value of $28,915 or $138 per cow due to the effects of other variables. Results highlight the sensitivity of the decision to individual farm values and demonstrate the importance of farm specific evaluation of this technology using the NPV analysis of the electronic spreadsheet described herein.

**Table 2. Farm 1 Sensitivity Analyses for Net Present Values by Milk Response and Electricity Costs.**

| | Energy Cost - $ per kW-hr | | | | | |
|---|---|---|---|---|---|---|
| Milk (lbs) | 0.04 | 0.06 | 0.08 | 0.10 | 0.12 | 0.14 |
| 1 | $3,818 | $2,691 | $1,564 | $437 | ($689) | ($1,816) |
| 2 | $17,703 | $16,576 | $15,449 | $14,322 | $13,195 | $12,068 |
| 3 | $31,587 | $30,460 | $29,334 | $28,207 | $27,080 | $25,953 |
| 4 | $45,472 | $44,345 | $43,218 | $42,091 | $40,964 | $39,838 |
| 5 | $59,357 | $58,230 | $57,103 | $55,976 | $54,849 | $53,722 |

**Table 3. Farm 2 Sensitivity Analyses for Net Present Values by Milk Response and Electricity Costs.**

| | Energy Cost - $ per kW per hour | | | | | |
|---|---|---|---|---|---|---|
| Milk (lbs) | 0.04 | 0.06 | 0.08 | 0.10 | 0.12 | 0.14 |
| 1 | ($32,542) | ($42,856) | ($53,170) | ($63,485) | ($73,799) | ($84,114) |
| 2 | ($7,508) | ($17,822) | ($28,137) | ($38,451) | ($48,765) | ($59,080) |
| 3 | $17,526 | $7,212 | ($3,103) | ($13,417) | ($23,732) | ($34,046) |
| 4 | $42,560 | $32,246 | $21,931 | $11,617 | $1,302 | ($9,012) |
| 5 | $67,594 | $57,280 | $46,965 | $36,651 | $26,336 | $16,022 |

## Conclusion

Farm business managers should evaluate the adoption of new technologies that require capital investment using appropriate methods of investment analysis. The NPV electronic spreadsheet for evaluating photoperiod manipulation enhances a manager's ability to evaluate the economic worth of the technology on an individual farm basis. Each farm business can expect differences with respect to added cash inflows and reduced cash outflows. The sensitivity of the model to variables differed between farms, but key variables that influenced the model the greatest included milk response, the cost of energy, and additional ration costs.

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**Appendix or Nomenclature**

NPV = Net Present Value

LDL = Long-day Lighting