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Economic Analysis of Fishing Industry Energy Conservation Technology

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ECONOMIC ANALYSIS OF FISHING INDUSTRY

ENERGY CONSERVATION TECHNOLOGY

by

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ABSTRACT

The rising cost of energy has focused attention on the application of energy conservation alternatives for commercial fishing vessels. Many fishing vessels are being refitted with a variety of devices that will reduce energy consumption. However, it is not always intuitively clear whether the lifetime energy savings of the new equipment will be greater than the current values of the sum of the initial cost and costs of operation. In an era when the cost of operating a fishing vessel is increasing and profits are declining, it is important that any decision to purchase an energy device does not further exasperate the problem.

This paper familiarizes the reader with a method of cost analysis that can be applied to energy conserving devices. Life-cycle cost analysis is an effective economic tool for the evaluation of an investment where the cost of energy, as well as other factors, is considered over the life of the investment. Formulas are given for all analyses.

The life-cycle tools are applied to the economics of a representative fishing vessel to evaluate two energy saving devices on a pretax and after-tax basis. Both the annual fuel consumption and the energy conservation rate are varied to evaluate the potential impact they will have on life-cycle costs.

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INTRODUCTION

Until the late 1800's, many fishermen used the wind to power their vessels. With the advancement of internal combustion engine technology in the early 20th century, the fishing industry became more productive and total life-cycle costs of engine power proved less expensive than sail power. As long as the price of petroleum remained low relative to other forms of energy, diesel oil continued to be the primary source of fuel for fishing operations around the world.

Many decisions in vessel design were based on the comparatively low price of diesel oil. For example, when fishermen specified their vessel requirements, they were more concerned about hold capacity, thrust, vessel size, and cost of construction than they were about the amount of fuel the vessel would burn. Larger engines replaced smaller engines so that a larger net could be pulled. Hulls were built with less attention to efficiency than to construction cost. Fuel costs simply were not important enough for the fisherman or designer to be concerned about a little extra drag. Consequently, the cost of constructing a vessel with a more efficient hull did not compare to the amount saved in fuel cost. Recently, however, the high cost of fuel has necessitated application of conservation technology in order to control operating costs.

This paper is intended to familiarize the reader with life-cycle analysis and to demonstrate the application of these tools on a representative fishing vessel.

IMPACT OF RISING FUEL PRICES

During the past decade there have been some dramatic changes in the economic situation of the domestic fisheries. There has been an upward trend in the price of fuel, fishing gear, and the general cost of fishing operations. An example of the impact of these changes is the Gulf of Mexico domestic shrimp fishery, a highly energy-intensive fishery. Figure 1 shows how fuel prices increased from $0.13 cents per gallon in 1971 to $0.95 per gallon in 1980 (Brown and Yanuck 19801, a 630% change; While ex-vessel prices have similarly changed; the net impact has been a serious challenge to economic survival of the commercial fishery.

ECONOMIC SURVIVAL

There are two fundamental approaches fishermen can follow to survive economically in an era of escalating fuel prices: increase revenues or decrease costs. Revenues are increased either by landing more product or by charging a higher price for the product. In most fisheries, however, the fisherman has little control of the ex-vessel price. If this is the case, then extra revenue may only come about through efforts to increase landings. If the extra landings are the result of additional fishing effort, then fishing costs will be increased. As long as the increased costs associated with the. additional level of effort are less than or equal to the extra revenue resulting from the greater landings, then the fisherman will increase profits. If, however, the additional costs are greater than the extra revenues, profits will be reduced.

Costs may be divided into two categories: fixed and variable. Over the time horizon for a fishing vessel most fixed costs (mortgage payments for example) remain constant. There is not much that can be done to reduce fixed costs. Additionally, since fixed costs in fishing are not a major proportion of total cost, it is not productive to concentrate in this area.

Variable costs may be reduced in a variety of ways: increasing the productivity of an input, reducing the price of the input, or changing the mix of inputs. Since the determination of input prices is usually defined by market forces where individual participation is small, this is not a viable alternative.

The relationship of physical (capital) inputs on a fishing vessel are relatively fixed; hence, this is also an unlikely candidate for change. Increasing the productivity of an input is the best alternative for reducing costs aboard commercial fishing vessels.

Since fuel has become one of the major contributors of total variable cost, significant cost reductions may result by concentrating on energy conservation. This appears to be the approach that many fishermen are following. However, not all energy conservation alternatives will ultimately result in reduced costs. Without careful consideration and analysis of the relevant economic factors, the fisherman could be in a situation where total costs increase rather than decrease.

ENERGY CONSERVATION INVESTMENT DECISION

If an energy conserving alternative requires an expenditure of capital and if there are significant post-purchase costs, then the decision maker needs some economic tools to organize and analyze the information. Because energy conservation investment decisions are not easily revoked, it is important to determine whether the alternative will pay for itself in reduced energy costs before the dollars are committed. Making a cost-reducing decision in an information-poor environment could have a significant profit reducing impact on the fishing business.

The objective of the energy conservation decision making process is to determine if an energy conserving investment is the lowest cost alternative for a particular task. This objective is achieved by applying a set of economic analytical techniques called life-cycle analysis. These techniques provide information about the cost of energy investments and include interest on capital, inflation, energy costs, etc. It is a powerful tool to overcome the inadequacies of "gut feeling."

There are several life-cycle tools that can be used to evaluate investments in energy conservation. Life-cycle cost (LCC) analysis and the benefit cost ratio (BCR) consider both first costs and future costs and savings. A third tool, the discounted payback (DPB) method does not use the full life-cycle approach but is quite useful for determining how soon an investment will be repaid.

LIFE-CYCLE ANALYSIS

Concepts and Terms

There are several concepts used in life-cycle cost analysis which stand out in importance. The following sections contain brief explanations of the key concepts.

Economic Efficiency

The concept of economic efficiency in the application of energy conservation measures is not the same as technical or engineering efficiency. A particular type of energy conserving equipment may be more technically efficient than another, but this type of information does not indicate whether the cost of the investment will outweigh the savings in energy conservation.

Life-cycle costing is an economic efficiency analysis incorporating technical efficiency. It determines the amount that can be spent on energy conserving equipment such that life-time vessel costs are reduced.

Time Value of Money

Since energy conservation costs and benefits occur over differing time horizons, any direct comparison of cash flows occurring in different periods of time would lead to erroneous results. All cash flows must be placed on a time equivalent basis. This is accomplished by discounting future values to a common time period. Discounting not only provides a common basis of corn-. paring alternatives but accounts for the time value of capital (Tibrewala 1978).

The discount rate is the rate of interest used to convert those costs and benefits occurring at different times to a common time. The proper. discount rate to be used in analysis of a project is the opportunity rate. That is, choose the value that would be used on an alternative investment having a similar risk.

The higher the discount rate the smaller the present value of future cash flows (Marshall and Ruegg 1980). Those energy investments with payoff occurring sooner will be favored over investments having payoff in the future.

Inflation

During the last decade, the prices of most goods and services have shown a steady increase. Escalating fuel prices, in particular, have had a significant impact on fishing industry profits (Swartz and Griffin 1979). Any analysis which does not account for price escalation would be naive. As a' result, the discounting procedure discussed below includes an escalation factor to account for inflation.

Discounting Formula

The present value of recurring costs which grow at a steady annual rate is calculated by applying the following formula:

$$PV = A \; \frac{(l+e/l+i) \;\; [l-(l+e/l+i)]^{n}}{l - \; (l+e/l+i)} \qquad (1)$$

where A is the annual cash flow, n the number of years or periods, e the expected annual escalation or inflation rate, and i the discount rate. Implicit in this present value formula is the assumption that the cash flow, discount rate, and inflation rate are the same for each period. If this assumption seems unreasonable, then it may be necessary to calculate the present for each period or periods where the rate varies. Since these calculations are used for estimation purposes, the analyst could simply use an average rate for e and i.

If an energy project is financed, then there will be an interest expense incurred. If it is not financed, then there is an opportunity cost associated with the expenditure. In either case, however, the interest cost is accounted for in the discounting procedure. Additionally, the cost of money is included in the discounting procedure and should not be added as a separate project cost.

Income Tax Factors

Income taxes paid by a fisherman can have a significant impact on many decisions. The deduction of fuel expenses is a legitimate business expense which reduces the fisherman's tax bill. If a conservation investment produces a fuel savings, then the fuel expense deduction is reduced and the tax bill is increased. For this reason, an energy conserving investment could result in after-tax dollar savings that are less than the before-tax value of the fuel saved (Tibrewala 1978). On the other hand, a conservation investment will provide additional depreciation and investment credit deductions which tend to reduce the increased tax effect.

Tax deductible expenses provide annual savings in the form of tax deductions. If a fisherman's tax rate is 40%, then he would incur expenses at 60% ((100% - tax rate) x expense) of the value of the expense (Formula l).

Depreciation is not included as an expense in life-cycle analysis since it is part of the initial cost. If, however, it produces a tax benefit, it should be included. The formula used to calculate 'the tax benefit is:

$$\text{Tax Benefit} = \text{Firm's Tax Rate} \times \text{Annual Depreciation.} \qquad (2)$$

In the Analysis of Energy Conservation Alternatives section of this paper, it was assumed that the firm's tax rate was 40%, straight-line depreciation was used, and a 10% investment tax credit was taken the first year. Both before-tax and after-tax results are shown.

Computer Analysis

There are tables available to obtain the required discount factor in a life-cycle cost analysis. However, the use of microcomputers will improve the analysis because more variables are considered in less time.

ECONOMIC TOOLS

Life-Cycle Costing

Life-cycle costing (LCC) is the energy cost of an energy project together with the net purchase and installation cost (less salvage value) plus the following discounted costs: salvage value, maintenance, repair, replacement of major items, and any other costs associated with the investment. Since there are substantial post-purchase costs associated with most energy-reducing fishing vessel investments, an appropriately discounted LCC analysis will provide an accurate and realistic evaluation of the expected cost of an investment. The investment alternative that has the lowest life-cycle cost while still filling the fisherman's "needs" is the preferred investment.

LCC analysis is intended for nonrevenue producing projects (Marshall and Ruegg 1980). Since the objective of purchasing energy-conserving retrofit projects for fishing vessels is to reduce energy costs, it is assumed that landings, and hence revenues, will not have an impact on the project. It is recognized, however, that some investments (nozzles, for example) may be employed to increase 'thrust and thereby pull larger or more gear through the water. Increased effort should produce more landings and thereby increase revenue rather than reduce energy costs. Situations such as this require an alternate economic technique called cash flow or capital budgeting analysis.

The general formula for calculating the LCC of an energy-conserving investment is shown below:

$$LCC = P - S + M + R + F, \tag{3}$$

where P is the purchase and installation, cost, S the present value of the salvage value, M the present value of the maintenance and repair costs, R the present value of the replacement cost, and F the present value of total energy costs.

The LCC value is the total cost of ownership over the life span of the alternative. If this method is used for a simple accept/reject investment decision, then the LCC must be less with the investment than without it (Brown and Yanuck 1980). In general, the smaller the LCC the more desirable the investment. This value, however, can be misinterpreted. A more useful result is available by considering the, energy savings rather than the total energy cost.

Net Present Value

In order to determine the life-cycle gain or loss of an investment, the net present value (NPV) criteria is the discounted energy savings or benefits less the discounted costs. NPV is a measure of the amount by which an alternative's benefits exceed all costs, including the opportunity cost of capital. The larger the calculated NPV, the more desirable the investment.

The NPV is determined by the relationship:

$$NPV = E - (P - S + M + R), \tag{4}$$

where E is the present value of the annual energy savings:. Other values are the same as those in the LCC formula.

Benefit Cost Ratio

When different purpose projects competing for the same budget are being considered, then the preferred tool of analysis is the benefit cost ratio (BCR). The NPV method is not always satisfactory in the situation where two projects satisfy the payback limitation and provide equal net present value of savings but the cost of one project exceeds the other. In this situation, the ranking method of the BCR is sensitive to the problem.

The BCR is also a discounted cash flow that relates the present value of the savings to the present value of the investment as a ratio.' If a project produces a net gain, then the ratio is greater than one. For a given project in a given time, the higher the ratio the greater the return on investment.

The benefit cost ratio is determined by the following formula:

$$BCR = (E + M) / (P - S + R), \tag{5}$$

where E is the present value of the project's energy savings, M the present value of any maintenance savings (+) or additional costs (-), and the values of P, S, and R are as previously mentioned.

The greater the BCR for an energy-saving alternative, the more desirable the project will be. A high BCR is more desirable, not only because it is more profitable, but it can withstand unforeseen circumstances and errors in estimates of savings and costs.

Payback Analysis

The third tool, payback analysis, enables the decision maker to determine the length of time required for the net energy savings to pay back the initial cost. If the calculated payback is greater than the economic life of the investment, it should not be pursued.

A simple payback may be calculated by dividing the cost of the project by the net annual savings. The resulting value is the payback number of years (or periods). In the following analysis, however, the simple payback is expanded to allow for fuel price escalation, as well as the time value of money. The formula for discounted payback (DPB) is shown below:

$$DPB = \frac{\text{Log } [(C/E)(l-(l/(l+e)/l+i)) + 1]}{\text{Log } [(l+e)/(l+i)]} \qquad (6)$$

where e is the fuel price escalation rate, i the discount rate, P the cost of the project, and E the net annual savings.

While this method indicates the time necessary to recover capital, it ignores payments after the payback period. Therefore, it should not be used as a decision ranking criteria if there are any savings expected afterpayback is reached. The benefit-cost method is a much better analysis for this type of information. It is also assumed that all costs occur uniformly over time and that the annual savings E is a net figure representing any increased or decreased costs.

Since DPB is the amount of time that the investor will have to wait to recover his initial investment, it is also a measure of the investor's risk.

Sensitivity Analysis

The evaluation of fishing vessel energy conservation projects is only as good as the values used in formulating the analysis. Since some uncertainty exists in projecting costs, a technique called sensitivity analysis can be used to determine the responsiveness of LCC, BCR, or DPB to changes in key factors about which there is uncertainty.

ANALYSIS OF ENERGY CONSERVATION ALTERNATIVES

Application of Economic Tools

In order to illustrate the application of life-cycle tools of analysis in the fishing industry, a budget was developed for a representative vessel employing an energy-conserving retrofit. The objective is to demonstrate the application of life-cycle costing using two known energy-saving devices: a nozzle, a two-stage propeller, and a combination of the nozzle and the two-stage propeller. The analysis of these alternatives does not imply that external propulsion system technology is the only avenue for energy savings. They were selected because they are a popular approach to energy savings and because data' were available from actual operations. The reader should keep in mind that the economic analysis is not necessarily representative of any situation beyond the stated assumptions.

Representative Vessel

Since there are a great variety of vessel configurations, it was necessary to focus on a specific size and type of vessel. The vessel selected was a 68-ft (21-m) wood trawler equipped with a 365 hp diesel engine. The typical annual fuel consumption for vessels in shrimp fishing is 50,000 gallons; hence, this figure was used for all analyses. The fuel was assumed to cost $.l.lO/gallon, escalating at 8% annually. A discount rate of 16% was employed and the evaluation and depreciation periods were 10 years.

Kort Nozzle

A survey was conducted (by the author) of 14 Gulf of Mexico shrimp vessels using a 1.52-m (60-in) nozzle. It was found that the average initial parts and materials cost for the representative vessel was $10,983. The installation cost was $3,167. Salvage value for the nozzle after 10 years was estimated to be $6,400. The annual maintenance and repair was $30.

It is recognized that the energy-saving advantage of a nozzle appears to be greatest at lower (trawling) speeds. A nozzle increases drag at higher hull speed, which can result in a greater energy cost rather than a reduction. Recent research by Veal et al. (1982) indicates that 70% of the total fuel is consumed during fishing operations. In light of this finding, a reported 15% overall savings appears to be reasonable. Keep in mind, however, that it is not the intent of this paper to demonstrate the determination of technical efficiency. This value is assumed to be predetermined. Additionally, a variety of fuel-saving rates were analyzed.

Two-Stage Prop

The application of nozzles is only one method of reducing fuel consumption. In a survey of seven vessels using the two-stage propeller, it was found that the average purchase and installation cost of this device was $42,000. The salvage value at the end of the lo-year economic life was estimated at $10,000. The annual maintenance and repair was $200, with average reported fuel reduction of 27%.

Very little cost, technical information, or actual experience was obtainable regarding the combination of a nozzle and two-stage propeller. Therefore, it was assumed that the cost of the combination was simply the sum of all the costs associated with the individual alternatives. Technical efficiency was assumed to be 35%.

Both the nozzle and the two-stage propeller are reported to improve technical efficiency and reduce fuel consumption under most circumstances. As previously mentioned, however, technical efficiency does not provide much information to the decision maker about the economic efficiency of an investment; i.e., does the investment reduce costs and increase profits? This will be shown in the next section.

Results

Under the assumptions stated above, the results of both a before-tax and after-tax analysis are shown in Table 1. The total life-cycle cost for the nozzle is over $335,000 ($202,000 after taxes), whereas the two-stage propeller and the combination have a life-cycle cost of $318,000 and $300,000, respectively. The lower life-cycle costs for the two-stage propeller or the combination nozzle and two-stage propeller are the results of greater fuel savings, as well as a larger investment tax credit and annual depreciation allowance.

The present value of the net savings over the life of the investment for the nozzle is about $44,000 ($25,000 after tax). The two-stage propeller results in a $61,000 savings and the combination provides a $78,000 net cost reduction.

If a fisherman wanted to know which investment produced the greatest return per dollar spent (highest rate of profit), then, according to the BCR criteria for this analysis, the nozzle is the first choice followed by the two-stage propeller. A before-tax return of $4.46 ($2.97 after tax) indicates, that the nozzle would return nearly $4.50 ($3.00 after tax) for every dollar invested. Note that all BCR's are greater than one, meaning that all investments would produce a positive return.

Table 1.--Life-cycle costs for three energy conserving investments.

		Nozzle	Two stage	Both
LCC	Total cost for life cycle	335,183	318,006	300,602
	After tax	202,433	192,828	183,708
NPV	Energy Savings for 10 years	43,943	61,120	78,524
	After tax-	25,043	34,648	43,768
BCR	Dollar return per dollar invested	4.46	2.54	2.50
	After tax	2.97	1.87	1.83
DPB	Years to pay back - Simple	1.72	2.83	2.92
	- Discounted	1.90	3.29	3.41

Less than 2 years are required to pay back the nozzle whether on a simple or discounted basis. That is, the net savings will pay for the initial cost of the nozzle in about 2 years. The two-stage propeller requires over 3 years to pay off, and the combination nozzle and two-stage propeller will take about 3 l/2 years.

Higher Fuel Consumption

A fisherman may want to know if net savings are significantly greater when more fuel is consumed. Table 2 shows the results when all factors were held constant except fuel consumption. If 80,000 gallons are burned rather than 50,000,- then the net present value of the energy savings is 1 l/2 times greater for the combination investment. The returns per dollar invested for the two-stage propeller and the combination indicate a similar increase. This analysis indicates that, as more fuel is consumed, the' fisherman will derive increased benefits with any one of the conservation investments. This is necessarily so because costs are not effective and benefits are proportional to initial fuel consumption.

Lower Fuel Consumption

A reduced fuel consumption has a significantly different effect. If the same representative vessel consumes 20,000 gallons of fuel annually (See Table 31, then it appears that the only energy conservation investment that should be considered in-this situation is the nozzle. Even though investment in the nozzle produces a BCR greater than one, it has a low NPV ($4,570 after tax) and a lengthy payback period. If the cost estimates for this alternative are inaccurate, the nozzle could be a risky investment.

The two-stage propeller and the combination two-stage propeller and nozzle are clearly not acceptable investments. In both cases, the fisherman would increase rather than reduce annual costs. The two-stage propeller, for example,

Table 2.--Life cycle costs when annual fuel consumption is 80,000 gallons.

		Nozzle	Two stage	Both
LCC	Total cost for life Cycle	528,537	484,063	448,461
	After tax	318,445	292,462	272,423
NPV	Energy Savings for 10 years	78,064	122,538	158,141
	After tax	45,516	71,499	91,537
BCR	Dollar return per dollar invested	7.15	4.08	4.02
	After tax	4.58	2.80	2.75
DPB	Years to pay back - Simple	1.07	1.77	1.82
	- Discounted	1.16	1.96	2.03

Table 3.--Life cycle costs when annual fuel consumption is 20,000 gallons.

		Nozzle	Two stage	Both
LCC	Total cost for life Cycle	141,829	151,949	152,743
	After tax	86,420	93,193	94,992
NPV	Energy Savings,for 10 years	9,822	-298	-1,092
	After tax	4,570	-2,203	-4,002
BCR	Dollar return per dollar- invested	1.77	0.99	0.98
	After tax	1.36	0.94	0.92
DPB	Years to pay back - Simple	4.29	7.07	7.29
	- Discounted	5.35	10.38	10.87

would cost the fisherman $2,200 over its lo-year life. The energy and/or tax savings do not equal the cost of the investment over the period of analysis.

The previous analyses illustrate a situation where the energy conserving alternatives are technically efficient but only one is economically efficient. Without this type of information, a fisherman employing the two-stage propeller or the combination two-stage propeller and nozzle could find that, while conserving energy, profits have been reduced and costs increased.

Lower Fuel Conservation Rates

In all cases shown above, the assumed energy savings for the nozzle was 15%, 28% for the two-stage propeller, and 35% for the combination. These figures may be somewhat optimistic. A less optimistic view assumes that the fuel savings are 10% for the nozzle, 10% for the two-stage propeller, and 15% for the combination. The result is shown in Table 4.

While the nozzle is still an attractive investment at a 10% fuel conservation rate, the two-stage propeller clearly would not produce any economic savings. Since the BCR is less than one, it is not a profitable investment. If the fisherman had a 30% tax rate rather than the assumed 40% rate, then the combination would produce a $2,700 net savings ($783 after tax).

Minimum Fuel Conservation Rate

Much of this information can be summarized by determining the fuel savings rate which would produce a zero NPV. These values are shown in Table 5.

The fuel savings rate for the nozzle must be at least 3.4% (4% after tax) for the investment's benefits to exceed costs. Similarly, the two-stage propeller must return at least an 11% fuel savings while the combination investment should return an 18% fuel savings. If any of the investments returned less than the calculated minimums, then the investment would increase costs and reduce profits.

Table 4.--Life cycle costs at lower energy conservation rates.

		Nozzle	Two stage	Both
LCC	Total cost for life cycle	354,139	382,457	376,427
	After tax	213,806	231,498	229,203
NPV	Energy Savings for 10 years	24,987	-3,331	2,699
	After tax	13,669	-4,023	-1,728
BCR	Dollar return per dollar invested	2.97	0.92	1.05
	After tax	2.08	0.90	0.97
DPB	Years to pay back - Simple	2.57	7.64	6.81
	- Discounted	2.96	11.67	9.82

Table 5.--Minimum fuel saving rate (%) for investment to be acceptable.

	Nozzle	Two stage	Both
	----------------------	%	----------------------
Before tax	3.4	10.9	14.3
After 'tax	4.0	11.8	15.8

Sensitivity Analysis

It may be apparent from the preceding analysis that some factors have a greater impact than others. Table 6 reveals the impact of a 10% increase in four different factors on the after-tax NPV. For example, a 10% increase in the fuel savings rate (20 to 22%) will result in over a 12% increase in the value of the energy savings for the nozzle and a 24% increase in energy savings for the two-stage prop.

If the tax rate is increased by 10%, then the NPV for the nozzle decreases less than 10% (7.66%). For the two-stage propeller, however, an increase in the firm's tax rate causes greater than a 10% (10.71%) reduction in net energy savings.

The factor which has the greatest impact on NPV is the discount rate. A 10% increase in the discount rate used for the two-stage propeller would reduce the investment's profitability by 20%.

This information can be valuable to the decision maker, because it shows how sensitive some factors are to change. This is especially useful for establishing the importance of accurate estimates. For example, a 1% error in the estimation of fuel savings will have a greater than 1% impact on the' calculated profitability of the investment.

In general, any increase in the fuel inflation rate, the energy conservation rate, the fuel price, the fuel consumption, or the life period of the investment will produce an increase in the NPV and BCR and a decrease in the DPB. An increase in the general inflation rate, discount rate, and tax rate will change the NPV and BCR in the opposite direction, whereas the payback' period will move in the same direction.

Table 6.--Impact of a 10% change (increase) on NPV (after tax).

	Nozzle	Two stage	Both
		%	
Fuel savings	12.49	24.29	47.17
Fuel escalation rate	4.64	9.03	17.53
Tax rate	-7.66	-10.71	-18.27
Discount rate	-8.96	-20.30	-42.86

SUMMARY

The recent increase in the cost of energy has focused attention on the application of energy conservation alternatives for commercial fishing vessels. In an era of increasing prices and reduced profits, it is critical that profits are not further reduced by economically inefficient investments.

Life-cycle cost analysis is an effective tool for the evaluation of investments where the cost of energy, as well as other factors, are considered over the life of the investment. It has been shown that, while some investments are technically efficient and the fisherman may "feel" that fuel will be saved by investing, the economics of the situation may be very different.' An economic analysis is an essential component in the decision making process. It can mean the difference between a fisherman's economic survival and extinction.

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