FORT MOJAVE RENEWABLE ENERGY FEASIBILITY

Installing Met Tower

Report prepared for Ft Mojave Tribe
by
ERCC Analytics LLC

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TABLE OF CONTENTS

Installation of Met Towers

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EXECUTIVE SUMMARY

Feasible Renewable Energy Developments

The Ft. Mojave tribe, whose reservation is located along the Colorado River in the states of Arizona, California, and Nevada near the point where all three states meet, has a need for increased energy supplies. This need is a direct result of the aggressive and successful economic development projects undertaken by the tribe in the last decade. While it is possible to contract for additional energy supplies from fossil fuel sources it was the desire of the tribal power company, AHA MACAV Power Service (AMPS) to investigate the feasibility and desirability of producing power from renewable sources as an alternative to increased purchase of fossil fuel generated power and as a possible enterprise to export green power.

Renewable energy generated on the reservation would serve to reduce the energy dependence of the tribal enterprises on off reservation sources of energy and if produced in excess of reservation needs, add a new enterprise to the current mix of economic activities on the reservation.

Renewable energy development would also demonstrate the tribe's support for improving environmental quality, sustainability, and energy independence both on the reservation and for the larger community.

To investigate the potential for renewable energy development an analysis framework was defined that included the multiple goals of economic development, environmental quality, sustainability, and energy independence. Once the framework was defined an inventory of possible sources of renewable energy production was made. These included: wind, biofuel and solar resources.

The wind resource was not well documented with specific, on reservation, data other than data from the ground level AZMET weather station. Two MET towers were installed and data collected at 20 to 50 meters heights. After a years worth of data were collected a consulting meteorologist and wind development consultant were hired to perform a feasibility analysis of a wind farm. Their conclusion was that the wind resource was marginal for the development of wind energy.

The potential biofuel resources on the reservation are directly related to the large tribal farm's operations. Potential sources include cotton stalks, gin trash, and animal manure. Potential technologies that were investigated include biodigestion of animal manure, pelleting of cotton stalks and gin trash, gasification of cotton stalks, and biodiesel production from cotton seed. The best of these technologies was biodigestion of animal manure which depends upon the construction and operation of a feedlot.

The solar resource was documented by the long term records from the AZMET weather station and was judged to be sufficient for further investigation of the potential for renewable energy production.

Costs analysis for photovoltaics resulted in this technology being found too expensive to install. This alternative was ruled out until technology advances reduce costs. (It should be noted that at the time the project is ending (Dec 2007) Nanosolor has in production thin film photovoltaic systems that are claimed to be competitive with conventional energy systems)

Two other solar technologies were identified that might be feasible to utilize the tribes solar resource. One, concentrated solar thermal, uses mirrors to concentrate heat which is then captured and converted to electrical energy by turbines. The technology for concentrated solar thermal systems not only has been developed but plants using the technology producing over 300 MW of power are in operation less than 200 miles from the reservation, near Barstow CA. Costs for these technologies are falling as several firms are building production facilities and developing solar energy farms. Current costs are reported to be about 10 cents per kWh with projections of costs below 6 cents per kWh in the near future, increasingly common.

The second, concentrated photovoltaics, uses lenses to concentrate solar energy on photovoltaic cells originally designed for use in space, that can operate at concentrations of 500 fold. This technology is just beginning to be deployed (Dec 2007) in commercial solar farms in Australia by Green and Gold Energy. The projected costs from Green and Gold Energy would suggest that this technology is competitive with conventional sources, but at present they are using all of their current production for their own solar farms. This technology is expected to be available for the US markets in the future as production expands.

For the concentrated technologies no commercial, off the shelf supplier, is currently available to supply the technology necessary to build a solar farm. Thus the exact costs and technical details of these systems remain proprietary and can only be accurately discovered via an RFP for a solar farm development. This is our recommendation as the best approach for the tribe to develop their renewable energy resources.

Our specific recommendations are:

Biomass

If a feedlot is built, a biodigester augmented with waste cooking oil is recommended.

Actions

- Contact RCM digesters for development of detailed construction and operating support.
- Secure access to waste cooking oil and or food waste.
- Become certified to sell Green Tags and Carbon Credits. Develop a marketing strategy for selling the Green Tags and Carbon Credits.
- Apply to USDA for loan guarantees and obtain financing.
- Construct and begin operating biodigester, Begin selling Green Tags and Carbon Credits

Expected result -- 200 kw electricity at 6 cents per kWh until loan is paid off in 7 years, essentially free for the remaining life of the project.

Wind

If locking in a price in the range of 8 to 10 cents per kWh for the 15 year period until the loan is paid off and 2 cents per kWh for the remaining 10 year life of the project is judged beneficial to the Tribe, development of a small wind farm is recommended.

Actions

- Contact for development of a detailed feasibility and design of a small wind farm. Possibilities are: Bob Lynette and Ron Nierenberg
- Install at least one additional 50 m MET tower north of the current 20 m tower.
- Become certified to sell Green Tags and Carbon Credits. Develop a marketing strategy for selling the Green Tags and Carbon Credits.
- Apply to USDA for loan guarantees and obtain financing.

- Find a way to capture at least part of the production tax credits by leasing the wind farm with an option to buy, or some other ownership structure that would allow the Tribe to capture the production tax credits and maintain control of the project.

- Construct and begin operating the wind farm, Begin selling Green Tags and Carbon Credits.

Expected result -- 3.2 MW of electricity at 9 cents per kWh until loan is paid off in 15 years and 2 cent per kWh for the remaining life of the project.

Solar

The most abundant source of renewable energy on the reservation is solar. While unconcentrated photovoltaic technologies are still not economically feasible except in special circumstances, concentrated solar technologies (both thermal and photovoltaic) do have potential.

Concentrated Solar Photovoltaic

Concentrated solar photovoltaic systems have the advantage of being able to be deployed at smaller capacities. Modules range from 300 W for a 1 meter square collector (Green and Gold Energy) to 250 KW for an Amonix collector. For solar farm applications multiple collectors would be needed. However, at the current time (Dec 2007) these systems are not available or not available at price points which would make feasible immediate adoption. It is, however, expected that within the next 1 to 3 years these systems will be available at price points competitive with nonrenewable sources of electricity. This would open the possibility of the smaller units being utilized in commercial or residential settings on the reservation and the possibility of development of a small solar farm to supply a large part of the reservations power needs. It is recommended that the tribe begin planning for these possibilities.

Actions

For the development of a small solar farm, since the technologies are new and proprietary the best approach would be to send out an RFP for a 10 MW plant requiring installation and operating cost guarantees.

Expected result -- 10 MW of electricity at rates competitive with purchased power

To explore the possibilities of smaller units on residential and commercial buildings it is recommended that an order be placed with Green and Gold energy for a small number of units for evaluation to be delivered when they begin marketing in the US.

In addition, it would be reasonable to consider an RFP in early 2009 for a small commercial application. By that time, it is possible that technical development and production advances would have advanced to the point where these products would be competitive.

Expected result -- some commercial and residential installations at rates competitive with purchased power

Concentrated Solar Thermal

Concentrated solar thermal power is another potential technology to convert the tribal solar resource to power. The two existing technologies, troughs and towers, require large installations to capture the economies of scale necessary to make them economically competitive. These installations would be on the order of 100 to 1000 MW and require approximately 1 section of area for each 100 MW of capacity. With installation costs of 3 dollars a watt of capacity the costs of installing a 100 MW system would be 300 million dollars and 3 billion dollars for a 1000 MW system.

In any project of this magnitude decisions must be made about how to share the risks and potential profits. The technological risks are reasonably low in that these systems have been developed and are in operation. However, they are still not in widespread use. The possibility exists for technological innovation to improve on the current designs, putting early adopters at a disadvantage. The economic risks due to government actions on portfolio standards, investment tax credits, carbon taxes, global warming policies, utility regulation and other policies are huge. Just the removal of investment tax credits would increase costs by 30%.

The financial resources required would require the tribe to have most of its investment portfolio tied up in a single enterprise if it were to purchase outright a thermal solar facility. This would not be appropriate risk management.

Actions

Due to the magnitude of these projects it is reasonable that the tribe partner with other tribal and commercial groups to develop a solar thermal project.

Expected result -- development of a major new economic resource for the tribe

PROJECT OVERVIEW

Evaluating the feasibility of renewable energy development requires a decision framework to define the feasibility/desirability of alternative actions. The fist step of our project was to define such a framework. The framework used involved a goal analysis of four goals potentially impacted by renewable energy development: economic, environmental, energy independence, and sustainability.

Economic analysis of renewable energy projects is much different than analysis of traditional energy projects. The difference is most evident when comparing the portion of costs accounted for by fuel, versus the costs for plant construction. Renewable energy projects typically have most of their costs in plant construction, not fuel charges. Wind is free. Sunshine is free. Access to these resources is not free, and because of the large areas that a renewable energy project can occupy rents and taxes become important considerations. In general, the investment costs and associated finance costs are more important in renewable energy projects. Further complicating the issue, is the complex and ever changing governmental regulation which may provide tax benefits for development of renewable energy. However this depends upon passage of specific authorization in the Energy bill and is not guaranteed on a long term basis. Further, governmental actions designed to increase the market value of renewable energy such as: portfolio standards, taxes on carbon, or stricter regulations on pollution, all directly and indirectly impact the market value of renewable energy.

An economic analysis framework that addressed these issues was a key component of the analysis framework. The other components of the analysis framework, environmental, sustainability, and energy independence were also developed in the early stages of the project.

The next major stage of the project was to develop a list of potential renewable energy resources on the reservation. Wind, solar, and biomass resources were identified in this screening process.

Next, technologies were identified which had the potential to transform the renewable resources into energy. For biomass the alternatives ranged from compression into fuel pellets or fire logs, gasification and then conversion to electricity, biodiesel production to biodigestion. For wind a small wind farm and for solar, photovoltaic, solar thermal and concentrated photovoltaic were identified as possibilities.

For each of the resource/technology combinations a preliminary economic analysis was used to screen out those combinations that did not meet the basic economic requirements. The remaining possibilities were then subjected to a more comprehensive analysis.

For those technologies judged to be feasible for implementation a suggested strategy for implementation was developed for consideration by the appropriate decision makers.

OBJECTIVES

The specific project objectives are to discover economically, environmentally, and sustainable renewable energy projects, which can be implemented on the reservation, and to develop a business and technical strategy to implement these projects.

DESCRIPTION OF ACTIVITIES PERFORMED

Recent Growth on Reservation

Decisions

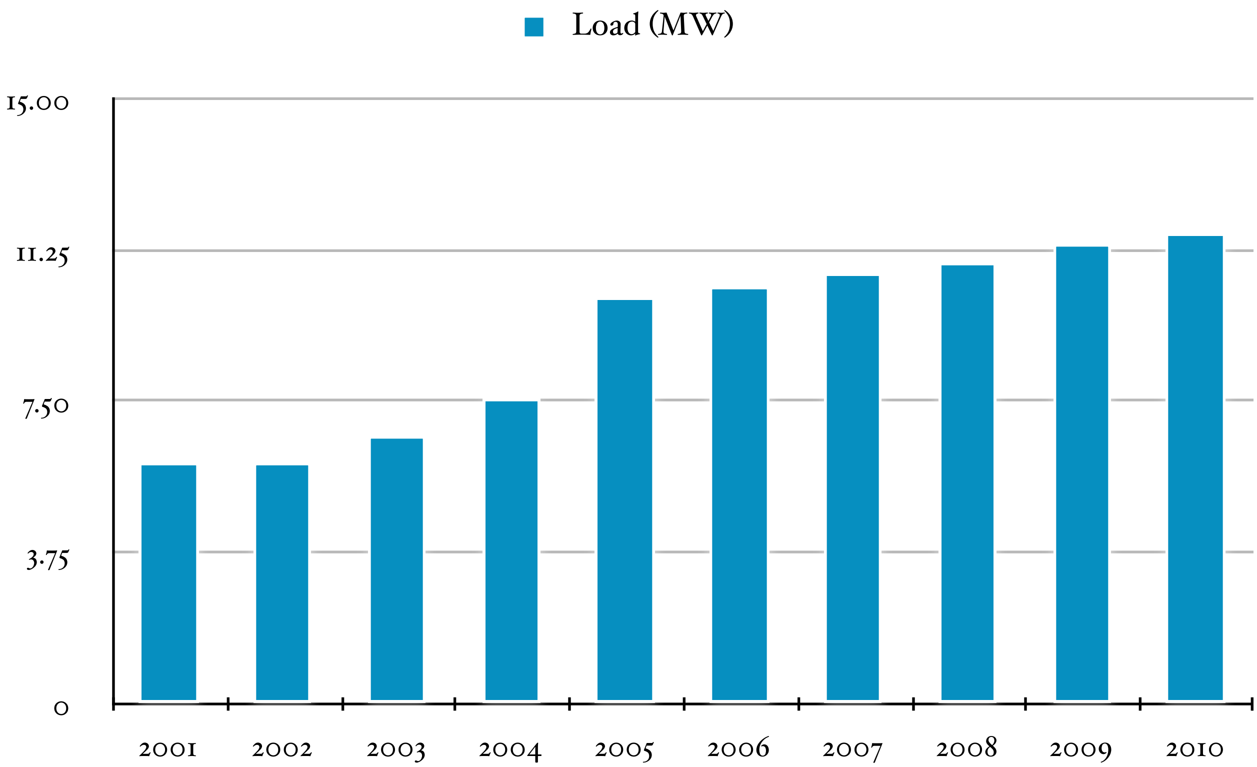
INTRODUCTION

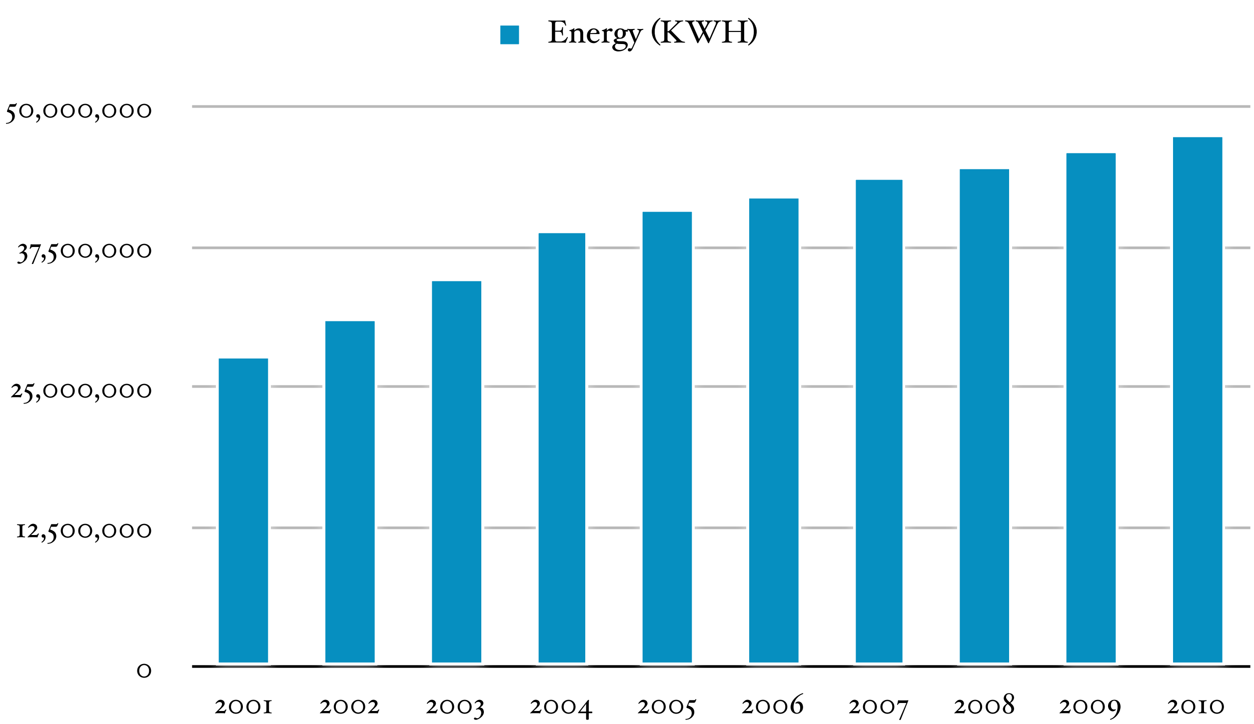
This document presents the basic information and analytical tools necessary for the tribal enterprises to make decisions on implementation of renewable energy production on the Fort Mojave Reservation. These decisions are not simple. A complete set of information on which to make decisions does not exist. The decisions involve comparison and selection of renewable energy production alternatives. The decisions also involve important considerations on the timing of renewable energy development. Further complicating the issue is the rapid change in the technology associated with renewable energy production and the rapid change in energy prices and markets for environmental amenities (green tags - carbon credits).

The objective is not to simply develop renewable energy on the reservation but to choose among alternative renewable projects (including the option to not develop renewable energy at this time) and to choose a timeline of development that is beneficial to the tribe. Investing too soon in an technology that is becoming more efficient should be avoided. Not investing in a technology that can efficiently produce renewable energy should also be avoided. Investing in a technology that would preclude choosing in the near future a better technology currently under development should also be avoided. These choices are not easy. There is no one best solution. Considerable judgement will be required.

ENERGY USE

Energy is distributed on the reservation by a tribal utility, Aha Macav Power Services (AMPS). The peak loads and energy usage have increased rapidly in recent years with the aggressive development of enterprises on the reservation. The graphs below document past use and future projections from AMPS' 2004 Integrated Resource Plan.


Load (MW)
15.00
11.25
7.50
3.75
0
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010


Energy (KWH)
50,000,000
37,500,000
25,000,000
12,500,000
0
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

Given the above energy needs projections, the reservation would need to develop 5 to 10 MW of renewable energy to significantly reduce its dependence on purchased power. Any renewable power produced in excess of the reservation needs could, of course, be sold in the open market.

Currently the utility buys a large share of its power from Arizona Public Service, APS. Purchases of energy from APS is the benchmark for comparison of power produced from renewable resources on the reservation. The comparison of renewable energy production economics with commercial purchase of power is complicated. Renewable energy production typically requires a long term commitment of 15 to 30 years. The commercial contracts for power purchase are for a 3 to 5 year time frame. This leads to a serious (apple vs oranges) comparison problem. This issue is central to the economic analysis of the alternatives and is discussed in more detail in the economic analysis section.

Choices

The key choices are to select the appropriate technology or technologies and the appropriate timeline for development. In order to make reasonable choices a decision framework for comparing alternatives is necessary. One could choose simply on the basis of the economics of the alternative developments. In this case the expected present value of the profit stream for a project is one reasonable decision metric. The avoidance of the risk of large increases in energy costs in the future is also of concern to decision makers. Unfortunately, there is no standard metric to measure this risk. Nor is there a standard to compare its importance to profits.

Further, economic performance is not the only relevant goal for renewable energy development on the Fort Mojave Reservation. Environmental concerns are relevant. The sustainability of the tribal resource base is important. In addition, the development of energy independence is also important to the tribe.

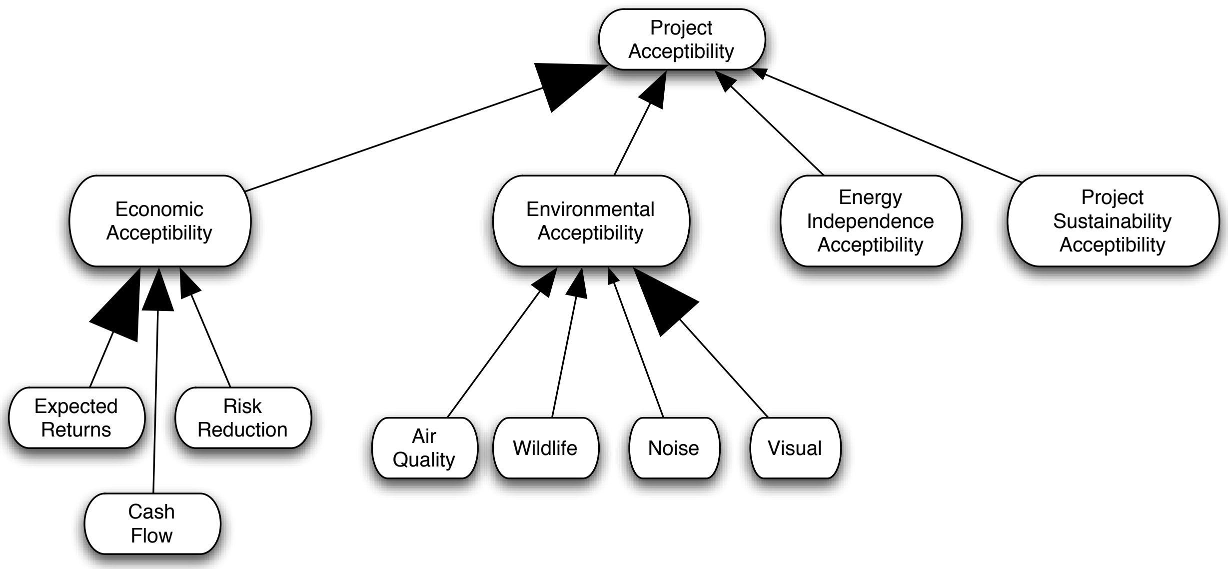
Decision Framework

To simultaneously consider all of these goals a simple multiple objective framework is useful. The key components of such a system are: 1) way to quantify the values of the alternative goals and 2) a means to consider tradeoffs among the goals. The purpose of the multiple objective analysis is not to present an exact answer as to which alternatives are best, but rather to present a framework for the decision makers to evaluate alternatives while considering alternative and possibly competing goals. The approach we have taken is to develop a measure of acceptability/feasibility for each of the alternatives considered when compared to the current situation. This measure is defined as zero for alternatives which are completely unacceptable/unfeasible and one hundred for those alternatives which are highly acceptable and feasible. A measure of 50 indicates alternatives which are neutral in acceptability and feasibility when compared to the current situation..

The general approach we have taken is to define a goal tree with more general goals as the main branches and less general goals as the lesser branches. The smallest branches of the goal tree (terminal branches) correspond to concepts whose acceptability/feasibility can be measured for each of the alternatives proposed. The level of acceptability for each of the smallest branches then flows up to the higher levels of goals by the use of a set of functions based on models of human perception and tradeoffs of goals. The importance of a branch of the goal tree is displayed as the size of the arrow forming the branches of the tree.

Goal Tree

The basis of the decision framework is the goal tree. For the analysis of renewable energy alternatives on the Ft. Mojave Reservation the following goal tree was developed. A description of the process used to define the multiple objective goals and tradeoffs is discussed in Appendix A. Technical details of the framework used in this feasibility are discussed in Appendix B.



Economic Goals

Economics is concerned with more than just profits. For the purpose of analyzing renewable energy projects we propose the following three goals as reasonable:

1. **Expected Returns**. A project is ,of course, more acceptable/desirable the more profits it returns to the tribe. This will be measured in terms of the net present value divided by the installation costs. This return on investment is translated into goals using the following table.

EXPECTED RETURN GOAL	
Return on Investment (life of project)	**Goal Value**
-25%	0
-10%	10
-5%	25
0%	40
10%	50
50%	55
100%	60
500%	100

2. **Cash Flow**. A project is more acceptable if it does not cause cash flow problems. Because most of the costs of renewable energy occur in the first few years of a project care must be taken to insure that funding is available to cover the costs for each year of the project. This will be measured by the cumulative cash flow at the point the loan is paid off divided by the investment cost.

CASH FLOW GOAL	
Cash Flow / Investment Cost	**Goal Value**
-25%	0
-10%	10
-5%	25
0%	50
>0	100

3. **Risk Reduction**. A project is more acceptable if it provides a hedge against future increases in energy costs. The goal values for the risk goal were subjectively determined for each technology by our analysis team and are detailed in the analysis section later in this report.

Environmental Goals

In general, environmental goals can be numerous and address many resources and media. For this renewable energy feasibility study, goals have been limited to those perceived as important on the reservation and clearly related to the final set of alternatives to be analyzed.

Through the project process, the following four environmental goals have been determined appropriate:

1. **Air Quality-** A project is more desirable/acceptable when it has less of a negative effect on air quality.

2. **Wildlife-** The environmental acceptability of a project decreases if wildlife are or have the potential to be injured or adversely impacted.

3. **Visual-** A project is more acceptable/desirable if its structural features are not visible or do not interrupt an existing viewshed.

4. **Noise-** Whether it be volume, duration or timing, a project that has features that increase or add noise is less acceptable/desirable than a project that creates no additional noise.

Sustainability Goal

While a great deal of consideration was given to establishing goals for sustainability, the final alternatives led analysts to an uncomplicated approach. For example, there is no reason to believe that solar radiation or wind would be depleted or that there would be a significant change/shortage of inputs to biodigestion. While unforeseen and catastrophic events could have impacts, it is impractical to evaluate these or their probability of occurrence within the context of the analysis. Therefore, the percent of a resource remaining (100 in the above examples) or probability of a resource being sustained, has been determined to be the single, appropriate goal for describing sustainability.

Energy independence Goal

A project is more acceptable the more energy it produces on the reservation under the control of tribal enterprises.

ENERGY PRODUCTION	INDEPENDENCE GOAL
0	50
100KW	55
500KW	60
1MW	70
10MW	100

MEASUREMENT SYSTEM

A measurement system for Goal achievement is measured in terms of acceptibility/desirability. A score of 0 indicates an alternative that is completely unacceptable and undesirable a score of 100 indicates a project that is completely acceptable and extremely desirable. A score of 50 indicates current conditions. Thus a score of 50 when analyzing a potential project would indicate a result that is no better or worse than the current situation without the project, i.e. neutral acceptability and desirability.

TECHNICAL INDICATORS

The approach to determining the overall acceptibility/desirability of an alternative is to first define the achievement level of the alternative on each of the terminal branches of the goal tree. This is accomplished by defining technical indicators (concepts that we can measure or score) for each of the terminal branches and then relating these technical indicators to the acceptability desirability measures for these terminal branches of the goal tree.

IMPORTANCE WEIGHTS

Not all of the components of the goal tree are of equal importance. The relative importance of the weights is indicated by the relative sizes of the arrows connecting the sub goals to the higher level goal or goals. In the diagram the importance of the economic subgoal is 50 , the environmental goal 25, the energy independence goal 15 and the sustainability goal 10. These goals importance weights can, and should, be changed by the decision makers if they have a different view of the relative importance of the components. The process we used to develop these importance measures and the specific mathematical weighting methodology is discussed in Appendix A and Appendix B.

Energy Customers

Analysis Framework

Economic Analysis

While the economic feasibility of development of a renewable energy resource is not the only criteria important to the Fort Mojave tribe it is an important criteria. The analysis of renewable energy projects which have an economic life of many years is not easy. Typically the majority of the costs are in the construction and implementation phase at the beginning of the project. These costs can be estimated with a reasonable degree of certainty. The operation and maintenance costs will occur over the life of the project and will be subject to inflation and the general uncertainty of estimating events 25 years into the future. However, it is reasonable to assume a general rate of inflation and estimate these costs. In most cases these operation and maintenance costs will be a smaller component of the overall costs compared to the purchase, installation and finance costs. The big problem comes in terms of estimating the value of the output of renewable energy production.

Value of Renewable Energy

The value of renewable energy, over the life of a renewable energy project, is a key consideration in evaluating the desirability of investing in the development of renewable energy sources. Unfortunately, it is also not knowable with a high degree of certainty.

Is the value of renewable energy the same as fossil fuel produced energy?

The answer is no. These values differ both at the market measured level and at the societal level. At the market level, the difference is due to the development of markets for renewable produced energy and for environmental amenities such as reduced CO_2 generation. These markets are just in the initial stages of development. At present, in the US these markets are driven by voluntary payments by socially concerned individuals and institutions, and by an increasing level of government mandated portfolio standards. On a world wide basis, the Kyoto accord has led to markets in carbon certificates. Will there be active markets for the benefits of renewable energy in the US within the lifetime of a renewable energy project? Most likely such markets will evolve. The key question is what the level of this additional value for renewable energy will be.

At the societal level, the non market values associated with environmental benefits of using renewable energy and the political and military costs of protecting foreign based energy resources are real and should encourage renewable energy development. However, for the purpose of evaluating the feasibility of development of renewable energy resources on the Fort Mojave Reservation these societal costs will be ignored except as they are reflected in the markets for renewable energy and associated markets for environmental amenities.

Market value of energy

To evaluate a renewable energy project with a productive life-span of up to 25 years requires estimating the value of electric power over this time period. Given the uncertainties in the recent energy markets this is impossible to do with any great degree of certainty. To allow the decision makers to view results with different assumptions about energy price increases we have chosen to use a sensitivity analysis approach and report results for a range of alternative scenarios. The table below demonstrates the increase in market energy prices for alternative possible energy price increases. Even at the most optimistic (from a consumers point of view) scenario of 2% annual energy price increases, the cost of power almost doubles in the 25 year period. At the 3% level the cost does double and at the 4% level it almost triples. At the extreme 10% increase the cost increases 10 fold over the 25 year period. If history is used to provide a basis for estimating price increases then the range of doubling to tripling over the 25 year period is the indicated result. However, as is obvious with the recent doubling of fuel prices in a short period, historical projections of price increases at a slow steady rate are suspect. The possibility of large and unpredictable price changes should be considered a possibility in the planning process for energy development.

POSSIBLE ENERGY PRICES OVER TIME					
	Annual rate of increase in energy value				
	2% increase	**3% increase**	**4% increase**	**6% increase**	**10% increase**
Year					
1	$0.0550	$0.0550	$0.0550	$0.0550	$0.0550
5	$0.0595	$0.0619	$0.0643	$0.0694	$0.0805
10	$0.0657	$0.0718	$0.0783	$0.0929	$0.1297
15	$0.0726	$0.0832	$0.0952	$0.1243	$0.2089
20	$0.0801	$0.0964	$0.1159	$0.1664	$0.3364
25	$0.0885	$0.1118	$0.1410	$0.2227	$0.5417

Another important characteristic of the above table is that there is no one price for energy. There is a stream of different prices over the 25 year period. To translate these price streams into a single value the standard approach of converting a stream of values to a single present value using discounting will be employed. The basic concept is that if one could put money in a bank at a fixed interest rate for the 25 year time period (termed the discount rate) how much would you have to deposit (termed the present value) to pay for 1 kWh, for example, each and every year and end up with zero in the bank account at the end of the 25 year period.

PRESENT VALUE OF 1 KWH PER YEAR FOR 25 YEARS					
	2% increase	**3% increase**	**4% increase**	**6% increase**	**10% increase**
Discount rate					
5% rate	$0.9451	$1.0497	$1.1702	$1.4707	$2.4195
10%rate	$0.5834	$0.6339	$0.6911	$0.8303	$1.2500
Assumes 5.5 cent per kWh starting price in year 1.					

From the table above two observations are important. One is that the information on prices over the 25 year period has been reduced to one number. For example, one can compare the difference between the 3% scenario and the 10% scenario assuming a 5% discount rate by just comparing two numbers, $1.0497 and $2.4195. The second observation is that these values, especially for projects with a long life span, are very dependent upon the choice of discount rate. A low discount rate would reflect the case of a low interest rate on borrowing or loaning funds and would value future results as more important than using a higher discount rate. Some analysts suggest using a high discount rate to reflect both the time value of money and the increased uncertainty involved in predicting events up to 25 years in the future. While this may be reasonable for cases where the estimation of events 25 years in the future is very uncertain, it is not appropriate for evaluating most renewable energy projects. For almost all renewable energy projects the costs are concentrated in the construction of the project. These costs are not subject to the uncertainty of estimating events far into the future. Thus, it is not economically sound to add a large risk component to the discount rate. A reasonable discount rate is the value that you can borrow funds for or the return rate you could get on alternative investments with similar risk levels (opportunity cost of capital).

The above table compresses the value of energy over the 25 year period into one number if the growth rate in energy prices and the discount rate are both known. While determining a reasonable discount rate can be based on current interest rates estimating the growth in energy prices over the next 25 years is more difficult. One solution would be to estimate the most likely path of energy prices given historical trends and use this value as the value of the renewable energy produced. This is not economically sound as it gives no consideration to the chances that, as recent oil price increases have illustrated, rapid and unexpected price increases can happen. The standard economic approach is to use the probabilities of the different price scenarios occurring to weight their importance. This results in an expected value for the price of energy that gives weight to the a range of different possibilities that may happen. For example, the following table presents the expected value of 1 kWh of power every year for 25 years. Comparing the results to the table above the expected value of power is somewhat greater than the 4% increase scenario ($1.19 expected value compared to $1.17 present value at 5% discount rate. This reflects including some consideration for scenarios with small but positive probabilities in the analysis. Of course, changing the probabilities assigned to the scenarios will change the expected values.

EXPECTED NET PRESENT VALUE OF 1 KWH PER YEAR FOR 25 YEARS					
Price scenario	2% increase	3% increase	4% increase	6% increase	10% increase
Probability	0.1	0.4	0.35	0.1	0.05
	Discount rate		Expected NPV		
	5% rate		$1.19		
	10%rate		$0.70		

The spreadsheet used to calculate the above tables is available at http://www.energy-renewable.com/spreadsheets/pve.xls and can be used to explore the impact of different discount rates and different probabilities of price scenarios and with minor modifications add or revise the price scenarios considered.

Market Value with Variable Energy Production

One of the characteristics of renewable energy production is that the production levels vary over time. For wind the variation is directly related to wind conditions. For solar, it is directly related to weather conditions. For biomass it is related to the production cycle of the specific biomass used as a fuel source. This variability has been often cited as reducing the value of the renewable energy produced. For the Ft. Mojave reservation the current situation is that power purchases are scheduled by the Western Area Power Administration (WAPA) as part of a RMS which includes several other power users in Arizona. Under the proposed rules any deviation between scheduled and used power for the reservation during on peak hours would involve a penalty of 10% of the power price if the deviation was in excess of 5MW. For off peak hours any sales of power in excess of 2MW from the scheduled amount would incur a 60% price reduction. Of peak power purchases in excess of scheduled would be subject to a 5MW window and the penalty would be 10%. (this information is from personal communications with WAPA)

Given the 5MW window and the 10% penalty for all but sales during off peak hours this is not likely to impact the economic value of renewable energy produced on the reservation. The likelihood of not being able to predict the production within the 5MW window would seem rather small.

MARKET VALUE OF ENVIRONMENTAL AMENITIES

Currently there are two instruments that can be used to sell environmental amenities, Renewable Energy Certificates RECs (green tags) and carbon credits. These markets are in the initial stages of formation but they are real and can provide revenue to a renewable energy project.

Green Tags -- Renewable Energy Credits (REC's) -- Carbon Credits)

Renewable energy credits is a term which represents the market value of a quantified and certified reduction in environmental impact by renewable energy production, when compared to fossil fuel energy production. Carbon credits represent the same concept applied more narrowly to just the CO2 reduction of renewable energy production, when compared to fossil fuel energy production

"Renewable energy certificates (RECs) represent the attributes of electricity generated from renewable energy sources. These attributes are unbundled from the physical electricity, and the two products—the attributes embodied in the certificates and the commodity electricity—may be sold or traded separately. RECs are quickly becoming the currency of renewable energy markets because of their flexibility and the fact that they are not subject to the geographic and physical limitations of commodity electricity. RECs are currently used by utilities and marketers to supply renewable energy products to end- use customers as well as to demonstrate compliance with regulatory requirements, such as renewable energy mandates. " [1]

"Electricity produced from renewable energy can be used by the producer or sold as a commodity to others. Unlike fossil-based generation, which can emit large amounts of air pollution—such as carbon dioxide, sulfur oxides, nitrous oxides, heavy metals, and other toxic substances—renewable-based generation is largely pollution free. Today, these environmental benefits are increasingly being quantified and marketed.

When electricity from a renewable energy producer is used or sold into the power markets as simply electricity, without taking any environmental credit for the source of that power, the environmental attributes of that renewable energy can be sold or traded separately as a commodity, called green tags. Green tags (also known as green energy certificates and tradable renewable certificates) provide an additional revenue stream to the project and can be sold to companies and consumers anywhere in the country. In this way, companies and consumers can choose green power even if their local utility does not offer a renewable-based power product.

The revenue generated by selling green tags can significantly benefit the finances of a renewable energy project. For example, the large 750-kilowatt wind turbine built on the Rosebud

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[1] from Emerging Markets for Renewable Energy Certificates: Opportunities and Challenges http://www.eere.energy.gov/greenpower/resources/pdfs/37388.pdf

Sioux reservation was partly paid for with a major green tags purchase by Native Energy, one of the leading U.S. marketers of green tags. A unique aspect of the Native Energy program is their ability and willingness to purchase the long-term green tags generation for the economic life of a project, instead of on a year-by-year basis.

Developers of larger projects will typically sign a contract with a green tag marketer to generate a constant income based on the actual amount of power produced. Although green tag marketers rarely disclose the amount of money they are paying for the green tags, they are currently selling them for as low as 1.5 cents per kilowatt-hour to as much as 4 cents per kilowatt-hour.

However, green tags have one drawback: the buyer of the green tag must trust the seller's promise that the green tag represents actual renewable energy generation. Green tags could easily be abused. For instance, a renewable power provider could sell the electricity to local consumers as green power and then also sell green tags for the same power—essentially selling the renewable attributes twice. To build trust in green tags and other green power products and to prevent their abuse, the non-profit Center for Resource Solutions has established Green-e,[2] a voluntary certification and verification program for green power products. The Green-e Web site on Tradable Renewable Certificates [3] explains in practical terms, how they are measured, verified, and traded. For a more detailed and thorough explanation, see their Regulator's Handbook on Tradable Renewable Certificates [4] For more information about green power, including options such as green tags, see the Environmental Protection Agency's Web site "What is Green Power?".[5] In addition, the Department of Energy's Green Power Network Web site [6] provides current information on green power, green pricing, green marketing, green certificates, and state policies. The section on Renewable Energy Certificates [7] gives updated information on all of the providers and marketers of green certificates in the United States.".[8]

Certification

Before a project can sell RECs they must be certified. This process involves a fee and inspection of the renewable energy project. A typical green tag buying utility or broker would require an application fee to review and qualify a green product. Currently a reasonable source for certification is the Green-e Renewable Electricity Certification Program. Their current fee is $6,000.

"The Green-e Renewable Electricity Certification Program is administered by the non-profit Center for Resource Solutions [9] and based in the Presidio of San Francisco, California. Green-e

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[2] http://www.green-e.org/what_is/what_is_index.html)

[3] (http://www.green-e.org/what_is/dictionary/trc.html)

[4] http://crs2.net/handbook

[5] http://www.epa.gov/greenpower/whatis/index.htm

[6] http://www.epa.gov/greenpower/whatis/index.htm

[7] http://www.eere.energy.gov/greenpower/markets/certificates.shtml

[8] from http://www.eere.energy.gov/tribalenergy/guide/green_tags.html

[9] http://www.resource-solutions.org/

provides an easy way for consumers to quickly identify environmentally superior electricity products in competitive markets.

Green-e certifies renewable electricity products that meet the environmental and consumer protection standards established by the Program. The Program also requires that electricity providers disclose information about their product to their customers in a standardized format. This enables consumers to make informed purchasing decisions and helps to build consumer confidence in retail renewable electricity products. Through these efforts, the Green-e Program hopes to expand the retail market for renewable electricity products and for power from cleaner non-renewable generation.

In each state where Green-e is active, the Green-e Program works with diverse stakeholders to form Regional Advisory Committees [10] who ensure that the consumer protection and environmental standards of the Green-e Program work for their regions. When consumers see the Green-e logo, they can be sure that the renewable electricity product is verified annually for its power content and that the electricity provider selling the power has met the Green-e Program's environmental and consumer protection standards." [11]

Current Retail Values of REC's

Currently there are two driving markets for renewable or green power. First. there are certain electricity users that want to use electricity that produces the least environmental impact (voluntary markets). This type of customer is willing to pay a premium for green power. Second, some customers require green/renewable power because of governmental mandate (compliance markets). At both the Federal and State level there are increasing efforts to require both certain types of electricity users to consume a percentage of their electricity from renewable sources, and also require electricity producers to produce a percentage of their total energy from renewable sources. These requirements are referred as Renewable Portfolio Standards and vary widely between federal, state and industry.

The market values of sales of RECs is reported on the web. see [12]

As of July 2005 the median reported value of a REC was about 2 cents per kWh and carbon credits were about $10 a ton of CO2 avoided.

The Chicago Climate Exchange® (CCX®) is a greenhouse gas (GHG) emission reduction and trading pilot program for emission sources and offset projects in the United States, Canada, and Mexico. The current values that their contracts are trading for is in the area of $2 a metric ton. Historical and current quotes are on the web. [13]

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[10] http://www.green-e.org/what_is/governance/governance_index.html

[11] from http://www.green-e.org/what_is/program_sum/program_summary.html)

[12] http://www.eere.energy.gov/greenpower/resources/tables/certificates.shtml?page=5

[13] http://www.chicagoclimatex.com/trading/marketData.html

What might they be worth in the future

The value of Green Tags, REC's and carbon credits for projects on the Ft. Mojave Reservation is directly dependent upon the implementation of Renewable Energy Portfolio (REP) Standards. Currently Arizona, California and Nevada have some form of REPs. If these were to be made mandatory and the levels of renewable energy increased or if a National REP were to be imposed the value of RECs would increase dramatically. However, for the purpose of this feasibility study a value of 1.5 cents per kWh and an increase over time of 5% a year are judged to be reasonable. Of course, these assumptions can be changed and results from different scenarios viewed by modifications of our analysis spreadsheets. Under these assumptions our present value for 1 kWh of power for 25 years is increased by 36 cents for a 5% discount rate and 21 cents for a 10 % discount rate. This would be in the range of about 30% of the market value of the power.

Recent Developments in Arizona

"Arizona utility regulators voted Wednesday (8-10-05) to dramatically increase the state's requirement on the amount of solar energy and renewable resources used by electricity providers.

The mandate is now 1 percent but the all-Republican Corporation Commission voted 4-1 to increase it to 15 percent by 2015. It has not yet worked out the details on how the requirement will be carried out.

"I see this as a strategic decision for Arizona's electrical energy future," said commission Chairman Jeff Hatch-Miller.

The commission is considering a raft of other issues that must be resolved as it toughens the "environmental portfolio standard" already in state rules."[14]

This action while by no means final, leads credibility to increasing levels and enforcement of renewable portfolio standards. This would suggest that the value of Green Tags could rise dramatically and be an even more important economic factor in the development of renewable energy.

Where to Sell Them

Our preliminary contacts with firms buying RECs and Carbon Credits would suggest that Native Energy [15] is the most likely buyer, and certainly a reasonable place to start when and if a renewable energy project is in the final planning stages.

In addition to selling RECs or carbon credits separate from the power, it is possible to sell green power at a premium to buyers required (Such as many government agencies) to use green energy. The DOE publishes a list of large purchasers of green power, such as federal and state agencies, cities, universities, and businesses. [16] You can find descriptions of green power purchases by these organizations by following the links contained in the web page.

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[14] http://www.azcentral.com/news/articles/0810EnvMandate10.html

[15] http://www.nativeenergy.com/

[16] http://www.eere.energy.gov/greenpower/resources/tables/customers.shtml

Economic Feasibility of a Renewable Energy Project

PRESENT VALUE

A project is economically feasible if the present value of the power produced (including green tag sales) exceeds the present value of the costs incurred (net present value is greater than 0). This simply means that if you set up a bank account at the discount rate and the bank paid all costs (charging the discount rate for interest) and collected all revenues (paying the discount rate as interest) there would be money left in the account at the end of the project period. This amount would be equal to what the present value of the project if deposited with the same terms would be at the end of the project period. The above section discussed the present value calculations for electricity produced by a 25 year project. Below is a table with similar calculations for costs. The key to the cost analysis is the accounting for both installation and operating costs. The following table displays the net present value of the costs of installing and operating a power plant. The rows correspond to alternative installation costs ranging from $1,000 per kW of capacity to $5,000 per kW of capacity , while the columns represent operation and maintenance costs ranging from .01 $/kWh to .03 $/kWh. The calculations assume an uptime for the plant of 90%. The values in the cells are the present value of the 25 year stream of costs. A 10 year loan at 5% was assumed and a 5% discount rate was used. As a reference point, the present value of one kW year of electricity at a 90% uptime under the worst case scenario of constant .055 $/kWh is a bit over $6,100 dollars.   Combinations with a lower cost than this worst case value are depicted in green in the table below.

PRESENT VALUE OF ALTERNATIVE COST POSSIBILITIES					
Operating Costs	**.01 $/kWh**	**0.015 $/kWh**	**0.02 $/kWh**	**0.025 $/kWh**	**0.03 $/kWh**
Installation Costs per kWh capacity	**Present Value of Cost Stream**				
$1,000	**$1,983**	**$3,456**	**$5,421**	$7,878	$10,825
$1,500	**$2,483**	**$3,956**	**$5,921**	$8,378	$11,325
$2,000	**$2,983**	**$4,456**	$6,421	$8,878	$11,825
$2,500	**$3,483**	**$4,956**	$6,921	$9,378	$12,325
$3,000	**$3,983**	**$5,456**	$7,421	$9,878	$12,825
$4,000	**$4,983**	$6,456	$8,421	$10,878	$13,825
$5,000	**$5,983**	$7,456	$9,421	$11,878	$14,825

CASH FLOW

The cash flow of a project is simply the costs paid out and the revenues paid in on a year to year basis. While the economic feasibility of a project can be measured in terms of the net present value, if money is not available to pay for costs during the periods when costs exceed revenues either from enterprise funds of from loans, the project is not financially feasible. The following table presents the net present value of alternative installation costs and alternative variable costs. Both net present value and whether the combination had any negative cash flows for the period until the loan for project installation is paid off are presented in the table below. The top value in a cell is he NPV. The bottom value is the cumulative cash flow for the period until the loan is paid. A positive cash flow number indicates a project that does not have a cash flow problem. The larger the negative number the larger the cash flow problem. As can be seen in the table it is possible to have a positive net present value and a negative cash flow for the period until the loan is paid off. The table displays the NPV and the sum of the cash flow for the first 15 years of the project. For technologies such as a biodigester, the top price applies. For solar technologies the bottom price applies. For example, if a technology based on biomass could be expected to operate on average 20 hours a day and had an installation cost of $4,000 per kw (after allowance for government subsidies) and a variable cost of 2 cents per kWh any energy value (combined energy price and green tag/carbon credit value) above 8 cents per kWh would result in an economically feasible project. For a solar project with the same net installation cost ($4,000) and a variable cost of 1 cent per kWh, an energy value of 13 cents per kWh would result in a viable project. For wind projects which operate at output levels that depend on wind conditions a detailed analysis is presented later. The spreadsheet used to calculate the values for the table is available at http://www.energy-renewable.com/spreadsheets/npvcf.xls .

Cash Flow and Net Present Value

Price per kWh over Variable Cost per kWh (20 hr operation per day)/(10 hr per day operation)		Installed Cost per kw Capacity								
		$1,000	$2,000	$3,000	$4,000	$5,000	$6,000	$7,000	$8,000	$9,000
.08 / .16	NPV	7,231	6,231	5,231	4,231	3,321	2,231	1,231	231	-769
	15 yr. CF	7,315	5,870	4,425	2,979	1,534	89	-1,356	-2,801	-4,246
.07 / .14	NPV	6,020	5,202	4,202	3,202	2,202	1,202	202	-798	-1,798
	15 yr. CF	6,220	4,775	3,330	439	439	-1,006	-2,451	-3,896	-5,341
.06 / .12	NPV	5,173	4,173	3,173	2,173	1,173	173	-827	-1,827	-2,827
	15 yr. CF	5.125	3,680	2,235	789	-656	-2,101	-3,546	-4,991	-6,436
.05 / .10	NPV	4,144	3,144	2,144	1,144	144	-856	-1,856	-2,856	-3,856
	15 yr. CF	4,030	2,585	1,140	-306	-1,751	-3,196	-4,641	-6,086	-7,531
.04 / .08	NPV	3,115	2,115	1,115	115	-885	-1,885	-2,885	-3,885	-4,885
	15 yr. CF	2,935	1,490	45	-1,401	-2,846	-4,291	-5,736	-7,181	-8,626
.03 / .06	NPV	2,087	1,087	87	-913	-1,913	-2,913	-3,913	-4,913	-5,913
	15 yr. CF	1,840	395	-1,050	-2,496	-3.941	-5,386	-6,831	-8,276	-9,721

Risk Reduction

Energy Price Risk

Developing renewable energy provides the advantage of having a reasonable estimate of power costs over the life of a project. This is due to the fact that most costs are in the construction phase and fuel purchase in a volatile fossil fuel market is not involved. Is this advantage worth anything? Of course it is, the question is how much is the risk of energy price fluctuations reduced and how much is that worth compared to the costs of energy. Since there are no future contracts for electricity with 25 year terms, there are no market indicators of the value of energy price risk reduction over the long term. Futures markets do exist for natural gas but the contracts do not extend to cover the life of a renewable energy project.

Technology Risk

The value of long term reductions in the risk of energy price increases is made more difficult as the technology for producing renewable energy is constantly changing. As long as the opportunity for developing renewable power exists then the opportunity for reducing risk exists. There is no benefit in implementing a break even project now if it is possible to wait until either energy prices rise or renewable technology becomes more cost effective. However, if there are long lead times in implementing a project (wind turbines orders now have a two to three year backlog) or if costs are expected to rise without offsetting improvements in technology, postponing a project may not be the right decision. Quantifying these risks in a completely objective manner based on observed historical data is impossible, or at least well beyond the resources of this feasibility project. The following values for the Risk reduction goal were derived by the project team using our knowledge of the industry.

TECHNOLOGY	RISK GOAL	
Wind	75	Mature technology Some risk in terms of increases in installation costs
Photovoltaic	50	Mature technology. Main risk is in terms of increased efficiency and reduced costs of installation.
Gasification	50	Mature technology but low numbers of installations. Main risk is in terms of increased efficiency and reduced costs of installation.

TECHNOLOGY	RISK GOAL	
Concentrated Solar	25	Not a mature technology. Main risk is in terms of increased efficiency and reduced costs of installation.
Biodigester	75	Mature technology. Some risk in terms of increased costs of installation.

Environmental Analysis

The environmental impacts of a proposed action or technological alternative are important to the acceptability/desirability of the action. While there is no feasibility determination similar to an economic analysis, an alternative with few negative environmental impacts is more desirable than an alternative with more. An alternative with significant adverse impacts or one that is predicted to violate an environmental or natural resource protection law may not be implementable. During our analysis the project process began with the adoption of a methodology that had been, typically, used for supporting national/global policy decisions and as such, promotes rigorous and exhaustive sets of sub-goals and indicators and tedious mathematical operations. Focusing on the Mohave Valley and technologies that are inherently environmentally friendly, the project team determined that a practical and understandable approach would be appropriate. Most applications of the methodology, and environmental impact analyses in general, focus on the rigorous definition of subgoals and specification/characterization of technical indicators. The results of these applications are able to reflect subtle changes in technical indicators and are appropriate where thresholds may be compromised or standards exceeded. However, for a user friendly, interactive method that is more concerned with the direction of changes and/or general comparisons, a less rigorous, practical and understandable approach is appropriate. The fact that none of the alternative technologies are predicted to violate an environmental or natural resource law or exceed any public health or environmental standard, and that there are few impacts associated with the alternatives, environmental acceptability has been established as the goal. As presented earlier in the Business Plan, environmental acceptability will be estimated through the components of Air Quality, Wildlife, Visual and Noise.

The following table reports our assessment of environmental quality for the technologies investigated. The overall environmental acceptability is calculated using the importance weights of 20 for Air Quality, 20 for Wildlife, 50 for Visual, and 10 for Noise.

TECHNOLOGY	AIR QUALITY	WILDLIFE	VISUAL	NOISE	OVERALL ENVIRONMENTAL ACCEPTABILITY
Biodigester	60 -- beneficial effect of eliminating feed lot waste	50 -- no impact	50 -- no impact	50 -- no impact	57
Photovoltaic	50 -- no impact	50 -- no impact	40 -- they are in view	50 -- no impact	49
Concentrated Solar	50 -- no impact	50 -- no impact	40 -- they are in view	50 -- no impact	49
Wind Farm	50 -- no impact	45 -- may be small number of bird strikes	30 -- the tall towers will be visible	45 -- small amount of turbine noise	43

Sustainability Analysis

The sustainability of a 'renewable energy' technology is important in determining the overall acceptability of the project. While an alternative technology may appear to be environmentally sound, economically feasible and promote energy independence, it must be reasonably foreseeable that the resource(s) upon which it depends will be continually available. While predicting the potential for the sustainability of a resource demands looking into the future, primarily by looking back at the past, where there are many unknowns, there are few statistics or hard numbers upon which to base the prediction. While a 'reasonably foreseeable' approach seems less accurate and more risky than, for example, an economic forecast, it is less complicated. The economic analysis depends on estimates including future energy costs of production, energy prices, interest rates as well as foreseeable changes in demand and future technology. For this analysis sustainability acceptability will be estimated through the percent of the required resource remaining. Specifically, sustainability (percent of resource remaining) will represent the availability of inputs to the biodigestion process, wind and solar radiation at any point in time. 100 represents the continued availability of the resource with no reason to believe that less of the resource will be available at any time. Any technical indicator value less than 100 represents that at some point in time there could be less of the required resource.

ENERGY SOURCE	SUSTAINABILITY
Solar	100
Wind	100
Biomass produced on farm	80
Imported Biomass	50

Energy Independence Analysis

The current level of purchases of power by the Tribal power company for distribution on reservation is by definition neutral. (goal value = 50). Producing all power on reservation with tribally controlled production facilities would result in a is highly desirable level of energy independence and would have a goal value of 100) The goal is defined for situations where less than 100% of energy used is produced by tribally controlled by the following somewhat arbitrary scale. The logic behind the scale is that even a small production of renewable energy would be noticed and important to the tribe, So the first units of renewable energy produced have a larger impact on the perception of energy independence that the last units.

Wildflowers 2005

ALTERNATIVES

Potential Alternatives

The first stages of the project developed a list of possible renewable power producing possibilities for the reservation resources. Other possibilities were added as the project progressed. Our complete list included the following.

SOURCE	PROCESS
Wind	1.5 to 2.0 MW turbines
Cotton stalks and gin trash	compression to fuel for pellet stoves
Cotton Stalks	gasification then conversion to electricity
Dairy Feedlot	biodigester
Manure	combustion then conversion to electricity
Manure	gasification then conversion to electricity
100 solar houses	integrated pv solar hot water and energy efficient design
Cotton Seed	biodiesel production
Solar	photovoltaic
Concentrated solar	solar to power turbines or photovoltaics

These alternatives were then analyzed for basic economic feasibility.

BIODIESEL

The first to fail the basic economic feasibility test was the biodiesel concept.

It is estimated that 5,000 acres of cotton would produce 1,875 pounds of seed per acre which would yield 52 gal of oil per acre, for a total of about 260,000 gallons of oil. Currently, there are no crush plants available to transform the cotton seed into oil. If a plant were available cottonseed oil could be used to produce biodiesel at a total cost in the range of $2.50 to $3.00 a gallon. The details of the calculations are in a spreadsheet at http://www.energy-renewable.com/spreedsheet/biodiesel.xls .

Due to the high costs of a crush plant and to the fact that this alternative would add little value to the revenue of the farm this alternative will not be investigated further. If biodiesel were to become a reasonable alternative to diesel and commercial production were to increase greatly, the farm would benefit by increases in the price of cottonseed.

While cottonseed can be converted to biodiesel at a cost of around 75 cents a gallon, the raw material is too valuable a feed source for dairies to make this a reasonable project. Other oil seed crops could be grown on the farm, but there is no information on yields and cultural information available. A research effort would have to be undertaken by the tribal farm or the University of Arizona College of Agriculture to determine the feasibility of of producing other oilseed crops.

Recommendation

Request the University of Arizona College of Agriculture to initiate field trials on possible oil seed crops.

COTTON STALKS

Cotton stalks can be harvested using conventional farm machinery such as a peanut digger. Cotton stalks vary in harvested quality and density depending on both crop quality and elapsed time between picking and stalk harvest. This variation in quality and density directly effect the value of cotton stalks as fuel. Harvested cotton stalks vary in density from around 9 to 20 pounds per cubic foot, depending on crop quality and harvest method. Wood by comparison is 35 or more pounds per cubic foot. Cotton stalk yield per acre can vary from 1 to 1.5 tons per acre, with spikes occasionally to 2.5 tons per acre. The longer that time elapses between picking and cotton stalk harvest, the more the cotton stalks value as fuel deteriorates, as the fine leaves and stems break off and are lost in the harvest along with their fuel value. Less than 70% of the material is harvested. Also dependent upon time of harvest, moisture values vary from a low of 20%, and averages about 35%. Cotton stalks may yield as much as 8000 btu per pound under ideal conditions. Under field conditions the harvested cotton stalks will contain 10% or more soil particles. When considered with average moisture, expected fuel value for cotton stalks is estimated to be around 6000 btu per pound. Given an estimate of 5,000 acres of cotton grown on the reservation 5,000 tons of cotton stalks are estimated to be available for production of renewable energy.

Gin Trash

"Cotton ginning involves removal of both seeds and foreign matter from cotton lint. While the market for cotton seed is well established (if not very lucrative), other byproducts are not always utilized to their full potential. With spindle-picked cotton, 680 kg (1500 pounds) of seed cotton are ginned to make a 227 kg (500 pound) bale of lint. The balance is approximately 363 kg (800 pounds) seed and 91 kg (200 pounds) trash." [17]

Currently the possibility exists for the tribe to operate a gin which is projected to process 15,000 bales of cotton a year. Each of these bales will produce about 200 pounds of gin trash for an annual supply of 1,500 tons. Currently the gin trash is spread back on the fields at a cost of $5 a ton. Alternative uses of the gin trash are to feed it to dairy springers in the proposed feedlot, make fuel pellets for pellet stoves, make fuel logs, run it through a combustion process to run a steam turbine for power production, or run it through a gasification process to provide fuel for electric generation.

Gin Trash and cotton stalks for pellets

Methods have been developed in Texas to convert gin trash and/or cotton stalks into fuel pellets suitable for use in pellet stoves. The preliminary cost estimates for the process indicated that this could be economically feasible if a market could be found for the pellets. Obviously, Needles, Bullhead and Laughlin are not potential markets for pellets. Upon further investigation in Northern Arizona it was discovered that the number of installed pellet stoves was not enough to support marketing of 5,000 tons of pellets. The details and costs of this process are documented here. [18]

Recommendation

Don't proceed further with this process unless a market is found for the pellets.

Gin Trash for cattle feed

Recommendation -- If the proposed dairy feedlot is built, the best use of the cotton gin trash would be for cattle feed. While this would not directly contribute to producing renewable energy

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[17] METHANE FROM GIN AND DAIRY WASTES
http://msa.ars.usda.gov/gintech/Funk-Methane%20from%20Gin%20and%20Dairy%20Wastes.pdf

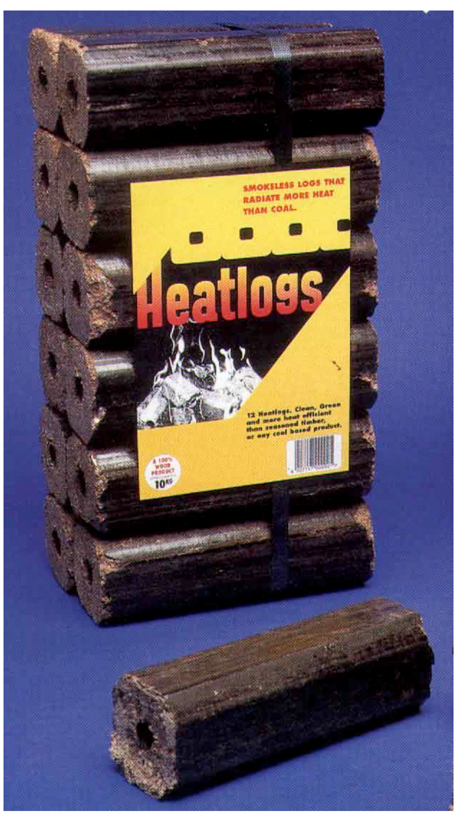
[18] PRELIMINARY ESTIMATES OF THE COST OF EXTRUSION PROCESSING OF COTTON GIN BY-PRODUCT AS A LIVESTOCK FEED http://www.aeco.ttu.edu/Publications/2001Beltwide/D033.PDF
ECONOMIC FEASIBILITY OF MANUFACTURING FUEL PELLETS FROM COTTON BYPRODUCTS
http://msa.ars.usda.gov/gintech/Holt-COBY%20Fuel%20pelletsEco%20.pdf

it would indirectly contribute if a biodigester or other energy production from the manure were implemented.

COTTON STALKS FOR HEATLOG®

It is possible to compress the cotton stalks after grinding them into a sawdust consistency into HEATLOG® logs. These logs weigh about 1.7 pounds each and are suitable for wood stoves, fireplaces, camp fires and barbecues. The wholesale price for these logs is estimated to be about 16 cents each with a cost of production estimated to be about 10 cents each. For the 5000 tons of cotton stalks estimated to be available this would result in an annual profit of almost $25,000 per year. This translates into a value per ton of the cotton stalks of $50. The key to this alternative is the marketing of the product. Because it does not depend upon an installed base of pellet stoves, but rather can be used in a large number of applications it should be similar to Presto logs in terms of marketability.

Another advantage, although not economic, is that this product is produced by a Native American Company Cree Industries. 200-100 Park Royal South, West Vancouver, British Columbia, V7T 1A2, CANADA.



Recommendation

This production of HeatLogs has potential. The process is well established with over 1,500 units in operation worldwide. Tests should be conducted with a sample of cotton stalks to insure that a quality product could be produced. If a quality product can be produced then a marketing plan needs to be developed including the possibility of licensing the Heatlogs brand. Test sales of the product at The Corner Feed & Tack would provide a real test of the market feasibility of the product.

BACK-HAUL MANURE

At the initiation of this feasibility project, the farm was bringing back 2 truckloads per day (approximately 18,250 tons per year) of dry dairy manure on the back haul for some of its hay deliveries. This manure was being used to improve the soil on fields with low organic matter. However, the costs of application were high and the improvements in the productivity of the fields was not worth the costs compared to other alternatives to address these problems.

An alternative to using this manure would be to combust an power a steam turbine to produce electricity. This could in fact be combined with the cotton stalks and gin trash to fuel the the steam generator. It is estimated that the back-haul of the dry manure could be resumed at a cost of $15 a ton.

GASIFICATION OF COTTON STALKS AND MANURE

The following information is based on information from from Bill Klein [19]

Objective:

Convert a quantity of dry cotton stalks and dry cow manure into a dense, homogenized feedstock that can be converted to a fuel, economically, to power an engine alternator and generate an amount of electricity consistent with industry standards, to the quantity of feedstock.

Procedure:

Several steps are necessary to prepare the raw feedstock to be properly gassified without waste or lost fuel value. These steps are intended to reduce the feedstock to a manageable size, create a degree of homogeneity and density that will result in a satisfactory fuel that can be economically gassified. It is our belief that what follows is a formula for the highest and best use of your proposed raw feedstock..

[19] President, International Innovations Incorporated http://www.3ialternativepower.com/

1. Employing augers or modified hay elevators. Transport the cotton stalks and manure to a field chopper.

2. The field chopper will reduce the stalks to flakes and the manure to a powder, discharging into a small pool of water. The water is required to enable a very thick slurry with less than a three inch slump.

3 The slurry is then made into briquettes that are ready to be used as fuel for gasification. (Powerhearth dries its own fuel via our patented torrification chamber)

From this point, the remaining steps towards the generation of electricity are without distinction and fully automatic.

The extent of labor involved during operation consists of a half hour "walk about" inspection, performed every eight or ten hours.

All operators and technicians are thoroughly trained by our team of specialists and are supported, in all areas, for the first year.

Recommendations: (from Bill Klein)

“This project has the potential of producing at least 500 kilowatts of electricity and probably in excess of 600. The primary costs of the project will be the equipment required. The briquette making equipment, of the correct size, will cost about $100,000 and the entire Powerhearth power plant will cost between two and three thousand dollars per kilowatt, turnkey and fully guaranteed.

We believe a twelve by twenty pole barn on a slab would be minimally sufficient as a mechanical room.

It is our recommendation that the project start small, prove itself and slowly expand over a couple of years. Regardless of the feedstock resources, a project beginning might be best satisfied at 100 KWe. The ""add on" systems, should the project continue, would be slightly less per KWe. ”

Cost Analysis

The installed cost of a 100 mw project is estimated at $210,000. The operating cost for the engine - alternator is estimated at .037 $kWh. The engine alternator cost of operation amount is based upon industry standards (used for calculations only) and does not necessarily represent reality. For example, the standardized cost of operation is based upon consumption of "factory brand" oil and consumables bought piecemeal - not bulk - and, similarly, includes labor of preventive maintenance at just over sixty dollars per hour. The actual cost of operation can be substantially reduced (per kWh) if lubricating oil and other consumables are bought in bulk and the engine alternator is cared for by a dedicated local mechanic rather than a factory represented mechanic from outside. It is important to note that the cost of operation can be higher than the estimated amounts if the engine alternator is improperly maintained and if consumables are bought piecemeal.

The cost of fuel, either cotton stalks or dairy manure is estimated to be $20 a ton processed into briquets ready for gasification. This adds another 3 cents per kWh to the costs. Using an expected life of 25 years, financing for 15 years at 5% and a discount rate of 5% the project is not a breakeven project under the worst case assumption of constant energy prices of 6 cents per kWh. In fact it would only cash flow at a price of electricity of 9.5 or more cents per kWh. Given the 6 cent energy price the value of the Economic goals of economic return and cash flow are both 0. Since the weighting system is multiplicative this means that if any one goal is zero the overall goal is zero. The spreadsheet for these calculations is at http://www.energy-renewable.com/spreadsheet/powerhearth.xls .

Recommendations

Gasification is a proven, environmentally friendly, technically efficient process for producing electricity. However, is not at present a cost effective way of producing electricity when the alternative is to purchase power at 6 cents per kWh. This results in a goal value of zero. This is one of those technologies that should be monitored as price reductions and/or efficiency improvements are likely. If green tags plus energy prices were to rise to above 9.5 cents/kWh then this would be an excellent choice. Such a price rise would have significant impacts on the acceptability as measured by our economic goals.

Biodigester

The potential exists to construct a biodigester in conjunction with the installation of a dairy heifer feedlot. A biodigester, in addition to providing a source of electricity would also produce fertilizer and compost and serve to eliminate feedlot odors. After the preliminary analysis showed this to be a potentially viable project we contracted with Mark Moser of RCM Digesters to provide us with a detailed feasibility study. See Appendix C for the detailed report.

BENEFITS AND COSTS

RCM developed the digester design based on the proposed plan to construct the Mojave Heifer Feedlot. It is assumed that approximately 50% of the manure would be collectable. Only fresh manure scraped from the concrete feed lanes will be considered. The digester design will accommodate an equivalence of 2,100 Animal Units (AU) at 1,000 pounds each or an approximate equivalence of 750 mature dairy cows plus capacity for other organic feedstock.

CAPITAL COSTS

This 1,500-cow digester system is estimated to cost $542,431 depending on construction techniques, the range of construction work completed by Tribal enterprises, possible grant funding awards, and energy buy back rates. Annual operation and maintenance costs average $6,886.

BENEFITS

This digester system can produce a total benefit of $52,897/year. The payback period for this system is 10.3 years. The heated digester could produce an average of about 92 kW per day worth over $43,749 in annual electrical sales for Mojave Heifer Feedlot.

There are fertilization benefits from digested effluent that can enhance irrigation application techniques and crop utilization of the nutrients. Environmental benefits include a significant reduction of odors, weed seeds and pathogens from the waste stream. Most dairy farms have manure storage pits, ponds, or basins, which often produce offensive odors. These structures were usually designed for waste storage needs and not necessarily for effective waste treatment. Consequently, the waste storage structures produce effusive and disagreeably odiferous volatile organic acids due to incomplete anaerobic digestion. On the other hand, long term, or complete anaerobic digestion produces a stable and odorless mixture of methane and carbon dioxide. The treated liquid form the anaerobic digestion process can be stored long term without any odor concern, due to the dominance of non-odor inducing anaerobic bacteria that would populate the storage reservoirs.

BIODIGESTER COSTS		
Remote Mix Tank		13,158
Manure Pump		25,484
Manure transfer pipes		6,000
Excavation		11,627
Digester		159,424
Gas/hot water field piping		16,850
Engine-generator building		23,467
Gas pump		44,917
Hot water Management skid		26,694
Engine-generator		110,500
Contingencies		43,812
Engineering/Site Assist		52,000
Startup fuel and equipment		8,500
	Total	542,433

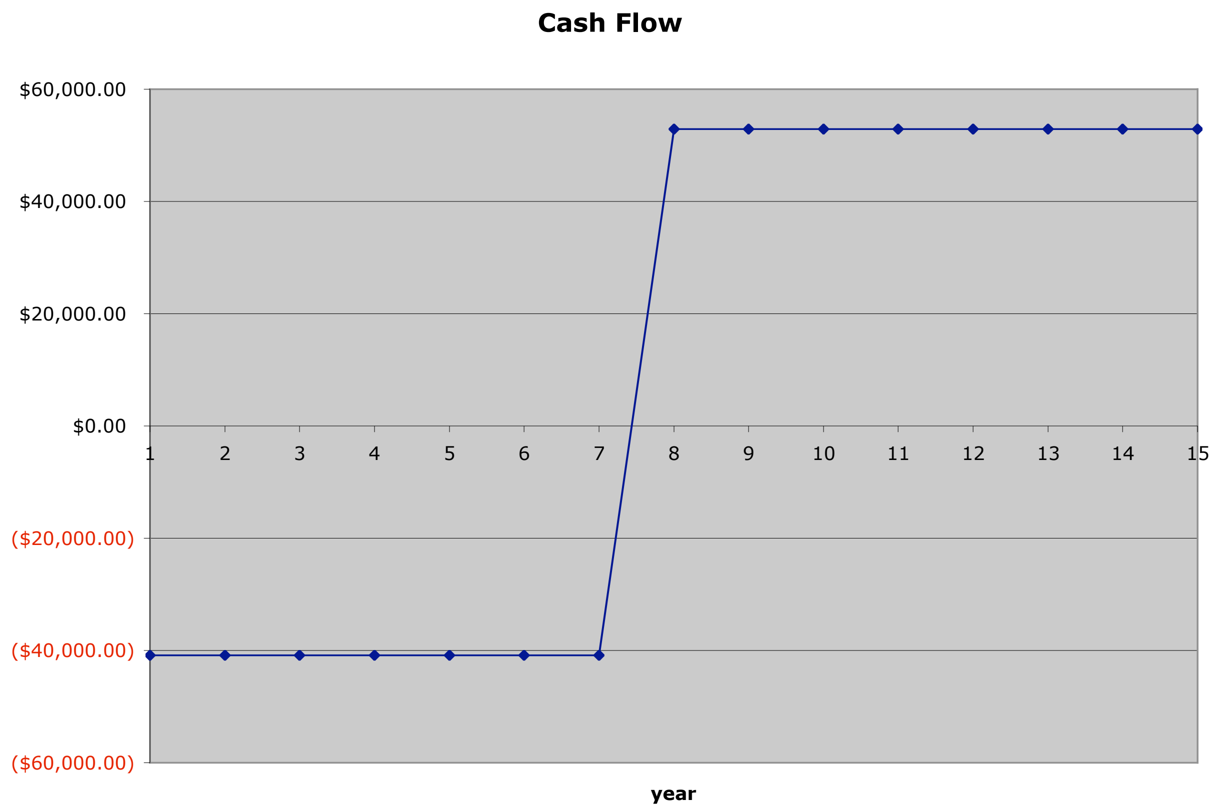
CASH FLOW						
Year	Sales of electricity @ 6 cents/kwh	Sales of digested solids	green tag sales	O&M	Loan Pay-ment	Net Cash Flow
0						
1	43,749	8,213	7,822	6,886	$93,743.17	($40,845.17)
2	43,749	8,213	7,822	6,886	$93,743.17	($40,845.17)
3	43,749	8,213	7,822	6,886	$93,743.17	($40,845.17)
4	43,749	8,213	7,822	6,886	$93,743.17	($40,845.17)
5	43,749	8,213	7,822	6,886	$93,743.17	($40,845.17)
6	43,749	8,213	7,822	6,886	$93,743.17	($40,845.17)
7	43,749	8,213	7,822	6,886	$93,743.17	($40,845.17)
8	43,749	8,213	7,822	6,886	0	$52,898.00
9	43,749	8,213	7,822	6,886	0	$52,898.00
10	43,749	8,213	7,822	6,886	0	$52,898.00
11	43,749	8,213	7,822	6,886	0	$52,898.00
12	43,749	8,213	7,822	6,886	0	$52,898.00
13	43,749	8,213	7,822	6,886	0	$52,898.00
14	43,749	8,213	7,822	6,886	0	$52,898.00
15	43,749	8,213	7,822	6,886	0	$52,898.00
					Net PV	$6,630.15

If it is assumed that the farm itself construct the biodigester instead of having an outside contractor do the job the costs for construction will be reduced approximately 20%. The following table presents the net present values for both the contractor and farm construction alternatives under several alternative assumptions about the increase in energy values over time. In all cases the NPV is positive but of course increases as the rate of increase in energy prices is increased. Also the savings in not using a contractor and building the biodigester with farm employees is substantial.

NET PRESENT VALUE UNDER DIFFERENT POWER PRICE SCENARIOS						
net present value			rate of power price increase			
		0%	1%	2%	3%	4%
contractor		$6,630	$35,469	$66,748	$100,686	$137,522
farm construction		$115,117	$143,956	$175,235	$209,172	$246,009

The bottom line is that the biodigester has a small but positive net present value under the assumption of a constant 6 cent energy per kWh energy value. At a more reasonable 3% price increase the present value increases to about $200,000 with the farm construction option.

Of interest is the cash flow. As is typical for renewable energy production costs, in the years until the construction costs are paid off, costs exceed exceed revenues from power sales. Of interest, is the energy costs per kWh over the life of the project. The costs for the time until the loan is paid off is about 12 cents per kWh. For the remainder of the project life the cost is negative as the sales of the other byproducts more than cover the cost of operating and maintaining the biodigester.



Augmented Biodigester

It is possible to increase the efficiency of the biodigester by the addition of waste cooking oil. The following is from the RCM Digesters report (Appendix C)

"If however, the project could accept restaurant or fryer oil or grease trap waste. The biogas output could be easily doubled as demonstrated by RCM digesters in Pennsylvania and New York. The cost of an engine with twice the output (160 kW) is only about $40,000 more than the selected unit. Adding less than 10% to the investment would yield double the revenue. The current most viable option that RCM could imagine would be to build a 1,500-cow digester with the heifer lot. The 1,500-cow unit would be adequate for the heifers plus up to 50% addition by volume of other organics. By selecting the quality of outside organic inputs, the digester system gas output could generate up to a 350 kW range."[20] Spreadsheets detailing the augmented option are available at: http://www.energy-renewable.com/spreadsheet/biodigesternet.xls .

Recommendation

If a dairy is built a biodigester augmented with waste cooking oil is recommended.

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[20] Manure Digester Pre-Design Study, RCM Digesters Inc. pages 20-21 see Appendix C

Actions

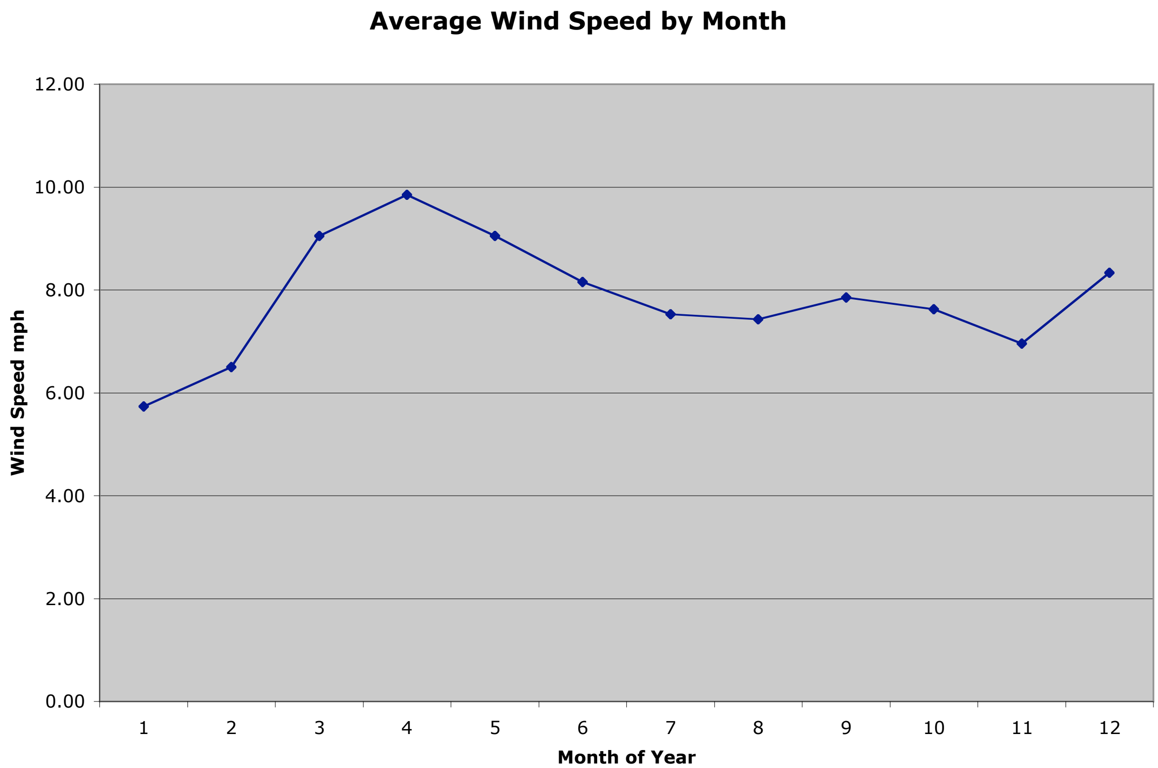
- Contact RCM digesters for development of detailed construction and operating support.
- Secure access to waste cooking oil and or food waste.
- Become certified to sell Green Tags and Carbon Credits. Develop a marketing strategy for selling the Green Tags and Carbon Credits.
- Apply to USDA for loan guarantees and obtain financing.
- Construct and begin operating biodigester, Begin selling Green Tags and Carbon Credits

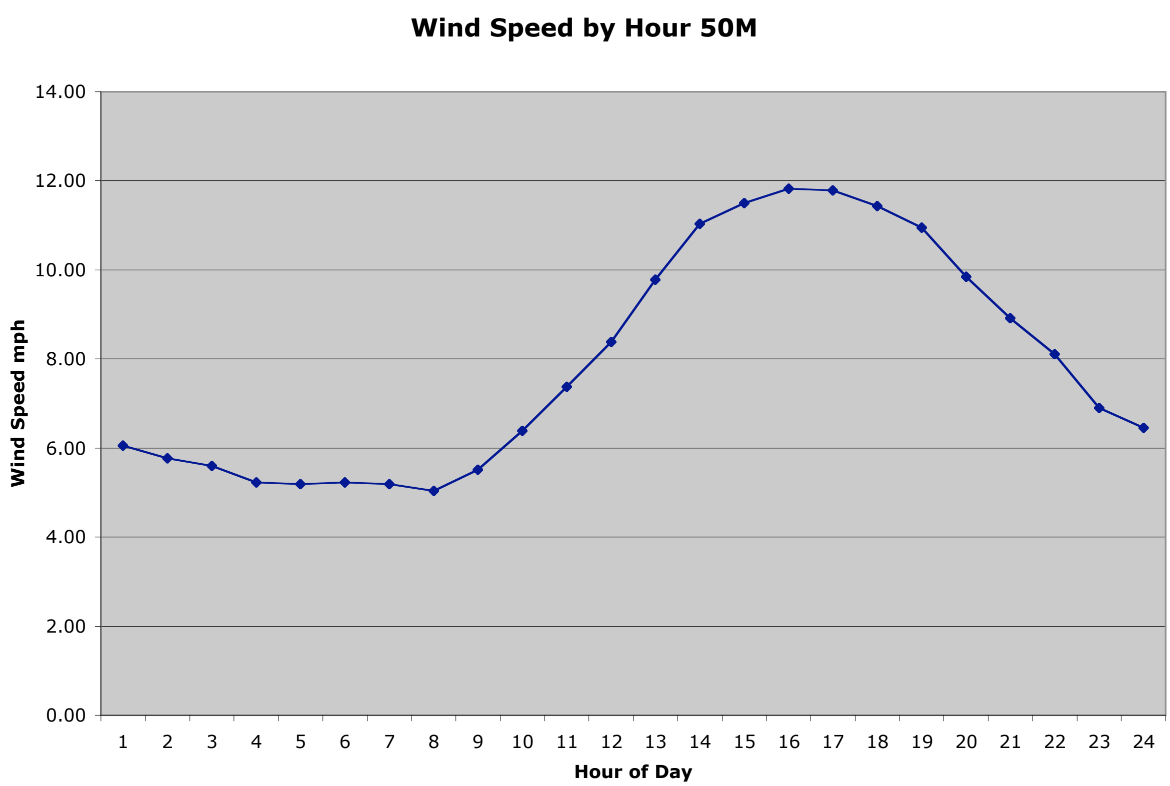
Expected result -- 360 kw electricity at 6 cents per kWh until loan is paid off in 7 years essentially free for the remaining life of the project.

Wind

According to the wind maps available at the beginning of the project and interpolation of the wind data collected from the Arizona Meteorological Network (AZMET) station on Boundary Cone Road, the wind resource on the Ft Mojave Reservation, had potential to be a good but not great wind resource for power generation. To determine the actual wind resource two MET towers were installed at sites selected as likely areas for a wind power station installation.

The following graphs provide an approximate summary of the characteristics wind resource available on the reservation. As can be seen, the average wind speed varies considerably throughout the day. The peak average wind speeds are in the afternoon and early evening which also corresponds to peak energy use times. The winds also vary seasonally, with the highest observed wind speeds occurring in the spring months.


Average Wind Speed by Month
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Wind Speed mph
1
2
3
4
5
6
7
8
9
10
11
12
Month of Year


Wind Speed by Hour 50M
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Wind Speed mph
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
Hour of Day

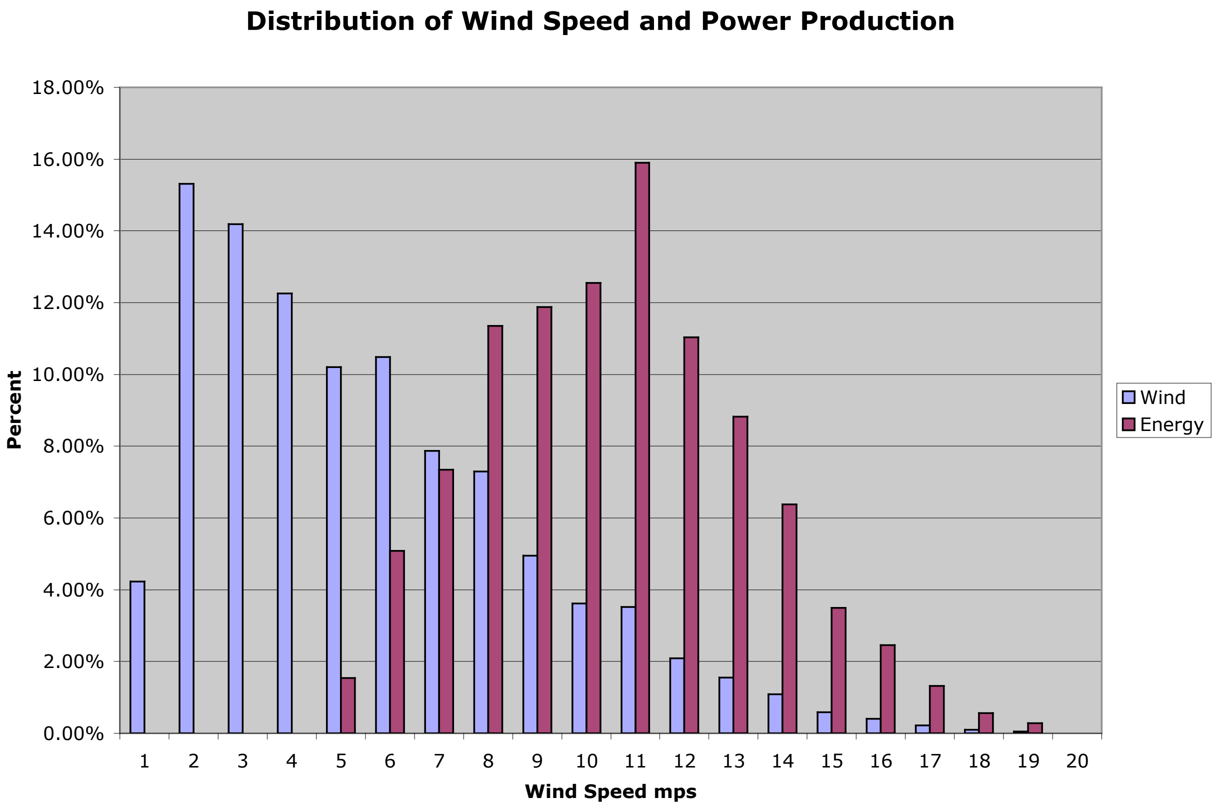
To translate the monitoring results (two towers plus the AZMET data) into estimates of wind energy potential it is necessary to extrapolate the monitoring results, which were collected at 20 an 50 meters heights above ground level to the height of the hub of a commercial turbine, which is typically 80 meters. It is also necessary to extend the time frame of the monitoring results at the tower sites by statistically correlating them to the long term AZMET observations. This estimate of the average wind conditions is used to make projections of the energy production from a typical commercial wind turbine. Commercial utility-grade wind turbines are produced in a variety of rotor sizes and tower heights to optimize output in differing wind conditions. Mr. Ron Nierenberg, a consulting meteorologist, who has been in the wind energy field for more than 25 years,was contracted to provide the translation of the monitoring results into estimates of wind energy production for a suitable for a commercial wind turbine.. His results are presented below. Note that wind speeds are in meters per second. The table presents a wind speed frequency distribution for the 20 meter tower site, projected to 80 meters, and integrated with the GE 77-meter rotor, 1.5 MW turbine's power curve, adjusted to the site's air density. The distribution shows a gross energy estimate of 2.2 GWh or a 16.6% gross capacity factor (CF). This is the long term estimated gross energy output for this site. The gross CF must be adjusted to account for losses such as:

- Grid unavailability
- Wind turbine unavailability (unscheduled and scheduled maintenance)
- Electrical line losses
- Energy consumed by the wind turbine when on standby
- Control losses (e.g. winds that haver around cut in and/or cut-out speed)
- Losses caused by soiled blades from dust and/or bugs
- Array losses from up-wind wind turbines

Such losses can vary from 5% to 15% or more for machines that are spaced closely together. A 10% loss for all causes is assumed for this study, resulting in a net CF of 14.94%.

DISTRIBUTION OF WIND SPEED			
Wind Speed	% of time	Energy per year	% of annual energy
meters per second		kWh	
0	4.23%	0	0.00%
1	15.31%	0	0.00%
2	14.19%	0	0.00%
3	12.26%	0	0.00%
4	10.20%	33,595	1.54%
5	10.48%	110,926	5.08%
6	7.87%	160,431	7.35%
7	7.29%	247,916	11.35%
8	4.95%	259,331	11.87%
9	3.61%	273,991	12.55%
10	3.52%	347,116	15.89%
11	2.09%	241,091	11.04%
12	1.56%	192,679	8.82%
13	1.08%	139,222	6.37%
14	0.58%	76,407	3.50%
15	0.41%	53,692	2.46%
16	0.22%	28,911	1.32%
17	0.09%	12,390	0.57%
18	0.05%	6,195	0.28%
19	0.00%	0	0.00%
20	0.00%	0	0.00%
	Total	2,183,893	

It is of interest to note (as demonstrated in the following graph) that energy production is not a linear function of wind speed. This explains the high percentage of energy produced during low frequency wind events. For example, 16% of the annual projected energy is due to winds in the 10 to 11 mps range which occurs only 3.5% of the time.



The conclusion is that the wind resource at the location of the 20 meter tower is capable of producing only about 15% of turbine capacity. The common rule of thumb,within the wind industry, is that a 30% CF is the lowest CF needed to make an installation commercially feasible without any grant funding or lending rates that are bellow normal commercial rates. This assumes that the federal production tax credit of 1.9 ¢/kWh for the first 10 years of the project is utilized, and the project is 50MW or larger to realize economies of scale. However, there are many differences between the tribal situation and a commercial wind farm. These differences and a more complete economic analysis follow.

Economic Analysis

This analysis is based on information and a spreadsheet template from Bob Lynette, a wind energy consultant who has been involved with the development of wind power projects for 25 years. The spreadsheet is available at http://www.enenry-renewable.com/spreedsheet/wind.xls .

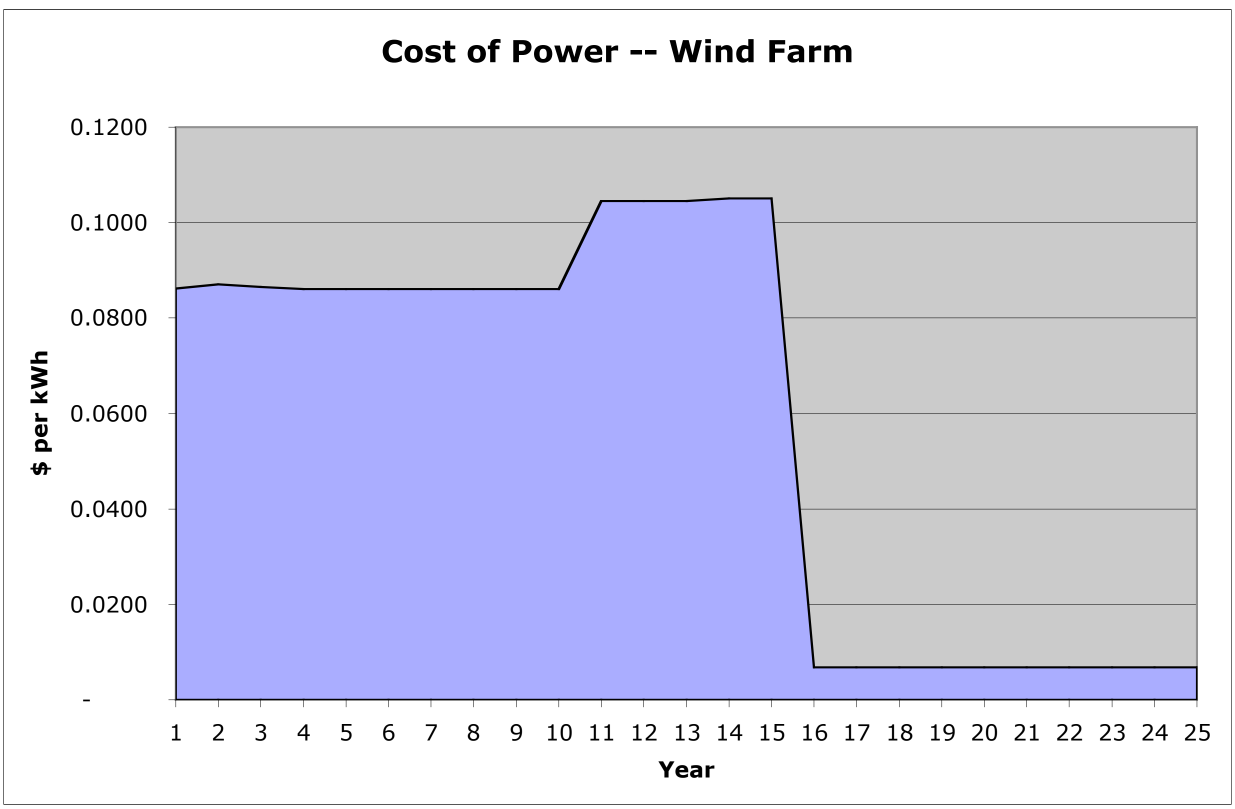
PROJECT DETAILS	
Project Rating (MW)	10
Wind Turbine Rating (kW)	2,000
Numbers of Wind Turbines	5
Net Capacity Factor	0.15
Annual Energy Production per WTG (kWh)*	2,628,075
Project annual energy (kWh)*	13,140,375
Energy rate ($/kWh)	0.07
Control & parts storage	$168,000
Wind turbines	$10,000,000
Installed project cost	$13,000,000
Debt %	100%
Amount financed	$13,000,000
Interest rate on debt	5%
Debt term (Years)	15

PERFORMANCE OVER TIME				
Year	1	10	15	25
Energy kWh	12,746	12,878	12,746	12,746
Energy Revenue	892,231	901,430	892,231	892,231
Operating Expenses				
Wind Turbine repairs	Warranty	77,265	76,477	76,477
Blade Cleaning	6,000	6,000	6,000	6,000
Station Repairs	4,680	4,680	4,680	4,680
Control System Repairs	Warranty	500	500	500
Management	20,000	20,000	20,000	20,000
Security (1 hour/week)	1,040	1,040	1,040	1,040
Contingency	0	11,590	11,472	11,472
Land rent	20,000	20,000	20,000	20,000
Interconnect Expense	1,000	1,000	1,000	1,000
Insurance	22,500	22,500	22,500	22,500
Interest on debt service	650,000	317,852	53,944	0
Principal on debt	602,450	934,597	107,226	0
Cash Flow with debt service	-435,438	-438,330	-447,410	805,040
1.9¢/kWh PTC	242,177	244,674	0	0
Cumulative cash flow of project with PTC	-193,261	-1,953,531	-4,176,960	3,873,439
net present value where discount rate = interest rate	298,073			

Cost Analysis

The cash flow analysis is for a 10MW wind farm and considers the value of the electricity produced to be 7 cents per kWh. This includes any green tag sale and is a conservative estimate (very conservative given the recent increases in power prices and the value of green tags and carbon credits). Given the costs in the table above, the project does have a small positive net present value of almost 300,000 dollars. As is typical for renewable energy projects with most costs occurring in the construction phase, the cash flow from the project is negative each and every year until the loans to construct the project are paid off (year 16). These cash flows are especially bad for the period from year 11 to 16 when payments for the production tax credit are not received.

The best way to characterize building such a wind farm is not for immediate profits but rather as a hedge against unexpected energy price increases and as investment in producing green tags and carbon credits. Producing ones own energy where the major components of cost are known at the start of the project does allow the locking in of energy costs over the 25 year expected life of the project. This reduction in exposure to future gyrations in energy prices is certainly of value, although this value is difficult to quantify. The additional ability to capture future increases in the value of green tags and carbon credits is also of value, again this value is difficult to quantify. The following graph illustrates the realities of the proposed wind farm. For the first ten years the cost of power are about 8.5 cents per kWh. Then the production tax credit runs out and the costs jump 1.9 cents per kWh to about 10.5 cents per kWh. When the loan is paid off in year 15 the costs fall to about .7 of a cent per kWh reflecting the fact that the wind is free and at that point the equipment is paid for. The spreadsheet used for these calculations is available at http://www.energy-renewable.com/spreadsheet/windcost.xls .



To further investigate the feasibility of such a project, sensitivity analysis was used to explore the net present value when different combinations of base energy value and energy value growth rates are used. Here we are considering a combined energy, green tag, and carbon credit value. The results indicate, as expected, that the economics of a project improve greatly as the rate of energy value growth increases. The cash flow problems disappear for the situations where the base price of power is 8 cents or more and the growth rate is 2% or more.

NET PRESENT VALUE AND CASH FLOW					
		rate of price increase			
initial price		0%	2%	3%	4%
5 cent power	NPV	-$3,31,270	-$1,336,379	-$121,886	$1,278,335
	15 yr. CF	-$8,024,461	-$6,554,472	-$5,717,833	-$4,804,914
6 cent power	NPV	-$1,506,598	$863,271	$2,320,663	$4,000,927
	15 yr. CF	-$6,100,711	-$4,336,723	-$3,332,756	-$2,237,254
7 cent power	NPV	$298,073	$3,062,920	$4,763,211	$6,723,519
	15 yr. CF	-$4,176,960	-$2,118,975	-$947,679	$330,407
8 cent power	NPV	$2,102,744	$5,252,570	$7,205,759	$9,446,112
	15 yr. CF	-$2,253,209	$98,774	$1,437,397	$2,898,067

This leaves a dilemma. A conservative analysis assuming no value increases in power does not result in any feasible projects below an energy value of 9 cents per kWh. A project would be reasonable if energy values were to increase (which is the popular opinion and supported by recent value increases in energy as well as green tags and carbon credits). Specifically, if the energy value is 7 cents and projected value increases are 4% or if the energy value is 8 cents and the projected value increases are 2% or more, a project would have both a positive NPV and CF.

The question then arises,if energy values are not currently high enough to justify a project, why not just wait until energy values increase to commit to a project? Several things could happen to make this a bad alternative. One, the costs of the project could increase due to increases in demand for turbines caused by energy price increases. This has happened in the period since the feasibility study began. Two years ago installed wind turbines were about $1,000,000 per MW capacity. Today, due to increased demand for steel, prices are $1,300,000 per MW. Two, the energy price increases could be sudden and the profits missed from not having a wind farm in place could be large. A second possibility is that the efficiencies of wind turbines could increase. Our team's wind farm expert, Bob Lynette suggests " The machines won't get much more efficient per unit of swept area - maybe 1-2% over the next 5 years if we are lucky. Most of the real gains over the past 5 years have been derived by simply placing the rotors higher up and economies of scale (i.e., 100-200 MW installations.)" So the real question is that of price changes for turbines and installation.

To investigate the consequences of delaying the installation of a wind farm the differences in Net Present Value for the situation where the energy price were to suddenly jump to 12 cents was explored. No change in turbine or installation costs were considered. The results are presented in the following table. For a one year delay 95% of the original NPV was captured. Even a 5 year delay captured 78% of the original NPV. Clearly the costs of a delay are real but the value of waiting until energy prices have actually risen to the point of making a project cash flow are real as well.

IMPACT OF DELAY	
Delay in Years	% Net Present Value Captured
5	78.35%
4	82.27%
3	86.38%
2	90.70%
1	95.24%
0	100.00%

Recommendation

If locking in a price in the range of 8.5 cents per kWh for the 15 year period until the loan is paid off and 1 cent per kWh for the remaining 10 year life of the project is judged beneficial to the Tribe, development of a small wind farm is recommended. To put this in perspective, this would correspond to a price of electricity of 7 cents and a green tag payment of 1.5 cents. These values are certainly reasonable, given the current market for energy and green tags.

Actions

- Contact for development of a detailed feasibility and design of a small wind farm. Suggest Bob Lynette and Ron Nierenberg
- Become certified to sell Green Tags and Carbon Credits. Develop a marketing strategy for selling the Green Tags and Carbon Credits.
- Apply to USDA for loan guarantees and obtain financing.

- Find a way to capture at least part of the production tax credits by leasing the wind farm with an option to buy, or some other ownership structure that would allow the Tribe to capture the production tax credits and maintain control of the project.
- Find a way to firm up the wind power resource by banking wind power in hydro facilities.
- Construct and begin operating the wind farm, Begin selling Green Tags and Carbon Credits.

Expected result -- 12,700 mWh per year of electricity at 9 cents per kWh until loan is paid off in 15 years and 1 cent per kWh for the remaining life of the project.

Solar

On site data collection has confirmed the 10 year satellite derived data from NASA that the Ft. Mojave reservation has an abundance of solar energy (Insolation) to be harnessed. The insolation is 5.6 kWh/m2/day on an average annual basis; this is more than over 90% of the country and represents a significant opportunity for utilization by the tribe. This has potential of becoming a significant resource for the tribe. A spreadsheet with the solar data for the reservation collected at the AZMET site on the reservation is available at http://www.energy-renewable.com/spreadsheet/solar.xls .

Opportunities in Housing Construction

The Tribal housing development at Mesquite Creek offers opportunity to implement solar energy related activities that would either reduce energy demand or produce energy. Since reducing energy use frees up energy for other uses it is in some ways equivalent to producing energy. However, since the tribal utility can't charge for saved energy it does have a different set of economic impacts. The following analysis is from team member Jeff Oldham.

Of the opportunities for saving energy the lowest hanging fruit is passive technologies. These would include proper building orientation, appropriate window glazing and overhangs, daylighting, interior mass, passive ventilation, shade cloth for south and west windows and high levels of insulation including radiant barriers in the attic. Deciduous shade trees strategically planted around structures can contribute 1000's of BTU's of cooling and improve the looks and value of the land while providing wildlife habitat and minimizing watering needs on the surrounding landscaping.

The remaining solar opportunities in housing construction are all active. Of these, the most economical is solar water heating. This is a no-brainer in the desert and the climate would even allow a passive “batch” type heater that stores the water in the collector eliminating the need for pumps, sensors and controls. These no-moving-parts systems are elegant, highly reliable and very cost effective. A typical unit will be 4’x 8’ look like a skylight and provide 70-80% of the homes annual hot water needs. On average, a solar water heater will offset 6-8 kWh/day or 15-25% of the total energy consumption of a home. The payback is typically under 10 year and often 6-8 years. The solar water heater becomes the “supply” for the back-up heater, this is a tank type gas or electric heater. If it is supplied with hot water the burners or element does not come on or it requires a modest boost, thus the energy savings and you still have the standard water heater to assure hot water in all weather conditions. A tankless (or instantaneous) type of water heater as the back-up will further increase savings, but consideration must be given to the lower flow rates and ability to supply multiple fixtures at the same time. Installed cost per home should be under $3,000.

Perhaps the most popular use of solar energy today are Photovoltaics (PV), these are electricity producing power modules. Typically they are mounted on the roof, garage or ground. Unlike solar thermal systems (solar water heaters) these do not like heat and output decreases with temperature increases. Never-the-less the Mojave Desert offers long sunny days for a better part of the year.

A possibility would be to utilized PV on 1-5 (.5-1% of the total) homes in an upper scale area of the development as a test bed for the concept and market acceptance. If there are to be any custom homes a few of these would be ideal candidates. The early adopter developers that are already incorporating PV into their new homes are finding that they cannot build them fast enough. Without a state or federal incentive system in place these PV systems are impossible to justify on a purely economics basis. It is this hurdle that often gets in the way seeing beyond the normal development models so that one can realize that the market for green building, self-sufficiency and energy independence is just not meeting the demand. Real Goods is the 3rd largest installer of PV in California and at least 90% of the PV customer’s list economics as among the last reasons for their motivation. Surveys show that 85% of Americans will pay a premium for green products and energy (reality/action shows the number much lower but it still a significant force). It pays (and I’ll argue, SELLS) better than premium carpets, counter tops or hardwood floors. The market for Zero Energy Homes (ZEH) is just taking off and promoted by DOE and the EPA. These builders and developers are riding on a fast and free PR train, gaining attention as it races across the U.S. and making their phones ring of the wall.

Examples:

A typical high performance home (a whole other topic that needs to be addressed) can use 25 – 50% of the energy of the same size home right next door built to “conventional” standards. This would put the usage at about 15 -20 kWh/day on an annual average. This would take a 4.3kW PV system tied to the utility and net-metered at a cost of about $28,000. Will it pay for itself over the 30 year mortgage? Not at today’s rates. Will it pay for itself over the life of the home? Yes! Now, if everything is bundled then it is cost effective and pays for itself in 20 years or less. By bundled I mean all extraordinary features beyond the typical homes being built. This would especially be the building envelope, examples would include strawbale, Insteel, rammed earth and PISE, to name a few. In addition there would be ultra-high performance glazing, doors, weatherization and appliances. In this case the electrical load should be below 15 kWh/day and meet it all w/PV for one of the nations first true ZEH.

Potential

Solar houses with integrated pv electric systems and solar hot water systems and an energy efficient design were judged to have a lower lifetime cost than the current construction methods. The increase in costs for building "green" could be from nothing for something like In-steel or strawbale (once a team is good at putting these together there would be no up-charge) to as much as a 30% premium. Of course the energy savings would overcome the increase in cost well within the mortgage life. Quite often the increase in the cost of building a high performance building is off-set by the reduction or even elimination of HVAC equipment.

The average 1200 sq.-ft. home in America uses 22 kWh/d, The Mojave climate could increase that to 30 kWh/d. By utilizing all of today's conservation techniques and state-of-the-art appliances and loads,passive design and advanced evaporative cooling we should get it down to 8-15 kWh/d. A PV system to meet 100% of this load for a true ZEH would be 2.5 - 3kW. At 3 kW it would be 250 sq.-ft. and add $25 - 27k to the cost of the home w/o any State or utility incentives.

However, the manager in charge of the tribal housing project at Mesquite Creek is convinced that potential buyers would not react favorably to the increased up front costs.

Recommendation -- Continue monitoring

The marketability of integrating energy producing and energy saving features into the construction of new homes on the Reservation needs further investigation and monitoring. Perhaps, more concern for energy efficiency will lead to demands for more efficient housing construction.

PV for Energy Production

A small commercial system of 50kW would produce 210 kWh/day or 76,650 kWh/year. It could be for a business operation or even a RV park. A solar parking structure to provide very valuable shade for the RV’s with the solar modules mounted on top is a logical design. A premium could even be fetched for the shaded spaces. This 50 kW system would cost about $325,000. This is $6,500 per kWh as shown in the earlier tables this has no way of being economically feasible or being able to cash flow without government subsidies or green tags. These cost correspond to an energy cost of over 30 cents per kWh. A simple spreadsheet is available to illustrate these calculations at: http://www.energy-renewable.com/spreadsheet/pvpv.xls .

A larger system sized to be equivalent to the power usage of a 100 h.p. pump could use a 100 kW system in a PV direct application. The cost for this example would be around $625,000. This is $6,250 per kWh. Unfortunately there are few if any economies of scale for PV installations. Again, this application has no way of being economically feasible or being able to cash flow without government subsidies or green tags.

Recommendation -- Continue monitoring

This technology has little chance of being economically feasible without large reductions in cost or large green tag payments or large government subsidies or a combination of all three. At an installed cost of $4,500 per kWh this technology may be feasible.

Thermal Concentrated Solar

By using mirrors or lenses to concentrate solar energy and then converting it to electricity increases in efficiency are possible. However, commercial application of concentrated solar has yet to be demonstrated to be economically viable. A 500 MW concentrated solar plant has been proposed to the tribe by an independent developer but few details were available to our team preparing the feasibility study due to the proprietary nature of the process. As best as we could determine the installed cost would be $4,000 to $4,500 per kWh. The operating cost would be significant as the mirrors need constant cleaning and the maintenance costs on the complicated tracking equipment and power plant must be considerable. To be marginally reasonable the price of electricity (including green tags) would need to be 5 cents per kWh greater than the variable costs of production. This probably means that the break even price of electricity is in the 8 to 10 cent range.

A very significant problem with the thermal concentrated solar technologies is the scale at which they become practical. For these technologies a 50MW plant is the smallest that might be economically reasonable. Even at $3,000 a kw for building such a plant that is 150 million dollars. At this point the bankers become more important than the technology. In addition, adding to the cost is the extra risk premiums developers, financiers and construction/engineering companies add to their charges because the technology is new and all of the performance risks are not known. These costs many in fact be on the order of 15 to 25% or more.

An example of this technology is the Stirling dish technology that is planned for a 500 MW project in Souther California. At $3,000 a kw this is a 1.5 billion dollar project. A description of the project follows:

“If all goes according to plan, a partnership between SES and Southern California Edison (SCE), would see the construction of an expansive 4,500-acre solar generating station in Southern California. When completed, the proposed power station would be the world's largest solar facility, capable of producing more electricity than all other U.S. solar projects combined.

The 20-year power purchase agreement signed today, which is subject to California Public Utilities Commission approval, calls for development of a 500-MW solar project 70 miles northeast of Los Angeles using innovative Stirling dish technology. The agreement includes an option to expand the project to 850 MW. Initially, Stirling would build a one-MW test facility using 40 of the company's 37-foot-diameter dish assemblies. Subsequently, a 20,000-dish array would be constructed near Victorville, Calif., during a four-year period.” [21]

Concentrated PV

"Concentrating solar electric power is on the cusp of delivering on its promise of low-cost, reliable, solar-generated electricity at a cost that is competitive with mainstream electric generation systems," said Vahan Garboushian, president of Amonix, Inc. of Torrance, Calif. "With the advent of multijunction solar cells, PV concentrator power generation at $3 per watt is imminent in the coming few years."

Photovoltaic (PV) concentrator units are much different than the flat photovoltaic modules sold around the world; almost 1,200 MW of flat PV modules were sold last year. PV concentrators come in larger module sizes, typically 20 kilowatts to 35 kilowatts each, they track the sun during the day and they are more suitable for large utility installations.

Ordinary, flat-plate solar modules have their entire sun-receiving surface covered with costly silicon solar cells and are positioned at a fixed tilt to the sun. In contrast, Amonix's systems offer significant cost savings by using inexpensive flat, plastic Fresnel lenses as an intermediary between the sun and the cell. These magnifying lenses focus and concentrate sunlight approximately 250 times onto a relatively small cell area. Through concentration, the required silicon cell area needed for a given amount of electricity is reduced by an amount approximating its concentration ratio (250 times). In effect, a low-cost plastic concentrator lens is being substituted for relatively expensive silicon.

These systems have been under development with Arizona Public Service's solar research facility.

"We have seen steady progress in photovoltaic concentrator technology," said Hayden, Solar Program Coordinator at APS. "We are working with advanced multijunction PV cells that are approaching 38% efficiency, and even higher is possible over time. Our goal is to install PV concentrator systems at $3 per watt, which can happen soon at production rates of 10 megawatts per year. Once that happens, higher volumes are readily achieved."[22]

The APS competitive solicitation requested a 1 MW trough ORC plant that operates unattended with automated startup, shutdown and offers remote monitoring capability. The bids were required to offer system capital costs less than a comparable photovoltaic system and have an operation and maintenance cost lower than the wholesale rate for power (~3¢/kWh). At least three companies bid on the project.

"The trough system that will be used for this project is an enhanced version of solar parabolic trough used at the SEGS plants in California," said Gilbert E. Cohen, Duke Solar VP of Engineering & Operations. "It includes the collector structure, the reflector panels , the absorber tube

[21] http://www.renewableenergyaccess.com/rea/news/story?id=35263

[22] http://www.renewableenergyaccess.com/rea/news/story?id=34626

(also called receiver), a control system and a drive system."

The receiver, one of the key elements of the collector, is a stainless steel tube with a special selective coating surrounded by a glass sleeve. The receiver is located at the focal point of the parabolic trough and heats a fluid circulating inside.

APS will use the plant to help satisfy their Arizona Environmental Portfolio Standard obligation that requires utilities to generate a portion of their energy from solar resources.

The utility believes that small, modular trough plants could provide a lower cost alternative that would help them meet their portfolio requirements within their budget. If cost and performance goals are achieved with the first plant, APS will consider up to an additional 10 MW of systems to be installed over a 10-year period.[23]

Other technologies are also being discussed as economically efficient energy producers. However, until they are in the production and deployment stage all of this discussion is suspect. Two, that look promising on the Web are the Sunflower [24] and the Sunball [25] Of course, only time will tell whether these approaches will produce cheap electric power. If one is too skeptical, it would be easy to miss a promising technology. If one is too gullible, it would be easy to invest in an unworkable technology. It is a fine line.

Only by keeping an open mind and following it up with rigorous analysis is there a chance to come to an acceptable conclusion about these new technologies.

Recommendation -- Continue monitoring

This technology has the best chance of being economically feasible if, as expected, installation costs can be reduced by improvements in the technologies and in reductions in production costs. Contacts with the producers of these technologies should be made and negotiations for development begun if the costs of power are reasonable.

[23] http://www.renewableenergyaccess.com/rea/news/story?id=7262

http://www.energyinnovations.com/sunflower250.html

[25] http://www.greenandgoldenergy.com.au/

Concentrated Solar

CONCLUSIONS AND RECOMMENDATIONS

Keys to Feasible, Acceptable, and Beneficial Renewable Energy Development

- Select technologies that work. Demand to see working installations and performance guarantees.
- Spend as much effort on the financing as on selecting the technology. A very large part of the costs are interest costs.
- Be sure to set up the ownership and control of the project to maximize government subsidies including tax subsidies and maximize tribal control of the project. This will involve some trade-offs.
- Be sure to utilize Green Tags and Carbon credits to provide revenue.

Potential Technologies

- Biodigester -- If a feedlot is built this should be part of the design. They are economically and environmentally reasonable.

- Wind Farm -- If energy prices are expect to increase a small wind farm could be constructed to reduce reliance on purchased energy.

- Concentrated Solar -- These technologies are the best fit with the renewable energy resources on the reservation.

Goal Summary

Acceptability												
	Over all	Economic				Environmental					Sus-tain-ability	Inde-pend ence
Devel-opment			NPV	Risk	Cash Flow		Wild-life	Visual	Noise	Air Qual-ity		
Biodi-gester	59	56	57	75	45	54	50	50	48	55	95	57
Photo-voltaics	0	0	0	75	0	49	50	40	50	50	100	51
Wind Farm	0	0	0	75	42	43	45	30	45	50	100	75
Concen-trated Solar	74	79	75	75	50	47	40	40	50	50	100	100

Of the alternatives investigated in detail, only the biodigester and concentrated solar scored an acceptable rating. However, it should be noted that the assumptions used in the economic analysis were extremely conservative . In particular the energy value was set at 5.5 cents per kWh and any green tags were set at 1.5 cents per kWh. Different assumptions about the value of energy and the potential rate of increase in energy values will lead to much different results. For that reason the basic analysis spreadsheets are available at:
http://www.energy-renewable.com/spreadsheet/biodigesternet.xls ,
http://www.energy-renewable.com/spreadsheet/pvnet.xls ,
http://www.energy-renewable.com/spreadsheet/windnet.xls
http://www.energy-renewable.com/spreadsheet/concsolaret.xls .

Lessons Learned

Economics

The economic analysis of renewable energy projects depends on more than just the costs and efficiencies of the technologies. Because the bulk of the costs of such technologies are in the construction phase of a project the finance costs and government tax and subsidy policies are of critical importance.

The standard approach of using the net present value for cost and income streams into the future needs to be carefully evaluated with respect to the discount rate used. When a high discount rate is used to reflect uncertainty about the future the value of the future energy supplies is reduced (discounted). Since most of the costs of a project are known at the initiation of the project and it is highly unlikely that energy values will fall in the future, it is our judgement that the discount rate used for analysis only reflect the time value of money not serve as an ad hoc method of handling uncertainty.

Because the costs of construction are being compared against a revenue stream for years into the future, the estimates of energy values in the future are of critical importance. As is obvious from the recent increases in oil prices, predicting the price of energy next year much less 25 years in the future is very difficult. Sensitivity analysis, considering a large number of future scenarios, should be used by the decision makers to assist in getting a feel for the possible consequences of renewable energy development. These alternative scenarios can be incorporated into an analysis by estimating the probabilities of various energy prices in the future and using these probabilities to calculate an expected value of the income streams. However, for most technologies, it will still require a judgement to determine whether to develop renewable energy now and count on higher energy prices in the future to pay for it.

Environment

The environmental impacts of renewable energy are in large part simply related to the scale of the development. Since renewable energy sources such as solar energy or wind energy or crop wastes are not concentrated in terms of energy content their environmental impact is related to scale of the project as well as to the technology used to harvest the energy. Whether large wind turbines or solar collectors or energy crops, the scale of development required to produce 10 MW of energy (approximately the requirements of the reservation) will result in visual and other environmental impacts of a magnitude that will be noticed. One can't easily hide 10 wind turbines or 100 acres of solar collectors. The acceptance of these significant visual changes by decision makers in return for the benefits of renewable energy development is a key decision in the development process.

Sustainability

The sustainability of renewable energy production by definition of renewable is high. If it is wind based or solar based it can be considered to be completely sustainable. Crop production, however depends upon land use changes and water allocations. As long as decisions insure the viability of farming on the reservation this source of renewable energy can be considered to be sustainable as well.

Independence

The energy independence of the reservation has two facets. One is simply the energy produced -- energy consumed balance for the reservation. Since there is a natural gas fueled power plant on the reservation this balance is in favor of energy produced when the plant is running. However, the tribal power utility has no control of the output from this plant, and at present the power produced is exported from the reservation. The question then becomes one of both energy production and control of the output. For the reservation to be truly energy independent, in our view, they would need to own and operate or otherwise control the production of about 60,000 MWH a year of energy production. To develop a renewable energy system to produce this level of power would require a 30 to 50 million dollar investment as well as development of the necessary technical management expertise to operate such a facility. If this were done then the reservation would be truly energy independent.

Sources of Information

Cost and performance information is available and reliable on technologies such as wind power and biodigestors that have a history of use in commercial applications. For other renewable technologies that are just beginning to be deployed in commercial applications, the public availability and reliability of cost and performance information is limited. Developers are very protective of their trade secrets. Further until these technologies have been implemented multiple times the design and costs will be continually changing as modifications are made by project developers. The result of the lack of publicly available data on the most recent renewable energy technologies is the inability to develop specific feasibility analysis applicable and reliable for these technologies. The best that can be done is to decide upon a particular class of renewable energy technologies and issue an RFP. This process should result in a firm cost and operating proposal that decision makers can consider without having the detailed information that is currently not publicly available.

Technical Conclusions

Transmission and inter-connection resources are available on the reservation or in the local area to meet the needs of renewable energy development on the reservation.

The wind resource is marginal for development of a wind farm of a scale that would supply a significant part of the reservation needs. If energy prices were to rise further this option might become viable if the visual impact of the towers were accepted.

A biodigester is feasible and reasonable if a feedlot is built on the reservation. However, it would not be of a scale that would provide large amounts of electricity.

Concentrated solar, both photovoltaic and thermal, is a good fit with the energy resources on the reservation.

Business Plan

The development of tribal renewable energy resources involves many tradeoffs. The information presented in the previous sections provide the framework for the analysis of tribally owned and operated renewable energy projects. There are other alternatives.

One possibility is for the tribe to contract for renewable energy instead of producing it. Currently, long term contracts have be bought by California utilities.. If the tribal utility might be able to contract at a reasonable rate then many of the goals of the tribe with respect to energy could be met. A long term supply at a reasonable price would be guaranteed. The energy would be environmentally friendly green energy. If supplies of renewable energy could not be contracted for at a reasonable price the tribe could continue purchase of power from traditional suppliers, including Glenn Canyon and Parker Davis hydropower sources, as well as market purchases.

A second possibility is to allow the development of a renewable energy project on the reservation to be built, owned and operated by a non tribal company and contract for power and receive rent from the project. In this case both a source of power at a known rate and a source of revenue could be obtained.

A third possibility is to allow the development of a renewable energy project on the reservation to be built, owned and operated by a non tribal company and contract for power and receive rent from the project. At the time where the tax benefits to the owners ended, the project could be sold to the tribe at a predetermined price. In this case both a source of power at a known rate and a source of revenue could be obtained as well as ownership and control of energy production at some point in the future.

The fourth strategy is to build, own, and operate a renewable energy project.

The business plan for option one is simple. No renewable energy development is required. Only development of reasonable purchase agreements and strategies for the procurement of power from off reservation sources.

The recommended business plan for option two is more complicated. The first step is to determine the acceptability of the various alternatives. The goal framework developed in this report can provide a basis for the discussion of these choices. Certainly the relative importance of the proposed goals can and should be changed to better reflect tribal priorities. The technical data can and should be augmented with specific proposals via the RFP process, once a technology is targeted as potentially acceptable. For development of tribally owned and operated renewable energy production, the financing, government subsidy, and tax considerations are extremely important. Unfortunately, all of these are subject to, and frequently do, change as political and macro economic situations change. Also of importance are the technical issues involved in designing, building and operating a renewable energy power project. For these the development of a business plan needs to include developing joint projects with developers with the experience and technical resources to get the project up and running and with plan to train tribal enterprise employees to manage and operate the project.

The recommended business plan for option three is simple. Select a technology that is acceptable to tribal goals and issue an RFP for developers to bid against. If a proposal is acceptable then the developer has the responsibility to engineer, build and operate the project in accordance with the terms of the contract.

The business plan for option four is to select projects that are feasible and of a scale that they can be financed and managed with only small increases in tribal enterprise resources. If a feedlot were to be built, the development of an associated biodigester is reasonable and could be done with only marginal increases in enterprise resources to operate the biodigester. Another alternative is small scale concentrated photovoltaics. No units are currently available at competitive prices. However, it is very likely that they will become available in the near future. Certainly, some of the tribal enterprises could incorporate this source of energy into their portfolio, although this would require coordination with the tribal power company.

APPENDIX A

Technical/Methodological Framework For Goal Quantification and Alternative Impact Analysis

The establishment of goals and implementation of the overall approach followed these steps:

1. Definition of the problem.
2. Definition of the components and attributes of each goal.
3. Preference weighting of the components and attributes.
4. Definition of the technical indicators.
5. Quantification of linkages between indicators and perceived attributes.
6. Specification of alternatives to be evaluated.
7. Assessment of the impact of the alternatives on technical indicators.
8. Evaluation of overall effects on a goal of an alternative

The following description of the process followed to accomplish the specification of goals, tradeoffs and impacts in the analysis references the eight steps presented.

The project team met in late 2003 and May 2004, successfully established the focus of the overall project on a 'business plan' format, reduced the number of potential technologies/ alternatives to be analyzed and identified the 'way forward' for the goal evaluation part of the project. Energy saving photovoltaic systems, wind turbine/wind farms, biodiesel, fuel pellet production, biodigestion and an integrated energy production facility were brought forward for further analysis. A meeting with tribal leaders was planned for October 2004 for presenting project progress and soliciting feedback on all aspects of the project. During the early stages of project activities, process items 1-5 were addressed in a preliminary manner.

On August 15, 2004 a first-cut definition of sub-goals, in the form of goal or component attribute trees for each of the four primary goals was presented to the project team for their inputs. Without considering what the final set of alternatives would be, the team was asked to evaluate the trees, suggest the appropriate further disaggregation for establishing technical indicators and propose weights that establish the importance of each attribute. Inputs were received from team members and study/process items 1-5 were refined and items 1 and 2, completed.

On October 13, 2004 a meeting at the Aha Macav Power Service offices addressed the AMPS Board of Directors, that includes the Tribal Chairperson, as representing the relevant interests for the Mojave Tribe. The project manager (Russ Gum) presented the status of the overall project with emphasis on the interim economic feasibility assessments for air turbine/ wind farm, biodigestion, photovoltaics and the use of crop residues and biodiesel alternative technologies. The only alternative technology that was presented as clearly feasible, at that time, was the wind turbine. The analysis of existing site wind data and economics had established the technology as a feasible alternative renewable energy source. The analysis of the use of a biodigester to produce methane for energy production was not clearly economically feasible. However, when Project Goal Achievement and the overall business plan approach are considered, the biodigestion technology becomes attractive and feasible. The off-the-shelf (biodigestion) technology is environmentally friendly, sustainable, meets independence goals and could have a positive economic contribution to overall tribal operations. If optimally installed, the technology/ unit would produce methane from feed lot waste, could lower labor costs for waste handling and produces a useful fertilizer. As a result of the October 13, 2004 meeting, the project team established the final alternatives to be analyzed, completed study item 6 and proceeded with the analysis.

On January 13, 2005 the project team met for the purpose of reviewing the final technologies, establishing the final definitions and weightings and reviewing linkage quantifications as outlined in items 2 through 5 in the study process. The spread sheet enclosed as Attachment 2 illustrates the application of the methodology in terms of values and impacts/effects of each alternative on project goals, effectively process item steps 1 through 8. The technologies carried forward for analysis are wind turbine/wind farm, biodigestion and photovoltaics. While photovoltaics are not clearly feasible economically, hardware costs could change and the technology has a high level of acceptability for the other goals.

Following the January 13, 2005 meeting, the draft Goal Quantification and Evaluation /Trade-off Analyses were completed and integrated into the Business Plan for the Overall project.

APPENDIX B

Technical/Methodological Framework For Goal Quantification and Alternative Impact Analysis

As presented in the Renewable Energy Project Management Plan, the referenced technical approach (Quantifying Societal Goals: Development of a Weighting Methodology, Water Resources Research, Volume 12, No. 4, August 1976) will be used to quantify the goals of Economic Development, Environmental Quality, Sustainability and Energy Independence. From the quantification in measurable terms, each technical alternative can be evaluated independently, with respect to the goals, and compared to other alternatives. The resulting evaluations will allow for trade-offs to be made between alternatives and provide a range of information, beyond economic performance projections, to tribal decision makers.

The method involves the use of a hierarchy such as the goal tree presented earlier in the business plan. The acceptability goals are disaggregated into component parts until the point is reached where human perceptions of changes in the components are possible and 'technical measures' can be established. Once the top-down linkage is established and alternatives can be applied the process reverses as information from the lower levels is aggregated to provide information at higher levels. Measures of an alternative's impact on an attribute determines the effect on more aggregated components and ultimately the impact on the acceptability of a goal.

The spreadsheet, included as attachment 2, illustrates the mathematical approach used in weighting technical preferences and assigning importance to goals and subgoals. Measures of technical indicators are defined as a power function where the powers or exponents assigned to a technical indicator indicate the relative weight of the indicator in determining the component and the sum of all of the exponents is equal to 1 (one). The importance of each subgoal in determining the next, higher level goal is specified by assigning 100 points between the subgoals. The referenced publication explains the process in detail and the justification for the approach mathematically and practically. The method allows technical measures and human perceptions to be integrated into a model of a complex system where tradeoffs can be evaluated.

APPENDIX C

Manure Digester Pre-Design Study

EVALUATION FOR A MANURE DIGESTION SYSTEM FOR 3,000 DAIRY HEIFERS WITH ALTERNATIVES

November 2004 FINAL REPORT
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DISCLAIMER

This assessment is provided as a next step in evaluating the financial and technical potential of methane recovery technology and is to be used as guidance only. The results presented are based on experience, limited data collection and cost estimating functions. Input errors or erroneous information affect the results. Cost estimates are reasonable planning level estimates based on recent pricing for similar materials. However, geographic location, labor costs and materials price changes will affect the results. A final design and cost estimate must be prepared. Qualified designers, engineers and suppliers should be included in the project implementation team. The AgSTAR Handbook may be used for additional reference and guidance in this process. [26]

[26] INFORMATION DEPICTED REPRESENTS BEST ESTIMATES BASED ON CURRENT KNOWLEDGE; ACTUAL PERFORMANCE MAY VARY

PROJECT OBJECTIVES

This study has been requested by The Mojave Tribal Utilities to determine the feasibility of methane production and recovery from manure at their proposed dairy heifer feedlot on the Mohave Reservation, Arizona. The objective of this study is to evaluate the feasibility of increasing revenues to tribal enterprises (Avi Kwa 'Ame Farms and Aha Macac Power Service) by optimizing the recovery and use of energy produced from anaerobically digested manure at the Mojave Reservation in Arizona. The principle resource evaluated was a planned heifer feedlot.

Additionally, the Mojave Tribe is acting in a proactive way to reduce environmental risks associated with manure management, including odor, pathogens and methane emissions.

SUMMARY

There is not an issue of whether a digester can be built and produce biogas at the Mojave Heifer Feedlot. Scraped dairy manure systems lend themselves very successfully to a plug flow digester design. Similar digesters are in use and proven worldwide. However, there are farm operations, equipment purchases, and initial project economic challenges to take into consideration as this project unfolds. Facility designs assumed in this study are similar to those employed in other comparable successful operations. The report is based on information collected during a site visit and interviews with the Mohave Tribal Utility management team. The system pre-engineering design proposal is based on proprietary RCM estimates of manure production, collection, costs and benefits.

This project will look into the possibility of developing an anaerobic digester for biogas production and generation of power for sale. The study has been limited to those degradable resources currently on the reservation or currently planned. Some organic waste may be available from restaurants and residences on the reservation. Other organic waste may be available in nearby cities.

The most viable option that RCM reviewed would be to build a 1,500-cow digester with the proposed heifer lot. The 1,500-cow unit would be adequate for the heifers plus up to 50% addition by volume of other organics. By selecting inputs the output could be in the 350 kW range. Such a project would have a positive NPV.

The heifer-only project is technically feasible, but not economically viable as a heifer manure only digester-to-electricity project. (Benefits of manure management, odor control and fertilizer benefits are not included in the preliminary economic analysis). Assuming all the electricity was sold at $0.06, the Project would have a negative Net Present Value. Increasing the value of electricity or adding other wastes to the heifer manure would increase the value of the project.

FACILITY CHARACTERISTICS

The proposed Mojave Heifer feedlot is to be a drylot with dry corrals for 3,000 heifers. There will be concrete feed lanes where the heifers will stand when eating. The feedlot will be designed for the potential conversion to a 3,000-cow dairy.

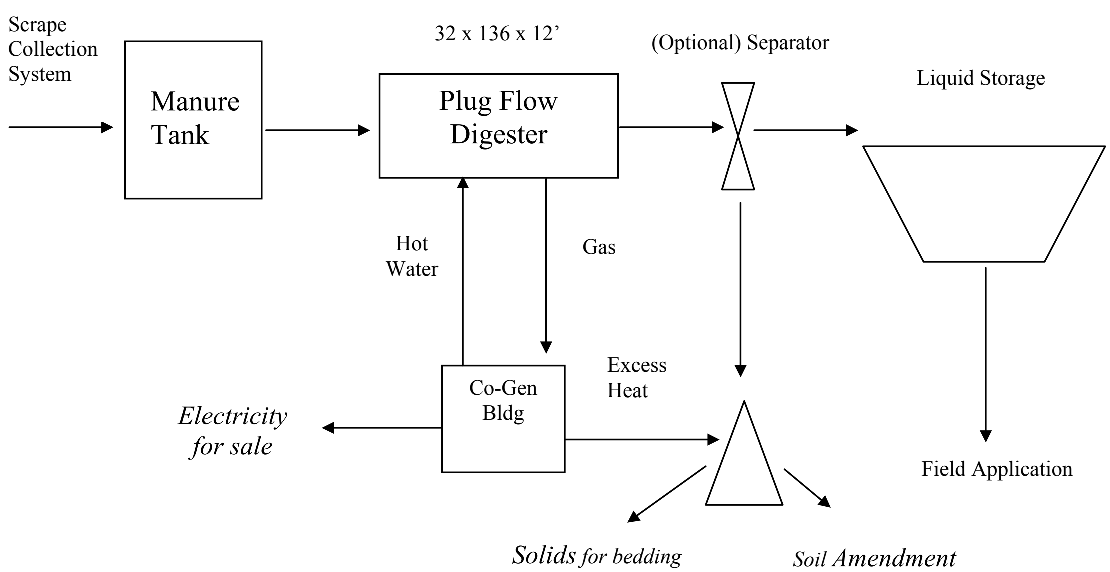
FEASIBILITY OF METHANE PRODUCTION

Methane production utilizing feedlot manure is technically feasible. The key to success is consistent management of the current method of manure collection. Direct economic benefits from the project would be generation of electricity for sale. Direct management benefits from the project would be an expanded manure solids utilization strategy that will enhance an efficient solids recycling protocol on the Tribal farmlands. Non-economic benefits from completion of the project are odor control, pathogen reduction, and a more readily useable liquid waste for crop fertilization.

DIGESTION SYSTEM FOR MOJAVE HEIFER FEEDLOT

Manure will be scraped from the animals housed in a feedlot with concrete feed lanes. The scraped manure would be pumped daily into a concrete plug flow digester with a flexible membrane gas collector. The digester would be heated for optimum gas production. If water is not added in excess, then no mechanical mixing is necessary. Biogas could be used to produce heat and electricity. Digestate could be marketed as a soil amendment. Liquid effluent from the digester will be stored in a waste storage pond to preserve fertility for application onto crops.

Conceptual Process Flow Diagram



BENEFITS AND COSTS

RCM developed the digester design based on the proposed plan to construct the Mojave Heifer Feedlot. It is assumed that approximately 50% of the manure would be collectable. Only fresh manure scraped from the concrete feed lanes will be considered. The digester design will accommodate an equivalence of 2,100 Animal Units (AU) at 1,000 pounds each or an approximate equivalence of 750 mature dairy cows plus capacity for other organic feedstock.

Capital Costs

This 1,500-cow digester system is estimated to cost $542,431 depending on construction techniques, the range of construction work completed by Tribal enterprises, possible grant funding awards, and energy buy back rates. Annual operation and maintenance costs average $6,886. These construction cost estimates will hold through June 2005.

Benefits

This digester system can produce a total benefit of $52,897/year. The payback period for this system is 10.3 years. The heated digester could produce an average of about 92 kW per day worth over $43,749 in annual electrical sales for Mojave Heifer Feedlot.

There are fertilization benefits from digested effluent that can enhance irrigation application techniques and crop utilization of the nutrients. Environmental benefits include a significant reduction of odors, weed seeds and pathogens from the waste stream. Most dairy farms have manure storage pits, ponds, or basins, which often produce offensive odors. These structures were usually designed for waste storage needs and not necessarily for effective waste treatment. Consequently, the waste storage structures produce effusive and disagreeably odiferous volatile organic acids due to incomplete anaerobic digestion. On the other hand, long term, or complete anaerobic digestion produces a stable and odorless mixture of methane and carbon dioxide. The treated liquid form the anaerobic digestion process can be stored long term without any odor concern, due to the dominance of non-odor inducing anaerobic bacteria that would populate the storage reservoirs.

ALTERNATIVES

Digestible Resources

Food waste from restaurants, cafeterias and prisons; food-processing waste, animal manures, and certain other organics can be co-digested to make biogas. Nearby Bullhead City and Laughlin, Nevada produces a great quantity of degradable organics and could be considered as sources.

However, the Council will have to decide if it wishes to import garbage or materials that would pay a tipping fee, and produce energy.

The Avi Casino is probably the largest source of food waste on the reservation. If these or any other sources can produce segregated waste streams, i.e. without metal, glass or plastic, the putrescible materials can be sent to an anaerobic digester.

One possibility that could pay the tribe a return from both tipping fees and high biogas output would be treatment of waste vegetable oils from restaurant fryers and grease trap wastes. Both are highly degradable waste hauled from restaurants regularly for a fee. This is being done in California and New York dairy digesters. These products are very highly degradable carbon with low content of fertilizer elements.

Composting for potting soil

Composting digested manure solids has benefits for fertility, pathogen, odor and fly control. If the option to separate the solids and develop a potting soil market for the digested solids does not seem viable, then current practices and utilization of the solids for crop fertilizer should be continued. A conservative estimated market value for salable potting soil has been included in the model for consideration.

Other options for the system operations may become apparent as the project is developed and may merit further investigation.

INTRODUCTION TO BIOGAS TECHNOLOGY

A PROMISING SOLUTION

Anaerobic digestion is one of the few manure treatment options that reduces the environmental impact of manure and produces savings and revenues. Anaerobic digestion will not solve all of the problems of manure. However, it will result in a return on the manure management investment and stop the manure from managing the owner.

OVERVIEW OF ANAEROBIC DIGESTION

Manure consists of partially decomposed feed, waste feed and water. Manure alone or mixed with process water and flush water is generally too concentrated to be decomposed aerobically in a manure treatment or storage structure, because oxygen cannot diffuse into solution fast enough to support aerobic bacteria. Therefore, manure is broken down sequentially by groups of anaerobic bacteria. An anaerobic digester is a vessel sized to grow and maintain a population of methane bacteria that feed on organic wastes placed in the unit. The bacteria grow without oxygen, decompose the waste, and produce methane as a useable fuel byproduct. Methane bacteria are slow growing, environmentally sensitive bacteria. These bacteria require a pH greater than 6.5 and adequate time to convert organic acids into biogas. Methane production is reduced as water temperature decreases.

Anaerobic digestion can be simply grouped into two steps. The first step is easy to recognize because the decomposition results in bad manure odors. In the second stage methane bacteria consume the products of the first step and produce biogas - a mixture of methane and carbon dioxide. Biogas from a stable digester contains 60% - 80% methane. Biogas is virtually odorless but contains a small amount of mercaptans such as hydrogen sulfide.

ENVIRONMENTAL BENEFITS

Much information has been published about energy production from anaerobic digesters.

Equally important, however, a properly designed and operated digester biologically stabilizes organic wastes, reduces odor, improves fertilizer value, and reduces pathogens. It can be expected that future regulations will increasingly require environmental control in farm wastes.

Numerous examples where effective odor control goals have been met with the installation of a digester can be found in the literature. The early pig manure digesters in the US were installed principally to control manure odors. A pork producer in Pennsylvania has a long history of effective odor control with his manure digester system. The farm was located within one half mile of towns and sub-divisions and had an acute odor problem prior to installing a digester. The heated digester has stabilized the manure, collected usable gas and most importantly, satisfied the objections of the neighbors, town council, and state regulators.

There are several additional examples of successful manure digester projects designed and installed by RCM Digesters, Inc. primarily for odor control measures. The AA Dairy in Candor, N.Y. has reported a high measure of odor control that has put him back in good standing with his neighbors. Swine facilities in Colorado, Illinois, Wyoming and South America have all reported a significant benefit from the tremendous odor reduction provided by their digester systems. While difficult to assign an exact measurable quantitative reduction in odors, the fact that nuisance complaints have stopped against these facilities supports the effectiveness of the digester systems in odor reductions.

EFFECT OF DIGESTION ON BOD, NUTRIENT, PATHOGEN AND WEED SEED

Anaerobic digestion in a digester will reduce biological oxygen demand (BOD) and total settable solids (TSS) by 80-90%. Odor is virtually eliminated. The digester will have minimal effect on the nutrient content of the digested manure. Pathogen reduction is greater than 99% in a 20-day hydraulic retention time (HRT) mesophilic digester (100 degree F). Half or more of the organic nitrogen (Org-N) is mineralized to ammonia (NH3-N). A small amount of the phosphorous (P) and potassium (K) will settle as sludge in most digesters. Digesters are very effective in killing weed seeds.

DIGESTER DESIGN CONSIDERATIONS

There is a plan to develop a dairy facility on an open 320 acres on the Mojave Reservation over the next 2 years. The working plan is to build corrals and populate them with growing dairy heifers between 600 and 800 pounds. The future plan includes the option to add a milking parlor and put 3,000 dairy cows in the corrals. Manure collected fresh from cattle can be anaerobically digested to produce biogas and electricity.

RELATIONSHIPS

Currently, the farm ships hay to several dairymen and receives manure for the back haul to be used as fertilizer. Unfortunately the manure shipped is, for the most part, too old to produce much gas. Should the management be changed to collect fresher manure, that manure could be used for digestion. This in unlikely to happen due to the fact that fresher manure has higher water content and thus less can be shipped on a truckload due to the increased weight.

CONCEPT

The basic concept being explored is to digest the manure from the planned feedlot. The planned feedlot can be built for regular manure collection. Other organics may be added to increase yield.

Grease trap and vegetable fryer oil waste seems to be the only simple fit for the digester.

Ultimately all the effluent from the digester will be field applied; the land area required will be based on the fertilizer content of the effluent.

WASTE GENERATION AND COLLECTION

Waste from the dairy heifer feedlot will include manure, wastewater and contaminated rainfall runoff. It is collected at regular intervals and transported either to storage or cropland.

ANIMAL POPULATIONS

The feedlot is to be a dry lot operation with dry corrals and concrete feed lanes where the cows will stand on concrete when eating. If the feedlot is build with gates between corrals at the feed lane, manure can be easily gathered and removed to an onsite digester.

The objective of this study is to evaluate the feasibility of increasing farm revenues by optimizing the recovery and use of energy produced from anaerobically digested manure at the Mojave Reservation in Arizona. This portion of the study will derive digester system parameters from animal population numbers and manure generation rates; it will also provide a cost estimate for the system and performance projections as well as assessing project economics.

With 3,000 heifers the feedlot manure management could use anaerobic digestion. The animal population estimate assumed for this study is summarized in Table 1.

Table 1: Animal Population Estimates

Type	Number	Average Weight- lb.	Total Weight- lb.
Heifers	3,000	750	2,100,000
Calves	0	200	0
Total	3,000		2,100,000

MANURE GENERATION

The 2,100,000 lb. of animal weight corresponds to 2,100 animal units. However, only half the manure from the animals can be collected because of the dirt surface of the feedlots. The manure collected from these animals would be about 1,730 ft3/day if collected raw at 12.7% total solids (TS). Onsite drying will reduce the volume collected to around 1,000 ft3/d. However, the manure would be rewet for digestion. Waste flow available to feed the digester is summarized in Table 2. (Some variables reflect rounding errors.)

Table 2: Waste to Digester

Animal Units	2,100	1000 lb. units
Manure Production	1,730	ft3/d
Process Water	0	ft3/d
Total Manure Inflow	1,730	ft3/d
Manure VS	10,358	lb/d

Other Waste Streams Added to Manure

Mojave Heifer Feedlot has no current plan developed to import outside organic matter for digester feed stock. However as noted earlier, the 1,500-cow unit would be adequate for the heifers plus up to 50% addition by volume of other organics.

DIGESTER SYSTEM DEVELOPMENT

DEVELOPING THE DIGESTER

This study considered options for digester designs and feedstock scenarios. A digester for Mojave Heifer Feedlot is sized and presented for approximately 3,000 heifers housed in a dry lot facility with scraped concrete feed lanes. The digester sizing reflects 2,100 animal units (AU) contributing manure to the digester system. Daily scraping manure fresh from the concrete feed lanes presents the most favorable situation to make methane from manure for the Mojave heifer farm.

DIGESTER DESIGN VALUES

Selecting the proper type of digester

A digester system is matched to the manure handling system. Mojave Heifer Feedlot will collect their manure using mechanical scrape system; therefore the manure will remain thick. This raw manure is too concentrated for a mixed digester. The manure is too thick for any covered lagoon or attached media reactor. Therefore, a plug flow digester is the best choice.

A plug flow digester is heated and not subject to any seasonal performance variations. It will efficiently produce gas year round. Unheated digesters make more gas in the summer than in the winter. Heated digesters can be smaller because the rate of reaction is higher when the bacteria grow in a warmed environment.

A heated plug flow digester will be developed and evaluated for the Mojave heifer ranch with scraped feed lane manure collection. The proposal is similar to existing RCM digesters that are operating at other scrape collection farms.

Sizing the Digester

Digester operation is dependent on controlling manure quantity and quality. All of the following factors need to be reviewed prior to constructing a digester. Each could affect the digester size.

If there is any outside organic waste (such as food waste or cheese whey), it could be added to a digester to make more gas. If such a scenario is pursued, it is recommended that an agreement concerning quantity, content and constant availability of the material be developed. This plan would need to be accounted for in the digester system design.

Not more than 25% of design volatile solids may come from any non-manure source.

Sufficient grit will settle in the digester to require cleaning in 6-12 years, depending on dirt contamination and water management.

Mojave Heifer Feedlot Digester Design Values

The influent volume of 12,937 gal/day is used to size the digester, estimate the average gas flow, and determine the engine generator size. The calculated values are presented in Table 3. The 750 mature cow equivalents will allow others to compare the assessment for the feedlot option with an assessment prepared for a full size dairy cow operation. It can easily be predicted that a 3,000-cow dairy, even with only of the manure collected, would produce a lot more manure and electricity than the heifer feedlot.

Table 3: Digester Parameters

Total Cow Number	750	Mature Dairy cow equivalents
Influent Volume	12,937	gal/d
Total Digester Volume	51,888	ft3
Number of Digesters	1	ea
Length	136	ft
Width	32	ft
Depth	12	ft
Diameter	NA	NA
Cover Dimension	4,787	ft2
Engine-generators	92	kW

Digester System Performance

The electrical performance of a 100 kW capacity system run at the expected 92 kW average output has been modeled and presented in Table 4. It is assumed that all electricity will be sold because a heifer ranch uses very little. Total estimated annual production would be 729,144 kWh. Electricity production valued at $0.06/kWh would produce $43,749 /yr.

Table 4. Electrical Performance (selling electricity at $0.06/kwh)

Month	days/mo	Biogas Ft3/day	Hourly Average kWh	Potential Biogas kWh/mo	Need v prod balance kWh/mo	Electricity Surplus sale $/mo
January	31	51,791	92	61,927	61,927	$ 3,716
February	28	51,791	92	55,934	55,934	$ 3,356
March	31	51,791	92	61,927	61,927	$ 3,716
April	30	51,791	92	59,930	59,930	$ 3,596
May	31	51,791	92	61,927	61,927	$ 3,716
June	30	51,791	92	59,930	59,930	$ 3,596
July	31	51,791	92	61,927	61,927	$ 3,716
August	31	51,791	92	61,927	61,927	$ 3,716
September	30	51,791	92	59,930	59,930	$ 3,596
October	31	51,791	92	61,927	61,927	$ 3,716
November	30	51,791	92	59,930	59,930	$ 3,596
December	31	51,791	92	61,927	61,927	$ 3,716
Totals		621,492		729,144	729,144	$ 43,749
AVERAGE		51,791	92	60,762	60,762	$ 3,646

BIOGAS USE OPTIONS

The biogas production of 51,791 cubic feet per day could be burned in a continuously operating engine-generator unit to produce electricity for sale into the grid. It is projected that a system at the Mojave Heifer Feedlot could produce about 92 kilowatt-hours on average.

Biogas can also be burned directly for heating systems. Seasonal variations in the available heat recovery must be considered due to the priority heating requirements of the digester during the coldest months. A seasonal minimum and maximum estimated heat recovery potential was presented in Table 5.

Table 5. System Outputs

	Heated Systems	
Gas Production	51,791	ft3/d
CO2 Equivalent	5,215	Metric T/yr
Electricity Output	92	kWh avg
Heat Recovery	339,634	Max Btu/hr
	96,905	Min Btu/hr

SAFETY

Prudent digester operation is safe. There are very few pieces of equipment or practices used with a digestion system that are not already on the farm. Biogas, while comprising of 60% methane, does not contain the oxygen necessary for combustion. The inflated digester top has no oxygen within. As with all manure management, confined spaces must be ventilated for safe entry. As with all internal combustion engines, certain operating norms should be maintained. This application is little different from standby engines using natural gas or propane.

Induction generators are used as added safety precautions for those times the utility is off line.

When the utility is not providing power, the induction generator will not produce power.

Backfeed to unwary linemen is nearly impossible. Moreover, redundant electronic safety relays and logic in the cogeneration control panel will also prohibit engine generator operation during outages. US utilities also require lockout boxes for their use when planning powered down line work. Local and federal regulations and standards should form the basis for operation.

DIGESTER PROJECT FOR MOJAVE HEIFER FEEDLOT

DIGESTER

Digester type

The digester would be scraped manure, high solids plug flow digester. A plug flow digester is not subject to any seasonal variations because it is a heated system.

Digester size

The digester is sized for up to 30 days of manure retention. The digester will be 32 feet wide, 12 feet deep and 136 feet long.

Digester construction materials

The digester will be made from reinforced concrete. The tank will have rigid walls and a flexible top will be attached. The digester will have an overflow weir at the effluent end. The weir keeps gas in, maintains the manure level, and lets digester effluent out.

Influent manure pipe

The influent manure and wastewater will enter the digester through an 8-inch PVC pipe located in the end wall.

Digester heating

The digester will be heated by circulating hot water through several racks of 3 inch steel pipe inside the digester. The pipe will not corrode because there is no acid and no air in the digester.

Digester insulation

Due to the relatively mild climate, no insulation will be included for the digester.

Digester mixing

The plug flow digester requires no agitators or moving parts. If too much water is added to the digester, then a mixer will be required

Digester gas collection

An inflatable top will be secured to the top of the digester wall and a 6-inch PVC gas withdrawal pipe will be installed inside the digester under the cover.

Digester influent chase size and location

The digester influent chase is a leak proof box on one digester wall where hot water pipes enter the digester and gas pipes leave the digester. Sometimes the manure entry pipe may pass through this same box. The pipe chase housing gas and water plumbing will be located near the feed end of the digester. An 8-foot wide x 6 feet long x 4 feet deep wood or cement block box built onto the side of the digester will be used. The chase should be covered.

Digester effluent structure

The digester effluent flows out of the digester through and over a weir that is built into the effluent end wall. Outside of the weir could be an effluent tank.

Effluent Tank/Chamber

A digested liquid will overflow the effluent weir into an attached tank for pumping either to separators, storage, cropland or a tanker for hauling. The effluent chamber would be covered with a treated wooded cover.

BIOGAS UTILIZATION EQUIPMENT

This section includes piping, buildings, and equipment to tie the digester to gas use.

Field Piping: Gas and Hot Water from the digester to gas uses

All buried pipes will be approximately 3 feet below the finished grade. All plumbing will run underground.

Influent Piping

Manure from the future heifer feed lot will be collected and pumped to the influent tank. A mixer/pump will be sized to deliver feedstock to the digester.

Gas piping

The collected biogas would be piped to the engine in an 8-inch PVC buried pipe. An 8 inch PVC pipe to a flare will be buried and properly sloped to avoid water becoming trapped and blocking the pipe.

Hot water piping

Hot water collected from the gas utilization system would be piped to the digester in buried insulated pipe.

Effluent piping

Effluent piping is planned to deliver the digested effluent to a waste storage basin.

BIOGAS UTILIZATION

Location

Biogas use equipment must be close to normal on-farm traffic patterns to make monitoring easier. Moreover, distance should be minimized between the heat recovery system and the heat uses

Equipment Housing

The engine-generator should be housed in a 30'x 40' co-gen building. The building will meet Federal standards of 22-gauge painted steel walls.

Gas management

Once the gas is collected from under the digester cover, it must be moved to the gas use equipment. Typical gas management would include a gas pressurization unit with meter, gas blower and particulate filter. A meter will track the system output and is a good indicator of overall digester operation. A particulate filter will remove some water and hydrogen sulfide from the gas.

Excess gas flare

Excess gas must be safely burned. Excess biogas would be released through a relief valve and burned in a 4-inch flare that will be located a minimum of 100 feet from any structure.

Gas Use

Biogas could be used to fuel:

Co – Generation system

Engine driven equipment, such as a refrigeration compressor

Hot water boiler system

Irrigation pumps

Engine Notes

The engine will require safety devices such as: low oil level shutoff, high oil temperature and high water temperature shutoff.

Electricity Generation Notes

The generator would be wired into the dairy 220-volt main electric panel. Automatically operated motor contactor at the generator and manual disconnects in the engine room and in the dairy electric panel room will ensure safe high quality power. The engine generator will operate in parallel with the utility system at a constant level of output controlled by the biogas supply equipment. Parallel generation means that electricity generated by the biogas unit will be mixed with the utility supplied power. Shortfalls in electricity production are automatically fed by the utility and excesses flow off the dairy and into the utility system. A utility-approved electrical safety system will be required to insure disconnection of the generator from the utility system during power outages to avoid energizing power lines off the dairy. Typical interties of this type include solid-state commercial relays to monitor voltage, amperage and frequency.

Hot Water Recovery, Storage and Utilization

Digester temperature maintenance is paramount to assuring adequate digester operation and performance. Hot water exchanged from the engine cooling and exhaust will enter a separate loop for digester heating. The hot water enters the digester and is pumped through a series of heat racks that are constructed of steel pipe. A hot water circulating pump of about 10 horse-power would be required.

Farm Energy Usage with Digester System

The digester will not add any significant new electric loads above and beyond what is already utilized by a dairy.

DIGESTATE MANAGEMENT

The digester produces a biologically stabile liquid digestate that has very little odor, has a 99% pathogen reduction rate, still contains most of the nutrients of the original manure, and is not a good host for fly production. Digestate is a combination of liquids and some residual solids that were not digestible. Solids can be separated or not. The digestate is then either stored, field applied or dried.

Solids Separation System

Digested solids are a valuable byproduct that may merit some product marketing as potting soil or soil amendment. However, the preliminary budget has not included the cost of an installed separator. Raw manure is pumped to the digester and digested effluent can be pumped to a separator before discharging to storage. The separated liquid as well as an emergency effluent chamber overflow will be plumbed to permit direct flow to the waste storage pond if needed.

Table 6 shows typical liquid nutrient and fiber characteristics after digestion.

Table 6. Characteristics of Fiber and Liquid

	Fiber*	Liquid+
	*lb./CY	+lb./1000 gallons
N	4.5-6.0	30-40
NH4+	2-3	15-20
P2O5	2-3.5	10-15
K2O	2-3.5	20-30
S	0.5-1.5	2-4
Mg	1-2	5-8
Ca	3-4.5	7-10
TS	20% - 30%	4.5%-5.5%
pH	7.8-8.5	7.5-8.2
Density	800-1000 lb./CY	8.5-8.6 lb./gal.
Consistency	"Moist peat moss"	"Chocolate milk"

Storage of Digestate and Nutrient Management Plan

RCM recommends a plan for the beneficial use of digestate nutrients be developed. It is beyond the scope of this study to address waste storage designs. Developing a management plan that results in applying manure nutrients to cropland at the time and in the correct quantity to meet crop fertility needs can optimize the value of manure nutrients. It is beyond the scope of this study to develop a nutrient management plan.

B E N E F I T S   A N D   C O S T S

BENEFITS TO RECOVERING METHANE IN A DIGESTION SYSTEM

Outputs

The principle beneficial output would be the value of biogas as a fuel, replacing another source of energy. A digester could easily produce electricity to sell to grid. The value of the digested fiber as a high quality bedding for milk cows can be significant. Another possibility might be to package the greenhouse gas reductions under the Kyoto Protocol and receive monetary benefit in exchange for operating the digester. Additionally, if a stable soil amendment market for the composted fiber were developed, the farm could realize an additional revenue source for the operation.

Monetary Benefits

There is positive cash flow for the project. The methane recovery and utilization system will produce financial gain for the digestion system owner over a 15-year project life. An important budgetary factor for consideration is the fact that the new construction was priced as “contractor built” with consideration for local rates, which can be as much as 20 to 25% higher than when a farm does its own construction. . Table 7 summarizes the system benefits assuming all electricity is sold at $0.06/kWh.

Table 7. Benefits

Type of Digester	Heated Plug Flow
Electricity purchase offset	$ -
Sale of excess electricity	$ 43,749
Electric Capacity Savings	$ -
Hot Water Offset	$ -
Sale of Digested Solids	$ 8,213
Greenhouse Gas Tax Credits	$ 7,822
TOTAL POTENTIAL BENEFIT	$ 59,783
LESS O&M @	$ 6,886
NET POTENTIAL BENEFIT	$ 52,897

Non-monetary benefits

There are other project benefits. Table 8 summarizes non-monetary benefits expected from the installation of a digestion system.

Table 8. Non-Monetary Benefits of a Digestion System

1. Odors from manure will be greatly reduced when biogas is produced in a controlled fashion, captured and burned.
2. Pathogenic organisms in the digested manure will be greatly reduced.
3. Recovery and combustion of methane reduces the uncontrolled release of methane, a highly reactive greenhouse gas, from manure management to the atmosphere.
4. Weed seed in land-applied fiber is greatly reduced.

ESTIMATED COSTS

The system designed for only the Heifer Ranch manure would be a plug flow digester. If other organic materials are imported, the design may become a complete-mix digester depending on the combination of wastes treated. The overall cost of the system is $542,431. This includes the cost of the digester system, the engine-generator set, design engineering and contingencies. Details of the cost estimate are provided in Table 9. The estimate does not include a manure storage facility which might cost as much as $50,000 because the ranch would be expected to have a minimum manure investment, which is at this time unknown. (Some variables reflect rounding errors.)

Table 9. Cost Estimate: Plug Flow or Complete Mix

Remote Mix Tank	$	13,158
Manure Pump, pipe, install	$	25,484
Manure transfer pipes	$	6,000
Excavation	$	11,627
Digester	$	159,424
Gas/hot water field piping	$	16,850
Engine-generator building	$	23,467
Gas pump, meter, filter skid	$	44,917
Hot water Management skid	$	26,694
Engine-generator	$	110,500
	$	**438,119**
Contingencies	$	43,812
Engineering/Site Assist	$	52,000
Startup fuel and equipment	$	8,500
	$	**542,431**

PROJECT ECONOMICS

An economic analysis for the project was conducted based on the assumptions that the project would not require a loan. The assumptions and factors used in the analysis are summarized in Table 10. It was also assumed that the project would sell all of the generated power since very little would be used at the heifer facility. The Project Operating Assumptions are presented in Table 11.

Table 10. – Project Economic Assumptions

Project life	15	Years
Loan period	0	Years
Down Payment	100	%
Loan Interest Rate	0	%
Discount Rate	10	%
Tax Rate	0	%
Depreciation	None	
O&M Costs	$0.010	/kWh
Energy Cost Growth	3	%

Table 11. Project Operational Assumptions

System Thermal parasitic	as needed	
System Power parasitic	8%	
System "uptime"	90%	
Boiler efficiencies	80%	
Electric Offset value	$ -	/kWh
Electric Sale value	$ 0.060	/kWh
Offset thermal valued based on	$ 10.75	$/MM Btu

ESTIMATED COSTS Based upon the investment and benefit assumptions made above, the economic analysis is described in Table 12. This resulted in an internal rate of return of 9% and a project payback of 10.3 years without grant assistance.

Table 12. – Economic Analysis of Investment

Calculated Values	Plug Flow
System Cost	$ 540,000
Amount Financed	$ -
3rd Year Revenue	$ 59,783
3rd Year O & M	$ 6,886
Performance Values	
Net Present Value	$ (17,075)
Internal Rate of Return	9%
Payback Years	10.3

Sensitivity of Economic Assumptions

The most sensitive elements of the analysis are the cost of the project and the value of the outputs. The cost of the system has been optimized to the assumptions, however the project has not investigated potential sources of funding such as grants. With a 25% grant award, the project payback period would drop to 7.7 years.

Value of Electricity

The most sensitive economic assumption is the value of electricity. It was assumed that $0.06/kWh would be available to the project. If the value of electricity sold were $0.086 the project Net Present Value would be zero and the project would be much more worth doing.

Gas Output

The digester can produce more gas and make more electricity. More electricity from the same investment would have a better return. If a 100 kW output could be reached by adding a small amount of other waste, then the internal rate of return increases to 6% but the NPV is still negative.

If however, the project could accept restaurant or fryer oil or grease trap waste. The biogas output could be easily doubled as demonstrated by RCM digesters in Pennsylvania and New York. The cost of an engine with twice the output (160 kW) is only about $40,000 more than the selected unit. Adding less than 10% to the investment would yield double the revenue.

CONCLUSION HEIFER DIGESTER PROJECT

In conclusion this project is technically feasible, but not economically viable using scraped heifer feedlot manure only. Adding other wastes to the heifer manure would increase the value of the project.

RECOMMENDATION FOR FURTHER CONSIDERATION

It is assumed that the Mojave and their contractor plan for the heifer lot to be converted to a 3,000-cow dairy. The current most viable option that RCM could imagine would be to build a 1,500-cow digester with the heifer lot. The 1,500-cow unit would be adequate for the heifers plus up to 50% addition by volume of other organics. By selecting the quality of outside organic inputs, the digester system gas output could generate up to a 350 kW range.

ISSUES, POTENTIAL PITFALLS AND SOLUTIONS

COST ESTIMATING

Issue

RCM used "contractor built" estimation techniques unless otherwise noted to arrive at costs for this analysis. Rapidly rising material and transportation costs are a constant factor affecting the budget estimates.

Significance

It is unknown how much involvement Mojave Heifer Feedlot will have in the actual construction of the digester. The method of construction and degree of contractor involvement will affect the costs. Long-term delays in the project schedule may create increases in the original budget due to rising material costs incurred during delays.

Recommendation

Evaluate the least cost method for construction utilizing on farm labor and equipment or contractors who are capable of the construction needed. Develop a maximum system design capacity based on best estimates for waste generation expansion plans for the dairy to ensure that costly system "retrofits" are not needed during the effective lifespan of the project. Identify and resolve any project showstoppers, such as lengthy permit requirements, as early in the project process as possible.

SYSTEM MANAGEMENT

Issue

The digester system will need daily oversight and consistency in management.

Significance

Immediate attention to unexpected maintenance, as well as daily observation and record keeping should be reliably provided. If not, digester outputs and equipment runtime may suffer. All farm waste inputs will need to be routinely monitored to track quantity and makeup. Any materials that might be damaging to the digester operation must not enter the collectable manure for the digester.

Recommendation

Find an interested operator who will be in position for several years. Develop a waste collection program that follows a regular schedule to ensure consistent digester feed. Evaluate the manure collection and plumbing system to eliminate any vulnerable points where contaminants might enter the manure stream to the digester. Maintain all system operational records. Do not accept any off farm wastes into the digester without consulting the system designer.

SYSTEM DESIGNERS

Issue

The history of farm digesters in North America shows that about 75% of all past manure digestion systems have failed. Each location has unique design demands. Attempting to replicate construction of an existing unit (aside from the legal implications) may result in installations insensitive to the realities of each individual site. Most often designs were inappropriate because they were proposed, designed and built by individuals or firms, though well intentioned, lacked experience.

Significance

Financial considerations may require the enticement of a bank or outside investor to build the facility. That investor must have absolute confidence the investment is sound. Success is expected with a dairy manure digester, if a good designer is chosen. Mojave Heifer Feedlot wishes to increase farm profitability through a manure digestion system. Mojave Heifer Feedlot must have a system that will function faultlessly from the beginning.

Recommendation

Request the services of a design firm with documented experience and liability insurance. The firm should have worked with similar manure, in a similar setting, and at a similar scale. The firm should be able to make output projections based on similar projects. The firm should be able to provide energy balances and mass balance for the proposed system. These balances will permit assessment of project technical feasibility.

RCM Digesters, Inc.

Appendix 1. Cash Flow; No Grant

Heifer Feed Lot	NO grant						Years								
Costs															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Down payment	$540,000														
Principal payment	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Interest expense	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Operation & Maintenance	$6,886	$7,093	$7,306	$7,525	$7,751	$7,983	$8,223	$8,469	$8,723	$8,985	$9,255	$9,532	$9,818	$10,113	$10,416
TOTAL CASH EXPENSE	$546,886	$7,093	$7,306	$7,525	$7,751	$7,983	$8,223	$8,469	$8,723	$8,985	$9,255	$9,532	$9,818	$10,113	$10,416
Savings and Revenues															
Electricity - kWh	$43,749	$45,061	$46,413	$47,805	$49,239	$50,717	$52,238	$53,805	$55,419	$57,082	$58,795	$60,558	$62,375	$64,246	$66,174
Electricity - demand	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Heat energy savings	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Greenhouse Gas Tax Credits	$7,822	$8,057	$8,299	$8,548	$8,804	$9,068	$9,340	$9,621	$9,909	$10,206	$10,513	$10,828	$11,153	$11,487	$11,832
Solids sales	$8,213	$8,459	$8,713	$8,974	$9,243	$9,521	$9,806	$10,100	$10,403	$10,715	$11,037	$11,368	$11,709	$12,060	$12,422
TOTAL CASH REVENUE	$59,783	$61,577	$63,424	$65,327	$67,287	$69,305	$71,385	$73,526	$75,732	$78,004	$80,344	$82,754	$85,237	$87,794	$90,428
Pretax NET	-$487,103	$54,484	$56,119	$57,802	$59,536	$61,322	$63,162	$65,057	$67,009	$69,019	$71,089	$73,222	$75,419	$77,681	$80,012
Depreciation	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total Tax deductions (1)	$6,886	$7,093	$7,306	$7,525	$7,751	$7,983	$8,223	$8,469	$8,723	$8,985	$9,255	$9,532	$9,818	$10,113	$10,416
TAX	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
AFTER TAX CASH FLOW	$ (487,103)	$ 54,484	$ 56,119	$ 57,802	$ 59,536	$ 61,322	$ 63,162	$ 65,057	$ 67,009	$ 69,019	$ 71,089	$ 73,222	$ 75,419	$ 77,681	$ 80,012

(1) Depreciation, O&M expenses, and interest expense.

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Worldwide Deployment of Anaerobic Digestion

Anaerobic digestion has not been deployed to any great degree in Mexico, Central or South America. However, Brazil started a program of energy self-sufficiency, including the promotion of anaerobic digestion systems. In contrast, China, Taiwan, India and Thailand formed government boards to investigate the reasons for success of digesters and to promote those successes. Research and training programs were developed and put into place to encourage small-scale energy and sanitation systems. Within China and India, there is a trend toward employing larger, more sophisticated farm-based systems with better process control that generate electricity.

In Taiwan, the desire to reduce pollution of rivers by direct discharge from the animal production industry led to the development of a standard anaerobic digester system now in use at thousands of farms. The Taiwan system utilizes ambient temperature tanks with inflatable rubber covers. Standard-size digesters are built in series until adequate capacity is achieved. Anaerobic digestion serves as pretreatment for aerobic systems. The goal is waste treatment and most biogas is simply burned off in flares.

Complex anaerobic processes for treatment of high-strength organic wastewaters are widely adopted in most countries of the world. Large centralized plants in Europe digest combinations of animal manures and municipal solid wastes for energy and non-energy benefits, although district heating is important. European governmental actions to reduce agricultural and industrial pollution, and control municipal solid waste landfill expansion raised costs for organic waste producers. Anaerobic digestion is more extensively used in Taiwan and Europe where animal waste pollution has been regulated for a longer time. The US and Pacific Rim countries have seen a recent increase in the use of digesters due to tighter enforcement of regulations.

In Europe, Germany led the way in small on-farm digesters for odor control. Italy developed a series of farm anaerobic digestion systems. European determination resulted in construction of over 2,500 new anaerobic digestion plants since 1987. Denmark and The Netherlands decided that small individual plants were not economically efficient and moved forward with large systems for groups of farms. Most experience with large centralized digestion facilities has been in Denmark, where more than 20 plants are now operating. More than 50 large, centralized digesters are operating in Europe, with more under construction or being planned. Some of these facilities have been in operation for more than 10 years. The goal of the centralized plants is to provide waste management and to redistribute nutrients in odorless liquids/solids to farms.

In the 1990's, Denmark's commitment to anaerobic digestion increased with the presentation of a renewable energy initiative by the Ministry of Environment and Energy. Germany has a similar program. The initiatives doubled biogas production by the year 2000, and may triple it by the year 2005. One of the key policy tools used to encourage technology deployment is "green pricing", which allows the manufacturers of biogas-generated electricity to sell their product at a premium. Interestingly, sales of co-generated hot water to new, specially built, district heating systems are becoming an important source of revenue to a number of Danish facilities. German farm-scale systems profit by direct sale of electricity to the electrical grid.

Biogas Production Potential

Table 1 shows the expected ranges of biogas production from typical US farm raised animals. The output is based on confined animal production, high cost feeds and 100% collection of fresh manure.

Table 1. Biogas Production Potential based on typical nutrition and 100% manure collection

	kWh/ head/day	Biogas Production ft3/d
Cow	2.5-3.7	**65-80**
Sow	0.2 - 0.3	**5-7.5**
Nursery	0.06 - .09	**1.4 –2.1**
Finisher	0.15 – 0.22	**3.5-5.5**
Beef Feeder	1.8 – 2.2	**45 - 55**
Laying hen	0.01	**0.25**

Anaerobic Digester System Components

An anaerobic digester system includes several components including:

- Manure collection,
- Pretreatment,
- An anaerobic digester,
- Biogas recovery,
- Biogas handling
- Biogas use.

Manure must be collected fresh on a regular schedule for digestion. A very important design consideration is the amount and potential contaminants of process water included in the manure collection. Process water includes all water from all sources that mixes with manure.

Pretreatment is used to adjust the manure or slurry contents to meet process requirements of the selected digestion technology. A mixing tank or a solids separator are pretreatment options. An anaerobic digester is an engineered containment vessel designed to promote the growth of methane bacteria. The digester may be heated or unheated, mixed or unmixed, a simple tank or a very complicated media packed column. Manure characteristics and collection technique determine the type of anaerobic digestion technology that can be used.

Biogas formed in a digester bubbles to the surface and may be collected by a fixed rigid top, a flexible inflatable top or a floating cover depending on the type of digester. The collection system directs biogas to gas handling components.

Biogas may be filtered for mercaptans and moisture removal. Biogas is usually pumped or compressed to operating pressure and then metered to the gas use equipment.

Biogas that is pressurized and metered can be used as fuel for heating, adsorption cooling, electrical generation and cogeneration. Biogas can be substituted for low pressure natural gas or propane in the equipment listed in Table 2.

Table 2. Biogas Use Options

Biogas Fueled Engine
Electrical generator - electricity for use or sale, heat recovery optional
Refrigeration compressors - cooling, heat recovery optional
Irrigation pumps - pumping, heat recovery optional

Direct Combustion Options
Hot water boiler - for space heat, process and cleanup hot water
Hot air furnace - for space heat
Direct fire room heater - for space heat
Adsorption chiller - for cold water production, heat recovery optional
Stove – for cooking gas

Available Anaerobic Digestion Technologies

Many configurations of anaerobic digesters have been developed but may or may not be commercially available for farms. Table 3 lists the operating characteristics of digester technologies. Covered lagoons, complete mix, and plug flow digesters are commercially available. All can be built at small scale successfully. The key to success is construction quality and the reuse of some of the energy produced to keep the digester warm to maximize the rate of methane production.

Table 3. Types of Digesters and Their Characteristics

Type of Digester	Level of Tech-nology	Influent Solids Concen-tration	Solids Allow-able	Supple-mental Heat	HRT (days) (1)
Ambient temperature covered lagoon	low	0.1 - 2%	fine	no	40+
Complete mix	medium	2.0 -10%	coarse	yes	15+
Packed reactor (2)	medium	0.5 - 2%	soluble	yes	2+
Plug Flow (3)	low	11 - 13%	coarse	yes	20+

(1) HRT = Hydraulic Retention Time = digester volume/daily influent volume
(2) Attached growth reactors
(3) Dairies only

Cost Effectiveness of Anaerobic Digestion

There are no simple answers to the question of cost effectiveness. The economics depend on the cost of electricity or heat energy. Digester projects will generally meet this requirement for farms with electricity costs of greater than $0.06/kWh that can use most of the electricity on site.

If there is value to fertilizer improvement, pathogen reduction or odor control and it can be accounted for in the farm balance sheet, then a digester may be more profitable. If a farm has to meet government regulations on waste management and a digester may be substituted for another management option, the added costs of a digester may have a very high return over spending money on a non-revenue alternative.

Most projects rely on a multitude of benefits to recover the investment. Heat that improves production, disease control that keeps animals and people healthy, and odor control that keeps people happy and productive are benefits that are seldom assigned their true worth. In some cases, a digester has recovered its cost by avoiding penalty fines, neighbor complaints or lawsuits. In other cases, particularly for dairies, the digester improves the handling capability of the material and saves the farm money on materials handling. At dairies, digested solids can be recovered and used for bedding.

Financial Structuring

Many digester systems are built with a combination of public and private funding. Most countries that are serious about pollution control offer the private farms a cost sharing arrangement, with 20-60% of a digester funding coming from the government. It is in the public interest to keep farms open, the farmers employed, farm products inexpensive to society, and to reduce or eliminate animal waste pollution of drinking water sources. Some "subsidy" is offered worldwide, either financial or through limited enforcement, based on the assumption that a farmer with little or no investment in manure management will not reduce pollution if the costs exceed the profits from animal production.

General Economic Effect

Digesters are considered expensive because of the time and capital costs involved in most projects. However, farms have been rapidly consolidating into larger units with larger pollution potential. The large pollution potential results in more people wanting to take advantage of digester technology to benefit from production of energy while reducing pollution.

Technical Challenges and Organizational Adjustments

In general, there are no technical barriers to anaerobic digestion. The economics are such that many large farms could have favorable returns on investment. Large farms are often targeted for regulation and required to manage manure, therefore those farms are more likely to invest in a digester. Small farms tend to have limited labor hours and pay less attention to managing manure. There is the opportunity for favorable economics depending on the value of electricity and labor. Still, many farms would rather not spend any money on pollution control regardless of the return because the farms prefer to target their time and investment in animal production. As a technology, digestion is superficially known. Another barrier to the use of the technology is the lack of knowledge in the areas of design by engineers and regulators.

Economic and Finance Aspects - Investment Recovery

Digesters are cost competitive with other manure treatment technologies. Surprisingly, farms or farm advisors do not regularly consider return on investment. Farmers assume that pollution control is a cost item and chose a lesser-cost alternative. Farm banks are reluctant to finance digesters because the technology is still not widely used. Government encouragement has had the most effect in implementing digesters. There are thousands of digesters in Taiwan and hundreds in Europe where the environmental benefits of anaerobic digestion are recognized and promoted.

Incentives - Disincentives

In general, there are few incentives for regulatory compliance and investment. A majority of farms prefer to minimize investment in manure management. Some incentives may be necessary to encourage farms to install and maintain manure management systems as has been done in Europe and Taiwan. Recently the United States has adopted a punitive and restrictive approach for farm manure management. Thus, the economics of manure change dramatically. Disincentives are now driving owners. More regulation and enforcement has forced farms to consider the options more carefully. Several have reached the conclusion that if they have to spend money on manure management, then they could use a digester to try to recover their costs.

Market Advantages

In the longer-term analysis, an anaerobic digester will improve the profitability of most, but not all farms. In the future, the advantages of the systems will be more fully appreciated. There are hundreds more digesters today than there were 10 years ago. Industry has embraced the technology as a lower cost alternative for pollution control and many farms will also. When the technology is compared with alternatives, farmers realize that the advantages exist. If farms in all countries must meet similar pollution control regulations, then they will all consider their options and many will select digestion for the small edge it will give them in profitability.

Does Anaerobic Digestion Solve the Problem?

A problem must be recognized before it can be solved. Farms and governments are recognizing the need for control of point source and non-point discharge from animal production. Controls cost money. Digesters make money for the farm from heat or electricity, reduced odor, reduced flies, reduced pathogens, killed weed seeds, and improved fertilizer values. All of the benefits can be verified. Therefore, anaerobic digestion can be a solution to the problem.