ECONOMIC VALUATION OF WIND ENERGY

THROUGH A REAL OPTIONS APPROACH

by

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(Under the Direction of Michael E. Wetzstein)

ABSTRACT

Energy price volatility may result in increased profits for some sectors and unexpected costs for others. Natural gas prices after their initial deregulation in 1989 presented periods of high volatility affecting sectors that rely on the energy as inputs. Energy price volatility has increased the uncertainty of production costs and vectored the agricultural sector in search of alternative energy inputs. This study develops a feasibility analysis using a financial real options approach to assess substituting natural gas powered irrigation systems with either electric or hybrid-(electric/wind) energy systems. The Texas Panhandle and Southwest Kansas geographical areas compromise the study area due to the current presence of a significant number of natural gas powered irrigation systems and consistency of wind velocity that fulfill energy generation requirements of wind turbine systems. Feasibility of quarter-mile sprinkler systems, three crops, and two pumping lifts are assessed. Breakeven points identify the price at which conversion from a natural gas irrigation system to a hybrid system is cost effective. Results indicate that net present value is more susceptible to investment adoption not considering the risk of volatility in input prices and that real option analysis may be a preferential analysis in the valuation of energy investments.

INDEX WORDS: Irrigation Systems, Real Options, Renewable Energy, Wind Energy.

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DEDICATION

To my parents Jorge and Helena, my wife Monica and daughter Stella

for their never-ending love, support and friendship.

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A special thanks to my parents Jorge and Helena for everything I am today is a result of their dedication, love and caring support. I am grateful for everything you have given me. I have immense gratitude to my wife Monica for bringing peace into my soul. I am certain that without Monica's presence in my life I would not be complete. Also, I am thankful for Stella my beautiful daughter, which has brought laughter and gentleness to my life, my brother Ronny for all we have been through while growing up together, and Alberto and Neuza for their care and support.

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CHAPTER 1

INTRODUCTION

Energy is a key input for a country's socio-economic development and continued wellbeing. The rate in which energy is consumed by a country often mirrors the prosperity level of the same, generally due to energy demand impact on higher production levels on the growth rate of Gross Domestic Product (GDP). Access to energy is particularly crucial to human development as it propels education services and improves public health. Nevertheless, data from the United Nations Organization indicate that more than 1.4 billion people worldwide do not have access to electricity, and another one billion receive intermittent energy (United Nations, 2011). The current gap between energy and global demand is expanding with increasing food demand and consequent need of increased energy for food production. Projections from Food and Agricultural Organization (FAO) indicate that by 2050 there will be a need to expand food production by 70% from current levels in order to meet global demand (FAO, 2012).

Energy and Agricultural production are highly interconnected. Energy is traditionally considered as an input for agricultural production being responsible for intensified farm mechanization, fertilizer production, and improving food processing systems and logistics. Nevertheless the new era of renewable energy production is continuously shifting the relationship of energy and agriculture through the use of farm available wind, solar, hydro, geothermal, and biomass resources. With increased implementation of renewable energy systems in the agricultural sector, global energy supply may be fulfilled as decentralized generation of energy becomes feasible to all countries with no concern to their GDP levels.

Even as the next generation of energy technology increasingly participates in the agricultural arena, the United States continues to rely on oil and natural gas. In 2010, American oil production reached its highest level since 2003, and total U.S. natural gas production reached its highest level in more than 30 years (White House, 2012). Nonetheless increased global energy demand, and in particular by countries like China and India, will feed the market with energy price volatility, since these commodities are a vital part of global markets. Projections from the International Energy Agency indicates that natural gas global demand is estimated to grow 1.7% annually by 2035, and that expansion of natural gas use in China will increase domestic demand to above 500 bcm by 2035, from 110 bcm in 2010 (International Energy Agency, 2011).

Natural Gas prices in the United States, after its initial deregulation in 1989 presented periods of high volatility affecting economic sectors that demand energy to conduct operations. It has specially impacted agricultural states that rely extensively on the energy as input for irrigation systems. The industrial natural gas price was relatively stable at around $2 per thousand cubic feet (Mcf) during the 1990's, nevertheless within the first decade of 2000 prices have been volatile and averaged $5.70 per Mcf. The average price in 2002 was around $4, while the average price in 2010 almost reached $10 (Energy Information Administration, Industrial Natural Gas Prices). Natural gas price swing has caused many farmers to alter their cropping patterns by changing crop mix, abandoning irrigated acreage, and lowering the amount of irrigation water applied to crops (Guerrero, 2006).

In the attempt to aid business investment decisions a proper feasibility analysis that takes into account dynamic market changes, and price volatility is indispensable. The commonly used Net Present Value (NPV) approach to capital budgeting decisions used by managers when facing the choice of an alternative investment project is straightforward. The NPV calculation is the sum of the present values of the expected future cash flows obtained from the investment and the salvage values of the project at maturity, deducted from the initial investment outlay. The NPV approach assumes that the underlying conditions remain stationary and definite in the future, but this assumption can be costly in the context of volatility and cash flow uncertainty, which is very evident in the energy sector, and especially in recent natural gas prices.

An alternative tool to perform feasibility analysis, which accounts for price uncertainty, is the Real Options Approach (ROA). ROA incorporates the existence of cash flow uncertainty into capital budgeting decisions. Incorporating price uncertainty into the investment model will lead to projections that fit energy market nondeterministic reality.

This study will focus on the feasibility analysis of utilizing a financial real options approach in substituting natural gas powered irrigation systems with either electric, or hybrid-(electric/wind) energy systems, and the option to switch from an electric based irrigation system to a hybrid energy system. Texas Panhandle and Southwest Kansas will compromise the study area due to the significant number of natural gas powered irrigation systems and consistency of wind velocity that fulfill energy generation requirements of wind turbine systems. Texas Panhandle and Southwest Kansas are assessed with a quarter-mile sprinkler system, three crops, and two pumping lifts. Breakeven points identify the price at which conversion from a natural gas irrigation system to a hybrid system is cost effective.

1.A. Energy Outlook

Projections indicate that energy demand will rise by 40% over the next 20 years (World Energy Council). Increasing energy demand results from population growth, increased industrialization by developing nations, and increasing global middle class, among other factors. At the same time, as previously stated, an incapacitated supply leaves 1.4 billion people without access to electricity (United Nations, 2011).

Global energy demand is met from a variety of sources, which include fossil fuel, nuclear, and renewable sources. The United States energy mix is heavily dependent on fossil fuels, which accounts for over 80% of the energy generated. Primary energy use in the United States by source is outlined in Figure 1 indicating that 37% of energy generated comes from petroleum, 25% from natural gas, 21% from coal, 9% from nuclear power, and 8% from renewable energy (Energy Information Administration, 2011). With recent volatility in energy prices, such heavy dependency on fossil fuels brings heavy monetary costs to businesses and consumers. Estimated monetary costs of $25 billion affects consumers every year for electricity to be lost due to inefficient transmission and distribution, and another $150 billion is lost to power outages and blackouts yearly (National Energy Technology Laboratory, 2007). The usage of coal, oil, and natural gas also engenders additional cost of pollution associated with its combustion to generate energy, imposing externalities that affect our health and impact the environment.

According to the Energy information Administration (EIA) in the year of 2008 the United States accounted for almost 20% of the world's total primary energy consumption. In 2009 impacted by the economic downturn, energy consumption in the American industrial sector suffered a 9% loss. As the American economy improved in 2010, consumption of energy started to grow once more, thus US was surpassed by China becoming the 2nd largest energy consumer in terms of total energy use (MSNBC).

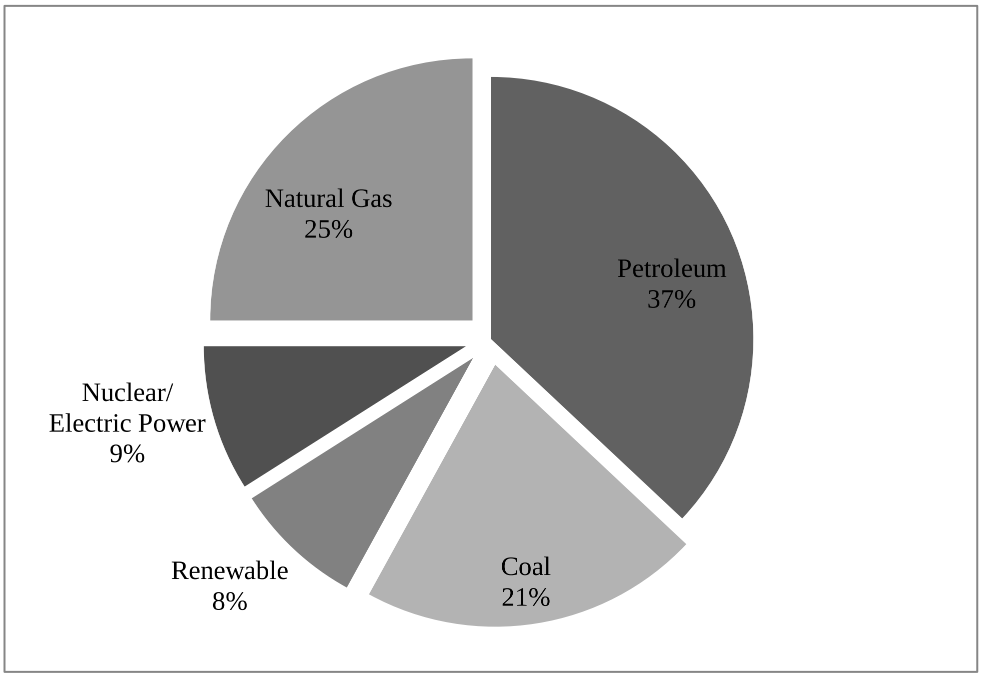

Figure 1.1: United States Primary Energy Consumption for 2010

Source: Energy Information Administration; Annual Energy Review 2010.

According to the Environmental Protection Agency, energy related activities in the US are the main sources of anthropogenic greenhouse gas emissions, accounting for over 86.7% of total greenhouse gas emissions on a carbon dioxide (CO_2) equivalent basis in 2010 (EPA, 2011). Electric power generation and transportation are the biggest sources of energy-related greenhouse gas emissions in our nation, the rest of our emissions result from direct use of fossil fuels in homes, commercial buildings, and industry.

There is not a single and unique solution to meet global energy needs. The answer to future energy consumption lies in diverse energy technologies that do not deplete our natural resources nor diminish our environment. A mix of renewable energy technologies is the solution for a healthy and sustainable economic growth.

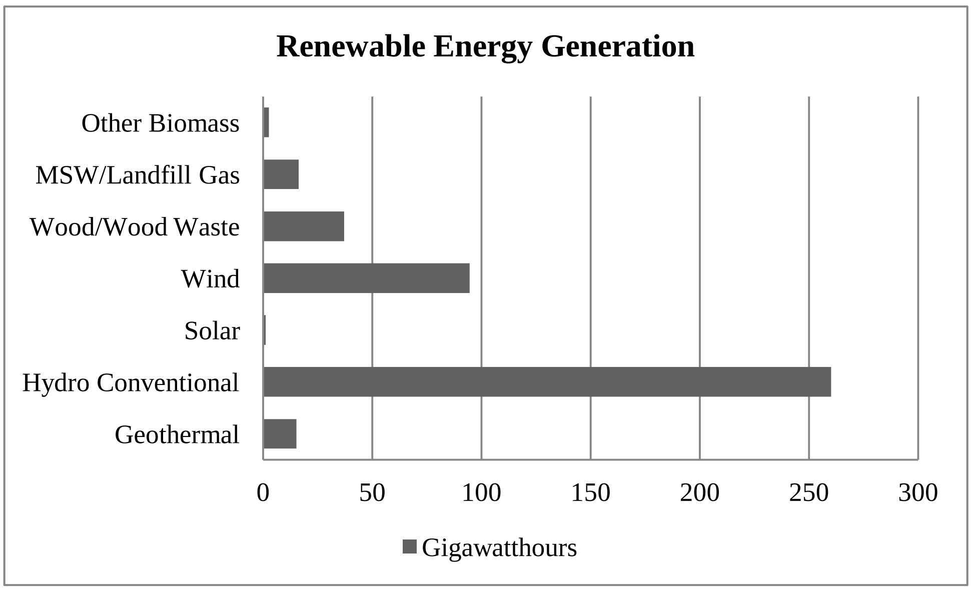

Figure 1.2: Net Renewable Electricity Generation for 2010

Source: Energy Information Administration; Annual Energy Review 2010.

1.B. Wind Energy in the United States

Sailing vessels relied on wind propelled energy from before 3,000 BC. Mechanical applications of wind soon followed, and generated energy was being used for grinding grain, and pumping water. During the 11th century, windmills where used in food production in the Middle East providing returning merchants and crusaders the technology application in Europe. The Dutch among others advanced windmills further, adapting usage to industrial applications such as sawing wood, making paper and draining lakes and marshes (International Panel on Climate Change, 2011).

Settlers carried this technology to the New World, and not far from the first successful English Colony in Jamestown, on James River, the first American windmill was set in 1621, pumping water at the Flowerdew Hundred Plantation (Baker, 1985). Although this windmill disappeared after a few years, a large number of European style windmills have populated the United States throughout the years and well after the American Civil War. Prior to the arrival of rural electrification in the 1930s and 1940s, American windmills provided the primary source of water on farms and ranches and in isolated communities, being an ever-present part of the rural landscape.

Although the long history of wind power activity, a real and robust interest in renewable energy from the wind did not resulted until the oil crisis in the 1970's and consequent fears of resource depletion and energy insecurity. Energy from the wind is viewed as a good resource being renewable and abundant it provides communities with a clean and local source of electricity, as opposed to imported fossil fuels. From 1974 through the mid-1980s the United States government partnered with industry to improve technology and empower large scale wind turbines (National Aeronautics and Space Administration, 2006). The NASA wind turbines were developed under a program to create a utility-scale wind turbine industry in the U.S. With funding from the National Science Foundation and later the United States Department of Energy (DOE). This research and development program pioneered many of the multi-megawatt turbine technologies in use today.

The American Wind Industry aided by policies concerned with energy security benefited from Federal and State Investment Tax Credits (ITC), the California wind industry alone installed 1.2 GW of wind power by 1986, accounting for almost 90% of global installations at the time. When oil prices deteriorated by a factor of three from 1980 through early 1990s, and the ITC expired in 1985, many turbine manufacturers left the business generating wind market stagnation in the United States.

In Europe, many countries were propelled by the solid renewable energy policies in place and led the wind energy market during 1990s. Technological advancements in both turbine power and productivity forced the prices of wind-generated electricity to drop by nearly 80% by the end of the decade (AWEA, 2007). In the US during the 1990s renewable energy policies such as production tax credit (PTC), enacted as part of the Energy Policy Act of 1992 (United States Agency of International Development, 2012), which gave producers 1.5 cents (adjusted annually for inflation) for every kilowatt-hour (kWh) of electricity produced from wind, where internment. The PTC expired and was reenacted twice resulting in investment uncertainty and restraining market growth.

Nearly two decades after the 1970's oil crisis and fears of energy insecurity faded into the past The Rio de Janeiro Earth Summit in 1992 brought political pressure to the world's energy arena with climate change issues as a result from anthropogenic emissions of greenhouse gases such as Carbon Dioxide. The political process achieved a successful negotiation of the Kyoto Protocol in December 1997, and commitment of industrialized nations in reducing greenhouse gas emission and engendering a globalized trend en route for renewable energy. To sponsor renewable energy systems many states within the US began to require electricity suppliers to achieve a percentage of their supply from alternative sources (Environmental Protection Agency, 2012), developing Renewable Portfolio Standards (RPS), with an increasing percentage over time. The United States governmental measures coupled with electricity energy sector restructuring and industry privatization has increased market competition providing availability of specialization in niches such as wind powered plants and fostering technological advancements in the energy sector.

The United States has tremendous wind resources both offshore and on land. In 2005 and 2006 the US led the world in new wind installations, by 2007 global wind power capacity exceeded 74 GW, and US wind power capacity reached 11.5 GW with wind power generation installed across 35 states delivering approximately 0.8% of the electricity consumed in the nation (Weiser and Bolinger, 2007). Although a considerable drop in wind energy contribution occurred in recent years at the close of 2010, the nation had more than 40,000 megawatts of land-based installed wind power capacity. That's enough to serve more than 9.65 million homes and avoid the annual emissions of 83.5 million tons of carbon dioxide. According to AWEA the fourth quarter of 2011 had 3,444 megawatts (MW) of wind power capacity installed, bringing total installations in 2011 to 6,810 MW. The U.S. wind industry totaled 46,919 MW of cumulative wind capacity through the end of 2011. Today, U.S. wind power capacity represents more than 20% of the world's installed wind power (American Wind Energy Association, 2012). The growth rate path of wind energy installations based on cumulative capacity and new installations is depicted in figure 3.

Currently the American wind industry encounters uncertainty regarding governmental policy. Manufacturing industries are currently restructuring such as the Vestas that made a company announcement on January 12th of 2012 planning layoffs of 2,335 employees in the coming months preparing for a potential market slowdown in case the current Production Tax Credit is not extended (Vestas Wind Systems, 2012).

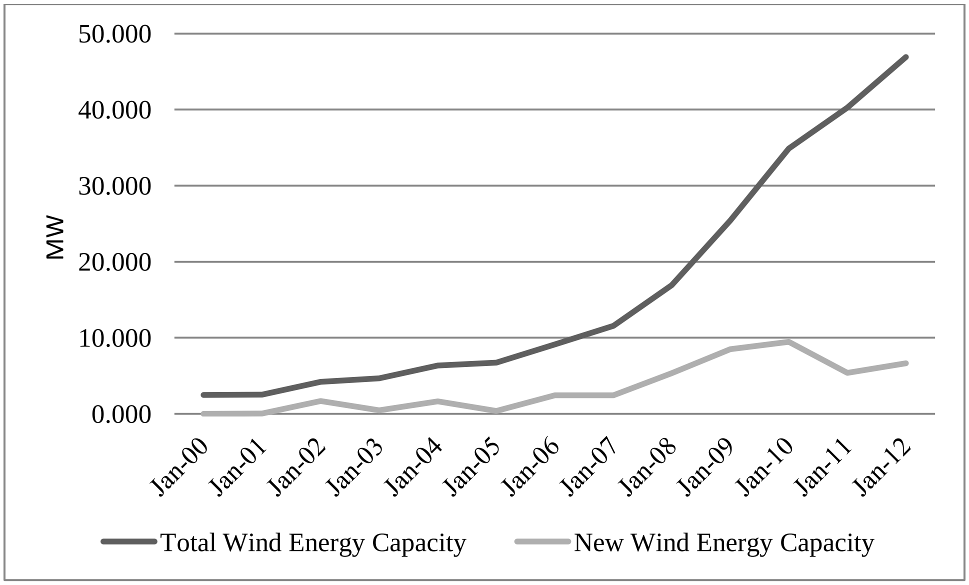

Figure 1.3: US Wind Power Generation Capacity in MW Cumulative Basis

Source: American Wind Energy Association

1.C. Wind Energy in Texas and Kansas

Favorable wind is available on exposed areas of the Great Plains accounting for a large portion of Northwestern Texas, Oklahoma and Kansas. Wind is classified according to power classes based on wind speed frequency distribution and air density. Wind classes range from low to high starting at Class 1 to Class 7, respectively. The most extensive area of class 4 wind (good wind speed averaging 7 to 7.5 m/s), extends from the Texas Panhandle to South Central Kansas.

Local terrain elevation variation results in differences in wind class level that may range from marginal speeds over lowlands to good and excellent over exposed uplands and hilltops.

Texas successfully produced its first Renewable Portfolio Standard as part of electricity industry restructuring in 1999 (State Energy Conservation Office, 2012) requiring specific amounts of renewable energy generation and resulting in rapid renewable energy acceleration in Texas sites. Texas is currently the leading state in terms of new wind power capacity and has exceeded the 10Gw milestone on a cumulative basis in 2010. As a result of favorable wind and state policy the state of Texas has more installed wind power capacity then all but five countries worldwide.

The state of Kansas encompasses a great percentage of the wind corridor and is the 3rd highest wind potential in the US with a projected 120,000 MW of possible wind power generation. The Department of Energy's National Renewable Energy Lab (NREL) estimates that the state can benefit from a $7.8 billion impact if Kansas were to develop 7,158 MW of new wind by 2030 (National Renewable Energy Lab, 2009).

CHAPTER 2

VALUE OPTION TO SWITCH

2.A. Net Present Value

When considering capital budgeting decisions the maximization of a corporation's net present value (NPV) has been a customary approach to feasibility analysis and investment decision making. The NPV is a standard technique to value long-term projects and is defined as the sum of the present values of all revenue inflow and expenditures outflows of a singular investment. If the NPV is higher than zero and the highest among alternative investment options (accounting for opportunity cost), the investment should be adopted. If the NPV is below zero indicating that the project would lower the company's value, the investment should not be undertaken.

NPV is represented as

$$NPV = -I_0 + \sum_{t=1}^{N} \left(\frac{E(CF_t)}{(1+r)^t}\right), \tag{2.1}$$

where I_0 denotes initial investment outlay, $E(CF_t)$ denotes expected cash flow from investment in period t and r is the selected discount rate.

Corporate analysts have used discounted cash flow method extensively, however academic research has pointed flaws in the NPV method. Mayers (1977) describes that traditional NPV analysis lacks growth options concerning follow up management decisions.

Hayes and Garvin (1982) criticize the NPV model for failing to appreciate investment opportunities by incorporating high discount rates in order to hedge from future uncertainties. Trigeorgis and Manson (1987) outlined that NPV model application assume certainty of future cash flows, and even if the analysis considers investment risks appropriately accounting for suitable discount rates (hurdle rates) and inflation, the model is static and deterministic in nature offering limited options of future scenarios, therefore in the presence of uncertainty NPV will provide a biased investment prediction.

The NPV investment analysis is further considered reversible based on a now-or-never decision and lack managerial flexibility. Nonetheless most investments, and especially investments in renewable energy, do not meet reversibility without sunk costs and present possibility of deferring investment. As pointed by Dixit and Pindyck (1994) these are important considerations that need to be incorporated in the valuation process.

In particular, in the presence of a dynamic energy market structure, a wind energy generation feasibility analysis as an alternative to natural gas powered irrigation systems performed through NPV method will not account for all investment barriers. A proper valuation method can be achieved through the real option analysis (ROA) by incorporating investment uncertainty, irreversibility and flexibility.

2.B. Real Options

Interaction among endogenous and exogenous variables generates alternatives that if not accounted for might generate undesirable consequences for the investor. Interaction among market factors introduces operational and managerial flexibility adding complexity in the valuation process. For developing effective feasibility analysis and surpass restrictions present in the NPV valuation method, a line of investment models designed to incorporate uncertainty, irreversibility and investment flexibility was established.

The theory of options pricing dates back to the 1900's with Louis Bachilier who inferred an option pricing formula based on the assumption that stock prices follow a Brownian motion with no drift. A theoretical framework was developed by Black and Scholes (1973), and Merton (1973), as a tool to value financial options based on the volatility of returns. The framework of real options assessed by Myers (1977) proposed that a company after making an investment decision can obtain the right to buy or sell an investment alternative or physical asset at some future time, thus seeing investment opportunities as involving options on real assets, and coining the term real options. An investment project value presenting a high uncertain factor should equal the net present value plus the value of the future option.

Real options has been applied to the energy sector to attain proper investment evaluations in the sector. The energy sector shifted from a regulated and monopolistic to deregulated, uncertain and competitive sector, requiring a more refined analysis to budgeting decisions. One of the first applications of this theory to the energy sector is the work of Tourinho (1979) using the method to evaluate natural resources, more specifically, oil reserves. Brennan and Schwartz (1985) also applied option pricing in evaluating diminishing natural resource assets.

McDonald and Siegel (1986) exposed key aspects contingent to most production projects by generating the value of waiting, given that investment is irreversible, until new options may emerge, and compared the present value of future investment option with the option of immediate invest. Trigeorgis (1993) explored the nature of the interactions of multiple real options choices present in most projects, classifying the real options into categories according to investment flexibility: Option to defer, option to abandon, option to switch, staged investment option, growth option, option to alter operating scale, and interacting option, thus concluding that a combined options value is usually different than the sum of their separate values.

The real options approach after initial application to financial markets has generated an evolving research line with emphasis on the investment opportunities that decision makers have, and proper evaluation to better grasp those opportunities. Opportunities to invest are options, not obligations (Dixit and Pindyck, 1994) viewed like holding a call option. A call option gives an investor the right to buy an asset by a determined date for a certain price. The investment decision can be made at some future time. When an irreversible decision is exercised the option to invest in some future date is lost, as well as the possibility of waiting for new information that may perhaps impact the decision. Therefore the concept of keeping your options open through waiting has value.

The NPV investment decision value threshold that set off investment lacks the value of holding an option, thus a firm should invest when the difference between the present value of the future cash flow and the initial investment cost is greater than or equal to the value of maintaining the investment option open. Thus, the expected present value of benefits not only exceeds cost but also account for the value of retaining an investment option. An illustration is the possibility that new information such as price, technology, cost reduction or policy will set and size the wind energy sector impacting the decision on wind energy investment level.

In summary, the real options approach derives from the three common features of investment decisions (Dixit, 1992); Investment entails a sunk cost, market and economic uncertainty exists for information arrives gradually, and managers may have a degree of flexibility over the timing of investments building on the traditional NPV approach and offering an enhanced foundation for risk management in investment projects. Under this framework, the value of waiting is weighted against the opportunity cost of current profit over the period of waiting. The real options criterion provides a trigger value threshold point where conditions are satisfactory and the decision maker should take the optimal investment opportunity.

2.C. Real Options Theory Applied to Wind Energy Projects

In the past decade the real options theory has been applied to the renewable energy field. Initial application of the theory directed to renewable energy dates to 2002, on research by Venetsanos et al. (2002) evaluating wind energy systems. With this work the authors designed an outline to evaluate renewable energy power projects by considering underlying uncertainties that are inherent to the energy production. The authors then evaluated the project, according the real options theory, using the Black Scholes Model and compared findings of a positive option value with the traditional Discounted Cash Flow Technique where the achieved net present value was negative.

A unique stream of literature has addressed wind energy projects making use of the real options perspective. Mora Luna. et al.(2003) analyzed a wind energy investment project in Colombia and generating results of profitability of real options methodology. Dykes (2007) used a Monte Carlo simulation as well as a binomial tree analysis for optimal decision analysis when facing investment on wind farms by small communities.

Munoz. et al.(2009) developed a model to evaluate wind energy investments. The authors used a stochastic model for the parameters affecting the NPV and a real options model to evaluate the probabilities to invest, wait or abandon the project. They also applied their model to several case studies. Mendez (2009) evaluated wind farm projects as compound real options, valuing the project through binomial lattices incorporating market and private risks. Regarding policy analysis, Wilson (2010) concluded that even under substantial cost reductions and improved efficiency wind energy projects are still dependable on incentives such as production tax credits to encourage immediate investment.

CHAPTER 3

THEORETICAL BACKGROUND

3.A. Stochastic Processes and Ito's Lemma

This section will rely on Dixit and Pindyck (1994) to cover mathematical concepts and techniques used to study capital investment decisions of firms stressing investment irreversibility and the ongoing economic environment uncertainty in which those decisions are made, providing the option value of waiting through a continuous time perspective. These mathematical insights form the foundation of the real options approach and are becoming extensively applied to a wide range of research fields.

3.B. Stochastic Process

A stochastic process accounts for the different possibilities in which a variable may develop over time, evolving in a way that is in part random. The stochastic process is the missing side to a deterministic process and instead of dealing with singular outcomes that a process will develop it deals with randomness and indeterminacy generated by probability distributions. Therefore, given the starting point of a process, probabilities are assigned to the different paths the process may evolve over time, some with larger likelihoods than others.

A stochastic process can be formally defined by the probability law for the evolution x_t of a variable x over time t. Therefore for known times $t_1 < t_2 < t_3$, etc., we are either given or able to formulate the likelihood that the corresponding values x_1, x_2, x_3, etc., are contained within some specified range such as, $prob(a_1 < x_1 \leq b_1\,,\ a_2 < x_2 \leq b_2 \ldots)$. When time t_1 arrives and the actual value of $x_1$is realized, we are then able to condition the probability of future events resting on this information.

The stochastic process can be categorized as being stationary or nonstationary, depending on pattern specific statistical properties. A stationary stochastic process is bounded by statistical properties over time and therefore presenting nearly constant properties in the long run. If a stochastic process grows without bound it is in that case classified as a nonstationary process. Additionally, variables can be classified as continuous-time stochastic processes if the variables vary constantly through time or as discrete-time stochastic process if the values of the variables only change at certain discrete points of time. Similarly the set of all logical values assigned to x_t, can be either continuous or discrete.

One of the most basic stochastic processes is the *discrete-time discrete-state random walk*. A random variable x_t with initial value of x_0 will take a jump of size 1 either up or down at times $t = 1,2,3,4 \ldots$ with a singular probability of $\frac{1}{2}$. Since the jumps are independent of one another, the variable x_t is exemplified by the equation:

$$x_t = x_{t-1} + \epsilon_t, \tag{3.1}$$

Where ϵ_t is a random variable with probability distribution

$$\text{prob}(\epsilon_t = 1) = \text{prob}(\epsilon_t = -1) = \frac{1}{2} \qquad (t = 1, 2, 3, 4\ldots)$$

The process is defined as discrete-state discrete-time for x_t can only take discrete values at discrete time intervals.

The probability of an upward jump is $\frac{1}{2}$ therefore identical as a downward jump, at time $t = 0$ the expected value of $x_t = 0$ for all t. In the attempt to broaden the process, restrictions can be modified, and the probabilities for an upward or downward jump changed. Let p be the likelihood for an upward jump and $q = (1 - p)$ be the probability of a downward jump, with $p > q$. At time = 0, the expected value of x_t for $t > 0$ is greater than zero and increasing with t. This process is called a *random walk with drift*. A greater generalization is achieved when we let the size of each jump at time t be a continuous random variable. For instance, let the size of each jump be normally distributed with mean zero and standard deviation σ. In this case x_t is a *discrete-time continuous-state stochastic process*.

The previously outlined processes have a common feature where the probability distribution for x_{t+1}depends only on x_t and not additionally on the history or path prior to time *t*. Such feature satisfies the Markov property.

3.C. Brownian Motion

Brownian motion was first observed in 1827 by the botanist Robert Brown when observing pollen grains suspended in water forming a zigzag path drawn by the random movement, at any time point, of particles as a result of random displacement. In the year of 1900 Louis Bachelier made use of Brown's observations in his Doctoral research; "The theory of speculation" a mathematical theory of the Brownian motion, which was later perfected by Norbert Wiener in 1923, hence the *Brownian motion* is also known by *Wiener process*. Since then Brownian motion has been used in multiple fields.

A Wiener process is a continuous time stochastic process presenting three essential characteristics;

-It is a Markov process for the current value of the process is the only requirement to make future predictions and therefore past values are irrelevant.

-It has independent increments because the likelihood of a change in the process at any time point is independent from any other time point.

- Changes in the process are normally distributed presenting a variance that increases linearly with the time horizon.

Formally, a Wiener process is expressed by

$$dz = \epsilon_t \sqrt{dt}, \tag{3.2}$$

where dz, is the Wiener process increment, ε_t is random variable normally distributed with zero mean and standard deviation of 1, and dt is an infinitesimally small time period.

A Wiener process can be used for building more complex processes. One of its simplest generalizations is the Brownian motion with a drift:

$$dx = \alpha\, dt + \sigma\, dz \tag{3.3}$$

where dz is, as defined previously, a Wiener process increment. In (3.3) the drift parameter is defined by α, and the variance parameter by σ. In this scenario, over any time interval Δt, the change in x, Δx, is normally distributed with expected value $\varepsilon(\Delta x) = \alpha \Delta t$, and variance $Var[\Delta x] = \sigma^2 \Delta t$. Figure 4 illustrates Brownian motion with and without a drift parameter.

3.D. Ito Process

The Wiener process, in fact, can be utilized as a strategic tool to model an assortment of stochastic variables. The following equation is a generalization of the simple Brownian motion with a drift representing a continuous time stochastic process $x(t)$ and is called an Ito process:

$$dx = a(x,t)dt + b(x,t)dz, \quad (3.4)$$

Once again dz represents the increment of a Wiener process, and $a(x,t)$, $b(x,t)$ are deterministic functions. The nuance in the Ito process is drift and variance coefficients as functions of the current state and time. We refer to $a(x,t)$ as the expected instantaneous *drift rate* of the Ito process.

One very important special case of the Ito process formally exposed by (3.4) is the Geometric Brownian motion with a drift. Within this scenario $a(x,t) = \alpha x$, and $b(x,t) = \sigma x$, where α and σ are constants. Therefore equation (3.4) can be written as

$$dx = a\ x\ dt + \sigma\ x\ dz. \quad (3.5)$$

Dixit and Pindyck (1994) illustrate through the use of Ito's lemma, that if $x(t)$ is given by (3.5), then $F(x) = logx$ results in the following equation of a simple Brownian motion with a drift:

$$dF = \left(\alpha - \frac{1}{2}\sigma^2\right)dt + \sigma\ dz, \quad (3.6)$$

Consequently, over a finite time interval t, the change in the logarithm of x is normally distributed with mean $\left(\alpha - \frac{1}{2}\sigma^2\right)t$ and variance $\sigma^2 t$. Regarding x if currently $x(0) = x_0$, the expected value of $x(t)$ is achieved through

$$\varepsilon[x(t)] = x_0 e^{\alpha t}, \tag{3.7}$$

where e represents the natural logarithm. The variance of $x(t)$ is given by

$$Var[x(t)] = x_0^2 \, e^{2\alpha t} \left(e^{\sigma^2 t} - 1\right) \tag{3.8}$$

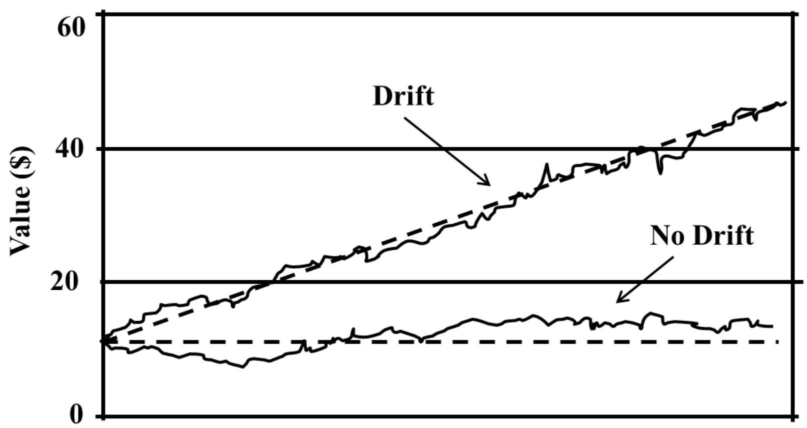

Figure 3.1: Brownian Motion With Drift and Without Drift

Source: New York Mercantile Exchange

CHAPTER 4

METHODOLOGY

4.A. Investment Adoption Option

The previous section provided mathematical insights of continuous time stochastic processes, which can be applied to the price evolution of a project's components. In our case we investigate an energy system investment and the resulting uncertainty regarding profit outcomes. Uncertainty plays an important role over the future flow of operational profit. This uncertainty that is restrained by market volatility, feeds profit flows with either positive or negative shocks. We are faced with the decision to switch energy source once the flow is negative, adopting renewable source energy in order to attain cost savings. This decision must be based on the real assumption that an investment entails sunk costs, which cannot be recovered. Thus, the firm has the opportunity to wait for new information regarding market conditions to arrive prior to investment commitment.

4.B. Investment Strategy

The economic analysis performed in this study, which was originally developed by McDonald and Siegel (1986), will be based on a real options pricing approach outlined by Dixit and Pindyck (1994) for an optimal decision threshold toward investment adoption. In our analysis a firm must decide when to invest in electric or hybrid alternative fuel source aimed at reducing operational costs. Hence, a structural assumption is that a project employment is made by an economic agent who is concerned with minimizing expected future cost of energy over a specific time horizon. The economic analysis of the project holds the agent as an agricultural producer who is a buyer of natural gas fuel or electricity to propel quarter-mile irrigation systems. The capital investment cost, I, is known and constant, but the value of the project, V, can be traced to energy input prices following a geometric Brownian motion. Because future values of the project are unknown, it is expected that the critical value V^* that exceeds I is larger than the net present value rule of $V>I$, due to an investment option holding premium.

Assume that the initial investment in adopting an alternative energy source is achieved through the cost difference between energy sources

$$\Delta I_a = (I_N + O_N) - (I_E + O_E), \quad \text{(4.1a.)}$$

$$\Delta I_b = (I_N + O_N) - (I_H + O_H), \quad \text{(4.1b.)}$$

$$\Delta I_c = (I_E + O_E) - (I_H + O_H), \quad \text{(4.1c.)}$$

where subscripts N and E and H represent natural gas, electricity and hybrid (wind/electric) energy sources, respectively, I_i is sunk cost associated with the alternative energy investment i, and O_i is discounted operational costs net of energy costs.

The investment in an alternative energy has value:

$$V_a = V_N - V_E, \quad \text{(4.2a.)}$$

$$V_b = V_N - V_H, \quad \text{(4.2b.)}$$

$$V_c = V_E - V_H, \quad \text{(4.2a.)}$$

which accounts for the stochastic energy cost price difference:

$$C_a = (IR_N \times E_N \times P_N) - (I_E \times E_E \times P_E), \quad (4.3.a.)$$

$$C_b = (IR_N \times E_N \times P_N) - (I_H \times E_H \times P_H), \quad (4.3.b.)$$

$$C_c = (IR_E \times E_E \times P_E) - (I_H \times E_H \times P_H). \quad (4.3.c.)$$

which were set on annual basis where IR_i is the amount of irrigation, E_i is the energy coefficient, and P_i is the price of energy, for $i = N, E, H$. It is assumed that cost differences evolve according to the following Brownian motion:

$$dC = \alpha C dt + \sigma C dz, \quad (4.4)$$

in which α is the drift rate, σ is volatility and dz is the increment of a Wiener process.

The value of the investment opportunity is $F(C)$. Since the payoff from investing at time t is $C_t - I$, we want to maximize its expected present value:

$$F(C) = \max E\,[(C_t - I)e^{-\rho T}] \quad (4.5)$$

where E denotes the expectation, T is the (unknown) future time that the investment is made, ρ is the discount rate, and the maximization is subject to (4.1) for C. We must also assume $\alpha < \rho$.

Because the investment opportunity, $F(C)$, yields no cash flow up to the time that the investment is undertaken, the only return from holding the investment is the capital appreciation resulting in the Bellman equation

$$\rho F dt = E(dF) \quad (4.6)$$

Requiring total expected return on the investment opportunity, $\rho F dt$, has the same value as the expected rate of capital appreciation (Dixit and Pindyck,1994). Using Ito's Lemma we expand dF. Then

$$dF = F^{'}(C)dC + \frac{1}{2} F^{''}(C)(dC)^2 \tag{4.7}$$

substituting (4.1) in terms of costs for dC and dividing through by dt, the Bellman equation becomes:

$$\frac{1}{2}\sigma^2 C^2 F^{''}(C_i) + (\rho - \delta)VF^{'}(C_i) - \rho F(C_i) = 0 \tag{4.8}$$

Where δ is the difference between $\rho - \alpha$, so $\delta > 0$.

The general solution to (4.8) is

$$F(C_i) = A_1 {C_i}^{\beta_1} + A_2 {C_i}^{\beta_2}, \tag{4.9}$$

The value-matching condition is

$$F({C_i}^*) = V({C_i}^*) - I \tag{4.10}$$

and the corresponding smooth-pasting condition

$$F^{'}({C_i}^*) = V^{'}({C_i}^*). \tag{4.11}$$

These can be solved for the optimal switching cost threshold:

$${C_i}^* = \frac{\beta_1}{\beta_1 - 1} \times \delta I \tag{4.12}$$

where

$$\beta_1 = \frac{1}{2} - \frac{\rho - \delta}{\sigma^2} + \sqrt{\left(\frac{\rho - \delta}{\sigma^2} - \frac{1}{2}\right)^2 + \frac{2\rho}{\sigma^2}} > 1 \qquad (4.13)$$

The optimal decision rule attained through the real options approach is to switch to the alternative fuel when the difference between energy costs is smaller than the threshold in (4.12); maintain status quo natural gas use otherwise. The threshold achieved through real options will be compared to the net present value rule of $V > I$, using the (2.1).

CHAPTER 5

DATA ANALYSIS AND PARAMETER ESTIMATION

Energy price volatility results in uncertain production costs leading to a search for alternative energy sources. Natural gas prices in conjunction with electricity prices will be employed to evaluate the feasibility of implementing electric or hybrid (wind and electricity) irrigation systems.

The first step is to determine the amount of energy used to perform irrigation for each crop. The energy use coefficient (E_i) for each crop by system is outlined in section 5.A, and is determined in a per acre inch of irrigation unit in order to achieve cost comparison resulting from the change in investment and operational costs from adopting an alternative energy system in the same unit. Section 5.B summarizes how irrigation figures (IR_i) for each crop where attained, and the resulting energy generation required from wind turbines, used in the hybrid system, to meet demand. Section 5.C delineates energy price (P_i) trends through detailed graphs and statistics, and describes the necessary data to compute equations (4.3.a.), (4.3.b.) and (4.3.c.).

Section 5.F. concludes the chapter listing investment costs (I_i) and operational costs (O_i) per energy system net of energy, necessary to calculate initial investment cost difference equations (4.1.a.), (4.1.b.), (4.1.c.). The operational costs for natural gas, electric and hybrid irrigation systems where calculated with a 20 year cash flow stream accounting for labor maintenance and repairs to the systems, taxes, insurance, buyback rates, inflation and discount rates.

5.A. Energy Requirements per System

Energy requirement calculated for each operational system is a consequence from the horsepower demand from irrigation systems and will vary according to water flow capacity and size of the well pumping lift for each location. Even though well size and flow capacity varied across the study area, two standard pumping lifts measures and a single flow capacity rate per state were chosen. According to Guerrero (2010) pumping lifts of 200 feet and 500 feet are considered sound standard measures for both states, but on the other hand, different flow rates as well as operating pressure are necessary. The flow rate capacity for Kansas is established being 1,200 gallons per minute (GPM) and a weighted average system operating pressure of 30 *psi*, while in Texas a flow rate of 600 GPM with operating pressure of 26 *psi*. The mathematical procedures to achieve energy requirements follows closely the one set forth by Guerrero (2010).

Horsepower is a measurement of the amount of energy necessary to do work over time. In determining the horsepower used to pump water, we must know the pumping rate in gallons per minute (GPM) and total head (H_T) in feet. The total head is the equivalent height that irrigation water is to be pumped in feet, calculated using the formula:

$$H_T = PL + \left(\frac{2.31\, ft}{psi} \times OP\right), \tag{5.1}$$

were PL is pumping lift in feet and OP is operating pressure, and 1 psi = 2.31 feet of head.

Once total head and flow rate are determined for each well size and state, horsepower requirement is computed as:

$$HP = \frac{GPM \times H_T}{3960 \times E_P \times E_{GH}} \tag{5.2}$$

The HP calculation for water pumps reflects the reality of imperfect efficiency by applying discount factors. The discount factor E_{GH} is gear head efficiency was assumed at 95% for both states and only applied to natural gas calculation. The discount factor E_P represents pump efficiency and assumed at 53% for a pumping lift of 200 feet and 66% for a pumping lift of 500 feet New (2005).

Horsepower measures were used to determine energy use per acre-inch water for electrical power and natural gas irrigation system using:

$$\frac{Mcf}{Acre-Inch} = HP \times \left(\frac{2{,}545\ BTU}{HP-HR} \times \frac{Mcf}{1{,}000{,}000\ BTU} \times \frac{1}{E_E} \times \frac{450}{GPM}\right) \qquad (5.4)$$

and

$$\frac{KWh}{Acre-Inch} = HP \times \left(\frac{2{,}545\ BTU}{HP-HR} \times \frac{KWh}{3{,}413\ BTU} \times \frac{1}{E_M} \times \frac{450}{GPM}\right). \qquad (5.5)$$

Natural gas engine efficiency (E_E) was determined to be 19% for the 200 foot lift and 23% for a 500 foot lift, while electric motor efficiency (E_M) was determined to be 90% for both pumping lifts (New 2005). Natural gas and electricity system requirements per acre-inch of pumping are presented in Table 5.1.

Table 5.1: Irrigation Energy Requirement per acre-inch

Energy Source	Texas		Kansas	
	200 ft lift	500 ft lift	200 ft lift	500 ft lift
Natural Gas (Mcf)	0.77	1.13	0.80	1.15
Electricity (kW)	46.52	80.24	48.22	81.60

5.B. Energy Use for Irrigation and Demanded Wind Production

The growing seasons for corn, wheat and grain sorghum are used to identify the months in which energy is necessary for irrigation (Guerrero 2010). Texas irrigation systems are active from March to October and the month of December, while Kansas irrigates these crops continuously from March through September.

Using of crop growth distribution within a season, the ratio of water used each month is computed from total amount applied. Then, the amount as well as the distribution of energy use are determined. Total energy usage for a quarter-mile center pivot irrigation system is calculated for natural gas and electricity through multiplying energy use per acre-inch by total monthly water use for 120 acres (Guerrero 2010).

Wind turbine energy generating capacity to meet irrigation energy demand is dependent on average hourly wind speeds adjusted for height, average monthly air density, power curve of wind turbine, and estimated operational availability of the wind turbine. The AOC 15/50 wind turbine is selected for the analysis. The turbine produces approximately 146 MwH per year in the Panhandle region of Texas and 151 MwH per year in Southwest Kansas with an average wind speed of seven meters per second (National Renewable Energy Laboratory, NREL, 2006), adjusted to height, with attained regional energy generation capacity difference due to variance in distribution of wind speed.

By accessing monthly wind power generation in conjunction with monthly irrigation energy usage requirements for each crop and state, excess wind power and shortage are quantified to achieve detailed cost distribution and feasibility calculation. Figures 5.1-5.6 provide energy distribution in kWh on monthly basis.

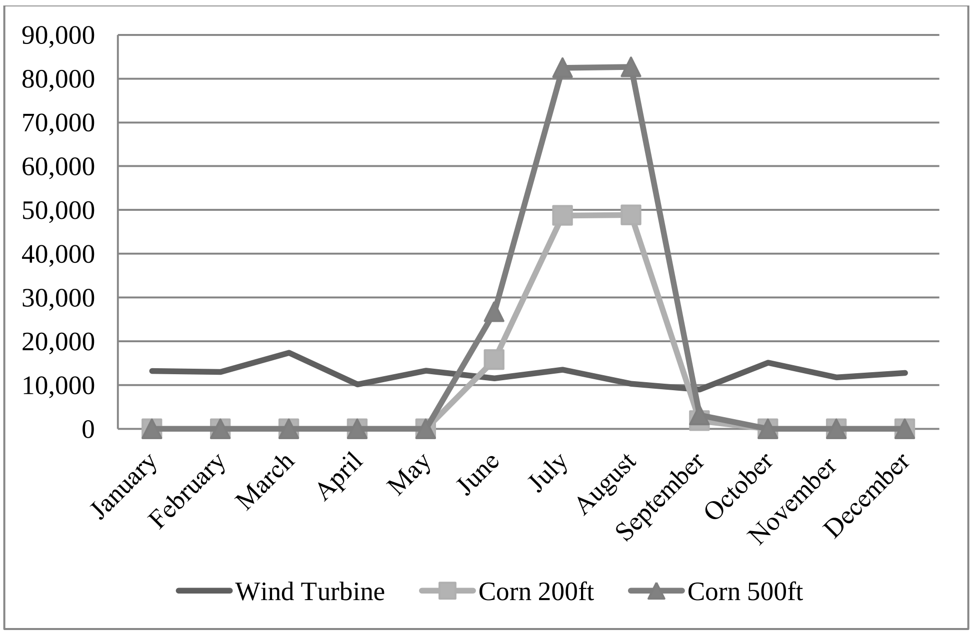

Figure 5.1: Energy Use in kWh for Corn in Kansas

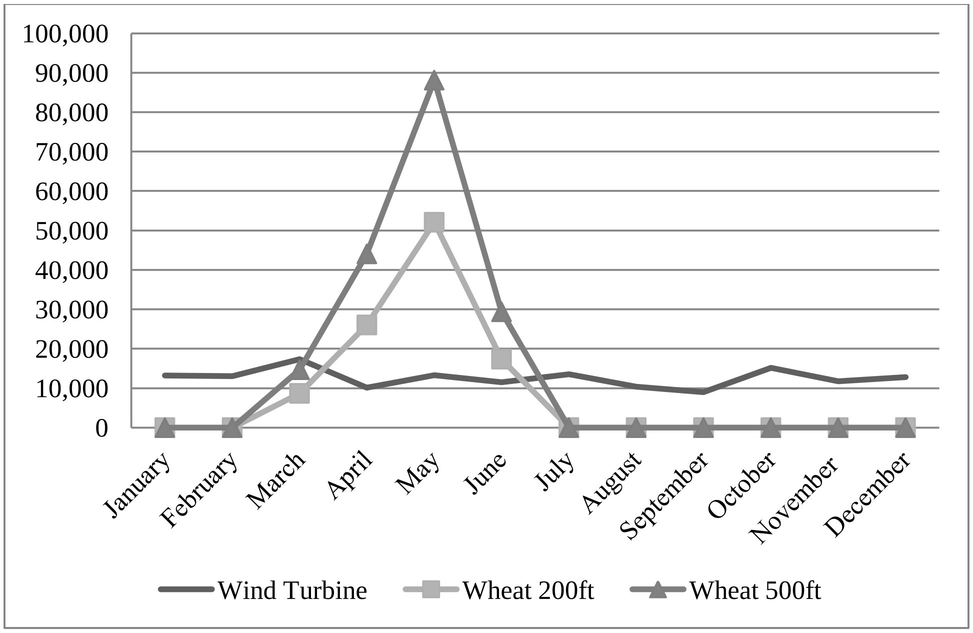

Figure 5.2: Energy Use in kWh for Wheat in Kansas

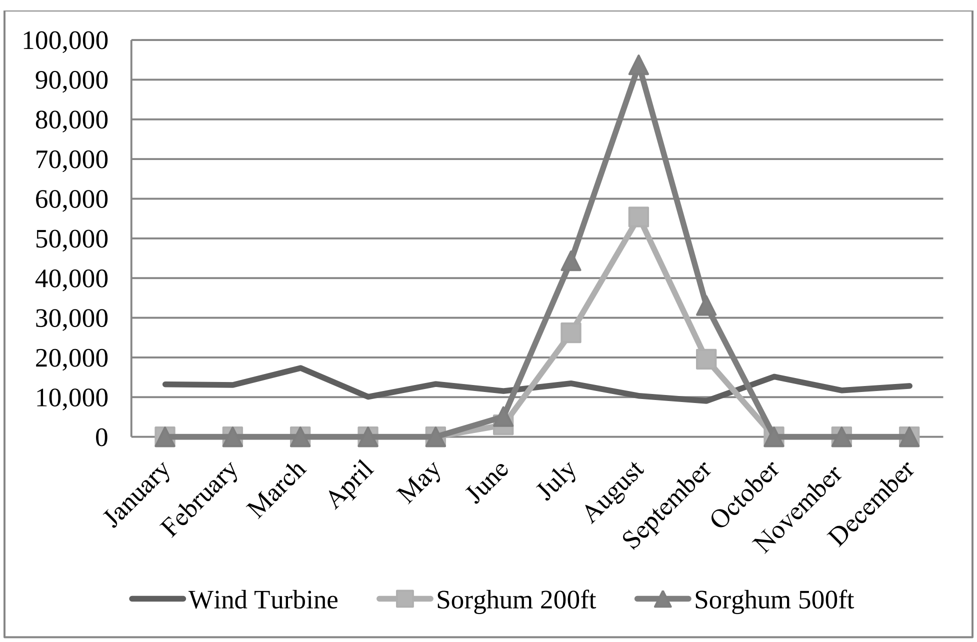

Figure 5.3: Energy Use in kWh for Sorghum in Kansas

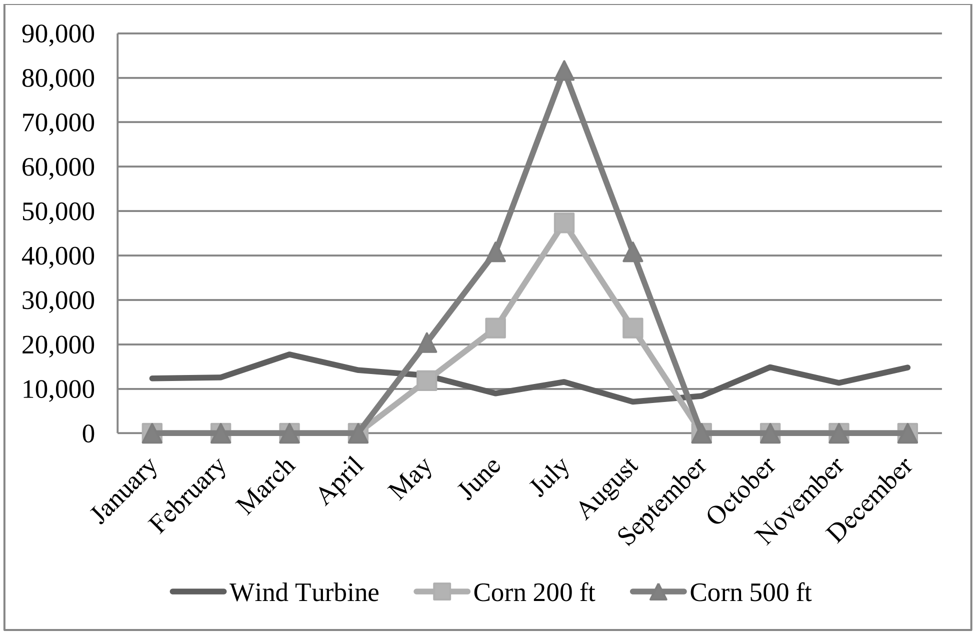

Figure 5.4: Energy Use in kWh for Corn in Texas

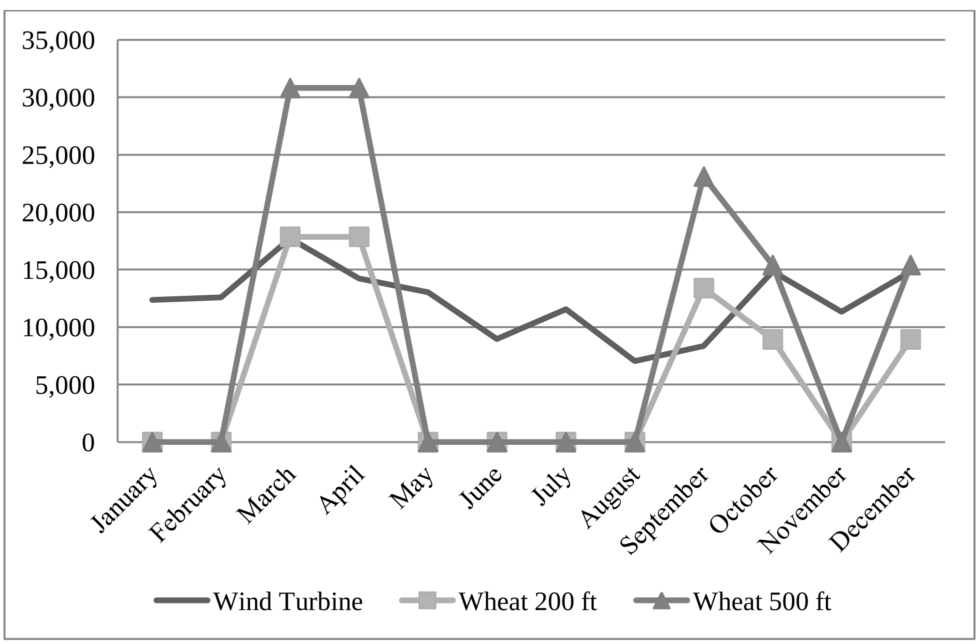

Figure 5.5: Energy Use in kWh for Wheat in Texas

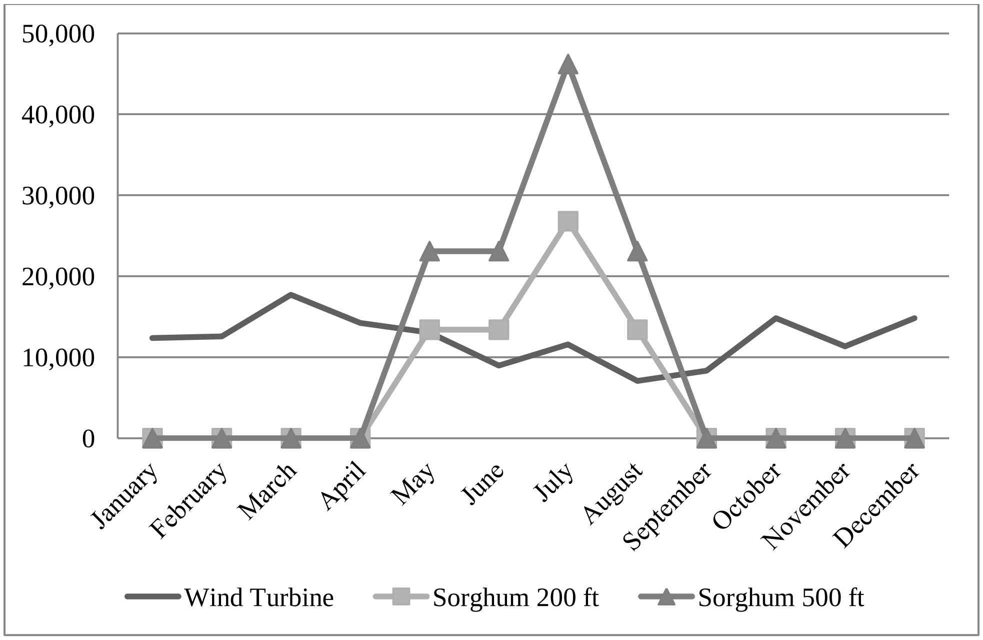

Figure 5.6: Energy Use in kWh for Sorghum in Texas

5.C. Natural Gas / Electric Costs and Buyback Rates

The data used for this study are from the United States Energy Information Administration (EIA) consisting of monthly industrial energy prices, averaged to annual basis for electric and natural gas pertaining to the state of Texas and Kansas. The monthly average prices for electricity and natural gas represent the cost per unit of energy sold and are calculated by dividing energy retail revenues by corresponding sales. Price data series for both energy sources range from 1997 to 2011 and are illustrated in Figures 5.7 and 5.8.

Natural gas prices during the sample period range between $3.12 and $9.65 per Mcf. Electricity prices range between $0.044 and $0.069 per kWh. Summary statistics on energy type are shown in the table 5.2. In addition, the buyback rates were determined for each state. Buyback rate for electricity in Texas varies depending on hourly surplus or shortage. For the purpose of this analysis, an average buyback rate of 65% of the electric price was used (Guerrero

2010) for the state of Texas, while an average buyback rate of 27% of the electric price was used in this analysis for Kansas.

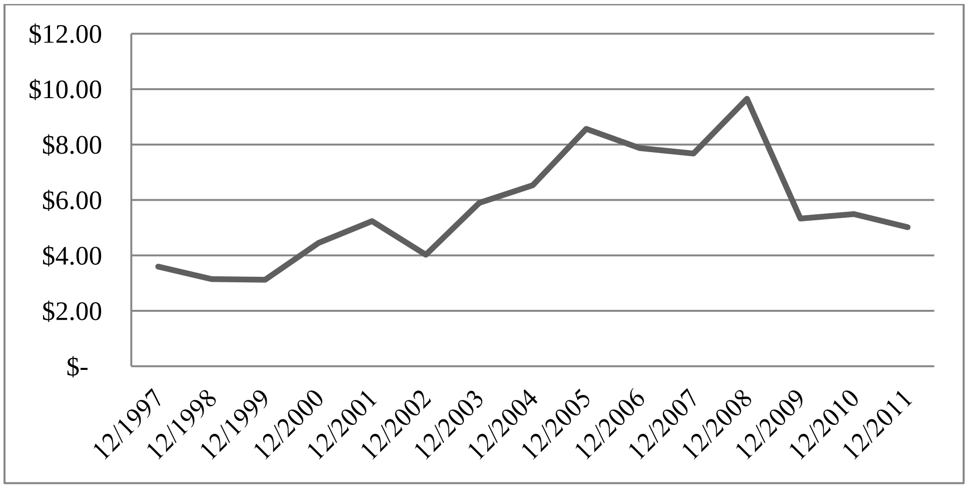

Figure 5.7: Industrial Natural Gas Prices

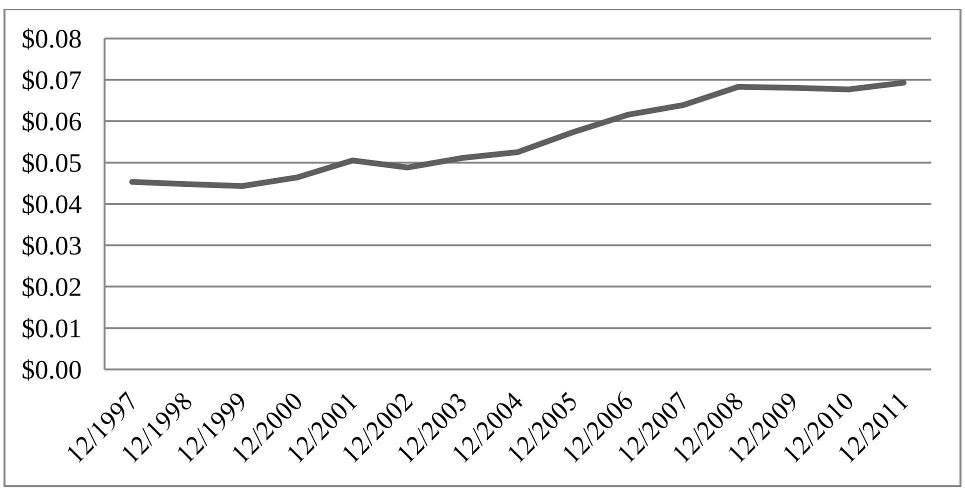

Figure 5.8: Industrial Electricity Price

Table 5.2. Summary Statistics for Natural Gas and Electricity Prices

	Mean	**Variance**	**Max**	**Min**	**Std Dev**
Natural Gas	5.705	4.002	9.650	3.120	2.000
Electricity	0.055	0.9 E-04	0.069	0.044	0.009

Energy system cost differences are calculated through the cost difference equations (4.3.a.), (4.3.b.) and (4.3.c.), and are shown in table 5.3.

Table 5.3. Summary Statistics for Energy System Cost Difference

Crop		**Texas**			**Kansas**		
		$C_N - C_E$	$C_N - C_H$	$C_E - C_H$	$C_N - C_E$	$C_N - C_H$	$C_E - C_H$
Corn 200	Mean	34.47	82.77	48.31	37.30	62.04	24.74
	Max	81.73	140.66	59.79	88.45	118.63	30.62
	Min	6.56	44.92	38.22	7.10	26.83	19.58
	Std Dev	25.08	29.37	8.30	27.14	29.08	4.25
Corn 500	Mean	37.93	86.13	48.31	40.28	64.90	24.74
	Max	104.39	163.32	59.79	110.84	141.02	30.62
	Min	0.26	37.96	38.22	0.28	19.17	19.58
	Std Dev	35.87	39.62	8.30	38.09	39.89	4.25
Wheat 200	Mean	21.68	69.74	48.06	33.70	57.85	24.15
	Max	51.41	110.03	59.48	79.93	109.39	29.89
	Min	4.12	42.24	38.02	6.41	25.66	19.11
	Std Dev	15.77	20.49	8.25	24.53	26.44	4.15
Wheat 500	Mean	23.86	71.84	48.06	36.39	60.44	24.15
	Max	65.66	124.28	59.48	100.16	129.62	29.89
	Min	0.16	37.86	38.02	0.25	18.75	19.11
	Std Dev	22.56	26.63	8.25	34.42	36.18	4.15

$\boldsymbol{C_N}$ is natural gas energy cost, $\boldsymbol{C_E}$ is electricity energy cost, and $\boldsymbol{C_H}$ is hybrid energy cost

Table 5.3. Summary Statistics for Energy System Cost Difference (continued)

Crop		Texas			Kansas		
		$C_N - C_E$	$C_N - C_H$	$C_E - C_H$	$C_N - C_E$	$C_N - C_H$	$C_E - C_H$
Sorghum 200	Mean	21.68	69.01	47.34	33.70	57.31	23.61
	Max	51.41	109.15	58.59	79.93	108.72	29.22
	Min	4.12	41.67	37.45	6.31	25.24	16.68
	Std Dev	15.77	20.40	8.13	24.53	26.39	4.05
Sorghum 500	Mean	23.86	71.12	47.34	36.39	59.89	23.61
	Max	65.66	123.40	58.59	100.16	128.69	29.22
	Min	0.16	37.29	37.45	0.25	18.32	18.68
	Std Dev	22.56	26.55	8.13	34.42	36.14	4.05

$\boldsymbol{C_N}$ *is natural gas energy cost,* $\boldsymbol{C_E}$ *is electricity energy cost, and* $\boldsymbol{C_H}$ *is hybrid energy cost*

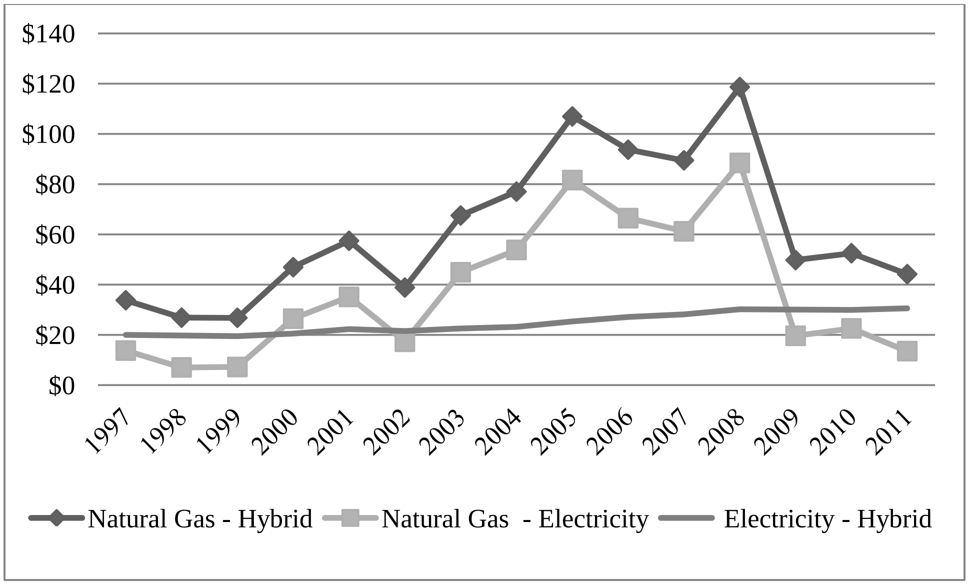

Figure 5.9: Energy Cost Difference for Corn at 200' Lift in Kansas

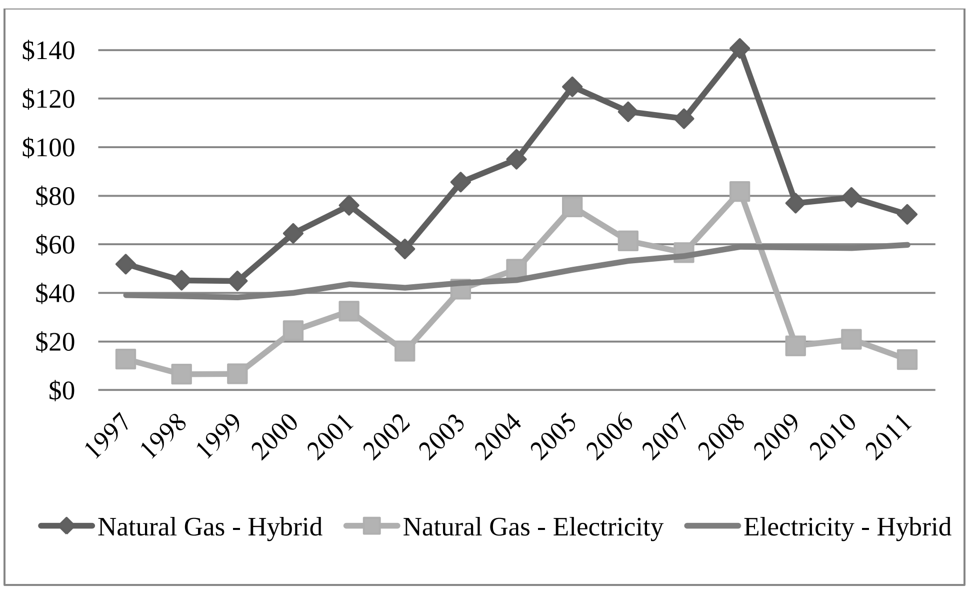

Figure 5.10: Energy Cost Difference for Corn at 200' Lift in Texas

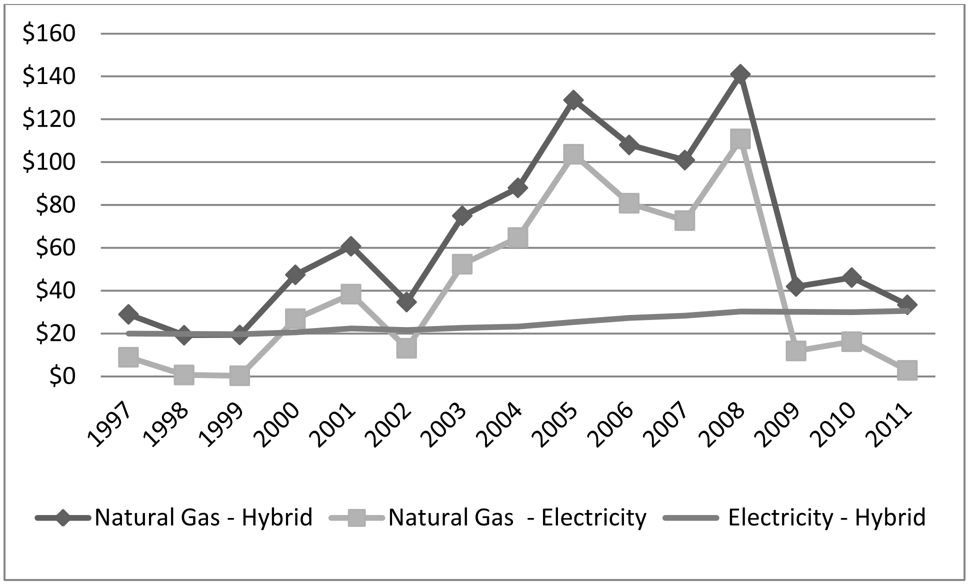

Figure 5.11: Energy Cost Difference for Corn at 500' Lift in Kansas

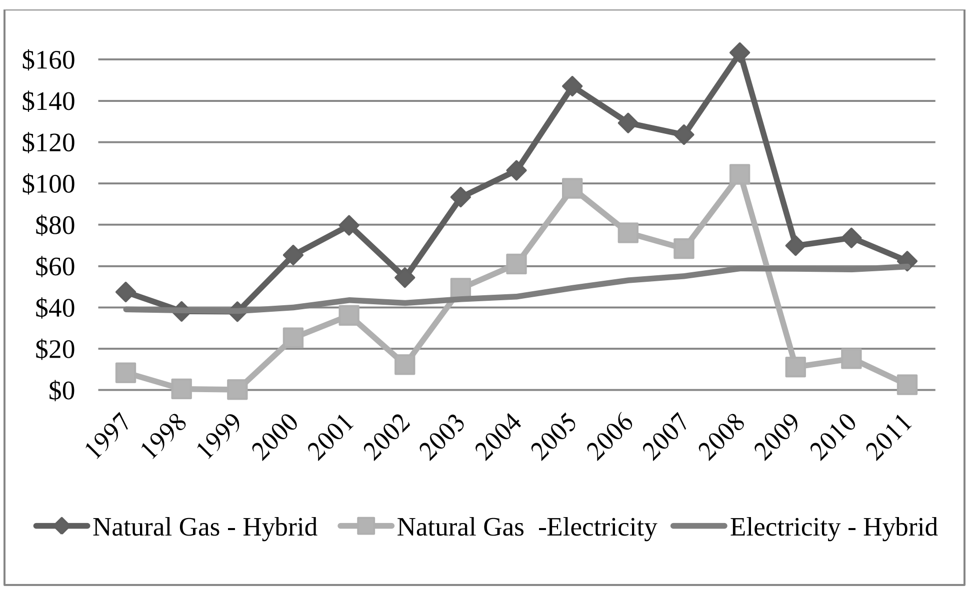

Figure 5.12: Energy Cost Difference for Corn at 500' Lift in Texas

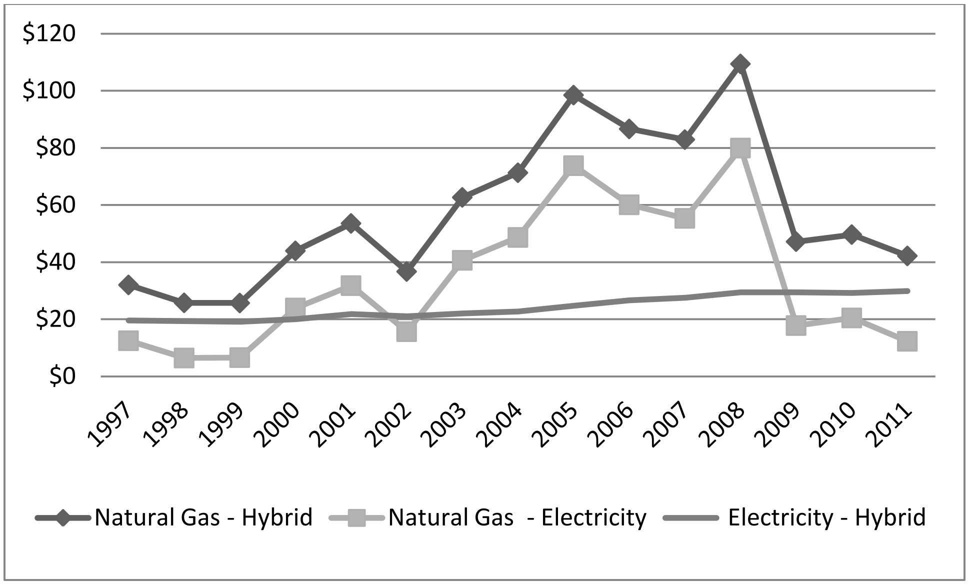

Figure 5.13: Energy Cost Difference for Wheat at 200' Lift in Kansas

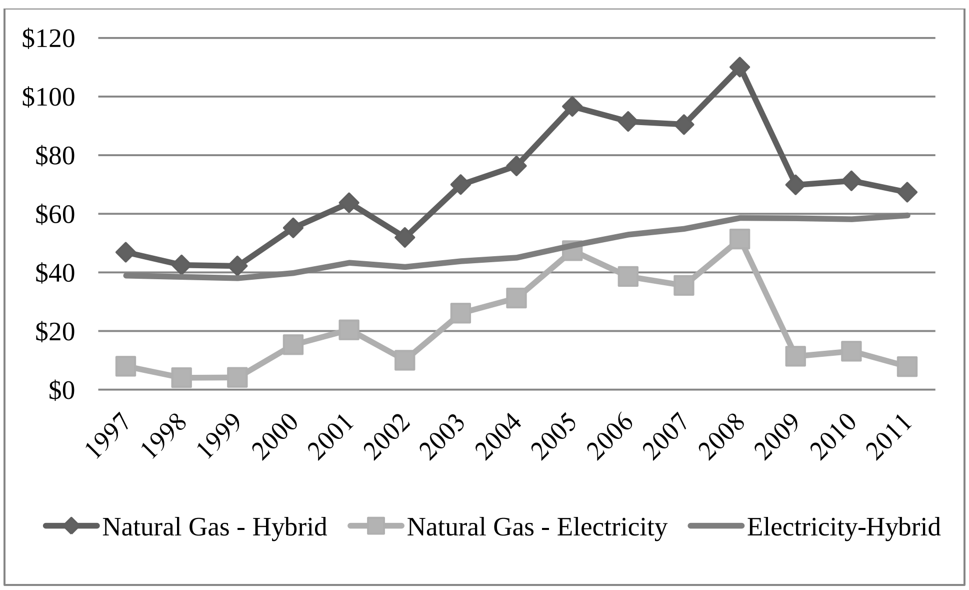

Figure 5.14: Energy Cost Difference for Wheat at 200' Lift in Texas

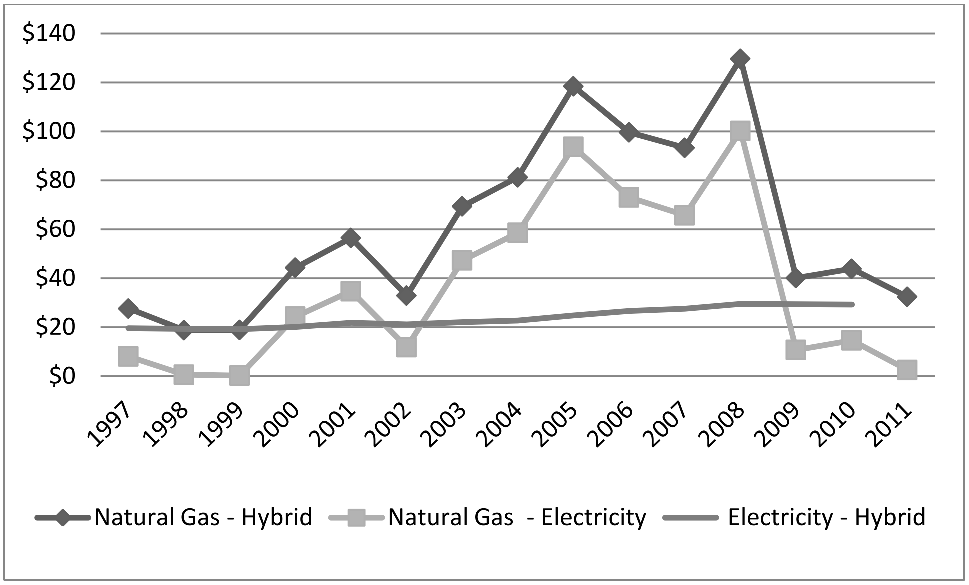

Figure 5.15: Energy Cost Difference for Wheat at 500' Lift in Kansas

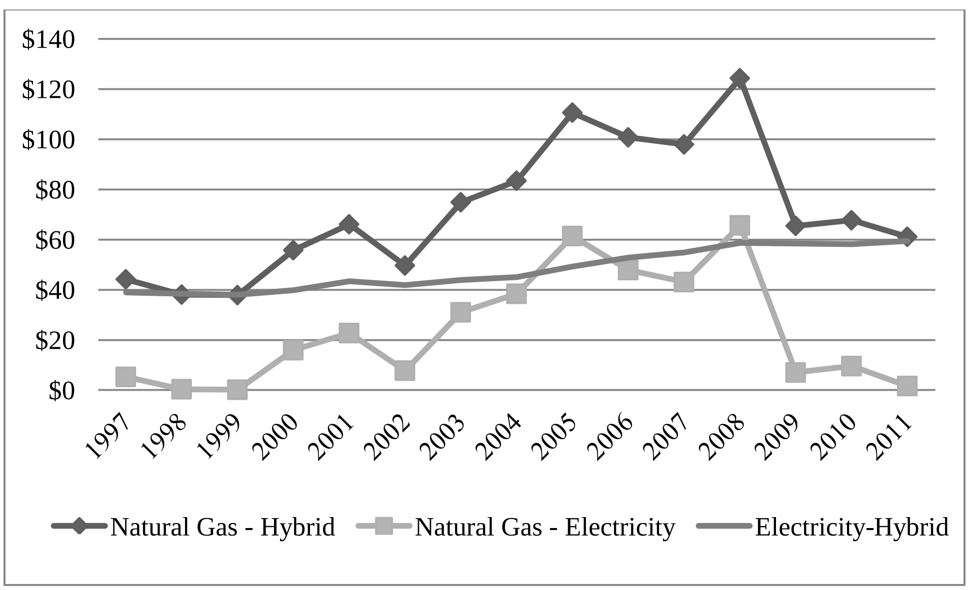

Figure 5.16: Energy Cost Difference for Wheat at 500' Lift in Texas

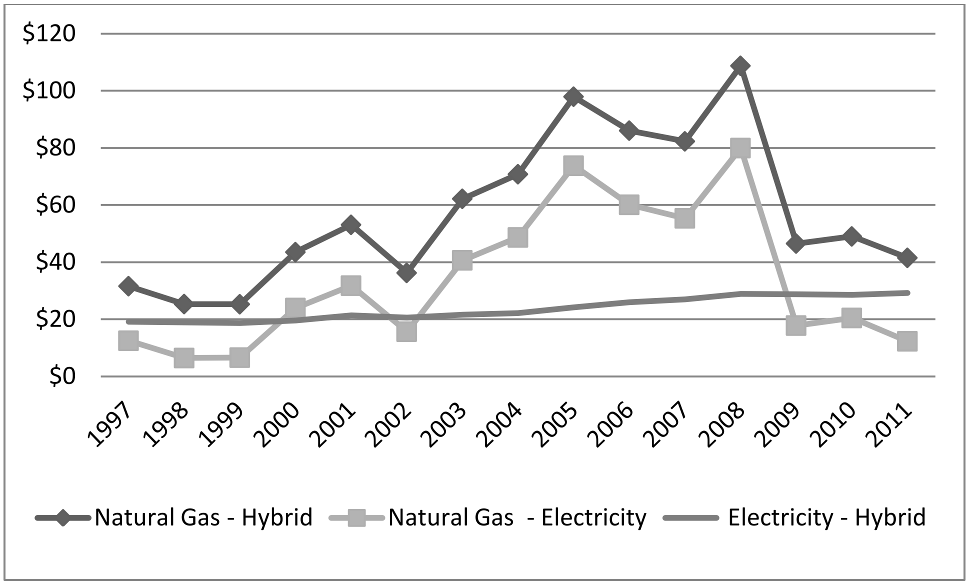

Figure 5.17: Energy Cost Difference for Sorghum at 200' Lift in Kansas

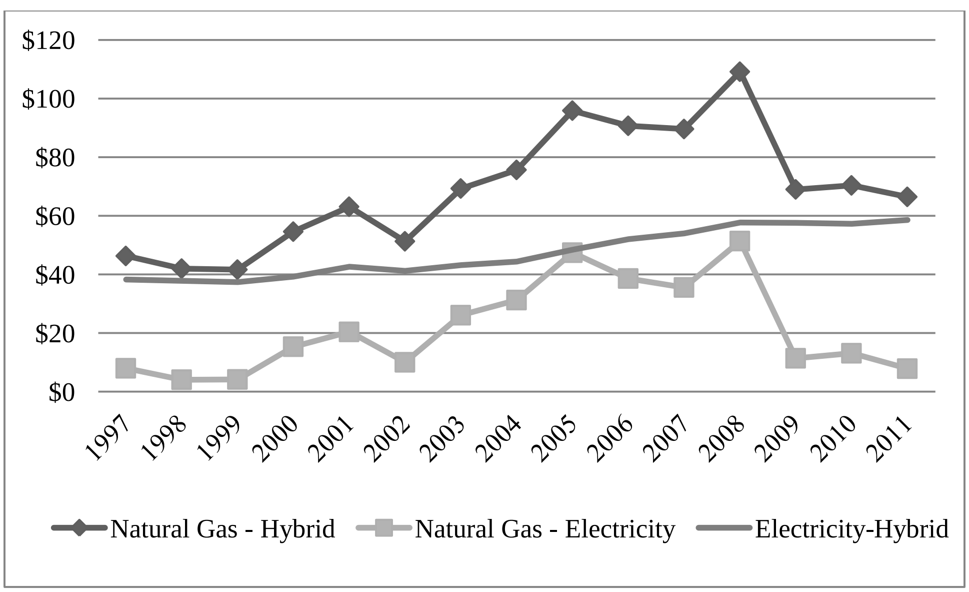

Figure 5.18: Energy Cost Difference for Sorghum at 200' Lift in Texas

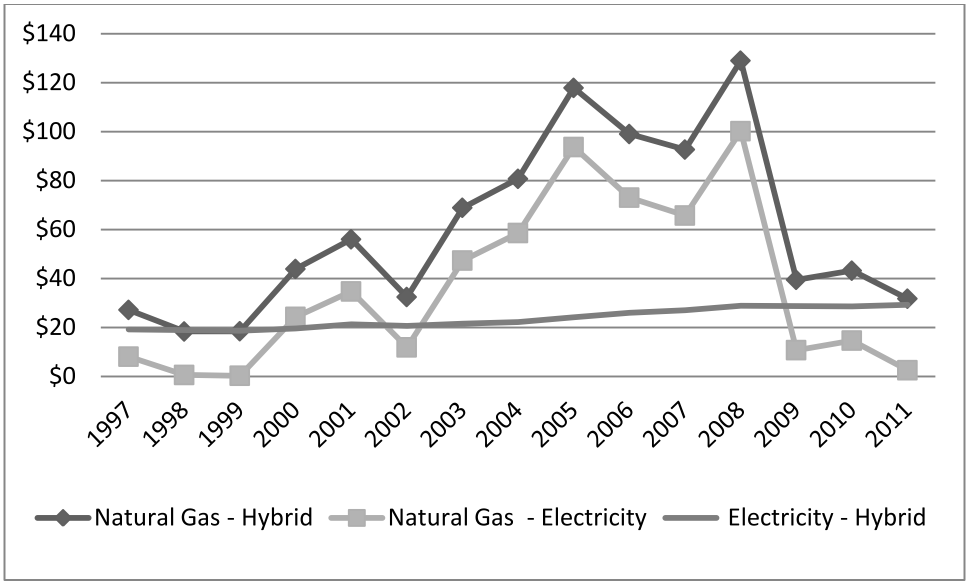

Figure 5.19: Energy Cost Difference for Sorghum at 500' Lift in Kansas

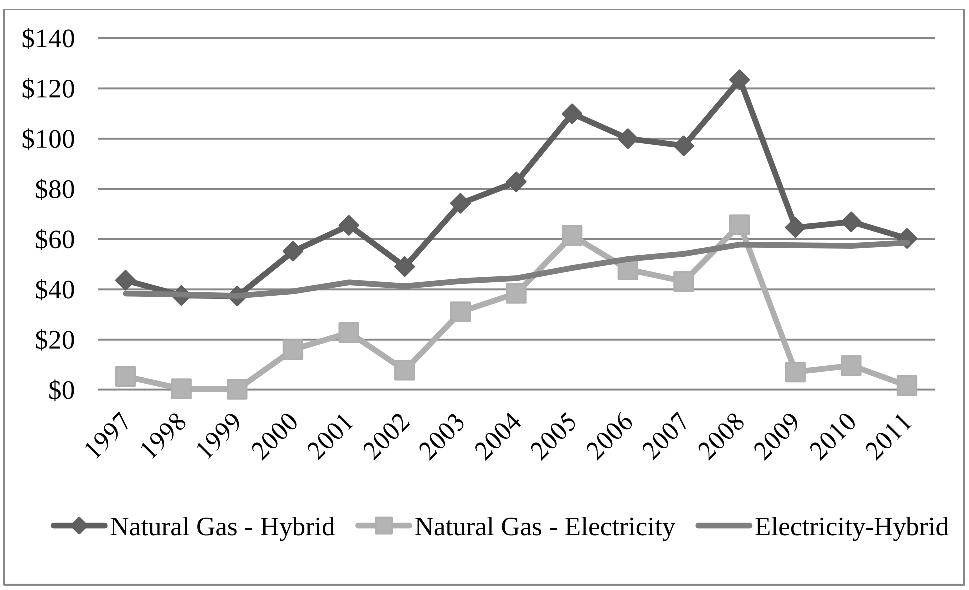

Figure 5.20: Energy Cost Difference for Sorghum at 500' Lift in Texas

5.D. Unit-Root Analysis

Natural gas and electricity cost data series are tested for unit root prior to Brownian motion parameter estimation. One of the most commonly used tests for a unit root is the augmented Dickey-Fuller test, where the null hypothesis is a unit root and the alternative is a stationary process. The augmented Dickey-Fuller test is applied to the first difference of the natural logarithm of energy source costs. The results presented in appendix table A.1 show that the hypothesis of a unit root is rejected.

5.E. Fixed and Variable Irrigation Pumping Costs by System

The economic cost comparison performed in the analysis is dependent on prices associated with investment, operation and maintenance for each irrigation system. Expenditures regarding initial outlay and maintenance of a natural gas engine, electric engine and hybrid systems are categorized by state and well depth and shown in Table 5.4, 5.5 and 5.6 respectively. Table 5.7 summarizes investment and operating costs by study area and energy system.

Natural gas irrigation system investment cost for Texas regarding a 200 and 500 feet lift are $10,997 and $35,940, respectively. Operational labor, maintenance and repair costs (LMR) are $1,084 for a 200 feet lift and $1,480 for a 500 feet lift. Kansas investment cost for a 200 feet lift and 500 feet lift are $35,940 and $43,550 with LMR of $1,480 and $2,178 respectively.

Table 5.4: Fixed and Variable Costs for a Natural Gas Irrigation Engine

Engine Costs			Useful Life	Salvage Value	Labor, Maintenance and Repair costs.	
Lift	Investment ($)	$/acre/yr	Years	% of Investment	Annual ($)	$/acre/yr
Texas						
200'	10,997	7.64	12	10%	1,084	9.03
500'	35,940	24.96	12	10%	1,480	12.33
Kansas						
200'	35,940	24.96	12	10%	1,480	12.33
500'	43,550	30.24	12	10%	2,178	18.15

Expenses related to investment, conversion, and maintenance of an electric motor are shown in Table 5.5. At a pumping lift of 200 feet in Texas, the electric engine investment costs are $4,812 with annual labor, maintenance, and repair costs of $450 per year. At 500 feet pumping lift, Texas electric engine investment costs are $8,835 and annual labor, maintenance and repair costs of $774. Kansas electric engine investment cost where higher due to the higher flow rate of 1200 GPM compared to 600 GPM in Texas (Guerrero 2010), and consequent horsepower requirements. Kansas investment for electric engine is $8,835 for a 200 feet pumping lift, with annual labor, maintenance and repair costs of $930. A 500 feet lift in Kansas has electric engine cost of $16,800 with an annual LMR cost of $1,416.

The cost to convert from a natural gas powered irrigation system to electric includes the fuse, control panel, pump conversion, and labor and installation (New 2006) and in this study range from $7,530 to $25,370.

Table 5.5: Fixed and Variable Costs for an Electric Irrigation Engine

Motor Costs				Useful Life	Salvage Value	Labor, Maintenance and Repair costs.	
	Investment ($)	Conversion ($)	$/acre/yr	Years	% of Investment	Annual ($)	$/acre/yr
Texas							
200'	4,812	7,530	6.86	15	10%	450	3.75
500'	8,835	15,440	13,49	15	10%	774	6.45
Kansas							
200'	8,835	15,440	13,49	15	10%	930	7.75
500'	16,800	25,370	23.42	15	10%	1,416	11.80

Turbine costs are gathered for the AOC 15/50 wind turbine and are combined with electric motor costs to determine the total fixed and variable costs for a hybrid system. Expenses related to investment, conversion, and the operation and maintenance of the system are shown in Table 5.6. Additionally turbines have a life of 20 years based on equipment wear and no salvage value. Operation labor, maintenance and repair costs are assumed at $0.01 per kWh:

$$LMR\ costs = \$0.01kWh \times (annual\ kWh\ production).$$

At the determined pumping lifts of 200 and 500 feet in Texas, investment costs were $228,067, and $240,000 and annual operation and maintenance costs are $15.92, and $18.62 per acre, respectively. In the same manner, Kansas investment costs are $240,000 and $257,895 annual operation and maintenance costs are $20.33, and $24.38 per acre for a 200 feet and 500 feet pumping lift respectively.

Table 5.6: Fixed and Variable Costs for a Hybrid Irrigation System

Investment Costs			Useful Life	Salvage Value	Labor, Maintenance and Repair costs	
Lift	Turbine, Motor, and Conversion ($)	$/acre/yr	Years	% of Investment	Annual ($)	$/acre/yr
Texas						
200'	228,067	95.03	15/20	0%	1,910	15.92
500'	240,000	100.00	15/20	0%	2,234	18.62
Kansas						
200'	240,000	100.00	15/20	0%	2,440	20.33
500'	257,895	107.46	15/20	0%	2,926	24.38

Table 5.7: Investment and Operating Costs by State and Energy System

Crop	Kansas			Texas		
	Natural Gas	Electric	Hybrid	Natural Gas	Electric	Hybrid
Corn 200'						
Investment ($\boldsymbol{I}$)	299.50	172.34	1970.05	91.64	93.69	1891.39
Operating ($\boldsymbol{O}$)	290.70	121.57	287.04	148.14	56.71	217.10
Corn 500'						
Investment ($\boldsymbol{I}$)	362.92	315.13	2112.83	299.50	172.34	1970.05
Operating ($\boldsymbol{O}$)	398.81	188.40	353.87	285.39	97.40	258.76
Wheat 200'						
Investment ($\boldsymbol{I}$)	299.50	172.34	1970.05	91.64	93.69	1891.39
Operating ($\boldsymbol{O}$)	290.70	121.57	287.04	148.14	56.71	217.10
Wheat 500'						
Investment ($\boldsymbol{I}$)	362.92	315.13	2112.83	299.50	172.34	1970.05
Operating ($\boldsymbol{O}$)	398.81	188.40	353.87	285.39	97.40	258.76
Sorghum 200'						
Investment ($\boldsymbol{I}$)	299.50	172.34	1970.05	91.64	93.69	1891.39
Operating ($\boldsymbol{O}$)	290.70	121.57	287.04	148.14	56.71	217.10
Sorghum 500'						
Investment ($\boldsymbol{I}$)	362.92	315.13	2112.83	299.50	172.34	1970.05
Operating ($\boldsymbol{O}$)	398.81	188.40	353.87	285.39	97.40	258.76

Investment Cost ($\boldsymbol{I}$) under electricity and Hybrid system includes conversion Costs.

Operating Cost ($\boldsymbol{O}$) is presented at the base interest rate of 6%.

5.F. Parameter Estimates

Parameters for the geometric Brownian motions (4.4) are estimated for the entire sample period, and additionally for the economic activity period of 1997 to 2005. Further, the time period of 2006 to 2011 is also considered to incorporate a period of economic recession. It is hypothesized that it will hold higher than average parameter estimates for energy cost. According to Ito's lemma, the logarithm of a cost variable following the geometric Brownian motion is described by the Brownian motion process:

$$dp = \left(\mu - \frac{1}{2}\sigma^2\right) dt + \sigma\, dz = \alpha dt + \sigma dz. \quad (5.6)$$

The respective estimators for the drift (α) and volatility (σ) in (5.6) are:

$$\hat{\alpha} = \frac{1}{n}\sum_{t=1}^{n} r_t, \quad (5.6)$$

and

$$\hat{\sigma}^2 = \frac{1}{n}\sum_{t=1}^{n}(r_t - \hat{\alpha})^2 \quad (5.7)$$

where $r_i = \Delta ln\, C_t = ln\, C_t - ln\, C_{t-1}$ is the first difference of the natural logarithm of corresponding annual cost at time t, and n is the number of observations. The volatility estimator can then be used directly for estimating volatilities of the geometric Brownian motion (4.4), while the corresponding drifts (α) can be estimated as:

$$\mu_i = \hat{\alpha} + \frac{1}{2}\hat{\sigma}^2 \quad (5.8)$$

Tables 5.8, 5.9, and 5.10 list the calculated drift, and volatility for the all sample.

Table 5.8: Parameter Estimates for the Full Sample

Full Sample 1997-2011					
Crop		NG-Hyb		El-Hyb	
Kansas		Drift (μ)	Volatility(σ)	Drift (μ)	Volatility(σ)
Corn	200	0.085	0.365	0.031	0.037
	500	0.147	0.524	0.031	0.037
Wheat	200	0.082	0.353	0.031	0.037
	500	0.139	0.505	0.031	0.037
Sorghum	200	0.083	0.357	0.031	0.037
	500	0.141	0.510	0.031	0.037
Texas					
Corn	200	0.056	0.255	0.031	0.037
	500	0.083	0.356	0.031	0.037
Wheat	200	0.045	0.195	0.031	0.037
	500	0.059	0.270	0.031	0.037
Sorghum	200	0.045	0.197	0.031	0.037
	500	0.060	0.272	0.031	0.037

Table 5.9: Parameter Estimates for the Economic Activity Sample

Economic Activity Sample 1997-2005					
		NG-Hyb		El-Hyb	
Kansas		Drift (μ)	Volatility(σ)	Drift (μ)	Volatility(σ)
Corn	200	0.203	0.344	0.030	0.042
	500	0.314	0.505	0.030	0.042
Wheat	200	0.195	0.332	0.030	0.042
	500	0.300	0.485	0.030	0.042
Sorghum	200	0.198	0.336	0.030	0.042
	500	0.291	0.465	0.030	0.042
Texas					
Corn	200	0.134	0.220	0.030	0.042
	500	0.190	0.313	0.030	0.042
Wheat	200	0.105	0.170	0.030	0.042
	500	0.142	0.234	0.030	0.042
Sorghum	200	0.106	0.171	0.030	0.042
	500	0.143	0.236	0.030	0.042

Table 5.10: Parameter Estimates for the Economic Recession Sample

Economic Recession Sample 2006-2011					
		NG-Hyb		El-Hyb	
Kansas		Drift (μ)	Volatility(σ)	Drift (μ)	Volatility(σ)
Corn	200	-0.075	0.389	0.024	0.027
	500	-0.092	0.534	0.024	0.027
Wheat	200	-0.073	0.377	0.024	0.027
	500	-0.091	0.517	0.024	0.027
Sorghum	200	-0.073	0.381	0.024	0.027
	500	-0.091	0.522	0.024	0.027
Texas					
Corn	200	-0.053	0.277	0.024	0.027
	500	-0.073	0.380	0.024	0.027
Wheat	200	-0.038	0.214	0.024	0.027
	500	-0.057	0.293	0.024	0.027
Sorghum	200	-0.039	0.216	0.024	0.027
	500	-0.057	0.296	0.024	0.027

CHAPTER 6

FEASIBILITY ANALYSIS

The feasibility analysis has the primary purpose to aid management decisions toward business operation cost reduction and expose possible benefits in cost savings that are expected from an alternative energy investment option. The agent faces the option to switch the current energy system to either electric or hybrid energy systems. The options are to propel a quarter-mile center pivot sprinkler irrigation system within two geographic areas, the Northern Texas Panhandle and Southwestern Kansas, where wind speeds are consistent and meet energy generation requirements for irrigation based on wind energy systems. The net costs associated with each alternative energy system are evaluated over at a 20 year time horizon.

In each geographic area, pumping lifts of 200 and 500 feet with flow capacities of 600 and 1200 gallons per minute where analyzed to irrigate the crops of corn, wheat and grain sorghum. The costs associated with each energy system included the investment expense of converting among energy systems, operational energy cost based on irrigation demand, operational labor, maintenance repairs and system replacement demand. The costs were analyzed for each combination of geographic area, crop and pumping lift, and expressed on a yearly per acre unit, to facilitate an agent decision making process. The yearly cost figures per energy system were used to calculate the cost difference between energy systems in equation (4.3).

A four year average of the annual cost difference for the energy alternatives in equation (4.3) corresponding to the period of 2007 to 2011 was used in both regions for each crop and pump combination to allow comparison between energy systems and serve as a baseline energy cost change per energy alternative, crop, location and pump requirement to be set against the real option and net present value analysis of investment. The same procedure was used for the economic activity and economic recession samples used under the sensitivity analysis.

The cash flow stream accounted for the taxes, insurance, buyback rates, inflation and discount rates. Taxes are figured as 1% of the value achieved through the tax assessment ratio of 0.20. Insurance costs accounted for 0.6% of the investment cost. Credit from selling excess electricity back to the grid from the hybrid system corresponded to the average buyback rates in the regions analyzed. Excess electricity was estimated on a yearly basis, based on monthly irrigation demand from a crop growing season. All costs after the first year where adjusted at 3% per year. A tax credit that reflects depreciation of certain business investments was approximated utilizing the Modified Accelerated Cost-Recovery System (MACRS) over five years at a 15% marginal tax rate. The net operational cost stream suffered a 6% discount rate, and was calculated with (2.1) for net present cost value and (4.12) for real options cost threshold.

Sensitivity analysis was conducted to estimate the effect of higher discount rates (increasing at 0.5% levels from 6% to 12%), have on the economic feasibility. Additional samples named, Economic Activity Sample and Economic Recession Sample, were used to analyze the Brownian motion parameter estimates behavior and its impact on threshold cost. The Economic Recession Sample is hypothesized to have higher than expected drift and volatility estimates. Sensitivity regarding monthly and annual net metering was also performed for the cost comparison of electric and natural gas against hybrid system.

6.A. Results

The analysis performed indicates that investment option in electric system from the current assumed natural gas irrigation system in both study regions will result in cost savings for the agricultural producer. The resulting cost savings change attained from investment in electric system was straightforward and a primary outcome of the analysis. Using the cost structure data of natural gas and electricity in (4.1.a.) $I_a = (I_N + O_N) - (I_E + O_E)$ and (4.3.a.) $C_a = (IR_N \times E_N \times P_N) - (I_E \times E_E \times P_E)$ results in a benefit regarding the change since $(I_E + O_E) < (I_N + O_N)$ and $(I_E \times E_E \times P_E) < (IR_N \times E_N \times P_N)$, therefore achieving cost savings from the switch in energy used to propel irrigation systems. Results in Texas under the full sample for corn crops with 200' lift at a 6% interest rate generated $16 under real options analysis (ROA) and $5.36 under net present value (NPV), with average energy cost difference calculated for the period of 2007-2011 of $37.99. The values attained from calculations of natural gas against the option to switch to electric systems are positive under all scenarios regarding combinations of study location, crop, and pumping lift. Results represent savings from the change and under the full sample period for Kansas and Texas are quantified in the tables A.2, and A.23 in the appendix section.

Results for all combinations of study region, crop, lift size, and sensitivity analysis are found in the appendix. It is important to notice that although all values are depicted as positive, investment cost changes for natural gas and electric to the hybrid system, from (4.1b.) and (4.1c.), are in fact negative since hybrid investment requires higher capital requirements, while all average energy cost differences are positive and denote benefits. The second investment option analyzed is the switch from an electric based irrigation system to a hybrid based system. Results under this investment option for Kansas under all samples produced a small threshold cost gap difference between real options (ROA) and net present value (NPV), mostly due to interaction of sunk costs and operational costs since both investments are based on electric pump and additionally to electric energy cost behavior presenting low volatility. The gap difference is 1% between ROA and NPV feasibility margins for the 200' lift corn crop at 6% interest. Even though the gap difference is small, the minimum cost threshold value for NPV of $117.79 is quite different than the one for ROA of $120.44. This result shows that the switch from electric to hybrid is not a feasible investment if compared to the average cost difference between energy systems (2007-2011) of $29.81. The results obtained for Texas follow closely the ones outlined in Kansas, therefore the switch from an electric system to a hybrid system is not feasible for any combination of study region, crop and lift. Figure 6.1 illustrates the pattern attained for all sample periods and all crop/lift combinations under the investment option to switch from electric irrigation systems to hybrid based systems.

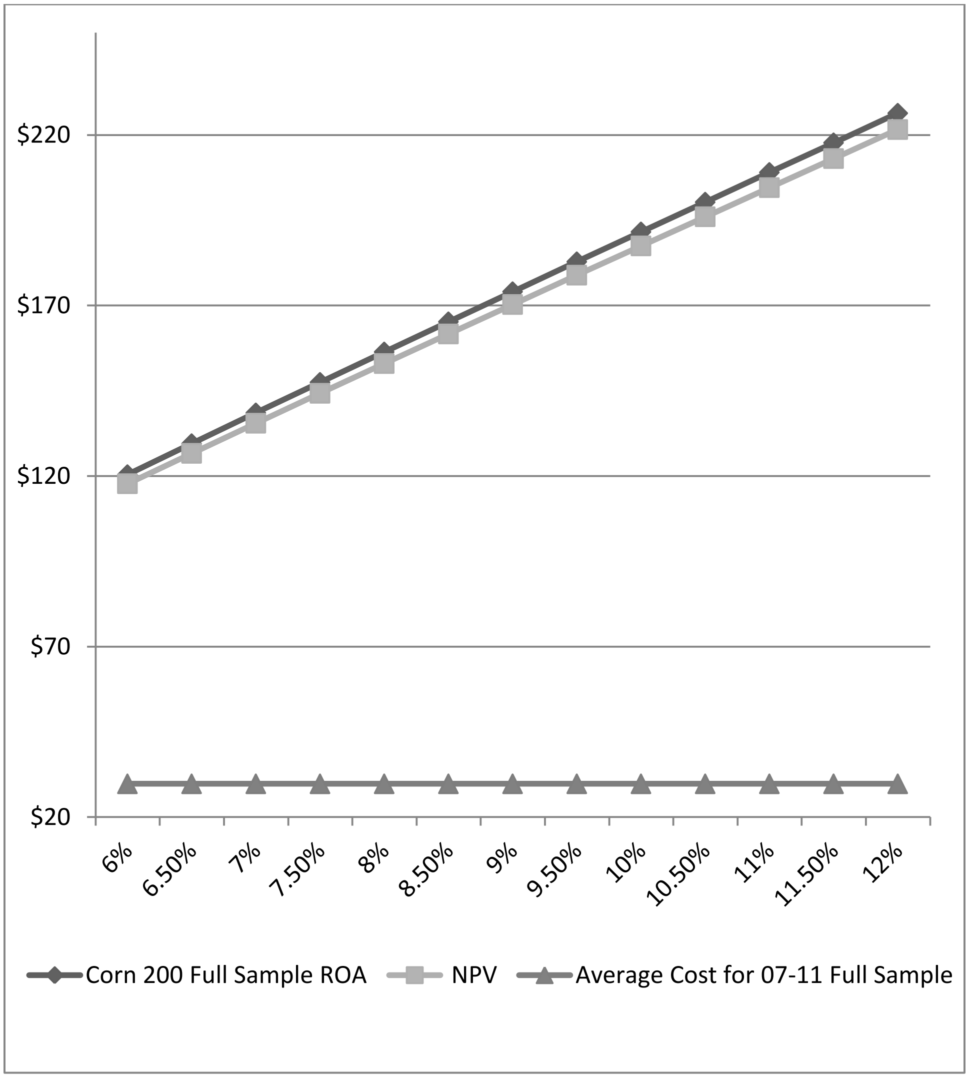

Figure 6.1: Option to Switch from Electric to Hybrid System

for Corn Crop at 200 Feet under Full Sample

Under the feasibility analysis of the investment option to switch from the current irrigation system, based on natural gas energy, to a hybrid based system results indicate that in Kansas while net present value was stable with a cost margin of $100.01 for a 200' lift and $102.3 for a 500' lift, without concern of crop grown, real options threshold margins varied greatly depending on the sample period analyzed and on lesser scale according to crop type. The variation achieved through sample analyzed was expected due to the drift and volatility change, while the small cost variation by crop type can be linked to the irrigation requirement among crops being closely related in Kansas, a larger energy requirement variation between crops is found in Texas. Throughout the analysis a much larger investment threshold margin was attained by the real options calculations then the ones achieved through NPV in both study regions.

The highest margins for the option to switch from natural gas to hybrid were attained during the Economic Recession Sample for both states. Particularly high for the Kansas region, that has a lower buyback rate than Texas. Kansas ROA reached a maximum cost of $557.25 a value 544% higher than NPV analysis, for the corn crop at a 500' lift, and a minimum cost of $382.23 for wheat at 200' lift, still 382% higher than NPV value for same crop lift combination. During the Economic Recession Sample period and Economic Activity Sample period the state of Kansas did not produce net present value or real options investment values confirming positive investment outcomes. The net present value to switch from natural gas to hybrid was achieved in the full sample for all crops under annual net metering scenario, and can be found on appendix table A.8.

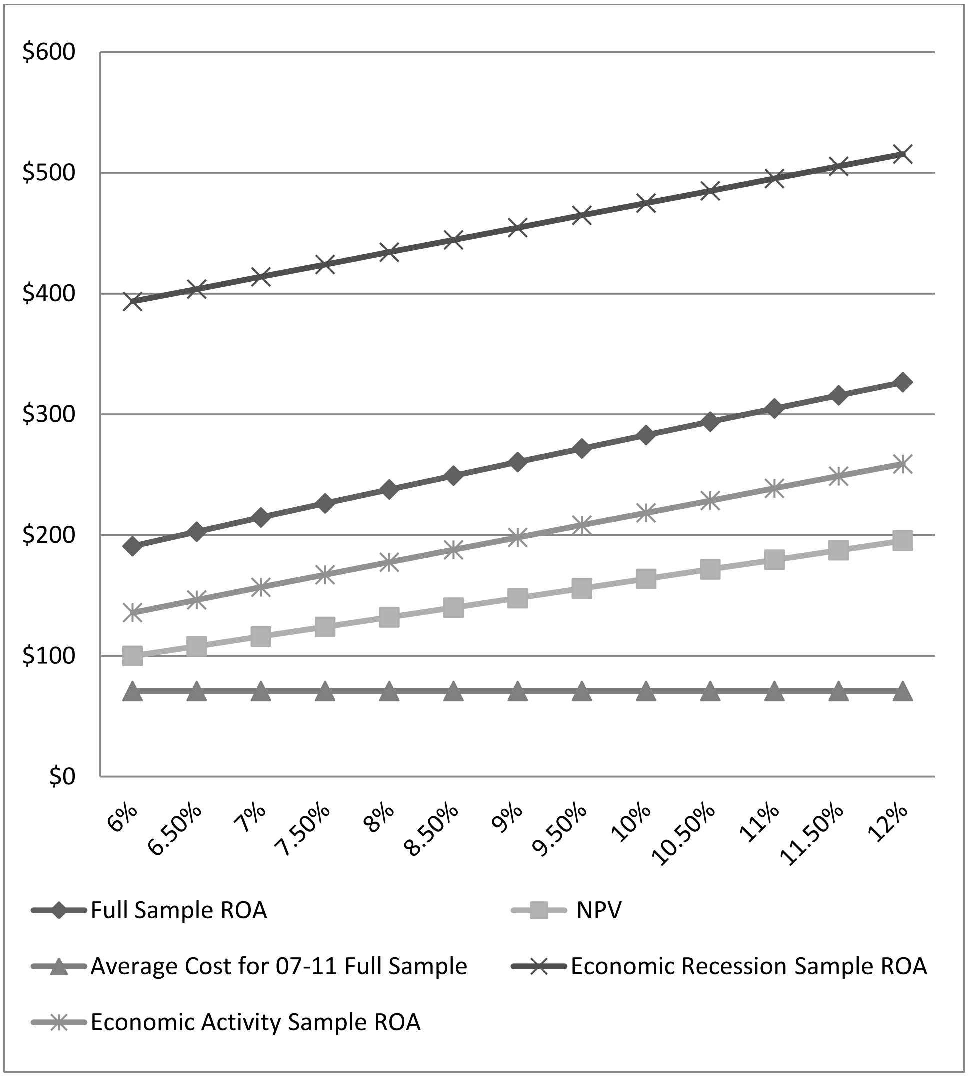

Figure 6.2: Option to Switch from Natural Gas to Hybrid system

for Corn Crop at 200' Lift in Kansas

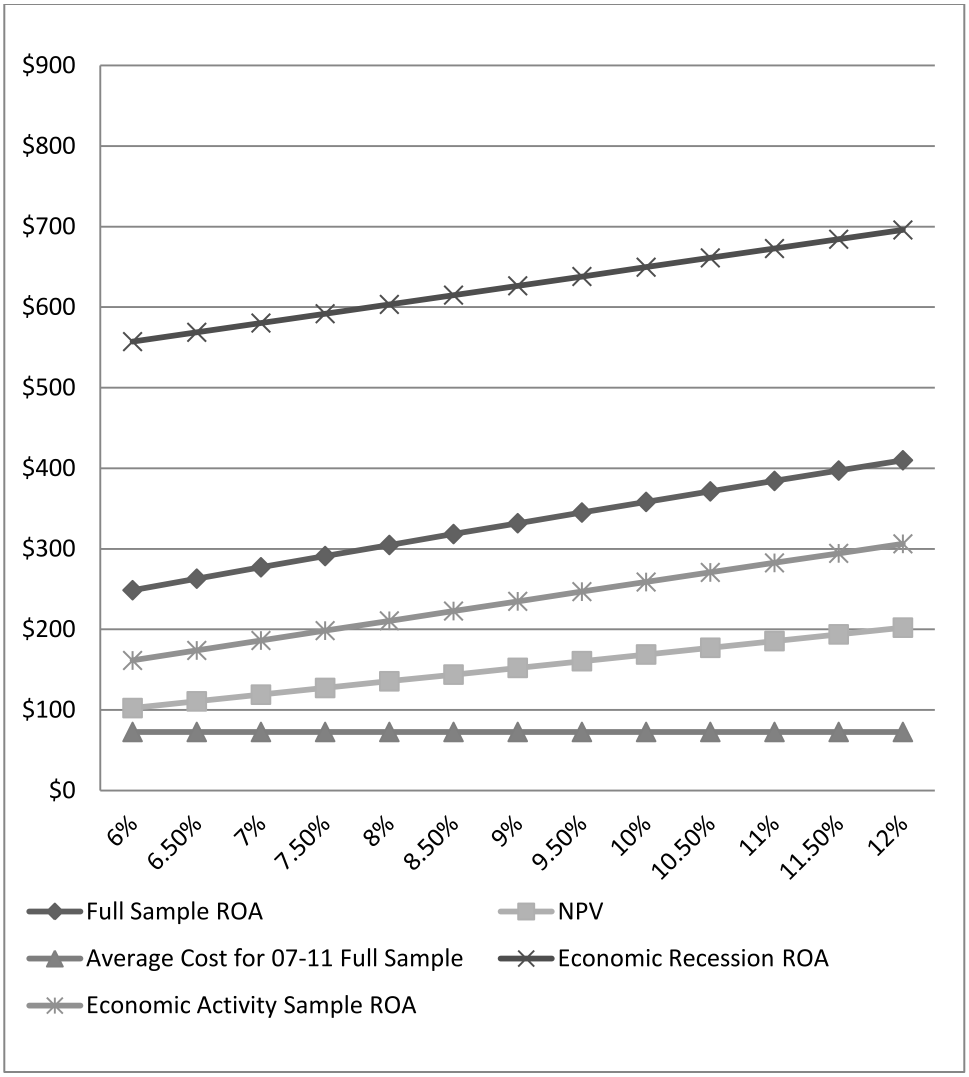

Figure 6.3: Option to Switch from Natural Gas to Hybrid System

for Corn Crop at 500' Lift in Kansas

The analysis for the state of Texas under the investment alternative to switch from natural gas to hybrid energy irrigation system followed somewhat the large cost threshold price difference between ROA against NPV. In Texas NPV trigger cost was constant at $112.12 for a 200' lift and at $98.64 for a 500' lift, while ROA varied by sample, having a low of $119.75

under economic activity sample period to a maxima of $379.81 under economic recession sample period. While the cost threshold margin difference in relation to real options remained large, it was lower than in Kansas. These results outline the impact of buyback rates in energy investments considering cost savings. The real options and net present value analysis produced no favorable investment scenario under any sample period. The closest threshold value was attained in the net present value analysis for corn crop at 500 feet where the average energy cost difference was $98.57 and the net present value was only $0.07 away at $98.64.

The ROA margins for investment adoption and the net present values for the combination of sample periods, crop, lift and range of interest rates can be found in the appendix. The results for corn crop at 200' and 500',as well as the crops of wheat and sorghum at 500' are illustrated in Figures 6.4, 6.5, 6.6, and 6.7 providing visual outline of the impact of varying interest rates.

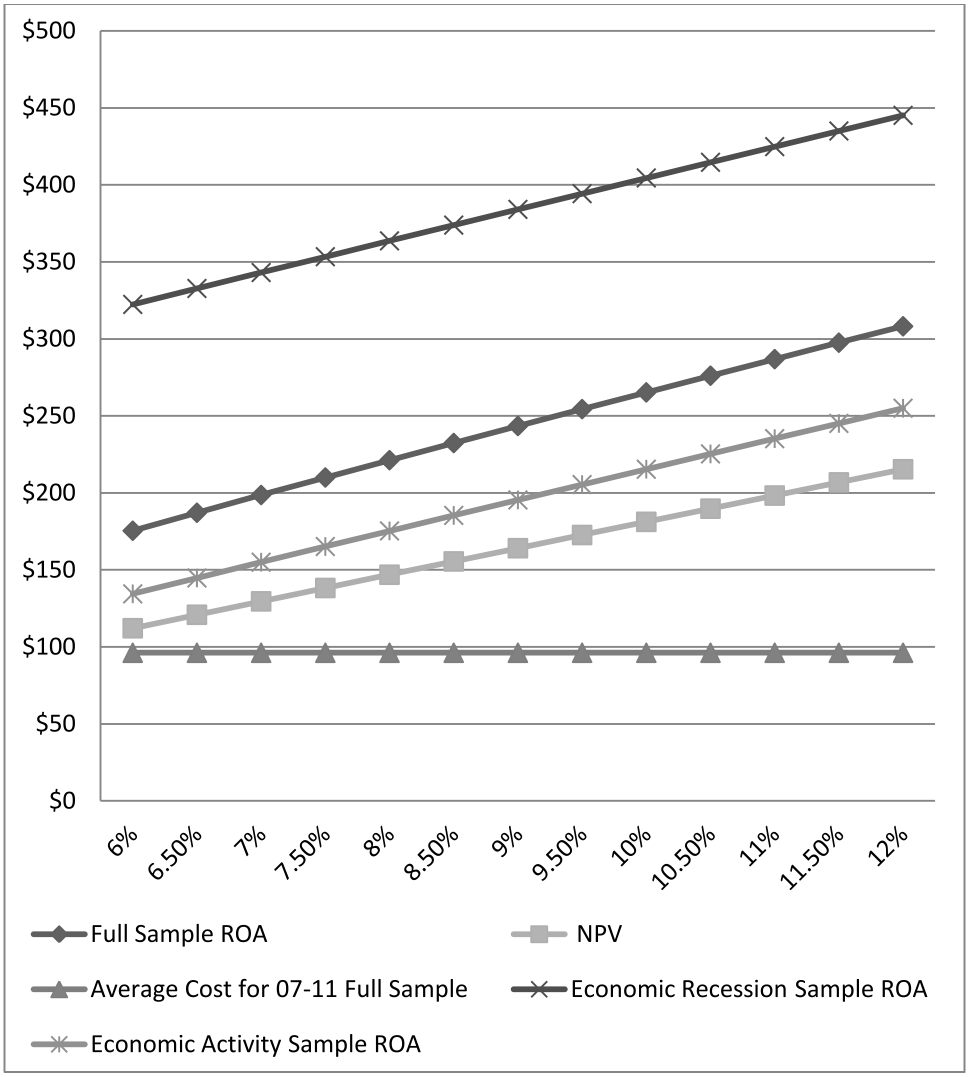

Figure 6.4: Option to Switch from Natural Gas to Hybrid System

for Corn Crop at 200' Lift in Texas

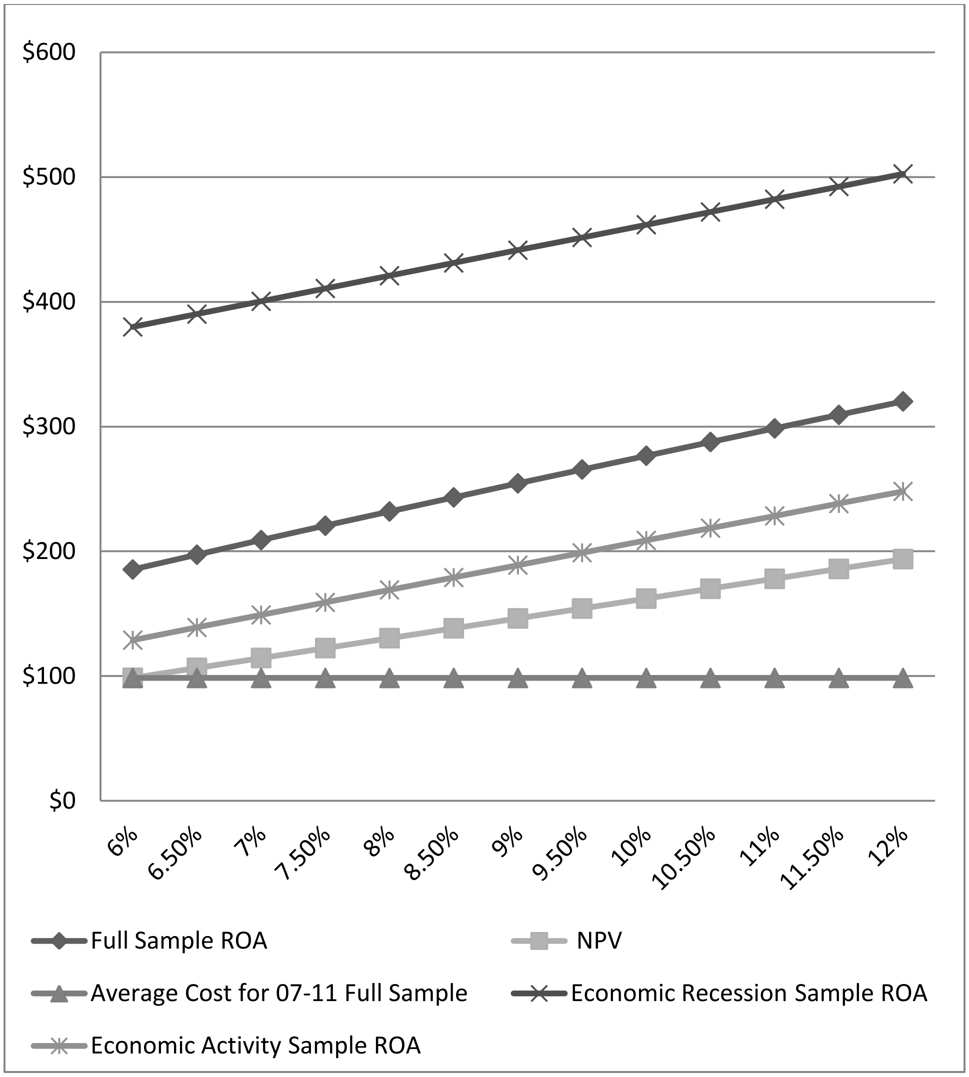

Figure 6.5: Option to Switch from Natural Gas to Hybrid System

for Corn Crop at 500' Lift in Texas

Figure 6.6: Option to Switch from Natural Gas to Hybrid System

for Wheat Crop at 500' Lift in Texas

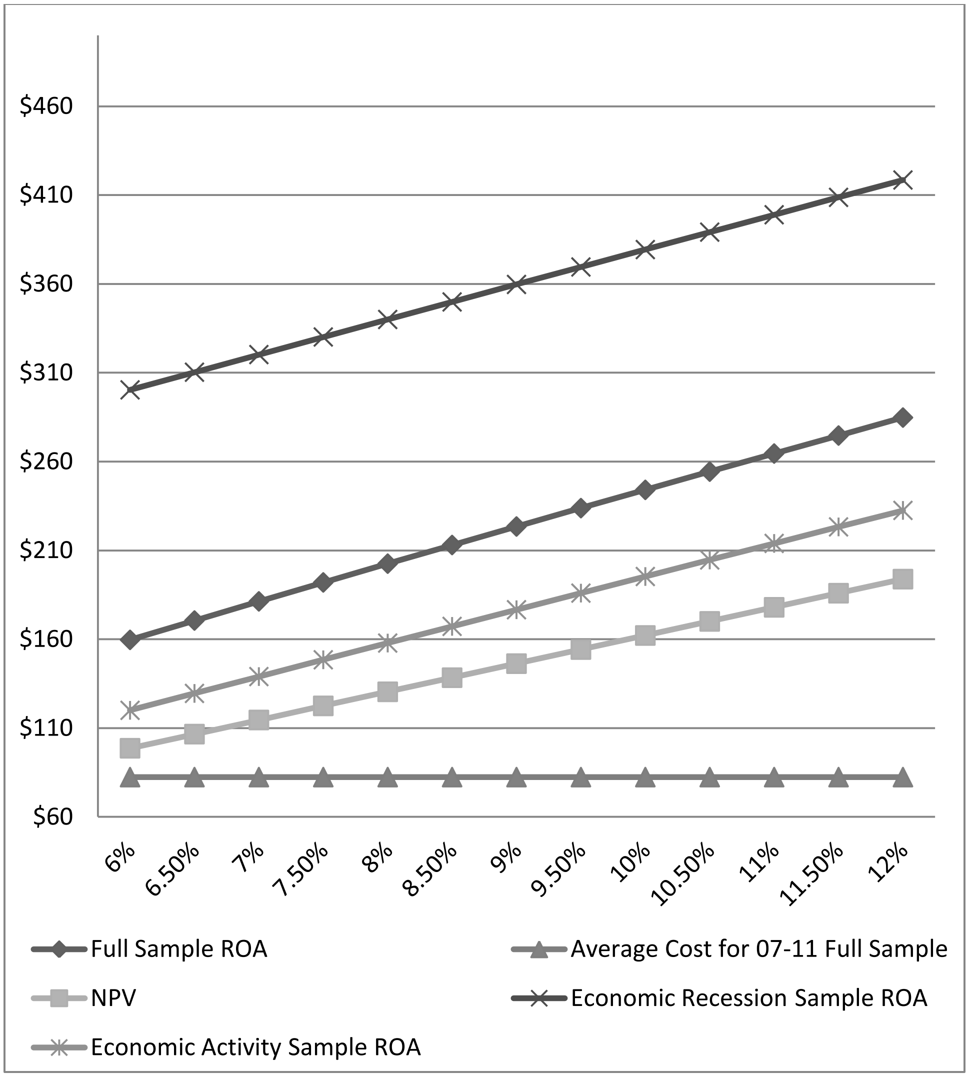

Figure 6.7: Option to Switch from Natural Gas to Hybrid System

for Sorghum Crop at 500' Lift in Texas

Results from net metering scenarios depict an increase in benefits from hybrid energy irrigation system through higher energy cost difference as a result from increased percentage of energy generated used toward crop irrigation. Under the monthly net metering scenario there was an average increase of energy use in Texas to 34% from 14% and even more to 75% under annual net metering. In Kansas an average of 10% of the energy was used to irrigate crop, under monthly net metering the figure increased to 27% and under annual net metering to 86%. Since not many utilities participate in net metering the results of feasibility analysis are not fully discussed and are found in the appendix section.

The parameters of Brownian motions estimated for the two subsamples (Economic Activity and Economic Recession) indicate variation depending not only on time period analyzed but also on investment cost alternative. The drift and volatility under Economic Recession Sample and cost difference alternative between the hybrid and natural gas irrigation powered system indicate consistent behavior of drift and volatility throughout all combinations of crop and lift. In illustrating this pattern the corn crop was selected at a 500 feet lift. The drift was negative at 9.2% for the recession period and under the full sample is found positive at 14.7%. The volatility under the recession period was also higher at 53.4% compared to 52.4% in the full sample. This pattern of negative drift and higher volatility was consistent for both regions analyzed under the cost difference of hybrid and natural gas for the economic recession subsample against the full sample, resulting in higher ROA threshold margins. On the other hand, for the economic activity sample the drift was positive and higher than the full sample while the volatility was lower under both states and all crop lift combinations, consequently generating lower ROA threshold cost margin.

When analyzing the parameter estimates for the cost difference between hybrid and electricity system a pattern of identical drift and volatility was attained for each individual sample and all crop lift combinations per sample. During the subsamples of economic recession and economic activity the drift was lower at 2.4% and 3.0% respectively than the full sample period at 3.1%. The volatility parameter was lower at 2.7% under economic recession sample and reached a high of 4.2% under economic activity sample compared to 3.7% for the full sample. The uniform outcome is once more associated with cost structure relationship of hybrid and electric energy systems.

CHAPTER 7

CONCLUSION

The primary objective of this study was to perform the feasibility analysis through financial real options approach in substituting irrigation energy systems with either electric, or hybrid-(electric/wind) energy systems in Texas Panhandle and Southwest Kansas, and compare results to those obtained with a net present value approach. Results confirm that investment option decision making that takes into account uncertainty regarding input energy cost prices as well as investment timing has proven to be a valuable tool and should be applied in the economic feasibility analysis of energy investment.

The energy adoption cost margin difference between proposed energy systems analyzed accounted for energy input prices, operational costs, and investment sunk costs considering well depth energy use and individual crop irrigation requirement, as well as the revenue attained from hybrid system excess energy sold to the utility grid, during time periods with varying drift and volatility. Results suggest that sample periods exhibiting higher volatility parameter increases investment cost threshold margin between natural gas against hybrid irrigation investment, and higher drift parameter estimate coupled with lower volatility decreases the ROA investment threshold cost margin.

Results indicate that the switch from natural gas to electricity should be adopted in both regions. In this scenario for all combinations of well depth, region and crop the investment sunk cost as well as the operational cost in electricity system will provide cost savings to the agent against the natural gas system. Results also indicate that net metering should be adopted if available since it increases benefits from hybrid system energy generation.

The Investment in renewable power technologies are often capital-intensive, with relatively high sunk costs and low operating costs. This particular feasibility analysis presented high hybrid investment sunk costs if compared to the benefits attained through its operation and the cost savings from the energy sold back to the grid from periods of excess electricity generation. Only at specific combination of energy cost price drift and volatility coupled with reasonable energy requirements, net metering or high buyback rates hybrid system becomes feasible. This scenario illustrates that investment costs in hybrid irrigation systems remains an emerging sector dependent on government policy and programs to improve its feasibility and lower investment costs. These federal incentives should be consistent in order to facilitate investment and consider benefits regarding not only for food production sector but also the mitigation of fossil fuel combustion environmental impact.

Further research in the implementation of energy storage coupled with renewable energy systems is advised, and even though it presents current investment and physical restrictions it has the possibility to further the feasibility of renewable decentralized energy systems.

Results obtained illustrate the value to use ROA in investment feasibility regarding the energy sector. The presence of volatility holds in investment timing a key feature that can result in either investment success or failure not accounted for under traditional methods.

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APPENDIX

Table A.1: Results for the Augmented Dickey-Fuller Test

	Kansas Natural Gas – Electricity		Texas Natural Gas – Electricity	
	t	N	t	N
Corn 200'	-4.91*	-1.34759	-4.90*	-1.30221
Corn 200'	-4.92*	-1.33060	-4.35*	-1.13806
Wheat 200'	-4.91*	-1.34828	-4.90*	-1.30221
Wheat 500'	-4.92*	-1.33330	-4.35*	-1.13806
Sorghum 200'	-4.91*	-1.34809	-4.90*	-1.30221
Sorghum 500'	-4.92*	-1.33253	-4.35*	-1.13806
	Kansas Natural Gas – Hybrid		Texas Natural Gas – Hybrid	
Corn 200'	-4.90*	-1.30221	-4.87*	-1.34963
Corn 200'	-4.35*	-1.13806	-4.91*	-1.34811
Wheat 200'	-4.90*	-1.30221	-4.82*	-1.34372
Wheat 500'	-4.35*	-1.13806	-4.88*	-1.35010
Sorghum 200'	-4.90*	-1.30221	-4.82*	-1.34403
Sorghum 500'	-4.35*	-1.13806	-4.88*	-1.35014
	Kansas Electricity – Hybrid		Texas Electricity – Hybrid	
Corn 200'	-3.22*	-0.97977	-3.22*	-0.97977
Corn 500'	-3.22*	-0.97977	-3.22*	-0.97977
Wheat 200'	-3.22*	-0.97977	-3.22*	-0.97977
Wheat 500'	-3.22*	-0.97977	-3.22*	-0.97977
Sorghum 200'	-3.22*	-0.97977	-3.22*	-0.97977
Sorghum 500'	-3.22*	-0.97977	-3.22*	-0.97977

*indicate that a unit root can be rejected at the 5% level.

Table A.2: Kansas Analysis of Natural Gas versus Electricity under Full Sample

Crop	**Lift/ Analysis**	**Interest Rate**												
		6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%
Corn	**200'**													
	ROA	53.03	54.24	55.33	56.32	57.23	58.07	58.85	59.59	60.28	60.93	61.56	62.17	62.76
	NPV	17.78	18.67	19.52	20.31	21.07	21.79	22.48	23.15	23.79	24.40	25.00	25.58	26.15
	Average	*Average Energy Cost Difference between Natural Gas and Electricity for Corn at 200'~$41.11*												
Corn	**500'**													
	ROA	103.07	102.85	102.46	101.91	101.26	100.52	99.71	98.84	97.95	97.03	96.10	95.16	94.23
	NPV	15.49	16.07	16.58	17.04	17.45	17.81	18.13	18.42	18.68	18.92	19.13	19.31	19.49
		Average Energy Cost Difference between Natural Gas and Electricity for Corn at 200'~$42.86												
Wheat	**200'**													
	ROA	53.03	54.24	55.33	56.32	57.23	58.07	58.85	59.59	60.28	60.93	61.56	62.17	62.76
	NPV	17.78	18.67	19.52	20.31	21.07	21.79	22.48	23.15	23.79	24.40	25.00	25.58	26.15
		Average Energy Cost Difference between Natural Gas and Electricity for Wheat at 200'~$37.14												
Wheat	**500'**													
	ROA	103.07	102.85	102.46	101.91	101.26	100.52	99.71	98.84	97.95	97.03	96.10	95.16	94.23
	NPV	15.49	16.07	16.58	17.04	17.45	17.81	18.13	18.42	18.68	18.92	19.13	19.31	19.49
		Average Energy Cost Difference between Natural Gas and Electricity for Wheat at 500'~$38.74												
Sorghum	**200'**													
	ROA	53.03	54.24	55.33	56.32	57.23	58.07	58.85	59.59	60.28	60.93	61.56	62.17	62.76
	NPV	17.78	18.67	19.52	20.31	21.07	21.79	22.48	23.15	23.79	24.40	25.00	25.58	26.15
		Average Energy Cost Difference between Natural Gas and Electricity for Sorghum at 200'~$37.14												
Sorghum	**500'**													
	ROA	103.07	102.85	102.46	101.91	101.26	100.52	99.71	98.84	97.95	97.03	96.10	95.16	94.23
	NPV	15.49	16.07	16.58	17.04	17.45	17.81	18.13	18.42	18.68	18.92	19.13	19.31	19.49
		Average Energy Cost Difference between Natural Gas and Electricity for Sorghum at 500'~ $38.73												

Average Energy Cost Difference is calculated for years of 2007-2011.

Table A.3: Kansas Analysis of Hybrid versus Electricity under Full Sample

Crop	**Lift/ Analysis**	**Interest Rate**												
		6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%
Corn	**200'**													
	ROA	120.44	129.53	138.55	147.50	156.41	165.26	174.08	182.86	191.61	200.33	209.04	217.73	226.40
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
	Average	*Average Energy Cost Difference between Hybrid and Electricity for Corn at 200'~$29.81*												
Corn	**500'**													
	ROA	120.44	129.53	138.55	147.50	156.41	165.26	174.08	182.86	191.61	200.33	209.04	217.73	226.40
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
		Average Energy Cost Difference between Hybrid and Electricity for Corn at 500'~$29.81												
Wheat	**200'**													
	ROA	120.44	129.53	138.55	147.50	156.41	165.26	174.08	182.86	191.61	200.33	209.04	217.73	226.40
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
		Average Energy Cost Difference between Hybrid and Electricity for Wheat at 200'~$29.09												
Wheat	**500'**													
	ROA	120.44	129.53	138.55	147.50	156.41	165.26	174.08	182.86	191.61	200.33	209.04	217.73	226.40
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
		Average Energy Cost Difference between Hybrid and Electricity for Wheat at 500'~$29.09												
Sorghum	**200'**													
	ROA	120.44	129.53	138.55	147.50	156.41	165.26	174.08	182.86	191.61	200.33	209.04	217.73	226.40
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
		Average Energy Cost Difference between Hybrid and Electricity for Sorghum at 200'~$28.44												
Sorghum	**500'**													
	ROA	120.44	129.53	138.55	147.50	156.41	165.26	174.08	182.86	191.61	200.33	209.04	217.73	226.40
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
		Average Energy Cost Difference between Hybrid and Electricity for Sorghum at 500'~$28.44												

Average Energy Cost Difference is calculated for years of 2007-2011.

Table A.4: Kansas Analysis of Hybrid versus Natural Gas under Full Sample

Crop	**Lift/ Analysis**	**Interest Rate**												
		6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%
Corn	**200'**													
	ROA	190.82	202.80	214.61	226.27	237.79	249.20	260.49	271.70	282.81	293.86	304.83	315.74	326.59
	NPV	100.01	108.02	116.01	123.98	131.94	139.90	147.84	155.78	163.72	171.66	179.59	187.53	195.47
	Average	*Average Energy Cost Difference between Hybrid and Natural Gas for Corn at 200'~$ 70.92*												
Corn	**500'**													
	ROA	248.61	262.97	277.10	291.02	304.76	318.34	331.77	345.07	358.24	371.31	384.28	397.16	409.96
	NPV	102.30	110.63	118.94	127.26	135.57	143.88	152.19	160.51	168.82	177.14	185.47	193.80	202.13
		Average Energy Cost Difference between Hybrid and Natural Gas for Corn at 500'~$ 72.67												
Wheat	**200'**													
	ROA	187.10	198.96	210.64	222.18	233.58	244.87	256.06	267.16	278.18	289.12	299.99	310.80	321.56
	NPV	100.01	108.02	116.01	123.98	131.94	139.90	147.84	155.78	163.72	171.66	179.59	187.53	195.47
		Average Energy Cost Difference between Hybrid and Natural Gas for Wheat at 200'~$ 66.24												
Wheat	**500'**													
	ROA	241.98	256.13	270.04	283.76	297.30	310.68	323.92	337.04	350.04	362.93	375.73	388.45	401.08
	NPV	102.30	110.63	118.94	127.26	135.57	143.88	152.19	160.51	168.82	177.14	185.47	193.80	202.13
		Average Energy Cost Difference between Hybrid and Natural Gas for Wheat at 500'~$ 67.83												
Sorghum	**200'**													
	ROA	188.20	200.09	211.81	223.38	234.82	246.15	257.37	268.49	279.54	290.51	301.41	312.26	323.04
	NPV	100.01	108.02	116.01	123.98	131.94	139.90	147.84	155.78	163.72	171.66	179.59	187.53	195.47
		Average Energy Cost Difference between Hybrid and Natural Gas for Sorghum at 200'~$ 65.59												
Sorghum	**500'**													
	ROA	243.92	258.13	272.11	285.88	299.48	312.92	326.22	339.38	352.44	365.38	378.23	390.99	403.67
	NPV	102.30	110.63	118.94	127.26	135.57	143.88	152.19	160.51	168.82	177.14	185.47	193.80	202.13
		Average Energy Cost Difference between Hybrid and Natural Gas for Sorghum at 500'~$ 67.17												

Average Energy Cost Difference is calculated for years of 2007-2011.

Table A.5: Kansas Analysis of Hybrid versus Electricity under Full Sample for Monthly Net Metering

Crop	**Lift/ Analysis**	**Interest Rate**												
		6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%
Corn	**200'**													
	ROA	120.44	129.53	138.55	147.50	156.41	165.26	174.08	182.86	191.61	200.33	209.04	217.73	226.40
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
	Average	*Average Energy Cost Difference between Hybrid and Electricity for Corn at 200'~$38.22*												
Corn	**500'**													
	ROA	120.44	129.53	138.55	147.50	156.41	165.26	174.08	182.86	191.61	200.33	209.04	217.73	226.40
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
		Average Energy Cost Difference between Hybrid and Electricity for Corn at 500'~$38.75												
Wheat	**200'**													
	ROA	120.44	129.53	138.55	147.50	156.41	165.26	174.08	182.86	191.61	200.33	209.04	217.73	226.40
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
		Average Energy Cost Difference between Hybrid and Electricity for Wheat at 200'~$40.84												
Wheat	**500'**													
	ROA	120.44	129.53	138.55	147.50	156.41	165.26	174.08	182.86	191.61	200.33	209.04	217.73	226.40
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
		Average Energy Cost Difference between Hybrid and Electricity for Wheat at 500'~$43.41												
Sorghum	**200'**													
	ROA	120.44	129.53	138.55	147.50	156.41	165.26	174.08	182.86	191.61	200.33	209.04	217.73	226.40
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
		Average Energy Cost Difference between Hybrid and Electricity for Sorghum at 200'~$37.67												
Sorghum	**500'**													
	ROA	120.44	129.53	138.55	147.50	156.41	165.26	174.08	182.86	191.61	200.33	209.04	217.73	226.40
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
		Average Energy Cost Difference between Hybrid and Electricity for Sorghum at 500'~$38.52												

Average Energy Cost Difference is calculated for years of 2007-2011.

Table A.6: Kansas Analysis of Hybrid versus Natural Gas under Full Sample for Monthly Net Metering

Crop	Lift/ Analysis	Interest Rate												
		6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%
Corn	**200'**													
	ROA	178.93	190.49	201.90	213.17	224.31	235.36	246.30	257.16	267.95	278.67	289.32	299.92	310.47
	NPV	100.01	108.02	116.01	123.98	131.94	139.90	147.84	155.78	163.72	171.66	179.59	187.53	195.47
	Average	*Average Energy Cost Difference between Hybrid and Natural Gas for Corn at 200'~$79.33*												
Corn	**500'**													
	ROA	226.72	240.34	253.76	266.99	280.07	293.00	305.80	318.49	331.07	343.56	355.96	368.28	380.53
	NPV	102.30	110.63	118.94	127.26	135.57	143.88	152.19	160.51	168.82	177.14	185.47	193.80	202.13
		Average Energy Cost Difference between Hybrid and Natural Gas for Corn at 500'~$81.61												
Wheat	**200'**													
	ROA	171.09	182.37	193.51	204.52	215.42	226.21	236.93	247.56	258.12	268.62	279.06	289.45	299.80
	NPV	100.01	108.02	116.01	123.98	131.94	139.90	147.84	155.78	163.72	171.66	179.59	187.53	195.47
		Average Energy Cost Difference between Hybrid and Natural Gas for Wheat at 200'~$77.99												
Wheat	**500'**													
	ROA	210.31	223.36	236.23	248.93	261.49	273.93	286.25	298.47	310.59	322.63	334.60	346.49	358.32
	NPV	102.30	110.63	118.94	127.26	135.57	143.88	152.19	160.51	168.82	177.14	185.47	193.80	202.13
		Average Energy Cost Difference between Hybrid and Natural Gas for Wheat at 500'~$82.04												
Sorghum	**200'**													
	ROA	174.84	186.26	197.53	208.66	219.68	230.59	241.42	252.16	262.83	273.43	283.98	294.47	304.91
	NPV	100.01	108.02	116.01	123.98	131.94	139.90	147.84	155.78	163.72	171.66	179.59	187.53	195.47
		Average Energy Cost Difference between Hybrid and Natural Gas for Sorghum at 200'~$74.81												
Sorghum	**500'**													
	ROA	219.19	232.55	245.72	258.71	271.55	284.25	296.84	309.31	321.68	333.97	346.17	358.30	370.35
	NPV	102.30	110.63	118.94	127.26	135.57	143.88	152.19	160.51	168.82	177.14	185.47	193.80	202.13
		Average Energy Cost Difference between Hybrid and Natural Gas for Sorghum at 500'~$77.26												

Average Energy Cost Difference is calculated for years of 2007-2011.

Table A.7: Kansas Analysis of Hybrid versus Electricity under Full Sample for Annual Net Metering

Crop	**Lift/ Analysis**	**Interest Rate**												
		6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%
Corn	**200'**													
	ROA	120.44	129.53	138.55	147.50	156.41	165.26	174.08	182.86	191.61	200.33	209.04	217.73	226.40
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
	Average	*Average Energy Cost Difference between Hybrid and Electricity for Corn at 200'~$70.24*												
Corn	**500'**													
	ROA	120.44	129.53	138.55	147.50	156.41	165.26	174.08	182.86	191.61	200.33	209.04	217.73	226.40
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
		Average Energy Cost Difference between Hybrid and Electricity for Corn at 500'~$84.97												
Wheat	**200'**													
	ROA	120.44	129.53	138.55	147.50	156.41	165.26	174.08	182.86	191.61	200.33	209.04	217.73	226.40
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
		Average Energy Cost Difference between Hybrid and Electricity for Wheat at 200'~$65.69												
Wheat	**500'**													
	ROA	120.44	129.53	138.55	147.50	156.41	165.26	174.08	182.86	191.61	200.33	209.04	217.73	226.40
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
		Average Energy Cost Difference between Hybrid and Electricity for Wheat at 500'~$84.97												
Sorghum	**200'**													
	ROA	120.44	129.53	138.55	147.50	156.41	165.26	174.08	182.86	191.61	200.33	209.04	217.73	226.40
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
		Average Energy Cost Difference between Hybrid and Electricity for Sorghum at 200'~$65.69												
Sorghum	**500'**													
	ROA	120.44	129.53	138.55	147.50	156.41	165.26	174.08	182.86	191.61	200.33	209.04	217.73	226.40
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
		Average Energy Cost Difference between Hybrid and Electricity for Sorghum at 500'~$84.97												

Average Energy Cost Difference is calculated for years of 2007-2011.

Table A.8: Kansas Analysis of Hybrid versus Natural Gas under Full Sample for Annual Net Metering

Crop	**Lift/ Analysis**	**Interest Rate**												
		6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%
Corn	**200'**													
	ROA	152.00	162.56	173.01	183.36	193.62	203.81	213.92	223.98	233.98	243.93	253.84	263.70	273.54
	NPV	100.01	108.02	116.01	123.98	131.94	139.90	147.84	155.78	163.72	171.66	179.59	187.53	195.47
	Average	*Average Energy Cost Difference between Hybrid and Natural Gas for Corn at 200'~$111.35*												
Corn	**500'**													
	ROA	172.53	184.21	195.75	207.18	218.51	229.75	240.91	252.00	263.03	273.99	284.91	295.78	306.60
	NPV	102.30	110.63	118.94	127.26	135.57	143.88	152.19	160.51	168.82	177.14	185.47	193.80	202.13
		Average Energy Cost Difference between Hybrid and Natural Gas for Corn at 500'~$127.84												
Wheat	**200'**													
	ROA	150.63	161.14	171.54	181.84	192.06	202.20	212.27	222.28	232.24	242.15	252.02	261.85	271.64
	NPV	100.01	108.02	116.01	123.98	131.94	139.90	147.84	155.78	163.72	171.66	179.59	187.53	195.47
		Average Energy Cost Difference between Hybrid and Natural Gas for Wheat at 200'~$102.83												
Wheat	**500'**													
	ROA	166.86	178.31	189.65	200.88	212.02	223.07	234.05	244.96	255.81	266.61	277.37	288.07	298.74
	NPV	102.30	110.63	118.94	127.26	135.57	143.88	152.19	160.51	168.82	177.14	185.47	193.80	202.13
		Average Energy Cost Difference between Hybrid and Natural Gas for Wheat at 500'~$123.70												
Sorghum	**200'**													
	ROA	150.63	161.14	171.54	181.84	192.06	202.20	212.27	222.28	232.24	242.15	252.02	261.85	271.64
	NPV	100.01	108.02	116.01	123.98	131.94	139.90	147.84	155.78	163.72	171.66	179.59	187.53	195.47
		Average Energy Cost Difference between Hybrid and Natural Gas for Sorghum at 200'~$102.83												
Sorghum	**500'**													
	ROA	166.86	178.31	189.65	200.88	212.02	223.07	234.05	244.96	255.81	266.61	277.37	288.07	298.74
	NPV	102.30	110.63	118.94	127.26	135.57	143.88	152.19	160.51	168.82	177.14	185.47	193.80	202.13
		Average Energy Cost Difference between Hybrid and Natural Gas for Sorghum at 500'~$123.70												

Average Energy Cost Difference is calculated for years of 2007-2011.

Table A.9: Kansas Analysis of Natural Gas versus Electricity under Economic Recession Sample

Crop	Lift/ Analysis	Interest Rate												
		6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%
Corn	**200'**													
	ROA	122.82	121.30	119.88	118.55	117.30	116.14	115.06	114.06	113.13	112.28	111.50	110.78	110.14
	NPV	17.78	18.67	19.52	20.31	21.07	21.79	22.48	23.15	23.79	24.40	25.00	25.58	26.15
	Average	*Average Energy Cost Difference between Natural Gas and Electricity for Corn at 200'~$41.11*												
Corn	**500'**													
	ROA	202.77	196.33	190.23	184.45	178.99	173.81	168.91	164.27	159.88	155.72	151.79	148.06	144.53
	NPV	15.49	16.07	16.58	17.04	17.45	17.81	18.13	18.42	18.68	18.92	19.13	19.31	19.49
		Average Energy Cost Difference between Natural Gas and Electricity for Corn at 500'~$42.87												
Wheat	**200'**													
	ROA	122.82	121.30	119.88	118.55	117.30	116.14	115.06	114.06	113.13	112.28	111.50	110.78	110.14
	NPV	17.78	18.67	19.52	20.31	21.07	21.79	22.48	23.15	23.79	24.40	25.00	25.58	26.15
		Average Energy Cost Difference between Natural Gas and Electricity for Wheat at 200'~$37.15												
Wheat	**500'**													
	ROA	202.77	196.33	190.23	184.45	178.99	173.81	168.91	164.27	159.88	155.72	151.79	148.06	144.53
	NPV	15.49	16.07	16.58	17.04	17.45	17.81	18.13	18.42	18.68	18.92	19.13	19.31	19.49
		Average Energy Cost Difference between Natural Gas and Electricity for Wheat at 500'~$38.74												
Sorghum	**200'**													
	ROA	122.82	121.30	119.88	118.55	117.30	116.14	115.06	114.06	113.13	112.28	111.50	110.78	110.14
	NPV	17.78	18.67	19.52	20.31	21.07	21.79	22.48	23.15	23.79	24.40	25.00	25.58	26.15
		Average Energy Cost Difference between Natural Gas and Electricity for Sorghum at 200'~$37.15												
Sorghum	**500'**													
	ROA	202.77	196.33	190.23	184.45	178.99	173.81	168.91	164.27	159.88	155.72	151.79	148.06	144.53
	NPV	15.49	16.07	16.58	17.04	17.45	17.81	18.13	18.42	18.68	18.92	19.13	19.31	19.49
		Average Energy Cost Difference between Natural Gas and Electricity for Sorghum at 500'~$38.74												

Average Energy Cost Difference is calculated for years of 2007-2011.

Table A.10: Kansas Analysis of Hybrid versus Electricity under Economic Recession Sample

Crop	**Lift/ Analysis**	**Interest Rate**												
		6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%
Corn	**200'**													
	ROA	119.52	128.55	137.51	146.40	155.24	164.03	172.79	181.51	190.20	198.87	207.52	216.15	224.77
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
	Average Energy Cost Difference between Hybrid and Electricity for Corn at 200'~$29.81													
Corn	**500'**													
	ROA	119.52	128.55	137.51	146.40	155.24	164.03	172.79	181.51	190.20	198.87	207.52	216.15	224.77
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
	Average Energy Cost Difference between Hybrid and Electricity for Corn at 500'~$29.81													
Wheat	**200'**													
	ROA	119.52	128.55	137.51	146.40	155.24	164.03	172.79	181.51	190.20	198.87	207.52	216.15	224.77
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
	Average Energy Cost Difference between Hybrid and Electricity for Wheat at 200'~$29.10													
Wheat	**500'**													
	ROA	119.52	128.55	137.51	146.40	155.24	164.03	172.79	181.51	190.20	198.87	207.52	216.15	224.77
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
	Average Energy Cost Difference between Hybrid and Electricity for Wheat at 500'~$29.10													
Sorghum	**200'**													
	ROA	119.52	128.55	137.51	146.40	155.24	164.03	172.79	181.51	190.20	198.87	207.52	216.15	224.77
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
	Average Energy Cost Difference between Hybrid and Electricity for Sorghum at 200'~$28.44													
Sorghum	**500'**													
	ROA	119.52	128.55	137.51	146.40	155.24	164.03	172.79	181.51	190.20	198.87	207.52	216.15	224.77
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
	Average Energy Cost Difference between Hybrid and Electricity for Sorghum at 500'~$28.44													

Average Energy Cost Difference is calculated for years of 2007-2011.

TableA.11: Kansas Analysis of Hybrid versus Natural Gas under Economic Recession Sample

Crop	**Lift/ Analysis**	**Interest Rate**												
		6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%
Corn	**200'**													
	ROA	393.44	403.65	413.84	424.03	434.21	444.38	454.55	464.71	474.87	485.02	495.17	505.32	515.47
	NPV	100.01	108.02	116.01	123.98	131.94	139.90	147.84	155.78	163.72	171.66	179.59	187.53	195.47
		Average Energy Cost Difference between Hybrid and Natural Gas for Corn at 200'~$70.92												
Corn	**500'**													
	ROA	557.25	568.79	580.33	591.87	603.43	614.98	626.54	638.10	649.65	661.21	672.77	684.32	695.87
	NPV	102.30	110.63	118.94	127.26	135.57	143.88	152.19	160.51	168.82	177.14	185.47	193.80	202.13
		Average Energy Cost Difference between Hybrid and Natural Gas for Corn at 500'~$72.68												
Wheat	**200'**													
	ROA	382.23	392.40	402.55	412.70	422.84	432.97	443.09	453.20	463.32	473.42	483.52	493.62	503.72
	NPV	100.01	108.02	116.01	123.98	131.94	139.90	147.84	155.78	163.72	171.66	179.59	187.53	195.47
		Average Energy Cost Difference between Hybrid and Natural Gas for Wheat at 200'~$66.24												
Wheat	**500'**													
	ROA	538.73	550.20	561.68	573.16	584.64	596.13	607.61	619.10	630.58	642.06	653.54	665.02	676.49
	NPV	102.30	110.63	118.94	127.26	135.57	143.88	152.19	160.51	168.82	177.14	185.47	193.80	202.13
		Average Energy Cost Difference between Hybrid and Natural Gas for Wheat at 500'~$67.83												
Sorghum	**200'**													
	ROA	385.53	395.71	405.88	416.04	426.19	436.33	446.46	456.59	466.72	476.84	486.96	497.07	507.18
	NPV	100.01	108.02	116.01	123.98	131.94	139.90	147.84	155.78	163.72	171.66	179.59	187.53	195.47
		Average Energy Cost Difference between Hybrid and Natural Gas for Sorghum at 200'~$65.69												
Sorghum	**500'**													
	ROA	544.16	555.65	567.15	578.65	590.15	601.66	613.16	624.67	636.18	647.68	659.18	670.68	682.17
	NPV	102.30	110.63	118.94	127.26	135.57	143.88	152.19	160.51	168.82	177.14	185.47	193.80	202.13
		Average Energy Cost Difference between Hybrid and Natural Gas for Sorghum at 500'~$67.18												

Average Energy Cost Difference is calculated for years of 2007-2011.

Table A.12: Kansas Analysis of Hybrid versus Electricity under Economic Recession Sample for Monthly Net Metering

Crop	**Lift/ Analysis**	**Interest Rate**												
		6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%
Corn	**200'**													
	ROA	119.52	128.55	137.51	146.40	155.24	164.03	172.79	181.51	190.20	198.87	207.52	216.15	224.77
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
	Average	*Average Energy Cost Difference between Hybrid and Electricity for Corn at 200'~$38.22*												
Corn	**500'**													
	ROA	119.52	128.55	137.51	146.40	155.24	164.03	172.79	181.51	190.20	198.87	207.52	216.15	224.77
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
		Average Energy Cost Difference between Hybrid and Electricity for Corn at 500'~$38.75												
Wheat	**200'**													
	ROA	119.52	128.55	137.51	146.40	155.24	164.03	172.79	181.51	190.20	198.87	207.52	216.15	224.77
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
		Average Energy Cost Difference between Hybrid and Electricity for Wheat at 200'~$40.84												
Wheat	**500'**													
	ROA	119.52	128.55	137.51	146.40	155.24	164.03	172.79	181.51	190.20	198.87	207.52	216.15	224.77
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
		Average Energy Cost Difference between Hybrid and Electricity for Wheat at 500'~$43.41												
Sorghum	**200'**													
	ROA	119.52	128.55	137.51	146.40	155.24	164.03	172.79	181.51	190.20	198.87	207.52	216.15	224.77
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
		Average Energy Cost Difference between Hybrid and Electricity for Sorghum at 200'~$37.67												
Sorghum	**500'**													
	ROA	119.52	128.55	137.51	146.40	155.24	164.03	172.79	181.51	190.20	198.87	207.52	216.15	224.77
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
		Average Energy Cost Difference between Hybrid and Electricity for Sorghum at 500'~$38.52												

Average Energy Cost Difference is calculated for years of 2007-2011.

Table A.13: Kansas Analysis of Hybrid versus Natural Gas under Economic Recession Sample for Monthly Net Metering

Crop	**Lift/ Analysis**	**Interest Rate**												
		6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%
Corn	**200'**													
	ROA	357.36	367.45	377.51	387.57	397.61	407.64	417.66	427.67	437.67	447.67	457.66	467.65	477.63
	NPV	100.01	108.02	116.01	123.98	131.94	139.90	147.84	155.78	163.72	171.66	179.59	187.53	195.47
	Average	*Average Energy Cost Difference between Hybrid and Natural Gas for Corn at 200'~$79.33*												
Corn	**500'**													
	ROA	495.29	506.61	517.93	529.25	540.56	551.87	563.18	574.49	585.79	597.08	608.37	619.66	630.94
	NPV	102.30	110.63	118.94	127.26	135.57	143.88	152.19	160.51	168.82	177.14	185.47	193.80	202.13
		Average Energy Cost Difference between Hybrid and Natural Gas for Corn at 500'~$81.61												
Wheat	**200'**													
	ROA	333.27	343.27	353.25	363.21	373.15	383.08	392.99	402.90	412.79	422.68	432.56	442.43	452.30
	NPV	100.01	108.02	116.01	123.98	131.94	139.90	147.84	155.78	163.72	171.66	179.59	187.53	195.47
		Average Energy Cost Difference between Hybrid and Natural Gas for Wheat at 200'~$77.99												
Wheat	**500'**													
	ROA	447.48	458.62	469.74	480.86	491.98	503.08	514.18	525.27	536.36	547.43	558.50	569.57	580.62
	NPV	102.30	110.63	118.94	127.26	135.57	143.88	152.19	160.51	168.82	177.14	185.47	193.80	202.13
		Average Energy Cost Difference between Hybrid and Natural Gas for Wheat at 500'~$82.04												
Sorghum	**200'**													
	ROA	344.84	354.88	364.90	374.90	384.89	394.87	404.84	414.79	424.74	434.68	444.62	454.54	464.47
	NPV	100.01	108.02	116.01	123.98	131.94	139.90	147.84	155.78	163.72	171.66	179.59	187.53	195.47
		Average Energy Cost Difference between Hybrid and Natural Gas for Sorghum at 200'~$74.81												
Sorghum	**500'**													
	ROA	473.48	484.72	495.96	507.19	518.41	529.63	540.85	552.05	563.26	574.46	585.65	596.83	608.01
	NPV	102.30	110.63	118.94	127.26	135.57	143.88	152.19	160.51	168.82	177.14	185.47	193.80	202.13
		Average Energy Cost Difference between Hybrid and Natural Gas for Sorghum at 500'~$77.26												

Average Energy Cost Difference is calculated for years of 2007-2011.

Table A.14: Kansas Analysis of Hybrid versus Electricity under Economic Recession Sample for Annual Net Metering

Crop	Lift/ Analysis	Interest Rate												
		6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%
Corn	**200'**													
	ROA	119.52	128.55	137.51	146.40	155.24	164.03	172.79	181.51	190.20	198.87	207.52	216.15	224.77
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
	Average	*Average Energy Cost Difference between Hybrid and Electricity for Corn at 200'~$70.24*												
Corn	**500'**													
	ROA	119.52	128.55	137.51	146.40	155.24	164.03	172.79	181.51	190.20	198.87	207.52	216.15	224.77
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
		Average Energy Cost Difference between Hybrid and Electricity for Corn at 500'~$84.97												
Wheat	**200'**													
	ROA	119.52	128.55	137.51	146.40	155.24	164.03	172.79	181.51	190.20	198.87	207.52	216.15	224.77
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
		Average Energy Cost Difference between Hybrid and Electricity for Wheat at 200'~$65.69												
Wheat	**500'**													
	ROA	119.52	128.55	137.51	146.40	155.24	164.03	172.79	181.51	190.20	198.87	207.52	216.15	224.77
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
		Average Energy Cost Difference between Hybrid and Electricity for Wheat at 500'~$84.97												
Sorghum	**200'**													
	ROA	119.52	128.55	137.51	146.40	155.24	164.03	172.79	181.51	190.20	198.87	207.52	216.15	224.77
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
		Average Energy Cost Difference between Hybrid and Electricity for Sorghum at 200'~$65.69												
Sorghum	**500'**													
	ROA	119.52	128.55	137.51	146.40	155.24	164.03	172.79	181.51	190.20	198.87	207.52	216.15	224.77
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
		Average Energy Cost Difference between Hybrid and Electricity for Sorghum at 500'~$84.97												

Average Energy Cost Difference is calculated for years of 2007-2011.

Table A.15: Kansas Analysis of Hybrid versus Natural Gas under Economic Recession Sample for Annual Net Metering

Crop	**Lift/ Analysis**	**Interest Rate**												
		6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%
Corn	**200'**													
	ROA	273.31	283.07	292.80	302.50	312.17	321.82	331.46	341.07	350.68	360.27	369.85	379.42	388.98
	NPV	100.01	108.02	116.01	123.98	131.94	139.90	147.84	155.78	163.72	171.66	179.59	187.53	195.47
	Average	*Average Energy Cost Difference between Hybrid and Natural Gas for Corn at 200'~$111.35*												
Corn	**500'**													
	ROA	333.22	343.84	354.44	365.02	375.58	386.12	396.65	407.16	417.66	428.15	438.63	449.10	459.55
	NPV	102.30	110.63	118.94	127.26	135.57	143.88	152.19	160.51	168.82	177.14	185.47	193.80	202.13
		Average Energy Cost Difference between Hybrid and Natural Gas for Corn at 500'~$127.84												
Wheat	**200'**													
	ROA	268.94	278.68	288.39	298.07	307.72	317.35	326.96	336.56	346.14	355.71	365.26	374.81	384.35
	NPV	100.01	108.02	116.01	123.98	131.94	139.90	147.84	155.78	163.72	171.66	179.59	187.53	195.47
		Average Energy Cost Difference between Hybrid and Natural Gas for Wheat at 200'~$102.83												
Wheat	**500'**													
	ROA	315.53	326.07	336.57	347.06	357.52	367.97	378.40	388.81	399.21	409.60	419.98	430.34	440.70
	NPV	102.30	110.63	118.94	127.26	135.57	143.88	152.19	160.51	168.82	177.14	185.47	193.80	202.13
		Average Energy Cost Difference between Hybrid and Natural Gas for Wheat at 500'~$123.70												
Sorghum	**200'**													
	ROA	268.94	278.68	288.39	298.07	307.72	317.35	326.96	336.56	346.14	355.71	365.26	374.81	384.35
	NPV	100.01	108.02	116.01	123.98	131.94	139.90	147.84	155.78	163.72	171.66	179.59	187.53	195.47
		Average Energy Cost Difference between Hybrid and Natural Gas for Sorghum at 200'~$102.83												
Sorghum	**500'**													
	ROA	315.53	326.07	336.57	347.06	357.52	367.97	378.40	388.81	399.21	409.60	419.98	430.34	440.70
	NPV	102.30	110.63	118.94	127.26	135.57	143.88	152.19	160.51	168.82	177.14	185.47	193.80	202.13
		Average Energy Cost Difference between Hybrid and Natural Gas for Sorghum at 500'~$123.70												

Average Energy Cost Difference is calculated for years of 2007-2011.

TableA.16: Kansas Analysis of Natural Gas versus Electricity under Economic Activity Sample

Crop	**Lift/ Analysis**	**Interest Rate**												
		6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%
Corn	**200'**													
	ROA	31.87	33.30	34.62	35.86	37.01	38.11	39.14	40.12	41.05	41.94	42.80	43.62	44.42
	NPV	17.78	18.67	19.52	20.31	21.07	21.79	22.48	23.15	23.79	24.40	25.00	25.58	26.15
	Average	*Average Energy Cost Difference between Natural Gas and Electricity for Corn at 200'~$41.11*												
Corn	**500'**													
	ROA	72.89	74.19	75.21	76.01	76.60	77.03	77.33	77.50	77.57	77.56	77.49	77.35	77.18
	NPV	15.49	16.07	16.58	17.04	17.45	17.81	18.13	18.42	18.68	18.92	19.13	19.31	19.49
		Average Energy Cost Difference between Natural Gas and Electricity for Corn at 500'~$42.86												
Wheat	**200'**													
	ROA	31.87	33.30	34.62	35.86	37.01	38.11	39.14	40.12	41.05	41.94	42.80	43.62	44.42
	NPV	17.78	18.67	19.52	20.31	21.07	21.79	22.48	23.15	23.79	24.40	25.00	25.58	26.15
		Average Energy Cost Difference between Natural Gas and Electricity for Wheat at 200'~$37.15												
Wheat	**500'**													
	ROA	72.89	74.19	75.21	76.01	76.60	77.03	77.33	77.50	77.57	77.56	77.49	77.35	77.18
	NPV	15.49	16.07	16.58	17.04	17.45	17.81	18.13	18.42	18.68	18.92	19.13	19.31	19.49
		Average Energy Cost Difference between Natural Gas and Electricity for Wheat at 500'~$38.74												
Sorghum	**200'**													
	ROA	31.87	33.30	34.62	35.86	37.01	38.11	39.14	40.12	41.05	41.94	42.80	43.62	44.42
	NPV	17.78	18.67	19.52	20.31	21.07	21.79	22.48	23.15	23.79	24.40	25.00	25.58	26.15
		Average Energy Cost Difference between Natural Gas and Electricity for Sorghum at 200'~$37.15												
Sorghum	**500'**													
	ROA	72.89	74.19	75.21	76.01	76.60	77.03	77.33	77.50	77.57	77.56	77.49	77.35	77.18
	NPV	15.49	16.07	16.58	17.04	17.45	17.81	18.13	18.42	18.68	18.92	19.13	19.31	19.49
		Average Energy Cost Difference between Natural Gas and Electricity for Sorghum at 500'~$38.74												

Average Energy Cost Difference is calculated for years of 2007-2011.

Table A.17: Kansas Analysis of Hybrid versus Electricity under Economic Activity Sample

Crop	Lift/ Analysis	Interest Rate												
		6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%
Corn	**200'**													
	ROA	121.18	130.33	139.40	148.40	157.35	166.25	175.11	183.94	192.73	201.50	210.25	218.98	227.70
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
	Average Energy Cost Difference between Hybrid and Electricity for Corn at 200'~$29.81													
Corn	**500'**													
	ROA	121.18	130.33	139.40	148.40	157.35	166.25	175.11	183.94	192.73	201.50	210.25	218.98	227.70
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
	Average Energy Cost Difference between Hybrid and Electricity for Corn at 500'~$29.81													
Wheat	**200'**													
	ROA	121.18	130.33	139.40	148.40	157.35	166.25	175.11	183.94	192.73	201.50	210.25	218.98	227.70
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
	Average Energy Cost Difference between Hybrid and Electricity for Wheat at 200'~$29.09													
Wheat	**500'**													
	ROA	121.18	130.33	139.40	148.40	157.35	166.25	175.11	183.94	192.73	201.50	210.25	218.98	227.70
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
	Average Energy Cost Difference between Hybrid and Electricity for Wheat at 500'~$29.09													
Sorghum	**200'**													
	ROA	121.18	130.33	139.40	148.40	157.35	166.25	175.11	183.94	192.73	201.50	210.25	218.98	227.70
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
	Average Energy Cost Difference between Hybrid and Electricity for Sorghum at 200'~$28.44													
Sorghum	**500'**													
	ROA	121.18	130.33	139.40	148.40	157.35	166.25	175.11	183.94	192.73	201.50	210.25	218.98	227.70
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
	Average Energy Cost Difference between Hybrid and Electricity for Sorghum at 500'~$28.44													

Average Energy Cost Difference is calculated for years of 2007-2011.

Table A.18: Kansas Analysis of Hybrid versus Natural Gas under Economic Activity Sample

Crop	Lift/ Analysis	Interest Rate												
		6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%
Corn	**200'**													
	ROA	135.85	146.36	156.81	167.20	177.53	187.82	198.06	208.27	218.44	228.58	238.69	248.78	258.84
	NPV	100.01	108.02	116.01	123.98	131.94	139.90	147.84	155.78	163.72	171.66	179.59	187.53	195.47
		Average Energy Cost Difference between Hybrid and Natural Gas for Corn at 200'~$70.92												
Corn	**500'**													
	ROA	161.40	173.83	186.18	198.44	210.63	222.76	234.82	246.83	258.79	270.70	282.57	294.39	306.18
	NPV	102.30	110.63	118.94	127.26	135.57	143.88	152.19	160.51	168.82	177.14	185.47	193.80	202.13
		Average Energy Cost Difference between Hybrid and Natural Gas for Corn at 500'~$72.67												
Wheat	**200'**													
	ROA	134.42	144.84	155.19	165.49	175.73	185.93	196.09	206.21	216.30	226.36	236.39	246.40	256.38
	NPV	100.01	108.02	116.01	123.98	131.94	139.90	147.84	155.78	163.72	171.66	179.59	187.53	195.47
		Average Energy Cost Difference between Hybrid and Natural Gas for Wheat at 200'~$66.24												
Wheat	**500'**													
	ROA	158.42	170.66	182.81	194.89	206.90	218.85	230.74	242.58	254.37	266.12	277.82	289.49	301.12
	NPV	102.30	110.63	118.94	127.26	135.57	143.88	152.19	160.51	168.82	177.14	185.47	193.80	202.13
		Average Energy Cost Difference between Hybrid and Natural Gas for Wheat at 500'~$67.83												
Sorghum	**200'**													
	ROA	134.84	145.28	155.66	165.99	176.26	186.48	196.67	206.81	216.93	227.01	237.07	247.10	257.10
	NPV	100.01	108.02	116.01	123.98	131.94	139.90	147.84	155.78	163.72	171.66	179.59	187.53	195.47
		Average Energy Cost Difference between Hybrid and Natural Gas for Sorghum at 200'~$65.59												
Sorghum	**500'**													
	ROA	154.06	166.03	177.93	189.76	201.53	213.24	224.90	236.52	248.09	259.63	271.12	282.58	294.01
	NPV	102.30	110.63	118.94	127.26	135.57	143.88	152.19	160.51	168.82	177.14	185.47	193.80	202.13
		Average Energy Cost Difference between Hybrid and Natural Gas for Sorghum at 500'~$67.17												

Average Energy Cost Difference is calculated for years of 2007-2011.

Table A.19: Kansas Analysis of Hybrid versus Electricity under Economic Activity Sample for Monthly Net Metering

Crop	**Lift/ Analysis**	**Interest Rate**												
		6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%
Corn	**200'**													
	ROA	121.18	130.33	139.40	148.40	157.35	166.25	175.11	183.94	192.73	201.50	210.25	218.98	227.70
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
	Average	*Average Energy Cost Difference between Hybrid and Electricity for Corn at 200'~$38.22*												
Corn	**500'**													
	ROA	121.18	130.33	139.40	148.40	157.35	166.25	175.11	183.94	192.73	201.50	210.25	218.98	227.70
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
		Average Energy Cost Difference between Hybrid and Electricity for Corn at 500'~$38.75												
Wheat	**200'**													
	ROA	121.18	130.33	139.40	148.40	157.35	166.25	175.11	183.94	192.73	201.50	210.25	218.98	227.70
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
		Average Energy Cost Difference between Hybrid and Electricity for Wheat at 200'~$40.84												
Wheat	**500'**													
	ROA	121.18	130.33	139.40	148.40	157.35	166.25	175.11	183.94	192.73	201.50	210.25	218.98	227.70
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
		Average Energy Cost Difference between Hybrid and Electricity for Wheat at 500'~$43.41												
Sorghum	**200'**													
	ROA	121.18	130.33	139.40	148.40	157.35	166.25	175.11	183.94	192.73	201.50	210.25	218.98	227.70
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
		Average Energy Cost Difference between Hybrid and Electricity for Sorghum at 200'~$37.67												
Sorghum	**500'**													
	ROA	121.18	130.33	139.40	148.40	157.35	166.25	175.11	183.94	192.73	201.50	210.25	218.98	227.70
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
		Average Energy Cost Difference between Hybrid and Electricity for Sorghum at 500'~$38.52												

Average Energy Cost Difference is calculated for years of 2007-2011.

Table A.20: Kansas Analysis of Hybrid versus Natural Gas under Economic Activity Sample for Monthly Net Metering

Crop	**Lift/ Analysis**	**Interest Rate**												
		6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%
Corn	**200'**													
	ROA	131.34	141.55	151.70	161.80	171.85	181.86	191.83	201.77	211.67	221.56	231.41	241.25	251.06
	NPV	100.01	108.02	116.01	123.98	131.94	139.90	147.84	155.78	163.72	171.66	179.59	187.53	195.47
	Average	*Average Energy Cost Difference between Hybrid and Natural Gas for Corn at 200'~$79.33*												
Corn	**500'**													
	ROA	151.77	163.56	175.29	186.95	198.55	210.10	221.60	233.05	244.47	255.84	267.18	278.49	289.76
	NPV	102.30	110.63	118.94	127.26	135.57	143.88	152.19	160.51	168.82	177.14	185.47	193.80	202.13
		Average Energy Cost Difference between Hybrid and Natural Gas for Corn at 500'~$81.61												
Wheat	**200'**													
	ROA	128.46	138.47	148.43	158.35	168.21	178.04	187.84	197.61	207.34	217.06	226.75	236.42	246.08
	NPV	100.01	108.02	116.01	123.98	131.94	139.90	147.84	155.78	163.72	171.66	179.59	187.53	195.47
		Average Energy Cost Difference between Hybrid and Natural Gas for Wheat at 200'~$77.99												
Wheat	**500'**													
	ROA	144.94	156.29	167.57	178.79	189.97	201.10	212.19	223.24	234.26	245.24	256.20	267.13	278.04
	NPV	102.30	110.63	118.94	127.26	135.57	143.88	152.19	160.51	168.82	177.14	185.47	193.80	202.13
		Average Energy Cost Difference between Hybrid and Natural Gas for Wheat at 500'~$82.04												
Sorghum	**200'**													
	ROA	129.83	139.94	149.99	159.99	169.94	179.86	189.74	199.59	209.41	219.20	228.97	238.72	248.45
	NPV	100.01	108.02	116.01	123.98	131.94	139.90	147.84	155.78	163.72	171.66	179.59	187.53	195.47
		Average Energy Cost Difference between Hybrid and Natural Gas for Sorghum at 200'~$74.81												
Sorghum	**500'**													
	ROA	143.79	155.07	166.30	177.47	188.60	199.68	210.73	221.74	232.72	243.67	254.59	265.48	276.35
	NPV	102.30	110.63	118.94	127.26	135.57	143.88	152.19	160.51	168.82	177.14	185.47	193.80	202.13
		Average Energy Cost Difference between Hybrid and Natural Gas for Sorghum at 500'~$77.26												

Average Energy Cost Difference is calculated for years of 2007-2011.

Table A.21: Kansas Analysis of Hybrid versus Electricity under Economic Activity Sample for Annual Net Metering

Crop	Lift/ Analysis	Interest Rate												
		6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%
Corn	**200'**													
	ROA	121.18	130.33	139.40	148.40	157.35	166.25	175.11	183.94	192.73	201.50	210.25	218.98	227.70
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
	Average	*Average Energy Cost Difference between Hybrid and Electricity for Corn at 200'~$70.24*												
Corn	**500'**													
	ROA	121.18	130.33	139.40	148.40	157.35	166.25	175.11	183.94	192.73	201.50	210.25	218.98	227.70
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
		Average Energy Cost Difference between Hybrid and Electricity for Corn at 500'~$84.97												
Wheat	**200'**													
	ROA	121.18	130.33	139.40	148.40	157.35	166.25	175.11	183.94	192.73	201.50	210.25	218.98	227.70
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
		Average Energy Cost Difference between Hybrid and Electricity for Wheat at 200'~$65.69												
Wheat	**500'**													
	ROA	121.18	130.33	139.40	148.40	157.35	166.25	175.11	183.94	192.73	201.50	210.25	218.98	227.70
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
		Average Energy Cost Difference between Hybrid and Electricity for Wheat at 500'~$84.97												
Sorghum	**200'**													
	ROA	121.18	130.33	139.40	148.40	157.35	166.25	175.11	183.94	192.73	201.50	210.25	218.98	227.70
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
		Average Energy Cost Difference between Hybrid and Electricity for Sorghum at 200'~$65.69												
Sorghum	**500'**													
	ROA	121.18	130.33	139.40	148.40	157.35	166.25	175.11	183.94	192.73	201.50	210.25	218.98	227.70
	NPV	117.79	126.69	135.52	144.30	153.02	161.69	170.33	178.93	187.51	196.06	204.59	213.11	221.62
		Average Energy Cost Difference between Hybrid and Electricity for Sorghum at 500'~$84.97												

Average Energy Cost Difference is calculated for years of 2007-2011.

Table A.22: Kansas Analysis of Hybrid versus Natural Gas under Economic Activity Sample for Annual Net Metering

Crop	Lift/ Analysis	Interest Rate												
		6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%
Corn	**200'**													
	ROA	121.73	131.29	140.80	150.27	159.71	169.11	178.49	187.84	197.18	206.49	215.79	225.08	234.35
	NPV	100.01	108.02	116.01	123.98	131.94	139.90	147.84	155.78	163.72	171.66	179.59	187.53	195.47
	Average	*Average Energy Cost Difference between Hybrid and Natural Gas for Corn at 200'~$111.35*												
Corn	**500'**													
	ROA	130.50	140.86	151.17	161.45	171.70	181.92	192.12	202.29	212.45	222.58	232.70	242.80	252.90
	NPV	102.30	110.63	118.94	127.26	135.57	143.88	152.19	160.51	168.82	177.14	185.47	193.80	202.13
		Average Energy Cost Difference between Hybrid and Natural Gas for Corn at 500'~$127.84												
Wheat	**200'**													
	ROA	121.27	130.79	140.27	149.71	159.11	168.49	177.84	187.16	196.47	205.76	215.03	224.29	233.53
	NPV	100.01	108.02	116.01	123.98	131.94	139.90	147.84	155.78	163.72	171.66	179.59	187.53	195.47
		Average Energy Cost Difference between Hybrid and Natural Gas for Wheat at 200'~$102.83												
Wheat	**500'**													
	ROA	128.48	138.69	148.87	159.02	169.13	179.22	189.29	199.34	209.37	219.38	229.38	239.36	249.33
	NPV	102.30	110.63	118.94	127.26	135.57	143.88	152.19	160.51	168.82	177.14	185.47	193.80	202.13
		Average Energy Cost Difference between Hybrid and Natural Gas for Wheat at 500'~$123.70												
Sorghum	**200'**													
	ROA	121.27	130.79	140.27	149.71	159.11	168.49	177.84	187.16	196.47	205.76	215.03	224.29	233.53
	NPV	100.01	108.02	116.01	123.98	131.94	139.90	147.84	155.78	163.72	171.66	179.59	187.53	195.47
		Average Energy Cost Difference between Hybrid and Natural Gas for Sorghum at 200'~$102.83												
Sorghum	**500'**													
	ROA	124.87	134.85	144.80	154.72	164.62	174.49	184.35	194.19	204.02	213.83	223.64	233.43	243.22
	NPV	102.30	110.63	118.94	127.26	135.57	143.88	152.19	160.51	168.82	177.14	185.47	193.80	202.13
		Average Energy Cost Difference between Hybrid and Natural Gas for Sorghum at 500'~$123.70												

Average Energy Cost Difference is calculated for years of 2007-2011.

Table A.23: Texas Analysis of Natural Gas versus Electricity under Full Sample

Crop	Lift/ Analysis	Interest Rate												
		6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%
Corn	**200'**													
	ROA	16.00	16.00	15.95	15.87	15.75	15.61	15.44	15.26	15.07	14.86	14.64	14.42	14.20
	NPV	5.36	5.51	5.63	5.72	5.80	5.86	5.90	5.93	5.94	5.95	5.95	5.93	5.92
		Average Energy Cost Difference between Natural Gas and Electricity for Corn at 200'~$37.99												
Corn	**500'**													
	ROA	125.80	127.02	128.04	128.90	129.63	130.26	130.80	131.28	131.70	132.09	132.45	132.79	133.12
	NPV	18.91	19.84	20.72	21.55	22.33	23.08	23.79	24.47	25.12	25.75	26.36	26.95	27.53
		Average Energy Cost Difference between Natural Gas and Electricity for Corn at 500'~$40.37												
Wheat	**200'**													
	ROA	16.00	16.00	15.95	15.87	15.75	15.61	15.44	15.26	15.07	14.86	14.64	14.42	14.20
	NPV	5.36	5.51	5.63	5.72	5.80	5.86	5.90	5.93	5.94	5.95	5.95	5.93	5.92
		Average Energy Cost Difference between Natural Gas and Electricity for Wheat at 200'~$23.89												
Wheat	**500'**													
	ROA	125.80	127.02	128.04	128.90	129.63	130.26	130.80	131.28	131.70	132.09	132.45	132.79	133.12
	NPV	18.91	19.84	20.72	21.55	22.33	23.08	23.79	24.47	25.12	25.75	26.36	26.95	27.53
		Average Energy Cost Difference between Natural Gas and Electricity for Wheat at 500'~$25.39												
Sorghum	**200'**													
	ROA	16.00	16.00	15.95	15.87	15.75	15.61	15.44	15.26	15.07	14.86	14.64	14.42	14.20
	NPV	5.36	5.51	5.63	5.72	5.80	5.86	5.90	5.93	5.94	5.95	5.95	5.93	5.92
		Average Energy Cost Difference between Natural Gas and Electricity for Sorghum at 200'~$23.89												
Sorghum	**500'**													
	ROA	125.80	127.02	128.04	128.90	129.63	130.26	130.80	131.28	131.70	132.09	132.45	132.79	133.12
	NPV	18.91	19.84	20.72	21.55	22.33	23.08	23.79	24.47	25.12	25.75	26.36	26.95	27.53
		Average Energy Cost Difference between Natural Gas and Electricity for Sorghum at 500'~$25.39												

Average Energy Cost Difference is calculated for years of 2007-2011.

Table A.24: Texas Analysis of Hybrid versus Electricity under Full Sample

Crop	**Lift/ Analysis**	**Interest Rate**												
		6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%
Corn	**200'**													
	ROA	120.12	129.21	138.22	147.17	156.06	164.91	173.73	182.50	191.25	199.98	208.68	217.37	226.04
	NPV	117.49	126.38	135.20	143.97	152.68	161.35	169.98	178.58	187.16	195.71	204.24	212.76	221.26
		Average Energy Cost Difference between Hybrid and Electricity for Corn at 200'~$58.20												
Corn	**500'**													
	ROA	120.18	129.27	138.28	147.24	156.14	164.99	173.81	182.59	191.34	200.07	208.77	217.46	226.14
	NPV	117.54	126.44	135.27	144.04	152.75	161.43	170.06	178.67	187.24	195.80	204.33	212.85	221.36
		Average Energy Cost Difference between Hybrid and Electricity for Corn at 500'~$58.20												
Wheat	**200'**													
	ROA	120.12	129.21	138.22	147.17	156.06	164.91	173.73	182.50	191.25	199.98	208.68	217.37	226.04
	NPV	117.49	126.38	135.20	143.97	152.68	161.35	169.98	178.58	187.16	195.71	204.24	212.76	221.26
		Average Energy Cost Difference between Hybrid and Electricity for Wheat at 200'~$57.90												
Wheat	**500'**													
	ROA	120.18	129.27	138.28	147.24	156.14	164.99	173.81	182.59	191.34	200.07	208.77	217.46	226.14
	NPV	117.54	126.44	135.27	144.04	152.75	161.43	170.06	178.67	187.24	195.80	204.33	212.85	221.36
		Average Energy Cost Difference between Hybrid and Electricity for Wheat at 500'~$57.90												
Sorghum	**200'**													
	ROA	120.12	129.21	138.22	147.17	156.06	164.91	173.73	182.50	191.25	199.98	208.68	217.37	226.04
	NPV	117.49	126.38	135.20	143.97	152.68	161.35	169.98	178.58	187.16	195.71	204.24	212.76	221.26
		Average Energy Cost Difference between Hybrid and Electricity for Sorghum at 200'~$57.03												
Sorghum	**500'**													
	ROA	120.18	129.27	138.28	147.24	156.14	164.99	173.81	182.59	191.34	200.07	208.77	217.46	226.14
	NPV	117.54	126.44	135.27	144.04	152.75	161.43	170.06	178.67	187.24	195.80	204.33	212.85	221.36
		Average Energy Cost Difference between Hybrid and Electricity for Sorghum at 500'~$57.03												

Average Energy Cost Difference is calculated for years of 2007-2011.

Table A.25: Texas Analysis of Hybrid versus Natural Gas under Full Sample

Crop	Lift/ Analysis	Interest Rate												
		6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%
Corn	**200'**													
	ROA	175.42	187.11	198.62	210.00	221.25	232.39	243.44	254.40	265.28	276.09	286.84	297.53	308.18
	NPV	112.12	120.87	129.58	138.25	146.88	155.49	164.08	172.66	181.21	189.76	198.29	206.82	215.35
		Average Energy Cost Difference between Hybrid and Natural Gas for Corn at 200'~$96.19												
Corn	**500'**													
	ROA	185.47	197.31	209.00	220.54	231.96	243.27	254.48	265.60	276.64	287.61	298.52	309.36	320.16
	NPV	98.64	106.60	114.55	122.49	130.42	138.35	146.27	154.20	162.12	170.04	177.97	185.90	193.83
		Average Energy Cost Difference between Hybrid and Natural Gas for Corn at 500'~$98.57												
Wheat	**200'**													
	ROA	155.83	166.78	177.60	188.30	198.91	209.43	219.88	230.25	240.57	250.83	261.04	271.22	281.35
	NPV	112.12	120.87	129.58	138.25	146.88	155.49	164.08	172.66	181.21	189.76	198.29	206.82	215.35
		Average Energy Cost Difference between Hybrid and Natural Gas for Wheat at 200'~$81.79												
Wheat	**500'**													
	ROA	158.86	169.73	180.48	191.11	201.66	212.12	222.51	232.84	243.10	253.32	263.48	273.61	283.69
	NPV	98.64	106.60	114.55	122.49	130.42	138.35	146.27	154.20	162.12	170.04	177.97	185.90	193.83
		Average Energy Cost Difference between Hybrid and Natural Gas for Wheat at 500'~$83.29												
Sorghum	**200'**													
	ROA	156.41	167.38	178.22	188.95	199.58	210.11	220.58	230.97	241.30	251.58	261.81	272.00	282.15
	NPV	112.12	120.87	129.58	138.25	146.88	155.49	164.08	172.66	181.21	189.76	198.29	206.82	215.35
		Average Energy Cost Difference between Hybrid and Natural Gas for Sorghum at 200'~$80.92												
Sorghum	**500'**													
	ROA	159.65	170.54	181.31	191.98	202.55	213.04	223.46	233.80	244.09	254.33	264.52	274.66	284.77
	NPV	98.64	106.60	114.55	122.49	130.42	138.35	146.27	154.20	162.12	170.04	177.97	185.90	193.83
		Average Energy Cost Difference between Hybrid and Natural Gas for Sorghum at 500'~$82.42												

Average Energy Cost Difference is calculated for years of 2007-2011.

Table A.26: Texas Analysis of Hybrid versus Electricity under Full Sample for Monthly Net Metering

Crop	**Lift/ Analysis**	**Interest Rate**												
		6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%
Corn	**200'**													
	ROA	120.12	129.21	138.22	147.17	156.06	164.91	173.73	182.50	191.25	199.98	208.68	217.37	226.04
	NPV	117.49	126.38	135.20	143.97	152.68	161.35	169.98	178.58	187.16	195.71	204.24	212.76	221.26
	Average	*Average Energy Cost Difference between Hybrid and Electricity for Corn at 200'~$61.41*												
Corn	**500'**													
	ROA	120.18	129.27	138.28	147.24	156.14	164.99	173.81	182.59	191.34	200.07	208.77	217.46	226.14
	NPV	117.54	126.44	135.27	144.04	152.75	161.43	170.06	178.67	187.24	195.80	204.33	212.85	221.36
		Average Energy Cost Difference between Hybrid and Electricity for Corn at 500'~$61.65												
Wheat	**200'**													
	ROA	120.12	129.21	138.22	147.17	156.06	164.91	173.73	182.50	191.25	199.98	208.68	217.37	226.04
	NPV	117.49	126.38	135.20	143.97	152.68	161.35	169.98	178.58	187.16	195.71	204.24	212.76	221.26
		Average Energy Cost Difference between Hybrid and Electricity for Wheat at 200'~$65.10												
Wheat	**500'**													
	ROA	120.18	129.27	138.28	147.24	156.14	164.99	173.81	182.59	191.34	200.07	208.77	217.46	226.14
	NPV	117.54	126.44	135.27	144.04	152.75	161.43	170.06	178.67	187.24	195.80	204.33	212.85	221.36
		Average Energy Cost Difference between Hybrid and Electricity for Wheat at 500'~$67.42												
Sorghum	**200'**													
	ROA	120.12	129.21	138.22	147.17	156.06	164.91	173.73	182.50	191.25	199.98	208.68	217.37	226.04
	NPV	117.49	126.38	135.20	143.97	152.68	161.35	169.98	178.58	187.16	195.71	204.24	212.76	221.26
		Average Energy Cost Difference between Hybrid and Electricity for Sorghum at 200'~$61.65												
Sorghum	**500'**													
	ROA	120.18	129.27	138.28	147.24	156.14	164.99	173.81	182.59	191.34	200.07	208.77	217.46	226.14
	NPV	117.54	126.44	135.27	144.04	152.75	161.43	170.06	178.67	187.24	195.80	204.33	212.85	221.36
		Average Energy Cost Difference between Hybrid and Electricity for Sorghum at 500'~$61.65												

Average Energy Cost Difference is calculated for years of 2007-2011.

Table A.27: Texas Analysis of Hybrid versus Natural Gas under Full Sample for Monthly Net Metering

Crop	**Lift/ Analysis**	**Interest Rate**												
		6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%
Corn	**200'**													
	ROA	172.92	184.51	195.95	207.24	218.41	229.48	240.45	251.33	262.14	272.89	283.57	294.20	304.79
	NPV	112.12	120.87	129.58	138.25	146.88	155.49	164.08	172.66	181.21	189.76	198.29	206.82	215.35
	Average	*Average Energy Cost Difference between Hybrid and Natural Gas for Corn at 200'~$99.40*												
Corn	**500'**													
	ROA	181.80	193.51	205.07	216.49	227.79	238.98	250.08	261.10	272.03	282.90	293.71	304.46	315.16
	NPV	98.64	106.60	114.55	122.49	130.42	138.35	146.27	154.20	162.12	170.04	177.97	185.90	193.83
		Average Energy Cost Difference between Hybrid and Natural Gas for Corn at 500'~$102.02												
Wheat	**200'**													
	ROA	151.51	162.29	172.94	183.49	193.95	204.33	214.63	224.87	235.05	245.19	255.28	265.33	275.35
	NPV	112.12	120.87	129.58	138.25	146.88	155.49	164.08	172.66	181.21	189.76	198.29	206.82	215.35
		Average Energy Cost Difference between Hybrid and Natural Gas for Wheat at 200'~$88.99												
Wheat	**500'**													
	ROA	151.38	161.96	172.42	182.80	193.08	203.30	213.45	223.54	233.58	243.57	253.52	263.43	273.30
	NPV	98.64	106.60	114.55	122.49	130.42	138.35	146.27	154.20	162.12	170.04	177.97	185.90	193.83
		Average Energy Cost Difference between Hybrid and Natural Gas for Wheat at 500'~$92.81												
Sorghum	**200'**													
	ROA	153.48	164.34	175.07	185.69	196.22	206.66	217.03	227.33	237.57	247.77	257.91	268.02	278.09
	NPV	112.12	120.87	129.58	138.25	146.88	155.49	164.08	172.66	181.21	189.76	198.29	206.82	215.35
		Average Energy Cost Difference between Hybrid and Natural Gas for Sorghum at 200'~$85.54												
Sorghum	**500'**													
	ROA	155.70	166.44	177.07	187.60	198.04	208.39	218.68	228.91	239.08	249.20	259.28	269.31	279.30
	NPV	98.64	106.60	114.55	122.49	130.42	138.35	146.27	154.20	162.12	170.04	177.97	185.90	193.83
		Average Energy Cost Difference between Hybrid and Natural Gas for Sorghum at 500'~$87.04												

Average Energy Cost Difference is calculated for years of 2007-2011.

Table A.28: Texas Analysis of Hybrid versus Electricity under Full Sample for Annual Net Metering

Crop	**Lift/ Analysis**	**Interest Rate**												
		6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%
Corn	**200'**													
	ROA	120.12	129.21	138.22	147.17	156.06	164.91	173.73	182.50	191.25	199.98	208.68	217.37	226.04
	NPV	117.49	126.38	135.20	143.97	152.68	161.35	169.98	178.58	187.16	195.71	204.24	212.76	221.26
	Average	*Average Energy Cost Difference between Hybrid and Electricity for Corn at 200'~$74.61*												
Corn	**500'**													
	ROA	120.18	129.27	138.28	147.24	156.14	164.99	173.81	182.59	191.34	200.07	208.77	217.46	226.14
	NPV	117.54	126.44	135.27	144.04	152.75	161.43	170.06	178.67	187.24	195.80	204.33	212.85	221.36
		Average Energy Cost Difference between Hybrid and Electricity for Corn at 500'~$82.55												
Wheat	**200'**													
	ROA	120.12	129.21	138.22	147.17	156.06	164.91	173.73	182.50	191.25	199.98	208.68	217.37	226.04
	NPV	117.49	126.38	135.20	143.97	152.68	161.35	169.98	178.58	187.16	195.71	204.24	212.76	221.26
		Average Energy Cost Difference between Hybrid and Electricity for Wheat at 200'~$66.84												
Wheat	**500'**													
	ROA	120.18	129.27	138.28	147.24	156.14	164.99	173.81	182.59	191.34	200.07	208.77	217.46	226.14
	NPV	117.54	126.44	135.27	144.04	152.75	161.43	170.06	178.67	187.24	195.80	204.33	212.85	221.36
		Average Energy Cost Difference between Hybrid and Electricity for Wheat at 500'~$76.39												
Sorghum	**200'**													
	ROA	120.12	129.21	138.22	147.17	156.06	164.91	173.73	182.50	191.25	199.98	208.68	217.37	226.04
	NPV	117.49	126.38	135.20	143.97	152.68	161.35	169.98	178.58	187.16	195.71	204.24	212.76	221.26
		Average Energy Cost Difference between Hybrid and Electricity for Sorghum at 200'~$66.84												
Sorghum	**500'**													
	ROA	120.18	129.27	138.28	147.24	156.14	164.99	173.81	182.59	191.34	200.07	208.77	217.46	226.14
	NPV	117.54	126.44	135.27	144.04	152.75	161.43	170.06	178.67	187.24	195.80	204.33	212.85	221.36
		Average Energy Cost Difference between Hybrid and Electricity for Sorghum at 500'~$76.39												

Average Energy Cost Difference is calculated for years of 2007-2011.

Table A.29: Texas Analysis of Hybrid versus Natural Gas under Full Sample for Annual Net Metering

Crop	**Lift/ Analysis**	**Interest Rate**												
		6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%
Corn	**200'**													
	ROA	164.30	175.57	186.70	197.71	208.60	219.39	230.10	240.73	251.30	261.80	272.25	282.66	293.02
	NPV	112.12	120.87	129.58	138.25	146.88	155.49	164.08	172.66	181.21	189.76	198.29	206.82	215.35
	Average	*Average Energy Cost Difference between Hybrid and Natural Gas for Corn at 200'~$112.60*												
Corn	**500'**													
	ROA	164.64	175.73	186.68	197.52	208.26	218.91	229.48	239.98	250.42	260.80	271.14	281.42	291.66
	NPV	98.64	106.60	114.55	122.49	130.42	138.35	146.27	154.20	162.12	170.04	177.97	185.90	193.83
		Average Energy Cost Difference between Hybrid and Natural Gas for Corn at 500'~$122.92												
Wheat	**200'**													
	ROA	150.58	161.32	171.94	182.46	192.88	203.23	213.50	223.71	233.87	243.97	254.04	264.06	274.05
	NPV	112.12	120.87	129.58	138.25	146.88	155.49	164.08	172.66	181.21	189.76	198.29	206.82	215.35
		Average Energy Cost Difference between Hybrid and Natural Gas for Wheat at 200'~$90.73												
Wheat	**500'**													
	ROA	145.74	156.09	166.35	176.51	186.60	196.63	206.59	216.50	226.36	236.18	245.96	255.71	265.43
	NPV	98.64	106.60	114.55	122.49	130.42	138.35	146.27	154.20	162.12	170.04	177.97	185.90	193.83
		Average Energy Cost Difference between Hybrid and Natural Gas for Wheat at 500'~$101.78												
Sorghum	**200'**													
	ROA	150.58	161.32	171.94	182.46	192.88	203.23	213.50	223.71	233.87	243.97	254.04	264.06	274.05
	NPV	112.12	120.87	129.58	138.25	146.88	155.49	164.08	172.66	181.21	189.76	198.29	206.82	215.35
		Average Energy Cost Difference between Hybrid and Natural Gas for Sorghum at 200'~$90.73												
Sorghum	**500'**													
	ROA	145.74	156.09	166.35	176.51	186.60	196.63	206.59	216.50	226.36	236.18	245.96	255.71	265.43
	NPV	98.64	106.60	114.55	122.49	130.42	138.35	146.27	154.20	162.12	170.04	177.97	185.90	193.83
		Average Energy Cost Difference between Hybrid and Natural Gas for Sorghum at 500'~$101.78												

Average Energy Cost Difference is calculated for years of 2007-2011.

Table A.30: Texas Analysis of Natural Gas versus Electricity under Economic Recession Sample

Crop	Lift/ Analysis	Interest Rate												
		6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%
Corn	**200'**													
	ROA	37.05	35.78	34.56	33.40	32.28	31.21	30.19	29.21	28.28	27.38	26.52	25.70	24.92
	NPV	5.36	5.51	5.63	5.72	5.80	5.86	5.90	5.93	5.94	5.95	5.95	5.93	5.92
Average Energy Cost Difference between Natural Gas and Electricity for Corn at 200'~$37.99														
Corn	**500'**													
	ROA	247.50	242.46	237.73	233.30	229.14	225.24	221.59	218.18	214.98	211.99	209.21	206.61	204.18
	NPV	18.91	19.84	20.72	21.55	22.33	23.08	23.79	24.47	25.12	25.75	26.36	26.95	27.53
Average Energy Cost Difference between Natural Gas and Electricity for Corn at 500'~$40.73														
Wheat	**200'**													
	ROA	37.05	35.78	34.56	33.40	32.28	31.21	30.19	29.21	28.28	27.38	26.52	25.70	24.92
	NPV	5.36	5.51	5.63	5.72	5.80	5.86	5.90	5.93	5.94	5.95	5.95	5.93	5.92
Average Energy Cost Difference between Natural Gas and Electricity for Wheat at 200'~$23.89														
Wheat	**500'**													
	ROA	247.50	242.46	237.73	233.30	229.14	225.24	221.59	218.18	214.98	211.99	209.21	206.61	204.18
	NPV	18.91	19.84	20.72	21.55	22.33	23.08	23.79	24.47	25.12	25.75	26.36	26.95	27.53
Average Energy Cost Difference between Natural Gas and Electricity for Wheat at 500'~$25.39														
Sorghum	**200'**													
	ROA	37.05	35.78	34.56	33.40	32.28	31.21	30.19	29.21	28.28	27.38	26.52	25.70	24.92
	NPV	5.36	5.51	5.63	5.72	5.80	5.86	5.90	5.93	5.94	5.95	5.95	5.93	5.92
Average Energy Cost Difference between Natural Gas and Electricity for Sorghum at 200'~$23.89														
Sorghum	**500'**													
	ROA	238.51	233.89	229.54	225.47	221.64	218.05	214.70	211.55	208.61	205.87	203.30	200.91	198.69
	NPV	18.91	19.84	20.72	21.55	22.33	23.08	23.79	24.47	25.12	25.75	26.36	26.95	27.53
Average Energy Cost Difference between Natural Gas and Electricity for Sorghum at 500'~$25.39														

Average Energy Cost Difference is calculated for years of 2007-2011.

Table A.31: Texas Analysis of Hybrid versus Electricity under Economic Recession Sample

Crop	Lift/ Analysis	Interest Rate												
		6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%
Corn	**200'**													
	ROA	119.21	128.23	137.18	146.07	154.90	163.69	172.44	181.16	189.85	198.51	207.16	215.79	224.41
	NPV	117.49	126.38	135.20	143.97	152.68	161.35	169.98	178.58	187.16	195.71	204.24	212.76	221.26
		Average Energy Cost Difference between Hybrid and Electricity for Corn at 200'~$58.20												
Corn	**500'**													
	ROA	119.27	128.29	137.25	146.14	154.97	163.77	172.52	181.24	189.93	198.60	207.25	215.89	224.51
	NPV	117.54	126.44	135.27	144.04	152.75	161.43	170.06	178.67	187.24	195.80	204.33	212.85	221.36
		Average Energy Cost Difference between Hybrid and Electricity for Corn at 500'~$58.20												
Wheat	**200'**													
	ROA	119.21	128.23	137.18	146.07	154.90	163.69	172.44	181.16	189.85	198.51	207.16	215.79	224.41
	NPV	117.49	126.38	135.20	143.97	152.68	161.35	169.98	178.58	187.16	195.71	204.24	212.76	221.26
		Average Energy Cost Difference between Hybrid and Electricity for Wheat at 200'~$57.90												
Wheat	**500'**													
	ROA	119.27	128.29	137.25	146.14	154.97	163.77	172.52	181.24	189.93	198.60	207.25	215.89	224.51
	NPV	117.54	126.44	135.27	144.04	152.75	161.43	170.06	178.67	187.24	195.80	204.33	212.85	221.36
		Average Energy Cost Difference between Hybrid and Electricity for Wheat at 500'~$57.90												
Sorghum	**200'**													
	ROA	119.21	128.23	137.18	146.07	154.90	163.69	172.44	181.16	189.85	198.51	207.16	215.79	224.41
	NPV	117.49	126.38	135.20	143.97	152.68	161.35	169.98	178.58	187.16	195.71	204.24	212.76	221.26
		Average Energy Cost Difference between Hybrid and Electricity for Sorghum at 200'~$57.03												
Sorghum	**500'**													
	ROA	119.27	128.29	137.25	146.14	154.97	163.77	172.52	181.24	189.93	198.60	207.25	215.89	224.51
	NPV	117.54	126.44	135.27	144.04	152.75	161.43	170.06	178.67	187.24	195.80	204.33	212.85	221.36
		Average Energy Cost Difference between Hybrid and Electricity for Sorghum at 500'~$57.03												

Average Energy Cost Difference is calculated for years of 2007-2011.

Table A.32: Texas Analysis of Hybrid versus Natural Gas under Economic Recession Sample

Crop	Lift/ Analysis	Interest Rate												
		6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%
Corn	**200'**													
	ROA	322.37	332.74	343.08	353.38	363.65	373.89	384.11	394.31	404.50	414.67	424.84	434.99	445.14
	NPV	112.12	120.87	129.58	138.25	146.88	155.49	164.08	172.66	181.21	189.76	198.29	206.82	215.35
		Average Energy Cost Difference between Hybrid and Natural Gas for Corn at 200'~$96.19												
Corn	**500'**													
	ROA	379.81	390.09	400.36	410.61	420.86	431.09	441.31	451.53	461.74	471.94	482.13	492.32	502.51
	NPV	98.64	106.60	114.55	122.49	130.42	138.35	146.27	154.20	162.12	170.04	177.97	185.90	193.83
		Average Energy Cost Difference between Hybrid and Natural Gas for Corn at 500'~$98.57												
Wheat	**200'**													
	ROA	259.22	269.44	279.60	289.70	299.77	309.79	319.79	329.76	339.70	349.62	359.53	369.42	379.30
	NPV	112.12	120.87	129.58	138.25	146.88	155.49	164.08	172.66	181.21	189.76	198.29	206.82	215.35
		Average Energy Cost Difference between Hybrid and Natural Gas for Wheat at 200'~$81.79												
Wheat	**500'**													
	ROA	297.92	307.85	317.76	327.64	337.50	347.35	357.18	366.99	376.79	386.58	396.36	406.14	415.90
	NPV	98.64	106.60	114.55	122.49	130.42	138.35	146.27	154.20	162.12	170.04	177.97	185.90	193.83
		Average Energy Cost Difference between Hybrid and Natural Gas for Wheat at 500'~$83.29												
Sorghum	**200'**													
	ROA	261.13	271.35	281.51	291.63	301.70	311.73	321.73	331.71	341.66	351.59	361.51	371.41	381.29
	NPV	112.12	120.87	129.58	138.25	146.88	155.49	164.08	172.66	181.21	189.76	198.29	206.82	215.35
		Average Energy Cost Difference between Hybrid and Natural Gas for Sorghum at 200'~$80.92												
Sorghum	**500'**													
	ROA	300.37	310.31	320.23	330.13	340.00	349.86	359.70	369.53	379.34	389.15	398.94	408.73	418.50
	NPV	98.64	106.60	114.55	122.49	130.42	138.35	146.27	154.20	162.12	170.04	177.97	185.90	193.83
		Average Energy Cost Difference between Hybrid and Natural Gas for Sorghum at 500'~$82.42												

Average Energy Cost Difference is calculated for years of 2007-2011.

Table A.33: Texas Analysis of Hybrid versus Electricity under Economic Recession Sample for Monthly Net Metering

Crop	**Lift/ Analysis**	**Interest Rate**												
		6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%
Corn	**200'**													
	ROA	119.21	128.23	137.18	146.07	154.90	163.69	172.44	181.16	189.85	198.51	207.16	215.79	224.41
	NPV	117.49	126.38	135.20	143.97	152.68	161.35	169.98	178.58	187.16	195.71	204.24	212.76	221.26
	Average	*Average Energy Cost Difference between Hybrid and Electricity for Corn at 200'~$61.41*												
Corn	**500'**													
	ROA	119.27	128.29	137.25	146.14	154.97	163.77	172.52	181.24	189.93	198.60	207.25	215.89	224.51
	NPV	117.54	126.44	135.27	144.04	152.75	161.43	170.06	178.67	187.24	195.80	204.33	212.85	221.36
		Average Energy Cost Difference between Hybrid and Electricity for Corn at 500'~$61.65												
Wheat	**200'**													
	ROA	119.21	128.23	137.18	146.07	154.90	163.69	172.44	181.16	189.85	198.51	207.16	215.79	224.41
	NPV	117.49	126.38	135.20	143.97	152.68	161.35	169.98	178.58	187.16	195.71	204.24	212.76	221.26
		Average Energy Cost Difference between Hybrid and Electricity for Wheat at 200'~$65.10												
Wheat	**500'**													
	ROA	119.27	128.29	137.25	146.14	154.97	163.77	172.52	181.24	189.93	198.60	207.25	215.89	224.51
	NPV	117.54	126.44	135.27	144.04	152.75	161.43	170.06	178.67	187.24	195.80	204.33	212.85	221.36
		Average Energy Cost Difference between Hybrid and Electricity for Wheat at 500'~$67.42												
Sorghum	**200'**													
	ROA	119.21	128.23	137.18	146.07	154.90	163.69	172.44	181.16	189.85	198.51	207.16	215.79	224.41
	NPV	117.49	126.38	135.20	143.97	152.68	161.35	169.98	178.58	187.16	195.71	204.24	212.76	221.26
		Average Energy Cost Difference between Hybrid and Electricity for Sorghum at 200'~$61.65												
Sorghum	**500'**													
	ROA	119.27	128.29	137.25	146.14	154.97	163.77	172.52	181.24	189.93	198.60	207.25	215.89	224.51
	NPV	117.54	126.44	135.27	144.04	152.75	161.43	170.06	178.67	187.24	195.80	204.33	212.85	221.36
		Average Energy Cost Difference between Hybrid and Electricity for Sorghum at 500'~$61.65												

Average Energy Cost Difference is calculated for years of 2007-2011.

Table A.34: Texas Analysis of Hybrid versus Natural Gas under Economic Recession Sample for Monthly Net Metering

Crop	Lift/ Analysis	Interest Rate												
		6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%
Corn	**200'**													
	ROA	314.43	324.79	335.11	345.39	355.63	365.85	376.04	386.22	396.37	406.52	416.65	426.78	436.90
	NPV	112.12	120.87	129.58	138.25	146.88	155.49	164.08	172.66	181.21	189.76	198.29	206.82	215.35
	Average	*Average Energy Cost Difference between Hybrid and Natural Gas for Corn at 200'~$99.40*												
Corn	**500'**													
	ROA	368.69	378.93	389.15	399.36	409.55	419.74	429.91	440.08	450.23	460.38	470.53	480.66	490.79
	NPV	98.64	106.60	114.55	122.49	130.42	138.35	146.27	154.20	162.12	170.04	177.97	185.90	193.83
		Average Energy Cost Difference between Hybrid and Natural Gas for Corn at 500'~$102.02												
Wheat	**200'**													
	ROA	244.91	255.09	265.20	275.26	285.27	295.24	305.18	315.09	324.97	334.84	344.68	354.50	364.32
	NPV	112.12	120.87	129.58	138.25	146.88	155.49	164.08	172.66	181.21	189.76	198.29	206.82	215.35
		Average Energy Cost Difference between Hybrid and Natural Gas for Wheat at 200'~$88.99												
Wheat	**500'**													
	ROA	274.25	284.07	293.86	303.63	313.37	323.09	332.79	342.48	352.16	361.82	371.47	381.11	390.74
	NPV	98.64	106.60	114.55	122.49	130.42	138.35	146.27	154.20	162.12	170.04	177.97	185.90	193.83
		Average Energy Cost Difference between Hybrid and Natural Gas for Wheat at 500'~$92.81												
Sorghum	**200'**													
	ROA	251.46	261.66	271.79	281.87	291.91	301.91	311.87	321.81	331.72	341.61	351.48	361.34	371.18
	NPV	112.12	120.87	129.58	138.25	146.88	155.49	164.08	172.66	181.21	189.76	198.29	206.82	215.35
		Average Energy Cost Difference between Hybrid and Natural Gas for Sorghum at 200'~$85.54												
Sorghum	**500'**													
	ROA	287.95	297.83	307.69	317.52	327.34	337.13	346.91	356.67	366.42	376.15	385.88	395.60	405.30
	NPV	98.64	106.60	114.55	122.49	130.42	138.35	146.27	154.20	162.12	170.04	177.97	185.90	193.83
		Average Energy Cost Difference between Hybrid and Natural Gas for Sorghum at 500'~$87.04												

Average Energy Cost Difference is calculated for years of 2007-2011.

Table A.35: Texas Analysis of Hybrid versus Electricity under Economic Recession Sample for Annual Net Metering

Crop	Lift/ Analysis	Interest Rate												
		6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%
Corn	**200'**													
	ROA	119.21	128.23	137.18	146.07	154.90	163.69	172.44	181.16	189.85	198.51	207.16	215.79	224.41
	NPV	117.49	126.38	135.20	143.97	152.68	161.35	169.98	178.58	187.16	195.71	204.24	212.76	221.26
	Average	*Average Energy Cost Difference between Hybrid and Electricity for Corn at 200'~$74.61*												
Corn	**500'**													
	ROA	119.27	128.29	137.25	146.14	154.97	163.77	172.52	181.24	189.93	198.60	207.25	215.89	224.51
	NPV	117.54	126.44	135.27	144.04	152.75	161.43	170.06	178.67	187.24	195.80	204.33	212.85	221.36
		Average Energy Cost Difference between Hybrid and Electricity for Corn at 500'~$82.55												
Wheat	**200'**													
	ROA	119.21	128.23	137.18	146.07	154.90	163.69	172.44	181.16	189.85	198.51	207.16	215.79	224.41
	NPV	117.49	126.38	135.20	143.97	152.68	161.35	169.98	178.58	187.16	195.71	204.24	212.76	221.26
		Average Energy Cost Difference between Hybrid and Electricity for Wheat at 200'~$66.84												
Wheat	**500'**													
	ROA	119.27	128.29	137.25	146.14	154.97	163.77	172.52	181.24	189.93	198.60	207.25	215.89	224.51
	NPV	117.54	126.44	135.27	144.04	152.75	161.43	170.06	178.67	187.24	195.80	204.33	212.85	221.36
		Average Energy Cost Difference between Hybrid and Electricity for Wheat at 500'~$76.39												
Sorghum	**200'**													
	ROA	119.21	128.23	137.18	146.07	154.90	163.69	172.44	181.16	189.85	198.51	207.16	215.79	224.41
	NPV	117.49	126.38	135.20	143.97	152.68	161.35	169.98	178.58	187.16	195.71	204.24	212.76	221.26
		Average Energy Cost Difference between Hybrid and Electricity for Sorghum at 200'~$66.84												
Sorghum	**500'**													
	ROA	119.27	128.29	137.25	146.14	154.97	163.77	172.52	181.24	189.93	198.60	207.25	215.89	224.51
	NPV	117.54	126.44	135.27	144.04	152.75	161.43	170.06	178.67	187.24	195.80	204.33	212.85	221.36
		Average Energy Cost Difference between Hybrid and Electricity for Sorghum at 500'~$76.39												

Average Energy Cost Difference is calculated for years of 2007-2011.

Table A.36: Texas Analysis of Hybrid versus Natural Gas under Economic Recession Sample for Annual Net Metering

Crop	**Lift/ Analysis**	**Interest Rate**												
		6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%
Corn	**200'**													
	ROA	286.82	297.12	307.36	317.55	327.71	337.84	347.93	358.01	368.06	378.10	388.12	398.13	408.14
	NPV	112.12	120.87	129.58	138.25	146.88	155.49	164.08	172.66	181.21	189.76	198.29	206.82	215.35
	Average	*Average Energy Cost Difference between Hybrid and Natural Gas for Corn at 200'~$112.60*												
Corn	**500'**													
	ROA	315.98	325.99	335.98	345.95	355.90	365.84	375.76	385.67	395.57	405.45	415.33	425.20	435.06
	NPV	98.64	106.60	114.55	122.49	130.42	138.35	146.27	154.20	162.12	170.04	177.97	185.90	193.83
		Average Energy Cost Difference between Hybrid and Natural Gas for Corn at 500'~$122.92												
Wheat	**200'**													
	ROA	241.81	251.98	262.08	272.13	282.13	292.09	302.02	311.91	321.78	331.63	341.46	351.27	361.07
	NPV	112.12	120.87	129.58	138.25	146.88	155.49	164.08	172.66	181.21	189.76	198.29	206.82	215.35
		Average Energy Cost Difference between Hybrid and Natural Gas for Wheat at 200'~$90.73												
Wheat	**500'**													
	ROA	256.19	265.93	275.62	285.29	294.94	304.56	314.17	323.75	333.33	342.88	352.43	361.97	371.49
	NPV	98.64	106.60	114.55	122.49	130.42	138.35	146.27	154.20	162.12	170.04	177.97	185.90	193.83
		Average Energy Cost Difference between Hybrid and Natural Gas for Wheat at 500'~$101.78												
Sorghum	**200'**													
	ROA	241.81	251.98	262.08	272.13	282.13	292.09	302.02	311.91	321.78	331.63	341.46	351.27	361.07
	NPV	112.12	120.87	129.58	138.25	146.88	155.49	164.08	172.66	181.21	189.76	198.29	206.82	215.35
		Average Energy Cost Difference between Hybrid and Natural Gas for Sorghum at 200'~$90.73												
Sorghum	**500'**													
	ROA	256.19	265.93	275.62	285.29	294.94	304.56	314.17	323.75	333.33	342.88	352.43	361.97	371.49
	NPV	98.64	106.60	114.55	122.49	130.42	138.35	146.27	154.20	162.12	170.04	177.97	185.90	193.83
		Average Energy Cost Difference between Hybrid and Natural Gas for Sorghum at 500'~$101.78												

Average Energy Cost Difference is calculated for years of 2007-2011.

Table A.37: Texas Analysis of Natural Gas versus Electricity under Economic Activity Sample

Crop	Lift/ Analysis	Interest Rate												
		6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%
Corn	**200'**													
	ROA	9.62	9.82	9.98	10.10	10.19	10.24	10.27	10.27	10.26	10.23	10.18	10.12	10.05
	NPV	5.36	5.51	5.63	5.72	5.80	5.86	5.90	5.93	5.94	5.95	5.95	5.93	5.92
		Average Energy Cost Difference between Natural Gas and Electricity for Corn at 200'~$37.99												
Corn	**500'**													
	ROA	88.97	91.62	93.99	96.13	98.07	99.83	101.44	102.93	104.31	105.59	106.80	107.94	109.03
	NPV	18.91	19.84	20.72	21.55	22.33	23.08	23.79	24.47	25.12	25.75	26.36	26.95	27.53
		Average Energy Cost Difference between Natural Gas and Electricity for Corn at 500'~$40.37												
Wheat	**200'**													
	ROA	9.62	9.82	9.98	10.10	10.19	10.24	10.27	10.27	10.26	10.23	10.18	10.12	10.05
	NPV	5.36	5.51	5.63	5.72	5.80	5.86	5.90	5.93	5.94	5.95	5.95	5.93	5.92
		Average Energy Cost Difference between Natural Gas and Electricity for Wheat at 200'~$23.89												
Wheat	**500'**													
	ROA	88.97	91.62	93.99	96.13	98.07	99.83	101.44	102.93	104.31	105.59	106.80	107.94	109.03
	NPV	18.91	19.84	20.72	21.55	22.33	23.08	23.79	24.47	25.12	25.75	26.36	26.95	27.53
		Average Energy Cost Difference between Natural Gas and Electricity for Wheat at 500'~$25.39												
Sorghum	**200'**													
	ROA	9.62	9.82	9.98	10.10	10.19	10.24	10.27	10.27	10.26	10.23	10.18	10.12	10.05
	NPV	5.36	5.51	5.63	5.72	5.80	5.86	5.90	5.93	5.94	5.95	5.95	5.93	5.92
		Average Energy Cost Difference between Natural Gas and Electricity for Sorghum at 200'~$23.89												
Sorghum	**500'**													
	ROA	88.97	91.62	93.99	96.13	98.07	99.83	101.44	102.93	104.31	105.59	106.80	107.94	109.03
	NPV	18.91	19.84	20.72	21.55	22.33	23.08	23.79	24.47	25.12	25.75	26.36	26.95	27.53
		Average Energy Cost Difference between Natural Gas and Electricity for Sorghum at 500'~$25.39												

Average Energy Cost Difference is calculated for years of 2007-2011.

Table A.38: Texas Analysis of Hybrid versus Electricity under Economic Activity Sample

Crop	**Lift/ Analysis**	**Interest Rate**												
		6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%
Corn	**200'**													
	ROA	120.87	130.00	139.06	148.06	157.01	165.90	174.76	183.58	192.37	201.14	209.89	218.62	227.33
	NPV	117.49	126.38	135.20	143.97	152.68	161.35	169.98	178.58	187.16	195.71	204.24	212.76	221.26
		Average Energy Cost Difference between Hybrid and Electricity for Corn at 200'~$58.20												
Corn	**500'**													
	ROA	120.93	130.07	139.13	148.13	157.08	165.98	174.84	183.67	192.46	201.23	209.98	218.71	227.43
	NPV	117.54	126.44	135.27	144.04	152.75	161.43	170.06	178.67	187.24	195.80	204.33	212.85	221.36
		Average Energy Cost Difference between Hybrid and Electricity for Corn at 500'~$58.20												
Wheat	**200'**													
	ROA	120.87	130.00	139.06	148.06	157.01	165.90	174.76	183.58	192.37	201.14	209.89	218.62	227.33
	NPV	117.49	126.38	135.20	143.97	152.68	161.35	169.98	178.58	187.16	195.71	204.24	212.76	221.26
		Average Energy Cost Difference between Hybrid and Electricity for Wheat at 200'~$57.90												
Wheat	**500'**													
	ROA	120.93	130.07	139.13	148.13	157.08	165.98	174.84	183.67	192.46	201.23	209.98	218.71	227.43
	NPV	117.54	126.44	135.27	144.04	152.75	161.43	170.06	178.67	187.24	195.80	204.33	212.85	221.36
		Average Energy Cost Difference between Hybrid and Electricity for Wheat at 500'~$57.90												
Sorghum	**200'**													
	ROA	120.87	130.00	139.06	148.06	157.01	165.90	174.76	183.58	192.37	201.14	209.89	218.62	227.33
	NPV	117.49	126.38	135.20	143.97	152.68	161.35	169.98	178.58	187.16	195.71	204.24	212.76	221.26
		Average Energy Cost Difference between Hybrid and Electricity for Sorghum at 200'~$57.03												
Sorghum	**500'**													
	ROA	120.93	130.07	139.13	148.13	157.08	165.98	174.84	183.67	192.46	201.23	209.98	218.71	227.43
	NPV	117.54	126.44	135.27	144.04	152.75	161.43	170.06	178.67	187.24	195.80	204.33	212.85	221.36
		Average Energy Cost Difference between Hybrid and Electricity for Sorghum at 500'~$57.03												

Average Energy Cost Difference is calculated for years of 2007-2011.

Table A.39: Texas Analysis of Hybrid versus Natural Gas under Economic Activity Sample

Crop	**Lift/ Analysis**	**Interest Rate**												
		6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%
Corn	**200'**													
	ROA	134.46	144.78	155.02	165.20	175.32	185.40	195.43	205.42	215.38	225.31	235.22	245.10	254.97
	NPV	112.12	120.87	129.58	138.25	146.88	155.49	164.08	172.66	181.21	189.76	198.29	206.82	215.35
		Average Energy Cost Difference between Hybrid and Natural Gas for Corn at 200'~$96.19												
Corn	**500'**													
	ROA	128.84	138.96	149.04	159.07	169.07	179.03	188.96	198.86	208.73	218.59	228.42	238.24	248.03
	NPV	98.64	106.60	114.55	122.49	130.42	138.35	146.27	154.20	162.12	170.04	177.97	185.90	193.83
		Average Energy Cost Difference between Hybrid and Natural Gas for Corn at 500'~$98.57												
Wheat	**200'**													
	ROA	128.44	138.34	148.18	157.97	167.71	177.40	187.06	196.69	206.29	215.86	225.42	234.96	244.48
	NPV	112.12	120.87	129.58	138.25	146.88	155.49	164.08	172.66	181.21	189.76	198.29	206.82	215.35
		Average Energy Cost Difference between Hybrid and Natural Gas for Wheat at 200'~$81.79												
Wheat	**500'**													
	ROA	119.75	129.24	138.70	148.13	157.53	166.91	176.26	185.60	194.92	204.22	213.52	222.80	232.07
	NPV	98.64	106.60	114.55	122.49	130.42	138.35	146.27	154.20	162.12	170.04	177.97	185.90	193.83
		Average Energy Cost Difference between Hybrid and Natural Gas for Wheat at 500'~$83.29												
Sorghum	**200'**													
	ROA	128.61	138.53	148.38	158.18	167.93	177.63	187.30	196.94	206.55	216.14	225.70	235.25	244.78
	NPV	112.12	120.87	129.58	138.25	146.88	155.49	164.08	172.66	181.21	189.76	198.29	206.82	215.35
		Average Energy Cost Difference between Hybrid and Natural Gas for Sorghum at 200'~$80.92												
Sorghum	**500'**													
	ROA	120.00	129.51	138.99	148.44	157.85	167.25	176.62	185.97	195.31	204.63	213.94	223.23	232.52
	NPV	98.64	106.60	114.55	122.49	130.42	138.35	146.27	154.20	162.12	170.04	177.97	185.90	193.83
		Average Energy Cost Difference between Hybrid and Natural Gas for Sorghum at 500'~$82.42												

Average Energy Cost Difference is calculated for years of 2007-2011.

Table A.40: Texas Analysis of Hybrid versus Electricity under Economic Activity Sample for Monthly Net Metering

Crop	Lift/ Analysis	Interest Rate												
		6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%
Corn	**200'**													
	ROA	120.87	130.00	139.06	148.06	157.01	165.90	174.76	183.58	192.37	201.14	209.89	218.62	227.33
	NPV	117.49	126.38	135.20	143.97	152.68	161.35	169.98	178.58	187.16	195.71	204.24	212.76	221.26
	Average	*Average Energy Cost Difference between Hybrid and Electricity for Corn at 200'~$61.41*												
Corn	**500'**													
	ROA	120.93	130.07	139.13	148.13	157.08	165.98	174.84	183.67	192.46	201.23	209.98	218.71	227.43
	NPV	117.54	126.44	135.27	144.04	152.75	161.43	170.06	178.67	187.24	195.80	204.33	212.85	221.36
		Average Energy Cost Difference between Hybrid and Electricity for Corn at 500'~$61.65												
Wheat	**200'**													
	ROA	120.87	130.00	139.06	148.06	157.01	165.90	174.76	183.58	192.37	201.14	209.89	218.62	227.33
	NPV	117.49	126.38	135.20	143.97	152.68	161.35	169.98	178.58	187.16	195.71	204.24	212.76	221.26
		Average Energy Cost Difference between Hybrid and Electricity for Wheat at 200'~$65.10												
Wheat	**500'**													
	ROA	120.93	130.07	139.13	148.13	157.08	165.98	174.84	183.67	192.46	201.23	209.98	218.71	227.43
	NPV	117.54	126.44	135.27	144.04	152.75	161.43	170.06	178.67	187.24	195.80	204.33	212.85	221.36
		Average Energy Cost Difference between Hybrid and Electricity for Wheat at 500'~$67.42												
Sorghum	**200'**													
	ROA	120.87	130.00	139.06	148.06	157.01	165.90	174.76	183.58	192.37	201.14	209.89	218.62	227.33
	NPV	117.49	126.38	135.20	143.97	152.68	161.35	169.98	178.58	187.16	195.71	204.24	212.76	221.26
		Average Energy Cost Difference between Hybrid and Electricity for Sorghum at 200'~$61.65												
Sorghum	**500'**													
	ROA	120.93	130.07	139.13	148.13	157.08	165.98	174.84	183.67	192.46	201.23	209.98	218.71	227.43
	NPV	117.54	126.44	135.27	144.04	152.75	161.43	170.06	178.67	187.24	195.80	204.33	212.85	221.36
		Average Energy Cost Difference between Hybrid and Electricity for Sorghum at 500'~$61.65												

Average Energy Cost Difference is calculated for years of 2007-2011.

Table A.41: Texas Analysis of Hybrid versus Natural Gas under Economic Activity Sample for Monthly Net Metering

Crop	**Lift/ Analysis**	**Interest Rate**												
		6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%
Corn	**200'**													
	ROA	133.67	143.93	154.12	164.25	174.33	184.35	194.33	204.28	214.19	224.08	233.94	243.78	253.59
	NPV	112.12	120.87	129.58	138.25	146.88	155.49	164.08	172.66	181.21	189.76	198.29	206.82	215.35
	Average	*Average Energy Cost Difference between Hybrid and Natural Gas for Corn at 200'~$99.40*												
Corn	**500'**													
	ROA	127.52	137.56	147.55	157.49	167.40	177.28	187.13	196.95	206.75	216.52	226.28	236.02	245.74
	NPV	98.64	106.60	114.55	122.49	130.42	138.35	146.27	154.20	162.12	170.04	177.97	185.90	193.83
		Average Energy Cost Difference between Hybrid and Natural Gas for Corn at 500'~$102.02												
Wheat	**200'**													
	ROA	127.16	136.97	146.73	156.43	166.08	175.70	185.28	194.82	204.35	213.84	223.32	232.79	242.23
	NPV	112.12	120.87	129.58	138.25	146.88	155.49	164.08	172.66	181.21	189.76	198.29	206.82	215.35
		Average Energy Cost Difference between Hybrid and Natural Gas for Wheat at 200'~$88.99												
Wheat	**500'**													
	ROA	117.36	126.69	135.98	145.25	154.49	163.71	172.91	182.10	191.27	200.43	209.57	218.71	227.84
	NPV	98.64	106.60	114.55	122.49	130.42	138.35	146.27	154.20	162.12	170.04	177.97	185.90	193.83
		Average Energy Cost Difference between Hybrid and Natural Gas for Wheat at 500'~$92.81												
Sorghum	**200'**													
	ROA	127.74	137.59	147.39	157.13	166.82	176.47	186.09	195.67	205.23	214.76	224.28	233.77	243.25
	NPV	112.12	120.87	129.58	138.25	146.88	155.49	164.08	172.66	181.21	189.76	198.29	206.82	215.35
		Average Energy Cost Difference between Hybrid and Natural Gas for Sorghum at 200'~$85.54												
Sorghum	**500'**													
	ROA	118.73	128.15	137.54	146.90	156.23	165.54	174.83	184.11	193.36	202.61	211.84	221.06	230.27
	NPV	98.64	106.60	114.55	122.49	130.42	138.35	146.27	154.20	162.12	170.04	177.97	185.90	193.83
		Average Energy Cost Difference between Hybrid and Natural Gas for Sorghum at 500'~$87.04												

Average Energy Cost Difference is calculated for years of 2007-2011.

Table A.42: Texas Analysis of Hybrid versus Electricity under Economic Activity Sample for Annual Net Metering

Crop	Lift/ Analysis	Interest Rate												
		6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%
Corn	**200'**													
	ROA	120.87	130.00	139.06	148.06	157.01	165.90	174.76	183.58	192.37	201.14	209.89	218.62	227.33
	NPV	117.49	126.38	135.20	143.97	152.68	161.35	169.98	178.58	187.16	195.71	204.24	212.76	221.26
	Average	*Average Energy Cost Difference between Hybrid and Electricity for Corn at 200'~$74.61*												
Corn	**500'**													
	ROA	120.93	130.07	139.13	148.13	157.08	165.98	174.84	183.67	192.46	201.23	209.98	218.71	227.43
	NPV	117.54	126.44	135.27	144.04	152.75	161.43	170.06	178.67	187.24	195.80	204.33	212.85	221.36
		Average Energy Cost Difference between Hybrid and Electricity for Corn at 500'~$82.55												
Wheat	**200'**													
	ROA	120.87	130.00	139.06	148.06	157.01	165.90	174.76	183.58	192.37	201.14	209.89	218.62	227.33
	NPV	117.49	126.38	135.20	143.97	152.68	161.35	169.98	178.58	187.16	195.71	204.24	212.76	221.26
		Average Energy Cost Difference between Hybrid and Electricity for Wheat at 200'~$66.84												
Wheat	**500'**													
	ROA	120.93	130.07	139.13	148.13	157.08	165.98	174.84	183.67	192.46	201.23	209.98	218.71	227.43
	NPV	117.54	126.44	135.27	144.04	152.75	161.43	170.06	178.67	187.24	195.80	204.33	212.85	221.36
		Average Energy Cost Difference between Hybrid and Electricity for Wheat at 500'~$76.39												
Sorghum	**200'**													
	ROA	120.87	130.00	139.06	148.06	157.01	165.90	174.76	183.58	192.37	201.14	209.89	218.62	227.33
	NPV	117.49	126.38	135.20	143.97	152.68	161.35	169.98	178.58	187.16	195.71	204.24	212.76	221.26
		Average Energy Cost Difference between Hybrid and Electricity for Sorghum at 200'~$66.84												
Sorghum	**500'**													
	ROA	120.93	130.07	139.13	148.13	157.08	165.98	174.84	183.67	192.46	201.23	209.98	218.71	227.43
	NPV	117.54	126.44	135.27	144.04	152.75	161.43	170.06	178.67	187.24	195.80	204.33	212.85	221.36
		Average Energy Cost Difference between Hybrid and Electricity for Sorghum at 500'~$76.39												

Average Energy Cost Difference is calculated for years of 2007-2011.

Table A.43: Texas Analysis of Hybrid versus Natural Gas under Economic Activity Sample for Annual Net Metering

Crop	Lift/ Analysis	Interest Rate												
		6%	6.5%	7%	7.5%	8%	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%
Corn	**200'**													
	ROA	131.00	141.07	151.09	161.04	170.94	180.80	190.62	200.40	210.16	219.88	229.59	239.27	248.94
	NPV	112.12	120.87	129.58	138.25	146.88	155.49	164.08	172.66	181.21	189.76	198.29	206.82	215.35
	Average	*Average Energy Cost Difference between Hybrid and Natural Gas for Corn at 200'~$112.60*												
Corn	**500'**													
	ROA	121.64	131.27	140.86	150.41	159.94	169.44	178.91	188.37	197.80	207.23	216.63	226.03	235.41
	NPV	98.64	106.60	114.55	122.49	130.42	138.35	146.27	154.20	162.12	170.04	177.97	185.90	193.83
		Average Energy Cost Difference between Hybrid and Natural Gas for Corn at 500'~$122.92												
Wheat	**200'**													
	ROA	126.88	136.68	146.42	156.10	165.74	175.33	184.89	194.43	203.93	213.41	222.88	232.32	241.75
	NPV	112.12	120.87	129.58	138.25	146.88	155.49	164.08	172.66	181.21	189.76	198.29	206.82	215.35
		Average Energy Cost Difference between Hybrid and Natural Gas for Wheat at 200'~$90.73												
Wheat	**500'**													
	ROA	115.61	124.81	133.98	143.13	152.26	161.36	170.45	179.52	188.58	197.63	206.67	215.70	224.73
	NPV	98.64	106.60	114.55	122.49	130.42	138.35	146.27	154.20	162.12	170.04	177.97	185.90	193.83
		Average Energy Cost Difference between Hybrid and Natural Gas for Wheat at 500'~$101.78												
Sorghum	**200'**													
	ROA	126.88	136.68	146.42	156.10	165.74	175.33	184.89	194.43	203.93	213.41	222.88	232.32	241.75
	NPV	112.12	120.87	129.58	138.25	146.88	155.49	164.08	172.66	181.21	189.76	198.29	206.82	215.35
		Average Energy Cost Difference between Hybrid and Natural Gas for Sorghum at 200'~$90.73												
Sorghum	**500'**													
	ROA	115.61	124.81	133.98	143.13	152.26	161.36	170.45	179.52	188.58	197.63	206.67	215.70	224.73
	NPV	98.64	106.60	114.55	122.49	130.42	138.35	146.27	154.20	162.12	170.04	177.97	185.90	193.83
		Average Energy Cost Difference between Hybrid and Natural Gas for Sorghum at 500'~$101.78												

Average Energy Cost Difference is calculated for years of 2007-2011.