# WIND FEASIBILITY REPORT

# for

# Colorado Livestock Operations

**August, 2008**

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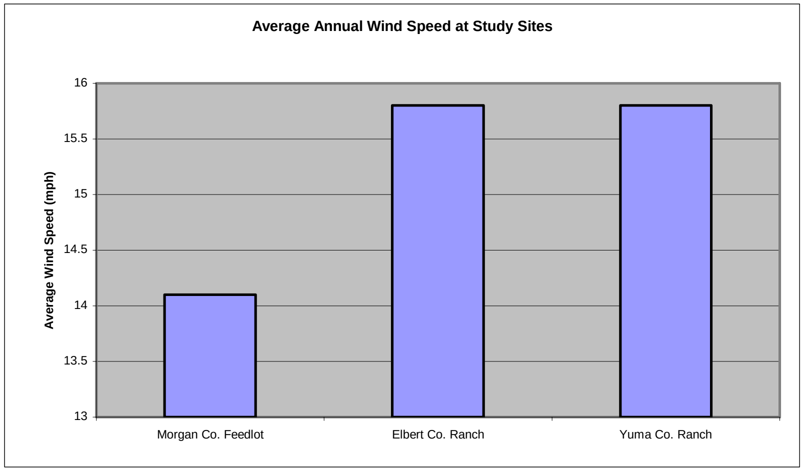
## EXECUTIVE SUMMARY

This study examines the economic feasibility of utilizing wind energy to generate electricity at three livestock operations in Colorado. One of the participating operations is a ranch in Elbert County, another is a feedlot in Morgan County, and the third is a diversified farming, cow-calf and feedlot operation in Yuma County. Multi-year electricity usage and cost data was examined from each site, and used in estimating the costs of wind-generated energy. The Yuma County Ranch provided two sets of electricity usage and cost data, one from its headquarters and another from some of its irrigation well motors. For comparative purposes, both datasets were included for analysis.

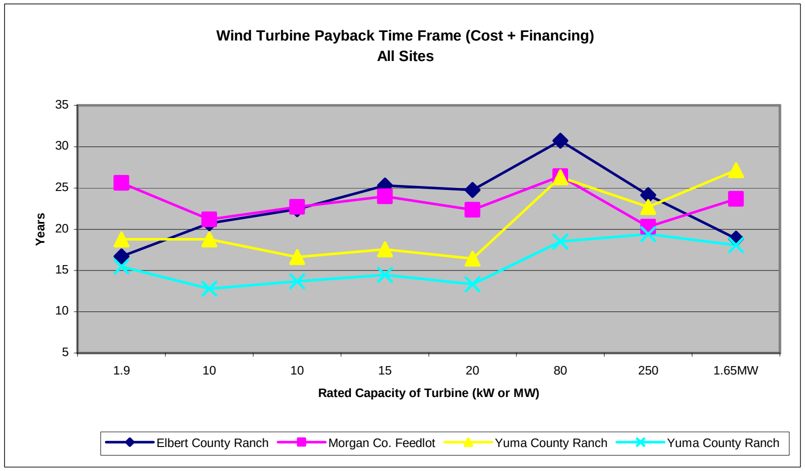
Figure 1.



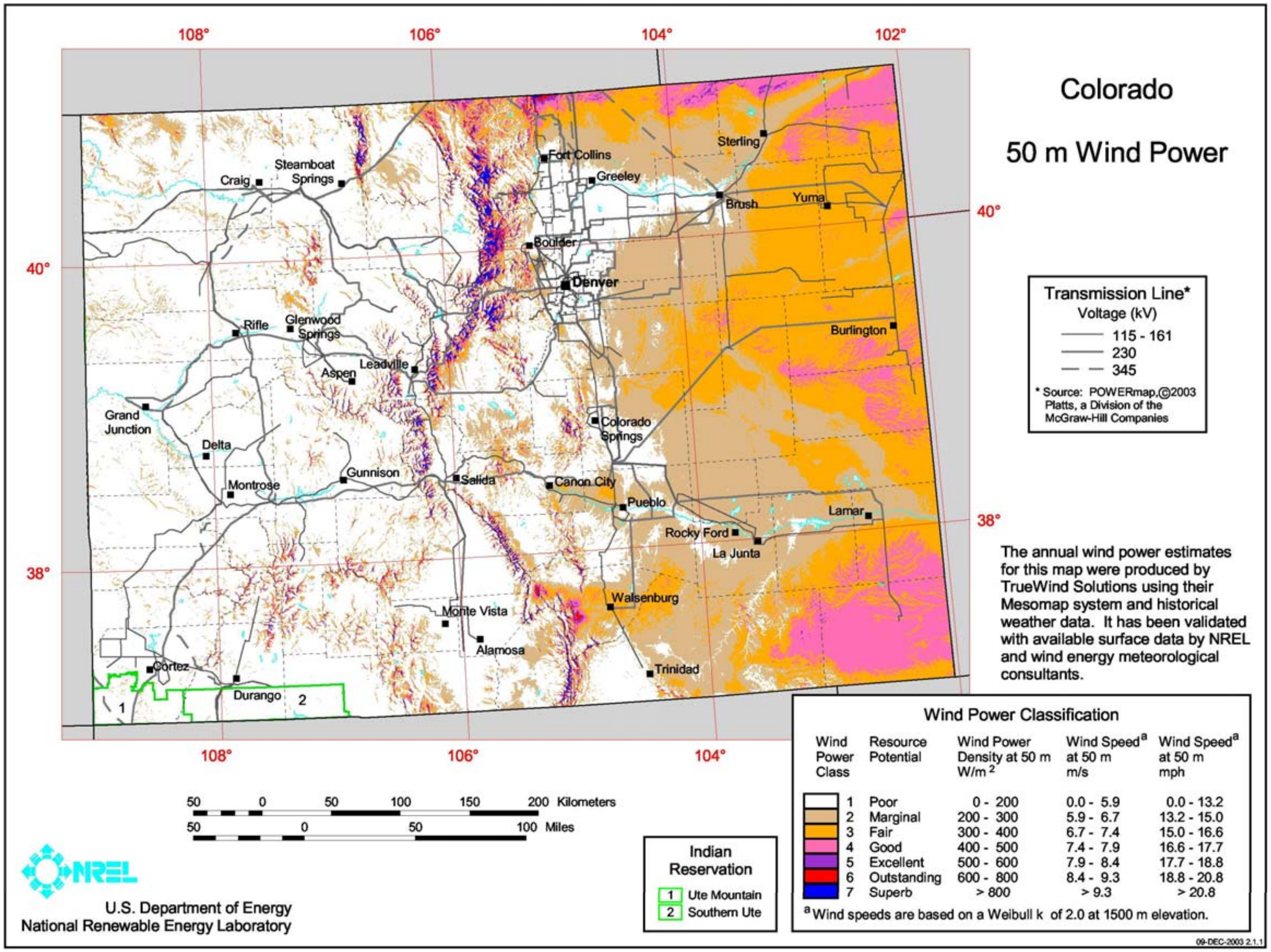

The average wind speed for each site was derived from U.S. Department of Energy (DOE), National Renewable Energy Laboratory (NREL) *Colorado 50 M Wind Power map* (attached on the following page). The cost and projected energy outputs of eight commercial wind turbines were analyzed. Power ratings of the turbines ranged from 1.9 kW to 1.65 Megawatts (MW). Turbine payback periods were calculated both on a 100 percent cash and a financed basis.

Figure 2 (below) displays the estimated time frame in which a given turbine would pay for itself at each site, with financing costs included. Seventy (70) percent of the cost was assumed to be financed at 6 percent interest over 15 years for all turbines except the largest turbine, the 1.65 MW unit. For this turbine, 95 percent of the installation cost was assumed to be financed under the same terms.

Figure 2.




Financing costs added an additional 4 and 7 years to the payback time period of a turbine. The site with the lower wind speed (Morgan County) tended to have longer payback times, with some exceptions. The average price paid for electricity coupled with the percentage of each facility's electricity usage that each turbine was able to offset also influenced the payback time period. Morgan County feedlot had the lower average wind speed, but it had the highest annual electricity usage.


Colorado
50 m Wind Power
108°
106°
104°
102°
40°
38°
Craig
Steamboat Springs
Fort Collins
Greeley
Sterling
Brush
Yuma
Boulder
Denver
Rifle
Glenwood Springs
Aspen
Leadville
Burlington
Grand Junction
Delta
Montrose
Gunnison
Salida
Colorado Springs
Canon City
Pueblo
Lamar
Rocky Ford
La Junta
Walsenburg
Monte Vista
Alamosa
Trinidad
Cortez
Durango
Transmission Line*
Voltage (kV)
115 - 161
230
345
* Source: POWERmap,©2003 Platts, a Division of the McGraw-Hill Companies
The annual wind power estimates for this map were produced by TrueWind Solutions using their Mesomap system and historical weather data. It has been validated with available surface data by NREL and wind energy meteorological consultants.
50 0 50 100 150 200 Kilometers
50 0 50 100 Miles
U.S. Department of Energy
National Renewable Energy Laboratory
Indian Reservation
1 Ute Mountain
2 Southern Ute
Wind Power Classification
Wind Power Class | Resource Potential | Wind Power Density at 50 m W/m 2 | Wind Speed a at 50 m m/s | Wind Speed a at 50 m mph
1 Poor 0 - 200 0.0 - 5.9 0.0 - 13.2
2 Marginal 200 - 300 5.9 - 6.7 13.2 - 15.0
3 Fair 300 - 400 6.7 - 7.4 15.0 - 16.6
4 Good 400 - 500 7.4 - 7.9 16.6 - 17.7
5 Excellent 500 - 600 7.9 - 8.4 17.7 - 18.8
6 Outstanding 600 - 800 8.4 - 9.3 18.8 - 20.8
7 Superb > 800 > 9.3 > 20.8
a Wind speeds are based on a Weibull k of 2.0 at 1500 m elevation.
09-DEC-2003 2.1.1

**BACKGROUND:**
Colorado livestock producers continue to experience rising fixed costs (inputs, energy, equipment, etc.). A 2006 report released by the Colorado Energy Forum projected Colorado's demand for electricity to increase approximately fifty (50) percent between 2006 and 2025. Livestock producers have a compelling financial need to reduce their energy costs wherever possible, and develop new sources of income. Income sources that enable livestock producers to diversify beyond conventional agricultural-based income sources help operators maintain a more stable financial condition, which in turns benefits rural city and county economies through job creation and tax revenues.

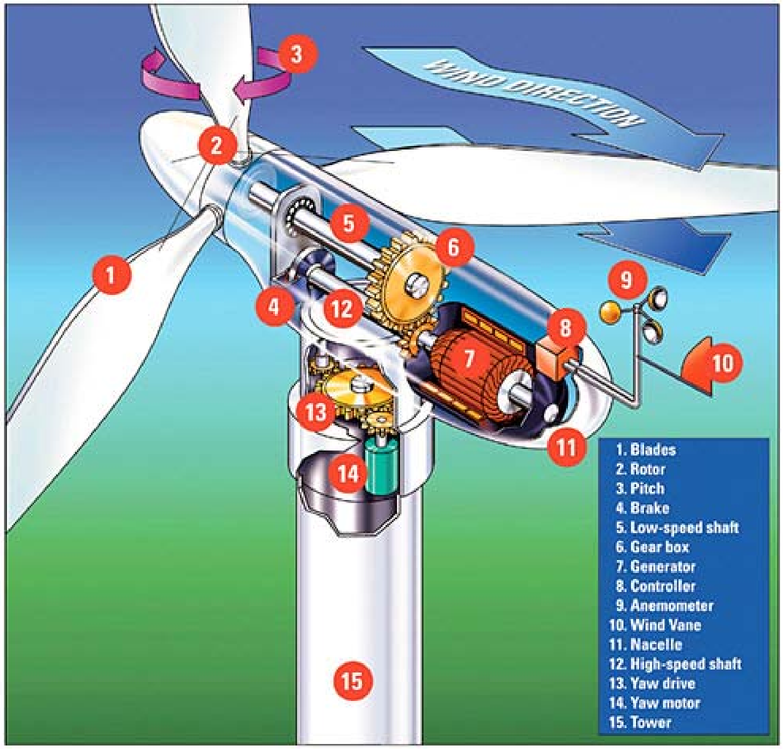
The American Wind Energy Association ranks Colorado 11$^{th}$ in the nation for wind energy resource potential. Utility scale wind generated electricity is now cheaper in some cases than convention electricity. Colorado livestock production facilities, especially animal feeding operations (AFOs), have several characteristics that are advantageous for producing and utilizing wind generated electricity. Livestock production facilities are typically:

- Located in moderate to high wind areas
- Relatively high electricity consumers with year-round usage
- Located in rural areas with space for wind turbines

**PROJECT OBJECTIVE:**
This study examines the economic feasibility of generating wind energy at livestock production facilities in Colorado, both for the purposes of internal consumption and external sale back to the power grid. Three livestock operations participated in the study. The operations are located in Elbert, Morgan and Yuma Counties, and are referenced by their county name in this report.

**WIND ENERGY:**
Wind (a moving air mass) possesses kinetic energy. The terms "wind energy" or "wind power" describe the process by which the wind's kinetic energy is converted by wind turbines into mechanical or electrical power. The energy contained within a moving air mass is both a function of its speed and density. Wind density declines with increasing altitude and increasing temperature.

Figure 1: Components of a Wind Turbine

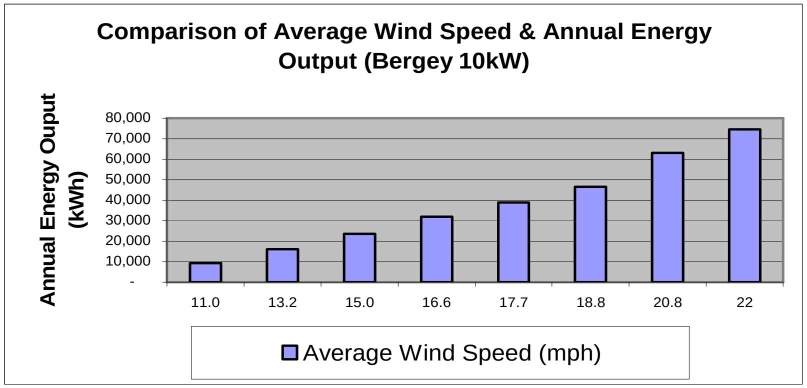



*Source: Alternative Energy News, 2008*

A wind energy generating system is made up of a turbine, a tower, and electrical wiring. The turbine is comprised of two or three rotor blades connected via drive shaft to an electrical generator, either directly or through a gear box. Additional turbine components may include a brake, a yaw motor drive, a controller system, and wind and temperature measuring systems. With the exception of the rotor, the turbine components are housed inside a protective outer cover called a nacelle. The turbine is mounted on a tower, which may be a guyed, three-sided tripod or a monopole. For grid-connected systems, electricity is typically generated by the turbine as alternating current (A/C), then conveyed via electrical wire to a control panel on the ground where it is converted to direct current (D/C), regulated or "conditioned", then converted back to A/C and brought onto the utility's grid.

The energy available in the wind is proportional to the cube of its speed. The importance of wind speed in determining energy output is displayed in Figure 3 (below), which compares the annual energy output of the same 10 kW turbine under different average wind speeds.

Figure 3.




As the chart indicates, a 22 mph average wind speed can generate almost eight times more electricity in a year than an 11 mph average wind speed.

The diameter of the turbine rotor and the turbine power rating are also important to wind energy generation. The rotor determines how much kinetic energy a wind turbine is able to harvest from the wind. The turbine power rating determines how much wind energy can be converted into electricity.

**WIND RESOURCE:**

Anyone who has lived and traveled around Colorado has likely observed that some places are windier than others. The U.S. Department of Energy (DOE), National Renewable Energy Laboratory (NREL) *Colorado 50 M Wind Power map* (displayed on page 3) shows the wind resource potential of any given location within the state using a scale of 1 (poor) to 7 (superb). The map indicates that the participating livestock operations in Elbert and Yuma Counties have "Fair" wind resource potential (Class 3 winds). Class 3 sites represent areas with average wind speeds ranging from 15 to 16.6 miles per hour (6.7 to 7.4 meters per second). The livestock operation in Morgan County is shown on the map as having "Marginal" (Class 2) wind speeds, which range from 13.2 to 15 miles per hour (5.9 to 6.7 meters per second). It is important to note that specific sites may have average wind speeds that vary significantly from the NREL wind power map. Additionally, the Colorado Wind Power map estimates average wind speeds at a height of 50 meters (164 feet) above ground level. Since surface friction (trees, buildings, etc.) reduces wind speed, the average wind speed for a given location would be lower at any lesser height. The Department of Energy's *Colorado Consumer Guide for Small Wind Electric Systems* notes that a 10-kW generator mounted on a 100-foot tower would produce 29 percent more power than the same generator mounted on a 60-foot tower.

As of March, 2008, the American Wind Energy Association reported that Colorado ranks 6th in the nation in megawatts of wind power installed.

**METHODOLODGY:**

Estimated wind energy production, value, cost and turbine payback time frame were determined for each site and are shown in Tables 1, 2 and 4. The method used to determine the outputs is described in the following paragraphs.

Individual turbine costs were gathered from the various turbine manufacturers. Price information was obtained for eight (8) turbines ranging in size class from 1.9 kW to 1.65 Megawatt. The estimated annual energy output of these turbines overlapped to varying degrees with electricity usage data among the sites, and provided for a useful comparison across a wide price and energy output range.

The average wind speed of each site was determined from the NREL Wind Power map, and the average number within the wind power class range was used. Thus, the average wind speed used for Morgan County Feedlot was 14.1 mph, and an average wind speed of 15.8 miles per hour was used for the operations in Elbert and Yuma Counties.

To estimate the Annual Energy Output (AEO) of each turbine, the following formula was used:

$$\mathbf{AEO = 0.01328\ D^2\ V^3}$$

Where:

AEO = Annual Energy Output, kWh per year

D = Rotor diameter, feet

V = Annual average wind speed, mph

This formula is recommended by the U.S. Department of Energy, Energy Efficiency and Renewable Energy, Small Wind Electric Systems Colorado Consumer's Guide as a means of "making a preliminary estimate of the performance of a particular wind turbine."

The cost of wind-generated electricity (per kWh) for each turbine was based on the cost of the turbine divided by its annual energy output (AEO) multiplied by 20 years (minimum expected life of the turbine). To make this same determination when a loan is used, an additional amount representing loan interest was added to the cost of the turbine.

At each site, the average retail cost of electricity charged by the electricity provider (cooperative electric association) was determined by taking the total invoice amount for a given time period and dividing it by the number of kilowatt hours (kWh) used. This method was used because the resulting number represents the actual average price paid for delivered electricity over time. Elbert County Ranch and the headquarters meter at the Yuma County Ranch both had monthly service charges on their bills, and these charges are included in the cost-averaging method described above.

The wholesale electricity rate is the estimated cost of electricity that a cooperative electric association pays to their utility, in this case, Tri-State Generation and Transmission Association, Incorporated. The wholesale rate is a combination of *energy* and *demand* charges. The *energy* charge is essentially the base rate that is charged by the utility for relatively consistent, predictable electricity usage. The demand charge is a higher rate per kilowatt hour that the utility charges for electricity during peak usage events, when demand load is high. For the customer, this may be shown on the bill as a monthly charge that is independent of the electricity actually used.

Financing costs: The installed cost of the turbines included for review in this study ranged from $15,000 to about $3.6 million. Financing needs can vary dramatically from one facility owner to another. In order to standardize the output for comparative purposes, a 30/70 finance ratio was used (30 percent down, 70 percent financed) for all turbines except the Vestas 1.65 MW unit. For the 1.65 MW turbine, 95 percent of the cost was assumed to be financed. The same interest rate (6 percent) and loan period of fifteen (15) years were used for all eight turbines. The total interest amount that would be paid over the life of the loan was added to the installed cost of the turbine when determining both the cost of wind-generated electricity (per kWh) and the turbine's payback time frame.

The value of the electricity generated by a given wind turbine was calculated by using the following formula: AEO Value = AEO x (≤ 100% of facility's annual electricity consumption in kWh x the retail rate of electricity) + (excess generated electricity x the wholesale rate).

The avoided electric purchase is the value of the electricity that is ***not*** purchased from the electric provider but instead is generated by the facility (via wind) and used internally by the facility. This was determined by multiplying the amount of electricity supplied by the wind turbine (≤ 100 % of the facility's annual usage) by the utility's retail electricity rate.

If surplus wind-generated electricity was produced (any amount exceeding annual facility usage), it was assigned a value by multiplying the annual surplus in kWh x the wholesale rate (rate that the utility buys electricity from Tri-State Electric).

Avoided Inflation: Electricity purchased from a utility is subject to inflation. Avoided inflation is the avoided annual electric purchase (described above) multiplied by an estimated inflation rate that is compounded over some time period.

Since this study calculated each turbine's cost per kWh and payback time frame based on a twenty year life, an inflation rate compounded over twenty years was also determined, and the average over the twenty year period was used.

Operation and Maintenance (O & M): Wind turbines require annual maintenance. Various references cite annual O & M costs ranging from 1 to 2 percent of the installed turbine cost. Direct drive systems which are often used in micro and small wind turbines average about 1 percent of installed cost per year. Gear drive system typical of "upper small", intermediate, and large turbines have O & M costs of approximately 2 percent of installed cost per year. Generally, the larger the turbine, the greater the servicing frequency. Most smaller units (~ ≤20 kW power rating) require servicing once annually. Larger units require two or more service visits per year. Most manufacturers offer service agreements through their distributors.

If annual O & M cost is tied directly to turbine energy output, the cited costs range from $0.01 to $0.005 per kWh. This study used an O & M cost of $0.005 per kWh because some of the required turbine maintenance is routine (changing the oil in the gearbox) and can be performed by the facility owner, which lowers the cost of maintenance.

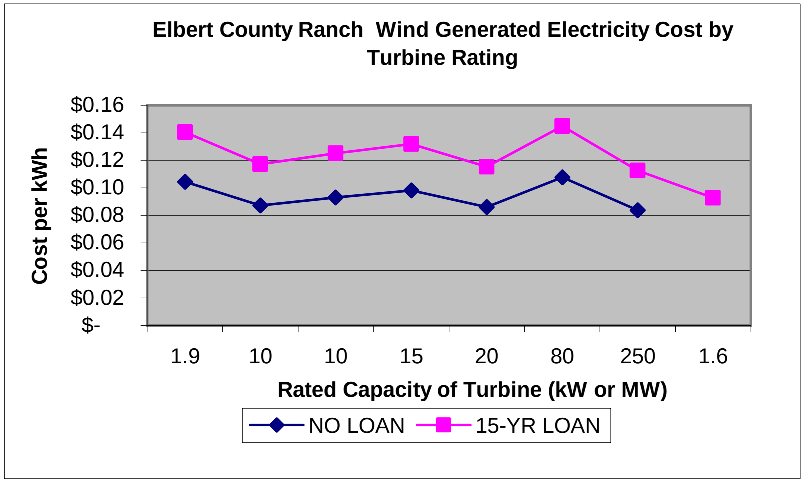
Colorado's Net-Metering Law: On March 26, 2008, Governor Ritter signed HB 1160, which requires municipally owned utilities (MOUs) and cooperative electric associations (CEAs) that serve 5,000 or more customers to provide net-metering to customers who generate electricity from renewable resources. Eligibility for the program extends to residential customers who generate up to 10 kilowatts from eligible energy resources and commercial or industrial customers who generate up to 25 kilowatts. The law also requires utilities and cooperatives to determine the compensation rate for customer-generators once annually for any excess kilowatt hours they generate.

**Elbert County Ranch:**
Elbert County Ranch is a cow-calf operation located north of Simla. Electricity is supplied by Mountain View Electric Association (MVEA). Multi-year electricity usage was examined from the meter serving the barn and associated pens. Total annual electrical usage is similar to that of a typical residence, though with more seasonal variability.

Based on the last four year's of data, the average electricity usage is about 3,100 kWh per year. In 2007, the average electricity cost was approximately $0.16 per kilowatt hour.

Figure 5 shows the estimated costs of wind generated energy by turbine rating based on all cash vs. 15-year loan purchase options. Table 1 on the following page provides the source data for the graph. On the 15-YR Loan line, the 1.6 MW turbine will produce electricity at the lowest cost. The economics of this turbine are discussed in greater detail later.

Figure 5.




The cost of producing electricity on a per kilowatt hour basis was similar among three turbines; the Bergey 10 kW, the Jacobs 20 kW, and the 250 kW WES unit. Any of these units would generate more electricity annually than Elbert County Ranch uses, at a cost of less than $0.09 per kWh (no loan) or about $0.12 per kWh with a loan (terms described previously).

As shown in Figure 6 (below) the time required to pay for the different turbines varies. The 1.9 kW Southwest Windpower unit would pay for itself most quickly regardless of whether it is financed or not. Note that this turbine was not the lowest cost electricity producer among the group. The reason it pays for itself most quickly is because its annual output most closely matches the ranch's annual electricity usage, so more of its annual output is counted at the retail rate (avoided purchase) of $0.16 per kilowatt hour, rather than the wholesale rate of $0.068 per kilowatt hour.

Figure 6.

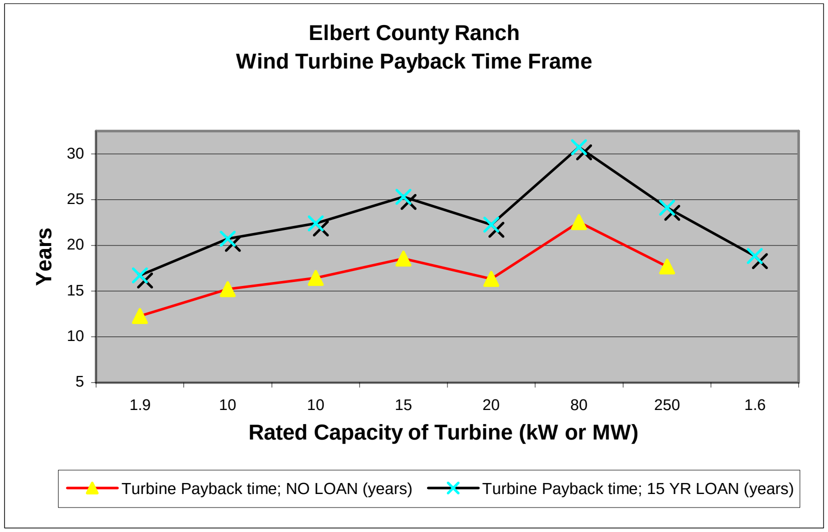


Table 1.

**Elbert County Ranch**

**Wind Energy Cost Analysis**

**Meter: Barn** 3,100 **kWh annual usage**

| Line # | Manufacturer Name | SW Windpower Skystream | Bergey Excel-S | ARE 442 | Proven Wind WT15000 | Jacobs (WTIC) | WES 80 kW | WES 250 kW | Vestas V82 (MW) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | **Rated Capacity of Turbine (kW)** | **1.9** | **10** | **10** | **15** | **20** | **80** | **250** | **1.6M** |
| 2 | Cost of unit | $ 15,000 | $ 27,900 | $ 39,600 | 55,370 | incl. in total | incl. in total | incl. in total | incl. in total |
| 3 | Add Installation & related costs[1] 30% | incl. in total | $ 8,370 | $ 11,880 | 16,611 | $ 20,000 | incl. in total | incl. in total | incl. in total |
| 4 | 100' (+/-) Tower | incl. in total | $ 9,200 | incl. in total | 13,000 | incl. in total | incl. in total | incl. in total | incl. in total |
| 5 | Approximate total installed cost[2] | **$ 15,000** | **$ 45,470** | **$ 51,480** | **$ 84,981** | **81,500** | **$ 375,000** | **$ 800,000** | **$ 3,600,000** |
| 6 | Total Loan Interest (30% down, 70% financed, 6% rate, 15yrs*) | $ 5,449 | $ 16,517 | $ 18,701 | $ 30,870 | $ 29,606 | $ 136,222 | $ 290,608 | $ 1,774,783 |
| 7 | **Estimated Annual Energy Output (AEO) in kWh[3]** | **7,543** | **27,627** | **29,228** | **45,669** | **50,338** | **182,667** | **507,437** | **3,244,000** |
| 8 | **Wind energy cost per kWh [4] NO LOAN** | **$ 0.10** | **$ 0.09** | **$ 0.09** | **$ 0.10** | **$ 0.09** | **$ 0.11** | **$ 0.08** | **$ 0.07** |
| 9 | **Wind energy cost per kWh [4] 15 YR LOAN** | **$ 0.14** | **$ 0.12** | **$ 0.13** | **$ 0.13** | **$ 0.12** | **$ 0.14** | **$ 0.11** | **$ 0.09** |
| 10 | Average retail electricity cost charged by REA; this meter (kWh): | $ 0.16 | $ 0.16 | $ 0.16 | $ 0.16 | $ 0.16 | $ 0.16 | $ 0.16 | $ 0.16 |
| 11 | Utility wholesale rate (kWh)[5] | $0.068 | $0.068 | $0.068 | $0.068 | $0.068 | $0.068 | $0.068 | $0.068 |
| 12 | **Annual Facility Electricity Usage (kWh):** | **3,100** | **3,100** | **3,100** | **3,100** | **3,100** | **3,100** | **3,100** | **3,101** |
| 13 | Turbine AEO as a Percentage of facility annual usage | **243%** | **891%** | **943%** | **1473%** | **1624%** | **5892%** | **16369%** | **104611%** |
| 14 | Avoided Cost (Usage Offset x Retail Rate) | $ 496 | $ 496 | $ 496 | $ 496 | $ 496 | $ 496 | $ 496 | $ - |
| 15 | Annual Surplus Electricity Value (Prod - usage x wholesale rate) | $ 302 | $ 1,668 | $ 1,777 | $ 2,895 | $ 3,212 | $ 12,211 | $ 34,295 | $ 220,381 |
| 16 | **Turbine AEO Production Value** | **$ 798** | **$ 2,164** | **$ 2,273** | **$ 3,391** | **$ 3,708** | **$ 12,707** | **$ 34,791** | **$ 220,381** |
| 17 | Avoided REA elec. inflation (4% annual); AVG next 20 YRS | $ 274 | $ 274 | $ 274 | $ 274 | $ 274 | $ 274 | $ 274 | $ - |
| 18 | Additional Value from Selling REC (use $20 per 1,000 kWh) | $ 151 | $ 553 | $ 585 | $ 913 | $ 1,007 | $ 3,653 | $ 10,149 | $ 64,880 |
| 19 | **Total Annual Wind Turbine Value** | **$ 1,223** | **$ 2,991** | **$ 3,132** | **$ 4,579** | **$ 4,989** | **$ 16,634** | **$ 45,214** | **$ 285,261** |
| 20 | **Turbine Payback time; NO LOAN (years)** | **12** | **15** | **16** | **19** | **16** | **23** | **18** | **13** |
| 21 | **Turbine Payback time; 15 YR LOAN (years)** | **17** | **21** | **22** | **25** | **22** | **31** | **24** | **19** |

(1) Shipping, sales tax, permit costs, foundation and anchoring, wire run, turbine and tower erection, electrical interconnection, insurance, etc.

(2) Based on price indicated by manufacturer

(3) Annual Energy Output (AEO) formula: AEO = 0.01328 D2 V3; where 0.01328 is a constant, D is the rotor diameter, V is wind speed (source: U.S. DOE, Small Wind Electric Systems Colorado Consumer Guide, Dec. 2006)

(4) Based on 20 year turbine life; includes $0.005/kWh for annual O&M cost

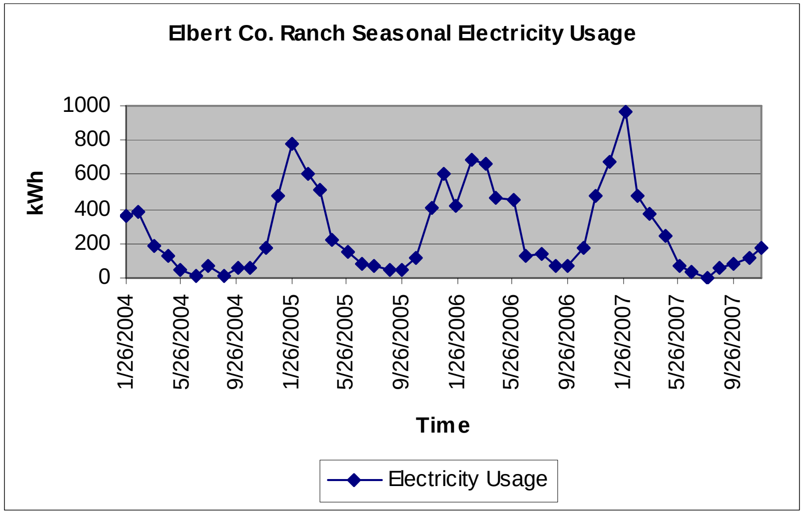
(5) Based on approximate average price of electricity charged by Tri-State to the REA

* Except Vestas, which uses a 95% financed scenario

All of the turbines would produce excess electricity beyond the amount that the ranch could use. The excess electricity would be sold back to MVEA. The buy-back rate (per kWh) for this excess electricity is unknown as MVEA has not yet established a policy in this regard.

As shown in Figure 7 below, most of Elbert County Ranch's electricity usage occurs during the coldest months, when water tank heaters are running and preparations are being made for the annual National Western stock show in January.

Figure 7.




**Net Metering:**

Colorado's net metering law requires that all electricity that is generated "behind the grid," (i.e. generated by the customer's turbine and used by the customer) is net metered. If Elbert County Ranch installs a wind turbine, any electricity produced by the turbine and used on the ranch's side of the meter is not subject to charges from the utility. The ranch's electricity usage is modest though quite variable throughout the year. Because usage is small and the average wind speed is "fair," a significant portion of electricity usage could likely be offset if a turbine is installed. There would also be times when excess electricity would be produced, and could be sold back to the CEA power grid.

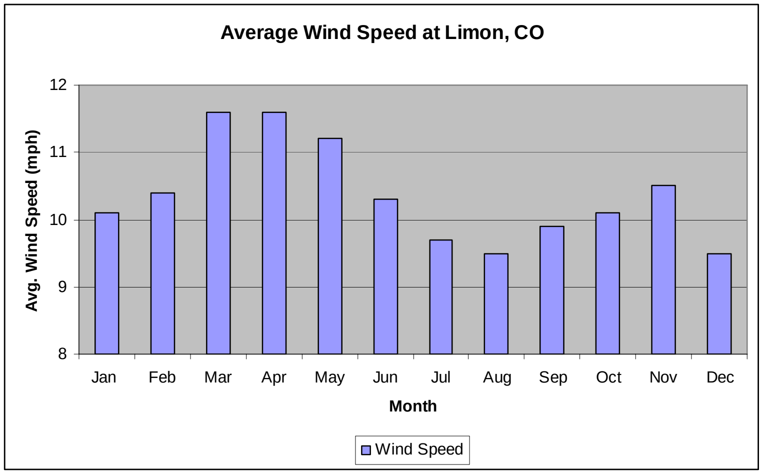
Under the 2008 net metering law, excess electricity sold to the grid is "carried forward from month to month and credited at a ratio of 1:1 against the customer-generator's energy consumption [expressed in kWh] **in subsequent months.**" There is currently disagreement as to whether the "one to one" crediting requires that excess monthly kilowatt hours be credited to the customer later at the CEA's retail or wholesale rate. This study presumes that all customer-generated electricity up to and equal to the facility's <u>annual</u> usage is credited at the retail rate against usage, and that true **excess** electricity – the annual amount produced by a customer-generator that exceeds his or her annual usage – would be paid or credited back to the customer-generator at the wholesale electricity rate.

If a CEA does not credit a customer-generator's monthly excess at the retail rate against all of his annual usage, it would significantly lengthen turbine payback time periods.

The net metering law also states that "within 60 days after the end of each annual period, the CEA shall account for any excess energy generation [expressed in kWh] accrued by the customer-generator and shall credit such excess generation to the customer-generator in a manner deemed appropriate by the Cooperative Electric Association." The annual accounting and crediting date of customer-generated electricity is sometimes referred to as the "true-up" date. The true-up date is important because it also marks the beginning of the next year's crediting period. The economic significance of this can be best explained with a comparative example using an irrigation well meter.

Suppose a small irrigation well uses 50,000 kWh annually and has a meter true-up date of October 1st. There is zero electricity usage at this meter from October 1 until May 1 of the following year (the start of the irrigation season), however, the well owner's 20 kW wind turbine has produced 35,000 kWh during this time, all of which have been delivered to the power grid. If the CEA credits this 35,000 kWh against the well's upcoming irrigation season usage at the retail rate ($0.10/kWh), it is worth $3,500. On the other hand, if the CEA credits at the wholesale rate ($0.068/kWh), it is worth $2,380. This seemingly small difference would add 6 years to the payback time of the wind turbine in this example (assuming in-season customer-generated energy was net metered).

Figure 8




Elbert County Ranch is located in an area with "Fair" wind resource potential (Class 3 winds). The local topography is characterized by rolling hills, and the crests of some of the higher hills have been identified as having Class 4 winds (16.7 to 17.7 mph). For this reason, at least two commercial wind energy development companies are interested in installing utility-class wind turbines in the area. These companies typically ask landowners with the best wind sites to sign long-term agreements that would allow them to install and operate wind turbines for at least thirty years. Landowners typically receive an annual royalty payment for each turbine installed on their land. If Elbert County Ranch is suitable for utility-class wind turbines, the landowner would reasonably be interested to know if it makes sense to install his own wind turbines instead of leasing land to others for this purpose. The answer will depend on each individual landowner's tolerance of debt and risk.

For example, a new 1.65 MW commercial turbine in this wind class area could be expected to produce about 3,244,000 kWh annually. The turbine would cost about $3.6 million installed and another $1.8 million in interest over the life of a 15-year loan (95% financed at a 6 percent interest rate), with a monthly payment (principal + interest) of about $29,000. The landowner would also have to conduct a grid interconnection study and negotiate an electricity purchase agreement with the CEA, which may want to pay at a rate discount to the Tri-State wholesale rate due to the variability of wind energy. If an adequate rate is negotiated with the CEA, the unit would pay for itself in about 20 years, and then begin providing $285,000+/- in income annually (renewable energy credit income included).

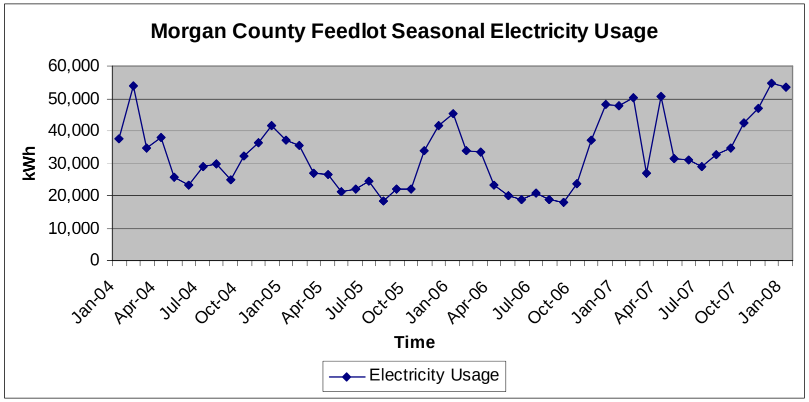
In contrast, if a landowner is paid a royalty of $12,000 per year for a single turbine located on his property, he would have realized $360,000 in income at the end of a 30-year period. If he owned the turbine, he would not begin realizing positive cash flow until year 20 (earliest), however, over the next 10 years, he would receive about $2.85 million in income (in this example). Note that these income assumptions are based on long term projections of wholesale electricity rates, O & M costs, and renewable energy credit (REC) values. Minor changes to any of these variables can dramatically change a turbine's cost and payback structure over a twenty to thirty year time frame.

**Morgan County Feedlot:**
Morgan County Feedlot is located a few miles from Fort Morgan and has a feeding capacity of approximately 25,000 head of cattle. The feedlot is located on the edge of the Platte River valley, in an area where the NREL 50 meter Wind Power map describes winds as being "marginal" for wind generation.

Electricity is provided by Morgan County Rural Electric Association. Multi-year electricity usage was examined from the meter serving the feedlot. Based on the last four years of data, the average electricity usage is about 395,000 kWh per year. In 2007, usage jumped to 532,000 kWh. The average price paid for electricity in 2007 was about $44,000, or $0.083/kWh.

Morgan County Feedlot is paying about 27% more for electricity today than they were at the beginning of 2004. Thus, the electricity inflation rate over the last four years (2004 through 2007) has been 6.8 percent per year.

Figure 8.




Morgan County Feedlot's peak electrical usage occurs during the coldest months of the year, and the lowest usage months are during the summer and early fall. This compares favorably with potential wind energy output based on seasonal average wind speeds. Of the three facilities examined, Morgan County Feedlot has the greatest potential of using wind power to directly offset its electricity usage (behind the meter).

Figure 9.

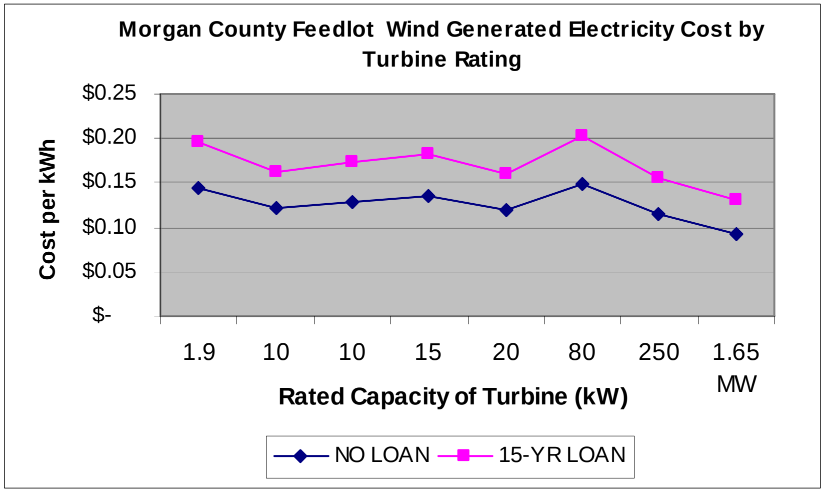
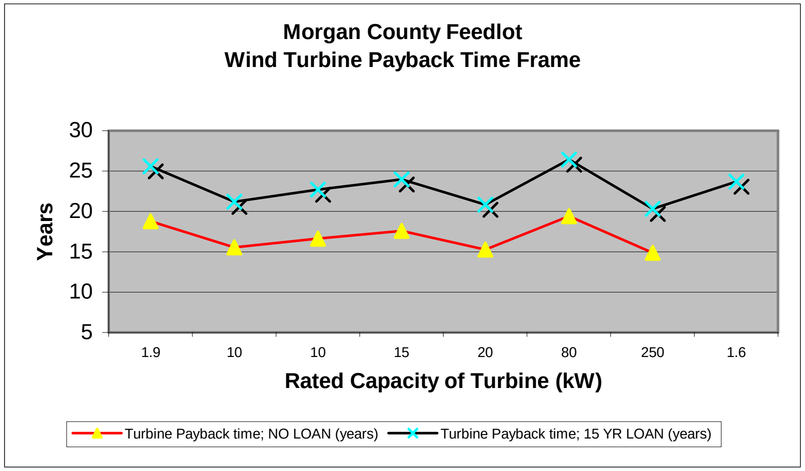



Figure 9 (above) displays the estimated cost of electricity production by turbine type on a kilowatt hour basis. The source for these data is Table 2 on page 14. The two largest turbines (1.65 MW and 250 kW) are the lowest cost producers in both categories. The cheapest of these two units costs approximately $800,000 installed, so an all cash purchase would be unlikely for most operators. Thus, the 15-year loan rate would be the most realistic rate of reference.

The next lowest cost producing unit (per kWh) is the 20 kW Jacobs turbine, which would produce an estimated 35,775 kWh of electricity annually for an average cost of $0.012 per kWh (no loan) or $0.16 per kWh (15-year loan). The Bergey 10 kW turbine also returned similar production costs per kilowatt hour. As shown in Figure 10 (below), the 250 kW WES turbine would pay for itself in the shortest time period because its annual output most closely matches (68 percent) annual electricity usage at the feedlot, so it offsets the greatest amount of purchased electricity. A competitively priced turbine with annual output of 532,000 kWh (i.e. the amount equal to usage) would theoretically be the most cost-effective turbine for this facility.

Figure 10.




One aspect that adds to the complexity of installing the larger wind turbines relates to the delivery of excess electricity back to the local utility's power grid. The excess output of small scale turbines can typically be absorbed by a utility's grid without significant problem, though a transformer upgrade may be required at the facility.

With larger systems, the power line capacity and distance to the substation become more important. A 2005 evaluation of the Highline Electric Association's distribution system (located in the northeast corner of Colorado) found that an appropriate location for a 1.5 MW GE turbine (irrespective of wind speed) would be a site that has existing 3-phase transmission line and is located within six miles of a substation. The study also pointed out that the Vestas V82 1.65 MW turbine (included for analysis in this study) would need to be located much nearer to a substation because of the larger voltage dip the Vestas would cause during turbine start-up at high speeds.

On the positive side, utility scale turbine manufacturers are continually improving their energy output control systems in order to help maintain voltage and minimize disruptions to utility power grids.

Table 2.

**Morgan Co. Feedlot**

**Wind Energy Cost Analysis**

**Meter: Feedlot** **532,000** **kWh annual usage**

**5/22/2008**

| Line # | Manufacturer Name | SW Windpower Skystream | Bergey Excel-S | ARE 442 | Proven Wind WT15000 | Jacobs (WTIC) | WES 80 kW | WES 250 kW | Vestas V82 (MW) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | **Rated Capacity of Turbine (kW)** | **1.9** | **10** | **10** | **15** | **20** | **80** | **250** | **1.65 MW** |
| 2 | Cost of unit | $ 15,000 | $ 27,900 | $ 39,600 | 55,370 | incl. in total | incl. in total | incl. in total | incl. in total |
| 3 | Add Installation & related costs(1) 30% | incl. in total | $ 8,370 | $ 11,880 | 16,611 | $ 20,000 | incl. in total | incl. in total | incl. in total |
| 4 | 100' (+/-) Tower | incl. in total | $ 9,200 | incl. in total | 13,000 | incl. in total | incl. in total | incl. in total | incl. in total |
| 5 | Approximate total installed cost(2) | **$ 15,000** | **$ 45,470** | **$ 51,480** | **$ 84,981** | **81,500** | **$ 375,000** | **$ 800,000** | **$ 3,600,000** |
| 6 | Total Loan Interest (30% down, 70% financed, 6% rate, 15yrs*) | $ 5,449 | $ 16,517 | $ 18,701 | $ 30,870 | $ 29,606 | $ 136,222 | $ 290,608 | $ 1,774,783 |
| 7 | **Estimated Annual Energy Output (AEO) in kWh(3)** | **5,361** | **19,635** | **20,773** | **32,457** | **35,775** | **129,829** | **360,635** | **2,210,600** |
| 8 | **Wind energy cost per kWh (4) NO LOAN** | **$ 0.14** | **$ 0.12** | **$ 0.13** | **$ 0.14** | **$ 0.12** | **$ 0.15** | **$ 0.12** | **$ 0.09** |
| 9 | **Wind energy cost per kWh (4) 15 YR LOAN** | **$ 0.20** | **$ 0.16** | **$ 0.17** | **$ 0.18** | **$ 0.16** | **$ 0.20** | **$ 0.16** | **$ 0.13** |
| 10 | Average retail electricity cost charged by REA; this meter (kWh): | $ 0.083 | $ 0.083 | $ 0.083 | $ 0.083 | $ 0.083 | $ 0.083 | $ 0.083 | $ 0.083 |
| 11 | Utility wholesale rate (kWh)(5) | $0.068 | $0.068 | $0.068 | $0.068 | $0.068 | $0.068 | $0.068 | $0.068 |
| 12 | **Annual Facility Electricity Usage (kWh):** | **532,000** | **532,000** | **532,000** | **532,000** | **532,000** | **532,000** | **532,000** | **532,000** |
| 13 | Usage Offset (turbine AEO as a Percentage of facility annual usage) | **1%** | **4%** | **4%** | **6%** | **7%** | **24%** | **68%** | **416%** |
| 14 | Avoided Cost (Turbine AEO x Retail Rate) | $ 445 | $ 1,630 | $ 1,724 | $ 2,694 | $ 2,969 | $ 10,776 | $ 29,933 | $ 44,156 |
| 15 | Annual Surplus Electricity Value (Prod - usage x retail or wholesale rate) | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ 114,145 |
| 16 | **Turbine AEO Production Value** | **$ 445** | **$ 1,630** | **$ 1,724** | **$ 2,694** | **$ 2,969** | **$ 10,776** | **$ 29,933** | **$ 158,301** |
| 17 | Avoided REA elec. inflation (4% annual); AVG next 20 YRS | $ 246 | $ 902 | $ 954 | $ 1,491 | $ 1,643 | $ 5,964 | $ 16,565 | $ 24,437 |
| 18 | Additional Value from Selling REC (use $20 per 1,000 kWh) | $ 107 | $ 393 | $ 415 | $ 649 | $ 716 | $ 2,597 | $ 7,213 | $ 44,212 |
| 19 | **Total Annual Wind Turbine Value** | **$ 798** | **$ 2,924** | **$ 3,094** | **$ 4,834** | **$ 5,328** | **$ 19,336** | **$ 53,711** | **$ 226,950** |
| 20 | **Turbine Payback time; NO LOAN (years)** | **19** | **16** | **17** | **18** | **15** | **19** | **15** | **16** |
| 21 | **Turbine Payback time; 15 YR LOAN (years)** | **26** | **21** | **23** | **24** | **21** | **26** | **20** | **24** |

(1) Shipping, sales tax, permit costs, foundation and anchoring, wire run, turbine and tower erection, electrical interconnection, insurance, etc.

(2) Based on price indicated by manufacturer

(3) Annual Energy Output (AEO) formula: AEO = 0.01328 D2 V3; where 0.01328 is a constant, D is the rotor diameter, V is wind speed (source: U.S. DOE, Small Wind Electric Systems Colorado Consumer Guide, Dec. 2006)

(4) Based on 20 year turbine life; includes $0.005/kWh for annual O&M cost

(5) Based on approximate average price of electricity charged by Tri-State to the REA

* Except Vestas, which uses a 95% financed scenario

**Yuma County Ranch:**
Yuma County Ranch is a diversified cow-calf, feedlot and farming operation. Electricity for all ranch and farm operations are supplied by Y-W Electric Cooperative. Multi-year electricity usage was examined from four (4) meters; one representing the ranch headquarters and feedlot, the other three representing irrigation wells supplying center pivots associated with crop land owned or managed by the ranch.

Based on the last three year's of data, the combined average electricity usage among all four meters was about 510,000 kWh per year. Most of the usage was associated with the three irrigation wells, which averaged 153,000 kWh per well annually. In 2007, thanks to timely rains, the electricity usage per well dropped to about 132,000 kWh. The cost per kilowatt hour varied from $0.09 to $0.13 among the three irrigation wells.

Table 3.

| | B | C | D | E | F |
|---|---|---|---|---|---|
| 69 | Yuma County Ranch Electricity Usage & Cost in 2007 | | | | |
| 70 | | | Usage (kWh) | Average Cost per kWh | Total Annual Cost |
| 71 | Irrigation wells (131,553 kWh per well) | | 394,660 | $ 0.10 | $ 40,630 |
| 72 | | Ranch HQ | 58,948 | $ 0.08 | $ 4,743 |
| 73 | | All 4 meters | 453,608 | $ 0.10 | $ 45,373 |

As indicated in Table 3, the total amount that Yuma County Ranch paid to their cooperative electric association for all electricity in 2007 was about $45,400. The average unit cost of electricity was $0.10 per kilowatt hour.

Table 4 on the following page displays the wind energy outputs and cost estimates for an irrigation well at Yuma County Ranch. The estimated value assigned to the "Avoided Purchase" (amount of electricity directly offset by the turbine's output) may be optimistic because irrigation well electricity usage does not overlap well with maximum turbine output (see Figure 11 below). As discussed previously, the CEA can set the true-up date at any time of the year, and one interpretation of the 2008 net-metering law is that a CEA may credit non-direct offset kilowatt hours at any rate the CEA deems appropriate, which could range from the retail rate to zero.

Figure 11.

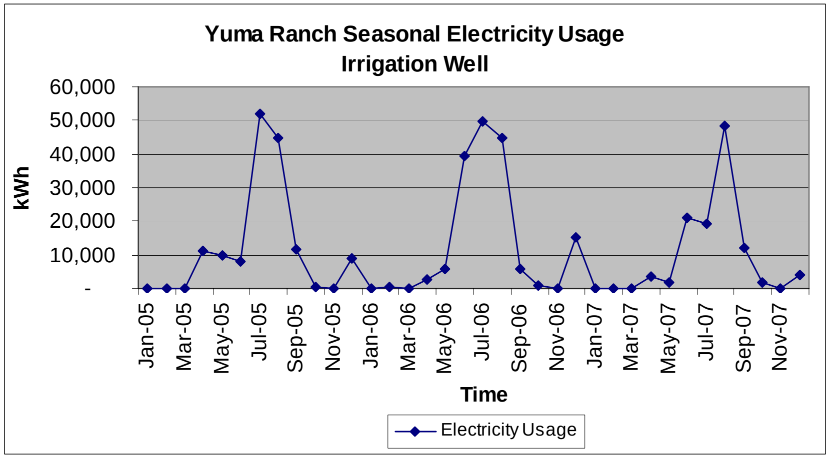



Figure 11 shows the annual fluctuation of energy usage for one of the irrigation wells. Most of the usage occurs in May through September, with the highest usage typically occurring in July and August. Unfortunately, these two months usually have relatively low average wind speeds. Conversely, the wells use little or no electricity from late winter to mid spring, which are the months with the highest average wind speeds. So, using a turbine to supply electricity to an irrigation well would only make economic sense if the CEA was willing to credit electricity produced by the turbine over the whole year at a ratio of 1:1 against the well's usage. This scenario would require the CEA to absorb peak demand costs and is probably not likely.

## Table 4

**Yuma County Ranch**

**Wind Energy Cost Analysis**

**Meter: Irrigation Well (average)** **132,000** **kWh annual usage**

**5/22/2008**

| Line # | Manufacturer Name | SW Windpower Skystream | Bergey Excel-S | ARE 442 | Proven Wind WT15000 | Jacobs (WTIC) | WES 80 kW | WES 250 kW | Vestas V82 (MW) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | **Rated Capacity of Turbine (kW)** | **1.9** | **10** | **10** | **15** | **20** | **80** | **250** | **1.65 MW** |
| 2 | Cost of unit | $ 15,000 | $ 27,900 | $ 39,600 | 55,370 | incl. in total | incl. in total | incl. in total | incl. in total |
| 3 | Add Installation & related costs[1] 30% | incl. in total | $ 8,370 | $ 11,880 | 16,611 | $ 20,000 | incl. in total | incl. in total | incl. in total |
| 4 | 100' (+/-) Tower | incl. in total | $ 9,200 | incl. in total | 13,000 | incl. in total | incl. in total | incl. in total | incl. in total |
| 5 | Approximate total installed cost[2] | **$ 15,000** | **$ 45,470** | **$ 51,480** | **$ 84,981** | **81,500** | **$ 375,000** | **$ 800,000** | **$ 3,600,000** |
| 6 | Total Loan Interest (30% down, 70% financed, 6% rate, 15yrs*) | $ 5,449 | $ 16,517 | $ 18,701 | $ 30,870 | $ 29,606 | $ 136,222 | $ 290,608 | $ 1,774,783 |
| 7 | **Estimated Annual Energy Output (AEO) in kWh[3]** | **7,543** | **27,627** | **29,228** | **45,669** | **50,338** | **182,667** | **507,437** | **3,244,000** |
| 8 | **Wind energy cost per kWh [4] NO LOAN** | **$ 0.10** | **$ 0.09** | **$ 0.09** | **$ 0.10** | **$ 0.09** | **$ 0.11** | **$ 0.08** | **$ 0.07** |
| 9 | **Wind energy cost per kWh [4] 15 YR LOAN** | **$ 0.14** | **$ 0.12** | **$ 0.13** | **$ 0.13** | **$ 0.12** | **$ 0.14** | **$ 0.11** | **$ 0.09** |
| 10 | Average retail electricity cost charged by REA; this meter (kWh): | $ 0.10 | $ 0.10 | $ 0.10 | $ 0.10 | $ 0.10 | $ 0.10 | $ 0.10 | $ 0.10 |
| 11 | Utility wholesale rate (kWh)[5] | $0.068 | $0.068 | $0.068 | $0.068 | $0.068 | $0.068 | $0.068 | $0.068 |
| 12 | **Annual Facility Electricity Usage (kWh):** | **132,000** | **132,000** | **132,000** | **132,000** | **132,000** | **132,000** | **132,000** | **132,000** |
| 13 | Usage Offset (turbine AEO as a Percentage of facility annual usage) | **6%** | **21%** | **22%** | **35%** | **38%** | **138%** | **384%** | **2458%** |
| 14 | Avoided Cost (Turbine AEO x Retail Rate) | $ 754 | $ 2,763 | $ 2,923 | $ 4,567 | $ 5,034 | $ 13,200 | $ 13,200 | $ 13,200 |
| 15 | Annual Surplus Electricity Value (Prod - usage x retail or wholesale rate) | $ - | $ - | $ - | $ - | $ - | $ 3,445 | $ 25,530 | $ 211,616 |
| 16 | **Turbine AEO Production Value** | **$ 754** | **$ 2,763** | **$ 2,923** | **$ 4,567** | **$ 5,034** | **$ 16,645** | **$ 38,730** | **$ 224,816** |
| 17 | Avoided REA elec. inflation (4% annual); AVG next 20 YRS | $ 417 | $ 1,529 | $ 1,618 | $ 2,527 | $ 2,786 | $ 7,305 | $ 7,305 | $ 7,305 |
| 18 | Additional Value from Selling REC (use $20 per 1,000 kWh) | $ 151 | $ 553 | $ 585 | $ 913 | $ 1,007 | $ 3,653 | $ 10,149 | $ 64,880 |
| 19 | **Total Annual Wind Turbine Value** | **$ 1,323** | **$ 4,844** | **$ 5,125** | **$ 8,008** | **$ 8,826** | **$ 27,604** | **$ 56,184** | **$ 297,001** |
| 20 | **Turbine Payback time; NO LOAN (years)** | **11** | **9** | **10** | **11** | **9** | **14** | **14** | **12** |
| 21 | **Turbine Payback time; 15 YR LOAN (years)** | **15** | **13** | **14** | **14** | **13** | **19** | **19** | **18** |

(1) Shipping, sales tax, permit costs, foundation and anchoring, wire run, turbine and tower erection, electrical interconnection, insurance, etc.

(2) Based on price indicated by manufacturer

(3) Annual Energy Output (AEO) formula: AEO = 0.01328 D2 V3; where 0.01328 is a constant, D is the rotor diameter, V is wind speed (source: U.S. DOE, Small Wind Electric Systems Colorado Consumer Guide, Dec. 2006)

(4) Based on 20 year turbine life; includes $0.005/kWh for annual O&M cost

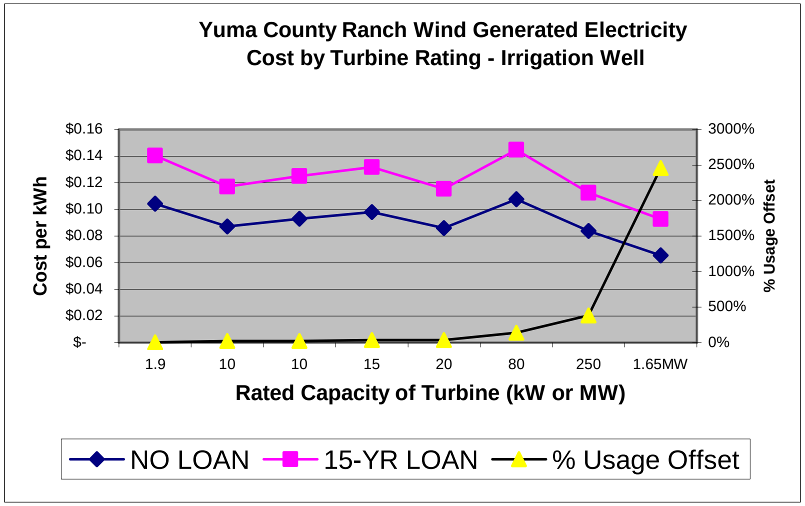
(5) Based on approximate average price of electricity charged by Tri-State to the REA

* Except Vestas, which uses a 95% financed scenario

Figure 12 (below) shows the estimated cost per kilowatt hour of electricity generated by the different turbines. The two largest turbines produce electricity most economically, but the 10 kW turbine and the 20 kW turbine would also be cost-effective at this site, particularly in the absence of financing.

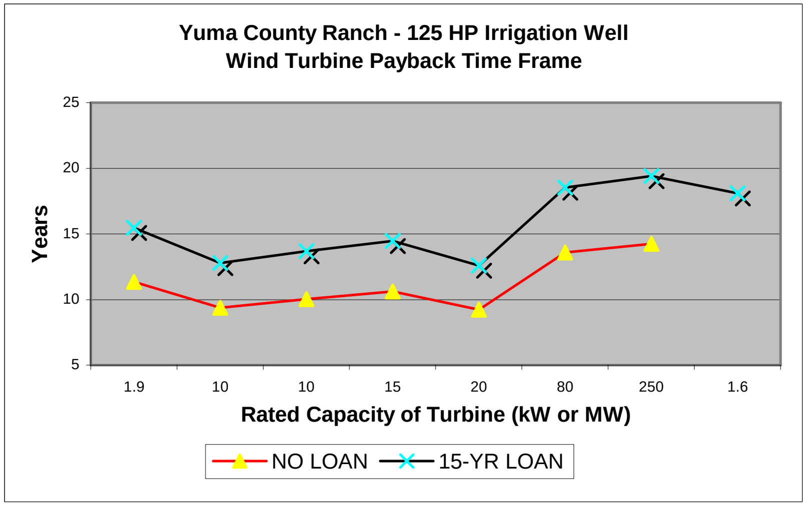
Figure 12 also includes a line representing the percentage of annual electricity usage that each turbine would offset. The output of the 80 kW turbine is138 percent of the irrigation well's annual usage, so it most closely matches the annual usage of the facility. Ordinarily, this turbine would have been expected to be the most cost-effective unit for this application. However, its cost per kilowatt hour is the most expensive of the group. This is because the 80 kW turbine has the highest installed cost to energy output ratio of all the turbines compared in this study.

Figure 12.




The estimated time required for a given turbine to pay for itself is displayed on Figure 13. In this case, the turbines that produced energy for the lowest cost per kWh will not pay for themselves in the shortest period of time. The 250 kW and 1.65 MW units have longer payback time periods because most of their output would be sold back to the grid at wholesale rates, whereas the annual output from the smaller turbines would be less than the well's usage, thus, 100 percent of their output is presumed to be credited at the retail rate.

Figure 13.



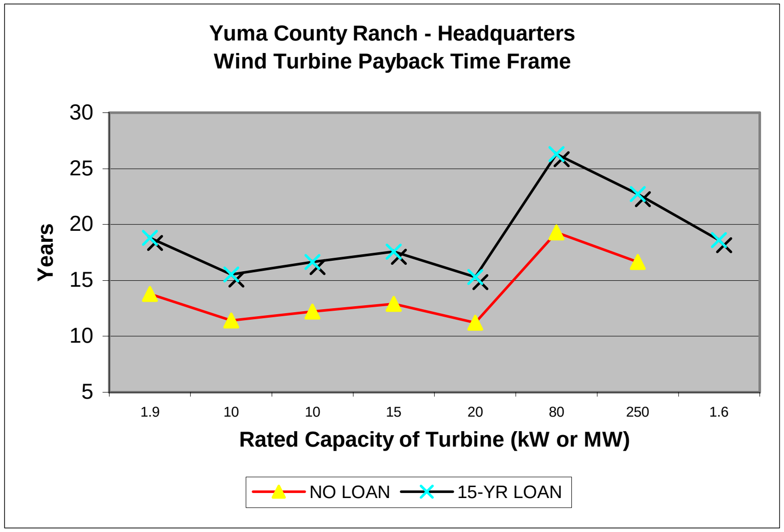

It is important to note that a wind turbine must be located at the site of usage offset. For example, to offset usage from an irrigation well, the turbine would need to be located near the well's meter. The turbine could not be located on some other part of the ranch, unless special provisions were made with the Cooperative Electric Association.

**Yuma County Ranch Headquarters**

Electricity usage at the Yuma County Ranch headquarters was also included for analysis in this study.  The meter serving the ranch headquarters represents fairly typical farmer – feeder electricity usage, and includes energy used in two residences, a shop, barn, water tank heaters, a stock well pump motor, and a horse barn.  As shown previously in Table 3 (page 15), the annual electricity usage at the ranch headquarters is about 59,000 kilowatt hours.

The cost of wind-generated electricity by turbine size (shown in Figure 12 on the previous page) is the same for the headquarters location as the irrigation well since both sites are located in the same wind speed area.  However, turbine payback times between the two sites differ slightly (see Figure 14 below).

Figure 14.




The 20 kW Jacobs turbine, with estimated annual output of about 50,000 kWh, would be the most cost-effective unit for the ranch headquarters, both in cost per kWh and pay-back time.

Note that any turbine serving the headquarters meter, the time required to pay for itself would be at least two years longer than for the irrigation well.  This is because the current average price paid for electricity to power the irrigation well motor is higher than at the ranch headquarters.  So, the value of both the avoided purchase and the avoided inflation were greater for the irrigation well than for the ranch headquarters.

**CONCLUSIONS:**

Wind generated electricity can be cost-effectively utilized at livestock operations in Colorado, even at sites with “marginal” average wind speed, under the right conditions.  The keys to installing an economically viable turbine are:

1) Offset electricity usage behind the meter (net metering) to the greatest extent possible.  In most cases, the turbine with output that most closely matches the facility’s usage will be the most cost-effective unit.
2) Use a turbine with a low cost to output ratio (installed cost divided by annual estimated output).
3) Study the renewable energy buy-back policy of your Cooperative Electric Associations (CEAs).  CEAs set the retail rate, excess buyback rate, and the annual true-up date, all of which significantly influence the economic viability of using wind energy at a given site.
4) Maximize the use of grants and low-interest loans.  Grants and low interest loans can substantially reduce the cost of output and turbine payback times.
5) Maximize the value of renewable energy credits (RECs).  Before selling RECs to an aggregator, shop around to see who offers the best deal.
6) High wind speed + high electrical usage generally equals the most favorable economic conditions for wind power.

As this report describes, many variables influence the cost and value of wind-generated energy at a given location. Variables include the turbine's cost plus installation, wiring and grid interconnection, and permitting, financing, operation and maintenance fees. Also, the energy output of the turbine, cost of electricity from the utility, and the excess electricity buy-back arrangement all have a major impact on the final cost of wind-generated electricity, as well as cash-flow and the turbine's pay-back time period. Finally, the value of the renewable energy credits is also an important variable.

A 20-year turbine life span was used in all of the turbine cost and payback estimates. Twenty years represents the minimum expected life of today's turbines. The cost per kilowatt hour and payback time periods will both decline for any of the turbines included in this study if they continue to function longer than twenty years, which is likely.

The findings of this study can also be applied to other electricity users, including local and county governments and other types of businesses.

**ZONING:**
In all counties, a building permit is required.

Elbert County: One wind turbine is allowed on Ag-zoned land under use by right with a minimum 60 acre parcel size. More than one turbine per 60 acres is considered commercial and requires a county special use permit.

Morgan County: "Small wind energy conversion systems" are allowed with a Conditional Use Permit within Ag / Agri-business zoned areas. The conditional use permit requires approval of a site plan by the county administrator, or by the county commission at the discretion of the county administrator.

Yuma County: There are no zoning regulations regarding wind turbines as of the date of this report. The county commission intends to develop zoning requirements in the near future.

**FINANCIAL INCENTIVES:**
The Governor's Energy Office (GEO) offers a Small Wind Incentive Program to interested partners from utilities, counties and municipalities as an incentive to increase installed renewable energy. The Small Wind Incentive Program offers matching grants to partners who will administer the rebates to residents and business owners who install small wind turbines. Partners/recipients are responsible for matching the grant dollar for dollar, and providing the staff support required to administer the rebate program in accordance with GEO's guidelines. Currently, the GEO is partnering with four utility companies to offer a rebate for Small Wind Turbine installations. The Small Wind Incentive Program partners are: Highline Electric Association, Sangre De Cristo Electric Association, Inc., Southeast Colorado Power Association, and the Town of Estes Park.

Colorado Department of Agriculture, which provided partial funding for this economic feasibility study, offers funding to promote energy-related projects beneficial to Colorado's agriculture industry. Funding is offered through the ***Advancing Colorado's Renewable Energy (ACRE) Program,*** which is administered by the Colorado Agricultural Value-Added Development Board. The Board has $500,000 available for allocation and award during the 2008/2009 fiscal year, which began on July 1, 2008. Eligible projects must, in some way, benefit Colorado's agriculture industry and may include biofuels development, biomass conversion, and wind and solar energy. Information about the ACRE Program can be accessed at: http://www.colorado.gov/cs/Satellite/Agriculture-Main/CDAG/1184661927876.

**FINANCING:**
The 2008 Farm Bill Rural Energy for America Program (REAP) will provide $250 million in grants and loan guarantees for agricultural producers and rural small businesses to purchase renewable energy systems and improve energy efficiency.

For 2008, USDA Rural Development has $36 million available for Section 9006 clean energy grants and loan guarantees. Approximately $16 million is targeted for grants, and the remaining $20 million will be used for loan guarantees. The grants provide a maximum of 25 percent cost share, not to exceed $500,000 for renewable energy systems. Farmers, ranchers and rural small businesses interested in installing energy efficiency upgrades and new renewable energy systems are eligible.

One method of reducing initial capital costs associated with the purchase and installation of the wind turbine(s) is through the up-front sale of renewable energy credits (RECs) that the wind turbine(s) will be producing. Renewable Energy Credits (RECs), also known as “green tags, are greenhouse gas emission offset products. For every unit of electricity generated from renewable sources, an equivalent amount of renewable certificates, or Green Tags, is produced. A purchase of green tags is intended to offset the environmental effects of burning coal, gas and other fossil fuels across North America (source: Bonneville Environmental Foundation website, 2008). Renewable energy credits are considered separate from the actual energy produced by the wind turbine.

Renewable energy credits are currently being marketed by various non-profit entities, for prices ranging from $10 to more than $40 per 1,000 kWh. If the generator gets, for example, $20 per 1,000 kWh, and he or she sells 10 years worth of RECs, the resulting income for the 20 kW turbine included in this study would be about $10,000, which can be used to help offset the turbine’s initial cost. After 10 years, the generator gets the RECs back and can begin selling them again.

Production Tax Credit (PTC): Unfortunately, the current federal PTC applies only to Utility-scale wind facilities.

**JOBS:**
The American Wind Energy Association estimates that “every megawatt of installed wind capacity creates about 2.5 job-years of direct employment (short-term construction and long-term operations and maintenance jobs) and about 8 job-years of total employment (direct and indirect). This means that a 50-MW wind farm creates 125 job-years of direct employment and 400 job-years of total employment. Wind and solar energy are likely to furnish one of the largest sources of new manufacturing jobs worldwide during the 21st Century.”

**POTENTIAL ADVERSE IMPACTS:**
Birds: The American Wind Energy Association cites the following statistics related to bird kills and wind turbines:

- Utility transmission and distribution lines, the backbone of our electrical power system, are responsible for 130 to 174 million bird deaths a year in the U.S.
- Collisions with automobiles and trucks result in the deaths of between 60 and 80 million birds annually in the U.S.
- The National Wind Coordinating Committee (NWCC) reported that, based on current estimates, commercial wind turbines cause the direct deaths of only 0.01% to 0.02% of all of the birds killed by collisions with man-made structures and activities in the U.S.

Bats: The *Interim Report: Bat Interactions with Wind Turbines at the Buffalo Ridge, Minnesota, Wind Resource Area: 2001 Field Season* indicates that the “population of bats susceptible to turbine collisions is large enough that the observed mortality is not sufficient to cause population declines.”

Noise: The American Wind Energy Association cites the following statistics related to noise and wind turbines:

| Source/Activity | Indicative noise level dB (A) |
|---|---|
| Threshold of hearing | 0 |
| Rural night-time background | 20-40 |
| Quiet bedroom | 35 |
| **Wind farm at 350m** | **35-45** |
| Car at 40mph at 100m | 55 |
| Busy general office | 60 |
| Truck at 30mph at 100m | 65 |
| Pneumatic drill at 7m | 95 |
| Jet aircraft at 250m | 105 |

The AWEA report notes that "today, an operating wind farm at a distance of 750 to 1,000 feet is no noisier than a kitchen refrigerator or a moderately quiet room."

**POWER STORAGE:**
All three of the facilities reviewed in this study receive power from their respective Cooperative Electric Associations (CEAs). Battery backup and other power storage schemes were not examined in this study since all three facility owners intended to sell excess electricity back to the power grid. Several of the turbines examined in the cost analysis section include optional battery backup systems for an additional fee.

**NEXT STEPS:**
Any of the sites examined in this study have the potential to generate wind energy economically. As mentioned previously, the average site specific wind speed is a critical variable in determining the cost of wind-generated electricity. The next step for a site considering wind power is to install an anemometer, which measures and records wind parameters (speed, direction, consistency) over time. Anemometers can be leased, but they are also available for loan from the Governor's Energy Office and the DOE Western Area Power Administration (WAPA). These two entities do not charge for the use of their anemometers, however, fees may be incurred if a private contractor is hired to install and take down the anemometers. Anemometers are typically deployed for one (1) year at a site in order to gather an accurate picture of wind characteristics. **As this report was being finalized, all three of the facilities that participated in this study were in the process of installing anemometers loaned by WAPA.**

As previously discussed, the buy-back rates and true-up date set by the local Cooperative Electric Association (CEA) can dramatically affect the economics of a wind turbine. Once you have determined your site has potential for wind energy generation and you have an idea of the general turbine size and output you are interested in installing, sit down with your local CEA and discuss your plan and find out how you will be compensated for excess electricity that is generated, when the annual true-up date will occur, and whether transmission system improvements will be needed at your site, such as a transformer upgrade.

**INSTALLATION:**
The Colorado Governor's Office of Energy Management and Conservation has a free Small Wind Applications Guide, which includes a DVD and accompanying documentation describing the step by step actions needed to assess and install a wind turbine. The guide is available by contacting the Governor's Energy Office at (303) 866-2100.

**WIND POWER ASSESSMENT:**
In addition to the NREL wind resource map utilized in this study, the website: http://firstlook.3tiergroup.com/ provides wind speed estimates for varying hub heights and locations.

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