# Pawnee Nation of Oklahoma

# Energy Options Analysis

## A Preliminary Review of Renewable Energy Development and Utility Cost Savings Options

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# EXECUTIVE SUMMARY

## E.1 Introduction

In 2003, the Pawnee Nation leadership identified the need for the tribe to comprehensively address its energy issues. During a strategic energy planning workshop a general framework was laid out and the Pawnee Nation Energy Task Force was created to work toward further development of the tribe's energy vision. The overarching goals of the "first steps" project were to identify the most appropriate focus for its strategic energy initiatives going forward, and to provide information necessary to take the next steps in pursuit of the "best fit" energy options.

Based on the request of Pawnee Nation's Energy Task Force the research team, consisting Tribal personnel and Summit Blue Consulting, focused on a review of renewable energy resource development potential, funding sources and utility organizational along with energy savings options. Elements of the energy demand forecasting and characterization and demand side options review remained in the scope of work, but were only addressed at a high level.

## E.2 Description of Activities Performed

### Renewable Energy Resource Development Potential

The research team reviewed existing data pertaining to the availability of biomass (focusing on woody biomass, agricultural biomass/bioenergy crops, and methane capture), solar, wind and hydropower resources on the Pawnee-owned lands. Using these data, combined with assumptions about costs and revenue streams, the research team performed preliminary feasibility assessments for each resource category. The research team also reviewed available funding resources and made recommendations to Pawnee Nation highlighting those resources with the greatest potential for financially-viable development, both in the near-term and over a longer time horizon.

### Energy Efficiency Options

While this was not a major focus of the project, the research team highlighted common strategies for reducing energy use in buildings. The team also discussed the benefits of adopting a building energy code and introduced two model energy codes Pawnee Nation should consider for adoption.

### Summary of Current and Expected Future Electricity Usage

The research team provided a summary overview of electricity usage patterns in current buildings and included discussion of known plans for new construction.

### Utility Options Review

Pawnee Nation electric utility options were analyzed through a four-phase process, which included: 1) summarizing the relevant utility background information; 2) gathering relevant utility assessment data; 3) developing a set of realistic Pawnee electric utility service options, and

4) analyzing the various Pawnee electric utility service options for the Pawnee Energy Team's consideration.

# E.3 Findings and Recommendations

Due to a lack of financial incentives for renewable energy, particularly at the state level, combined mediocre renewable energy resources, renewable energy development opportunities are limited for Pawnee Nation. However, near-term potential exists for development of solar hot water at the gym, and an exterior wood-fired boiler system at the tribe's main administrative building. Pawnee Nation should also explore options for developing LFGTE resources in collaboration with the City of Pawnee. Significant potential may also exist for development of bioenergy resources within the next decade. Pawnee Nation representatives should closely monitor market developments in the bioenergy industry, establish contacts with research institutions with which the tribe could potentially partner in grant-funded research initiatives.

In addition, a substantial effort by the Kaw and Cherokee tribes is underway to pursue wind development at the Chilocco School Site in northern Oklahoma where Pawnee is a joint landowner. Pawnee Nation representatives should become actively involved in these development discussions and should explore the potential for joint investment in wind development at the Chilocco site. A summary of development opportunities and next steps is provided in Table 1-1.

**Table 1-1. Summary of Renewable Energy Development Opportunities and Next Steps**

| | Biomass | Solar | Wind | Hydro |
|---|---|---|---|---|
| **Resource Availability (+ = favorable; +/- = mediocre; - = poor) based on available data** | + | +/- | +/- | +/- |
| **Should conduct further research to better understand resource availability?** | Y | N | Not Recommended as Near-Term Priority | Not Recommended as Near-Term Priority |
| **Economically Viable Development Opportunities Currently Exist?** | Likely for wood-fired boiler system (more detailed assessment recommended); possibly for methane capture if wastewater treatment facility improvements take place and/or pursue landfill potential with City of Pawnee | Yes, solar hot water on gym | Not on Pawnee land, though possibly on Chilocco School Site | Not likely |
| **Would financial incentives make development economically** | Most likely | Yes | Not likely, due to poor resource on Pawnee lands, but potentially for | Resource issue is larger factor, though financial incentives would improve if |

| | | | | |
|---|---|---|---|---|
| **viable?** | | | Chilocco School Site | resource is sufficient |
| **Key Next Steps** | Conduct economic analysis of wood boiler system; make contacts with Oklahoma Bioenergy Center; monitor biofuel market developments; explore potential for methane capture as part of potential future landfill / wastewater treatment facility development | Pursue solar hot water development on gym (see solar installer contact info provided) | Explore opportunities for coordination with other tribes for wind development on Chilocco School Site | Determine whether it's a priority for the tribe to better understand hydro resource availability. |

Financial incentives for project development are generally structured to provide tribes with access to conventional financing mechanisms. Grant funding for project construction is currently difficult to obtain. Substantial new opportunities for biofuel development may exist in the next few years with passage of the 2007 Farm Bill, and through opportunities made available through Oklahoma's new Bioenergy Center.

Pawnee Nation could increase its chances of obtaining financial incentives by partnering with a research entity in pursuing research activities related to biomass or other renewable energy resources; or by applying for funds through a tribe-affiliated business enterprise. Given that energy efficiency appears to be Pawnee Nation's most cost-effective resource development opportunity, and given that funding is available to support rural energy-related business enterprises, members of the Pawnee tribe should consider establishing an energy services business focused on implementing energy efficiency improvements at buildings owned by Pawnee Nation and its members. Establishing an energy services business also furthers the goals set forth in Pawnee Nation's strategic energy vision in that it would empower tribal members with education and greater energy independence, and it would build energy-related employment opportunities. It would also provide the Tribe and its members with substantial energy and cost savings.

Another key recommendation is for Pawnee Nation to adopt a building energy code. Adopting an energy code will ensure that new facilities meet minimum standards for energy conservation and quality construction. Architects and engineers are familiar with energy codes, and it is a simple, no-cost way to further the Nation's goals for sustainable energy use. Adoption of the latest International Energy Conservation Code (IECC) would be consistent with the code in place in Oklahoma.

A review of potential alternatives to Pawnee Nation's current electricity supply scenario revealed that a range of options could be viable. These include the following scenarios: business as usual, alternative supply, negotiate lower rates with City of Pawnee, focus on reducing energy usage, develop electric utility organization. Under any circumstances, Pawnee Nation should purse strategies to reduce energy usage, as this is the simplest means of reducing electric costs and environmental impacts. The research team also recommends that Pawnee Nation initiate some focused discussions with the City of Pawnee, with GRDA, and with IEC to discuss its wholesale supply purchase options. These discussions will better inform the Pawnee Energy Team of the

specific pros and cons of its wholesale power supply options, and will assist the Team's broader decision-making on utility-related issues. The ultimate path chosen by Pawnee Nation will depend on further consideration of priorities and potential barriers by Pawnee Nation's Energy Team.

# 1 INTRODUCTION

## 1.1 Project Objectives

In 2003, the Pawnee Nation leadership identified the need for the tribe to comprehensively address its energy issues. During a strategic energy planning workshop a general framework was laid out and the Pawnee Nation Energy Task Force was created to work toward further development of the tribe's energy vision. The overarching goals of the "first steps" project were to identify the most appropriate focus for its strategic energy initiatives going forward, and to provide information necessary to take the next steps in pursuit of the "best fit" energy options. Six tasks were defined in initial project planning documents:

1) Energy demand forecasts and characterization
2) Characterization of the demand side management (DSM) potential
3) Review of supply side options
4) Legal analysis
5) Consideration of the air quality and water impacts of each development alternative.
6) Review of the financial risks

During the project kickoff meeting, the Pawnee Nation Energy Task Force requested that the research team focus on a review of renewable energy resource development potential, funding sources and utility organizational and energy savings options. Elements of the energy demand forecasting and characterization and demand side options review remained in the scope of work, but were only addressed at a high level.

## 1.2 Overview of Activities Performed

Based on Pawnee Nation's priorities and the resources available for the project, the primary focus of the research was in two areas: 1) exploring opportunities for renewable energy resource development potential, led by Summit Blue Consulting; and 2) exploring opportunities to realize cost savings and greater service quality through potential changes in utility service arrangements (led by Red Mountain Tribal Energy). Within the area of renewable energy resource development opportunities, the research team explored options for developing wind, solar, biomass and small hydroelectric resources present on Pawnee-owned lands. The research team also explored financial incentive and options available to facilitate renewable energy project development. Research in the area of utility-related issues focused on whether Pawnee Nation could achieve energy cost savings by owning and/or operating its own electric utility, the potential to negotiate an arrangement with an alternative electricity supplier, as well as opportunities to leverage water resources as a means of negotiating lower electric rates.

Additional activities performed included providing a summary of simple steps the tribe can take to maximize energy efficiency at tribe-owned buildings, and providing an overview of current electricity consumption, and likely contributors to future growth in electricity consumption.

Based on findings from this research, the research team presented a discussion of implications for Pawnee Nation's existing strategic energy plan, and next steps the tribe should take to pursue opportunities identified through this "first steps" assessment.

## 1.3 Document Organization

This report is organized as follows:

Section 2 presents background information regarding Pawnee Nation and the tribe's past strategic energy planning efforts.

Section 3 presents discussion of the team's preliminary assessment of renewable energy development opportunities, including discussion of wind, solar, biomass and hydropower opportunities, as well as a review of financial incentives that may help defray the costs of renewable energy project development.

Section 4 provides a brief summary of energy efficiency opportunities that would be simple for Pawnee Nation to pursue at tribe-owned facilities.

Section 5 provides an overview of current electricity uses and potential contributors to future growth in electricity use.

Section 6 presents an assessment of utility-related issues, focusing on opportunities to negotiate more economically favorable utility service arrangements.

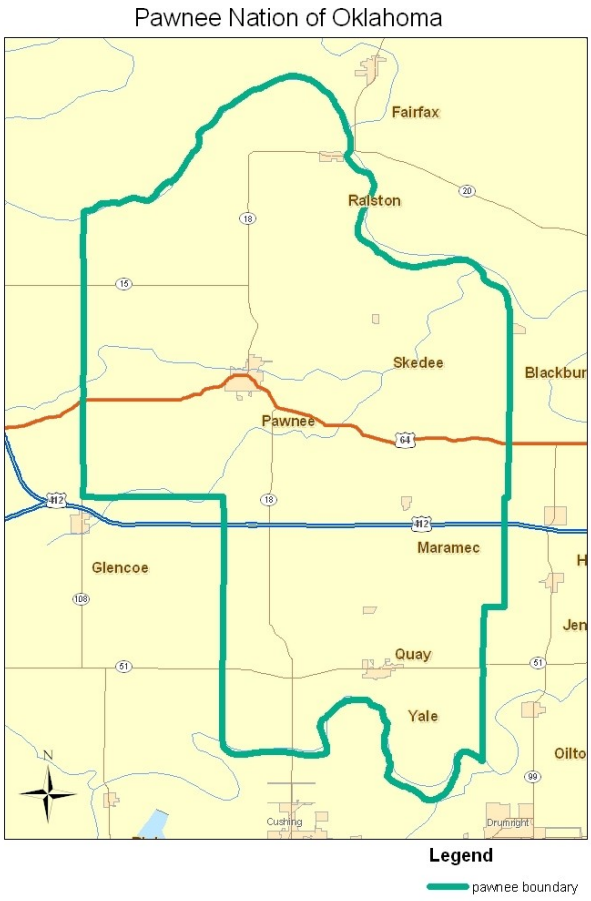
Section 7 includes conclusions and recommended next steps for Pawnee Nation to take to pursue the "best-fit" energy development and utility-related options. This section also discusses implications of the report's findings on Pawnee Nation's existing strategic energy plan.

# 2 BACKGROUND

## 2.1 Overview of Pawnee Nation

The Pawnee Nation of Oklahoma ("Nation") is a federally recognized tribe within meaning of United States Code 18 U.S.C. 1151. The Pawnee Nation exercises jurisdiction over a total of 29,951 acres of tribally-owned, individually owned, and federal trust lands over a three-county area. Of that land base, roughly 786 acres are contiguous, in the north central section of the Pawnee Nation land base. The Pawnee Tribal Reserve is a federally recognized Indian reservation, located directly adjacent to the City of Pawnee. Pawnee is the county seat for Pawnee County, and is 57 miles Northwest of Tulsa and 91 miles Northeast of Oklahoma City. Pawnee land is scattered throughout central Oklahoma, within the boundaries indicated in Figure 2-1.

**Figure 2-1. Pawnee Nation Reservation Boundaries**



The tribe's current member enrollment is 3,190 with approximately 600 members residing locally. About 100 tribal members reside on Trust lands, with the remainder residing on fee lands within the Reservation in towns.

The Pawnee Nation is currently served by two electric utilities: the City of Pawnee and Indian Electric Rural Electric Cooperative. The City of Pawnee provides power for the tribe's government offices and Indian Electric serves the electricity needs for the Travel Plaza and Casino. The Pawnee Nation currently has no energy codes in place and does not formally follow any energy efficiency guidelines.

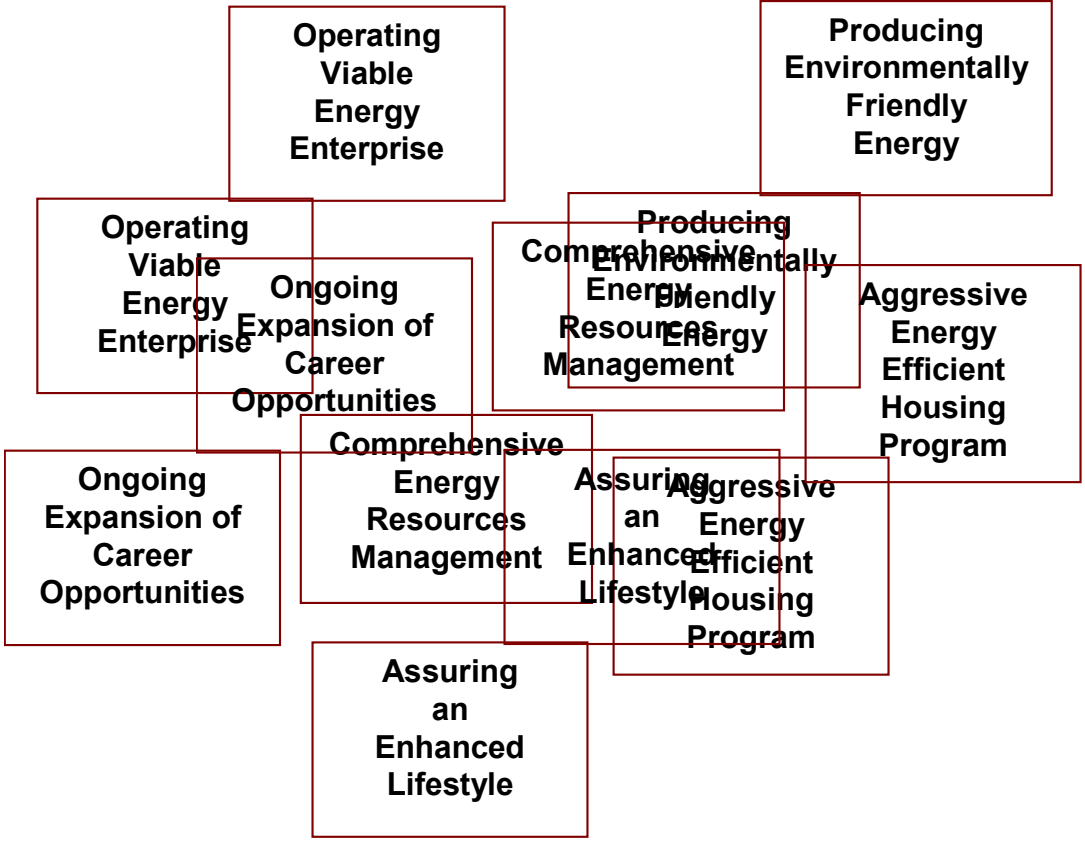
The Pawnee Nation has access to natural gas supply lines and electric transmission lines. The tribe's drinking water needs are met by groundwater wells (on tribal land) and there is supplementary access to City of Pawnee water supply lines (off-reservation sources). There is no agreement in place for water transfer between City of Pawnee and the tribe.

The Pawnee Nation also owns approximately 800 acres of Chilocco Indian School lands near Newkirk, OK. Pawnee is currently pursuing a Class III gaming compact, and has plans to build a casino on its land.

The Pawnee Nation has an existing Utility Authority, the Pawnee Nation Utility Authority, approved by the Pawnee Nation Business Council on January 12, 2001. As indicated by the Pawnee Nation Utility Authority Act of 2001, the purpose is to define the policies, establish, organize and identify the necessary rules, ordinances and regulations for the operation, maintenance and management of the various utility services located on lands within the jurisdiction of the Pawnee Nation, and to establish the Utility Authority.

## 2.2 Tribal Energy Vision

The Pawnee Nation leadership recognized that tribal energy resources were integral in maintaining self-determination and in progressing into the future with a secure economic foundation, and in 2003, the Pawnee Nation began to develop a strategic energy plan. Using facilitated workshops, the Pawnee formulated their strategic energy plan to address the tribe's future needs and goals. Tribal members established a six-point vision:




The facilitated workshops also outlined a general plan of action to promote the strategic energy plan. The general plan addressed funding, research and development, community capacity building, community support, and energy plan implementation, and was defined by the following objectives:

- Establish a firm foundation through research and development;
- Promote community support and involvement:
- Define authority in energy development;
- Develop and implement Pawnee Nation's energy plan;
- Empower individuals with energy education;
- Engage funding sources proactively;
- Create energy department.

A major priority identified was for the Pawnee Nation to create an Energy Department.

In 2004, Pawnee Nation President George E. Howell of the Pawnee Business Council created the Pawnee Nation Energy Task Force based on the previously identified strategic priorities. The Energy Task Force was created to pursue beneficial energy and resource development opportunities. The Task Force comprised tribal leadership, tribal government staff, and at-large tribal members. Priority responsibility was for the Task Force to update the Pawnee Strategic Energy Plan by conducting research and collaborating with experts from the energy field to determine renewable energy development opportunities for the tribe with the most potential. The Task Force was given the following responsibilities:

- Conducting an evaluation of the Pawnee Energy and Utility Department and providing necessary recommendations on it organization development
- Developing any needed updates to the Tribe's current utility ordinance

- Developing new codes based on the proposed energy options analysis findings.

# 3 RENEWABLE ENERGY RESOURCE DEVELOPMENT OPPORTUNITIES

## 3.1 Biomass

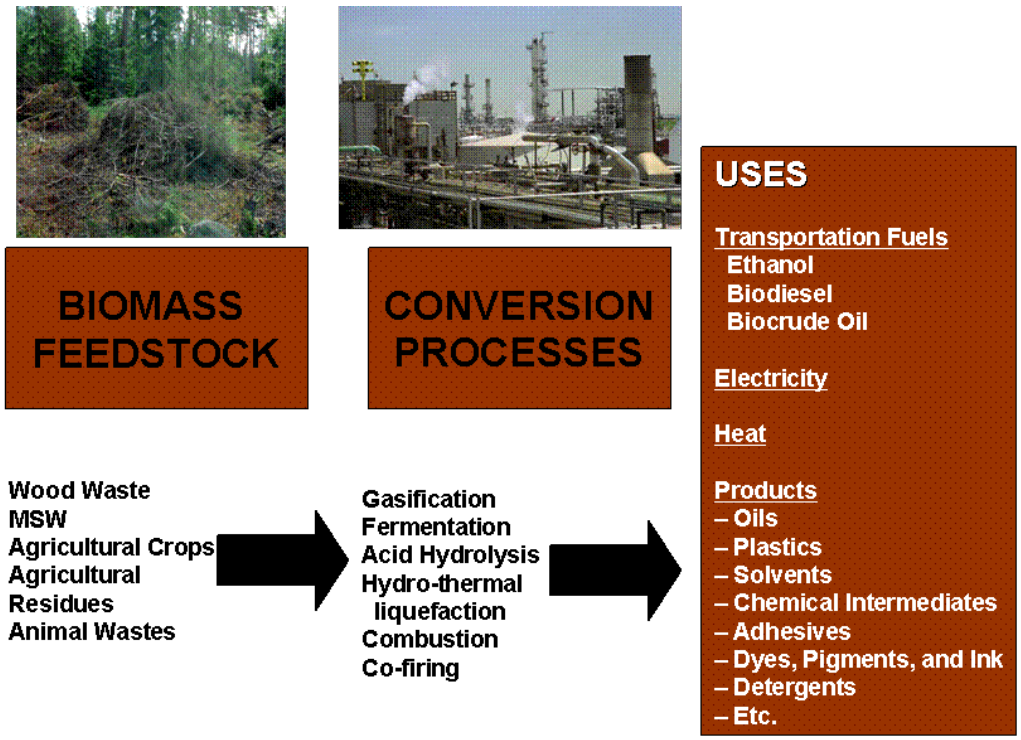
This section first provides an overview of the different types of biomass resources that can be used for energy production, and the screening process used to determine feasibility for pursuing development opportunities. The section next describes data that were collected as part of this assessment, and data challenges encountered by the research team. This is followed by a summary of biomass-related energy development potential on Pawnee lands in general, and then more detailed discussion of resource potential in the following three categories: woody biomass, agricultural biomass, and methane capture.

### 3.1.1 Overview of Biomass Resource Types and Assessment Process

The purpose of this section is to introduce the different types of biomass resources available for use in energy production, and to describe the initial screening process for assessing biomass energy potential. It is necessary to screen development opportunities based upon consideration of inputs (feedstocks), technologies and markets.

Figure 3-2 provides a broad overview of the range of feedstocks, conversion processes and end uses that may be considered in a biomass project.

**Figure 3-2. Biomass Overview**




Because biomass is an encompassing term, it is generally useful to define what material is of interest. For this study, biomass is defined to include a broad range of carbonaceous material including:[1]

- Woody biomass derived from trees in the form of logs, whole tree chips, clean urban wood waste (e.g., untreated construction and demolition wood), tree residues associated with line clearing and urban forestry, forest thinnings and residues from forest products firms such as sawmills and paper mills.
- Agricultural residues include crop residues associated with harvest of crops such as corn, sorghum, and wheat.
- Energy crops, either as a grass or woody form, can be utilized for power, liquid fuels and thermal applications, as well as for production of specialty chemicals. The pulp industry has pioneered the growth of plantations and the energy industry will follow, although there are only demonstration projects at this time. For Pawnee there is considerable

[1] Material that is often of interest but not included in this study includes municipal solid waste (MSW) and re-cycled tires. The rationale for not including these feedstocks is the lack of uniform recognition as a qualified resource for either inclusion in state renewable portfolio standards or for the trading of renewable energy certificates. Generally trash to energy plants make economic "sense" in densely populated areas that have intense competition for landfill space. There are many tire burning facilities in the US and the technology is well known. As with MSW, the more urban the area the better the economic returns.

potential for cultivation of crops such as soybeans, switchgrass, miscanthus, and other crops.

- Anaerobic digestion of human wastes produces methane that can be captured and used as a fuel source for generating electricity. This application is technically and economically feasible in many situations.
- Food processing operations often create a potential feedstock from not-to-grade or culled material. There is potential to produce energy from these residues rather than dispose of them in a landfill.
- Animal manures are ideal feedstocks and are most often derived from confined animal feeding operations (CAFO) such as large feedlots, dairy operations and hog farms. Energy recovery from CAFOs is well-established for both environmental compliance reasons as well as distributed generation implementation.

While biomass resources are varied, the approach for opportunity evaluation for different biomass resources follows a similar sequence of steps. The primary emphasis is always on the resource, as the resource base often dictates appropriate applications. It is necessary to understand the resource definition, quantity, seasonality, form and delivered cost of biomass feedstocks before one can begin to address applications and economic feasibility.

In general, the greater the resource availability, the more options there are for implementation. As a corollary observation, the greater the resource base the greater the likelihood there are already competing uses for the feedstocks. Once options for applying the resource are understood, next steps include technology and economic evaluation, permit analysis, and ultimately the creation of a business model for developing the resource. The following sections provide a brief overview of the relevant elements for initial screening of biomass opportunities.

Quantity of a biomass resource is differentiated between “technical potential” and “available resources,” recognizing that it is unrealistic to expect all of the feedstocks to be recovered. Because most biomass is wet, it is important to distinguish between a “wet” ton and a “dry” ton of material. A wet ton is the form in which the feedstock is generally obtained. Moisture Content (MC) may be as high as 55% for some trees, and higher yet for dairy wastes. On the other hand, field dried agricultural residues may be 20% MC or less. The water content is generally driven off in energy conversion processes and the higher the MC the greater the energy penalty that will exist in terms of efficiency losses. Thus it is useful to normalize biomass resource measurements in terms of dry tons to facilitate accurate comparison across resources. Another general observation is that a project developer seeks, at a minimum, twice as much of the available resource as the project requires, and lending institutions often require an even higher level of resource availability.

Seasonality is an especially important aspect of biomass resource assessment efforts due to the variable nature of supply access. While it may be immediately apparent that crop residues are only available after harvest, it is less obvious that many forestry feedstocks are available only at certain times of the year due to harvest constraints related to weather, environmental restrictions (e.g., endangered species nesting season), and the actual availability of certain tracts for harvest due to procedural considerations. It is rare for forestry-derived biomass to be harvested on a 12-month basis. The solution to variable harvest schedules is to stockpile material to accommodate the supply cycle.

Form of biomass is a major consideration when one begins to assess transportation and utilization requirements. Woody biomass may be in the form of whole logs, chips, or sawdust. Transportation of logs is accomplished with log trucks while chips and sawdust require some fashion of chip van. Each type of truck has advantages and economic consequences for the delivery radius of biomass. Because the energy density is low for biomass, especially relative to another solid fuel, coal, the consequence is to limit the haul distance to somewhere in the range of a 50-75 mile radius.

Delivered cost is a function of resource acquisition costs (i.e., stumpage), processing (i.e., felling, forwarding, skidding and chipping), plus transportation costs. Delivered costs may vary due to seasonal considerations associated with weather conditions. It is important to evaluate delivered costs on a consistent basis to foster an appropriate comparison of alternatives.

## 3.1.2 Data Sources

As noted above, a fundamental first step in assessing the feasibility of biomass applications is quantifying the available resources. Our resource assessment was divided into three main categories:

- Woody Biomass – using hardwood resources based primarily on forestry inventories;
- Agriculture Biomass – residues acquired from agricultural crops as well as dedicated energy crops such as soybeans or switchgrass;
- Methane Capture – utilizing the release of methane from sources such as landfills and wastewater treatment plants.

The majority of research time focused on identifying reliable and current data sources for each type of resource. The intent of this section is to identify the data sources used as well as the obstacles encountered.

### Woody Biomass

The BIA completed a forest inventory on the Pawnee Reservation in approximately 1995. The U.S. Department of Agriculture's Forestry Service Southern Research Station (SRS) maintains a database of existing hardwood biomass resources. The SRS conducts forest inventories for 13 southern states including Oklahoma. Inventory data is available to the public at the county level for any state through use of their RPA 2002 Tabler/Mapmaker online application.[2] Unfortunately, the most recent data for Oklahoma is from 1993, and thus is not highly reliable for assessing current resource potential. However, the quantities for live biomass can be used to make a high level assessment of hardwood resources. In addition, the National Resources Conservation Service (NRCS) provides county maps quantifying the Red Cedar Canopy Cover[3] for the state of Oklahoma. This provides an approximate acreage of Red Cedar, based on satellite data obtained in 2002.

### Agricultural Biomass

The USDA National Agriculture Statistics Service was the primary source for evaluating potential agricultural energy crops. The database is available online and contains harvest statistics

[2] http://ncrs2.fs.fed.us/4801/fiadb/rpa_tabler/webclass_rpa_tabler.asp

[3] http://www.ok.nrcs.usda.gov/technical/GIS/County%20Base%20Maps/Red_Cedar_Canopy.html

for Pawnee County from 1990 to present.[4] Crops included are corn, hay, oats, sorghum, soybeans, and wheat. Specific metrics provided include acres planted and harvested, bushel yields, and bushel production for each crop.

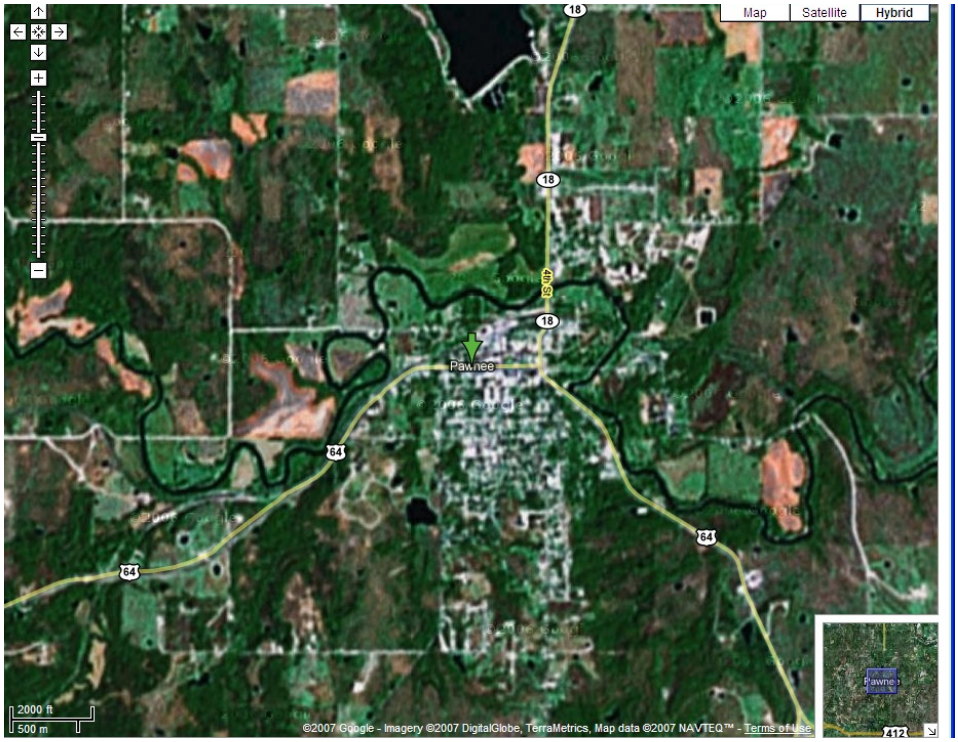
## Methane Capture

Pawnee Nation's solid waste is collected by a private contractor and transported approximately 18 miles to the Payne County Landfill. Payne County engages in methane recovery landfill gas to energy (LFGTE) operations. Data for the amount of methane collected and the energy produced (kWh) from the landfill gas (LFG) is unavailable.

## Data Challenges

A letter requesting current agricultural and forestry resource data for Pawnee Nation was submitted to the BIA in July, and several follow up communications were attempted, however, no data were received. In the absence of these data, the research team's analysis was limited to the resources outlined above, which were dated in the case of the woody biomass resource, and were not specific to the reservation boundaries in the case of the agricultural biomass resource.
Given the lack of availability of current resource inventory data, the research team explored satellite images to gain a better understanding of current vegetation resources in the Pawnee region. The research team was unable to obtain satellite images with a high enough resolution to use as a basis for the biomass resource. However, the satellite images did indicate further investigation into biomass as a sustainable energy resource is warranted.

### Figure 3-3 . Satellite Image of Pawnee, OK



Source: Google Maps

[4] http://www.nass.usda.gov/Statistics_by_State/Oklahoma/index.asp

### 3.1.3 Overview of Biomass Development Potential

This section presents the research team's estimate of the upper bound potential for biomass resource production on Pawnee Nation lands. The intent of calculating the potential production is to frame the discussion on what is possible with the land base. This provides a basis for determining appropriate next steps.

The research team's approach included the following steps. The team relied upon present documentation of land utilization patterns on the Pawnee Nation provided by the US BIA. For each of the separate land categories, the team estimated a crop rotation schedule, annual harvested acres, estimated yield per acre based upon current technology and subsequently calculate an annual yield per land category. For the approximately 19,000 acres the team calculated about 95,000 green tons (gt) per year of biomass that would be possible to harvest.

The information discussed here intentionally focuses on the technical rather than market potential, and assumes almost all of the existing acreage is managed as an energy crop. While some references are made to the market potential in later discussion, that was not the focus of this first steps assessment. The team's approach purposefully ignores existing uses (e.g., grazing on pastures or converting some acreage to alternative uses such as housing development) and practical considerations such as the ability to cultivate a crop. For instance, the team did not address a broad variety of agricultural considerations such as irrigation, slope of the land, or soil types.

With an upper end resource base of 95,000 gt/year, it is possible to begin to consider what energy related options are plausible and what options are not. For instance, biopower is not a practical consideration for Pawnee. The agricultural resource base could support approximately 5MW of power production on a BTU basis. However in the U.S. there are presently no biopower facilities that rely upon either crop residues or agricultural crops (e.g., switchgrass, corn stover, etc.). Thus, the only practical Pawnee resource for power generation would be the 2,440 gt/year of woody biomass. Such a small resource would not support even a 1MW biopower plant. For reference, background information on biopower applications are included in Appendix A. However, as discussed in a later section, Pawnee Nation's woody biomass resource would be sufficient to support heating applications at Pawnee-owned commercial buildings.

Liquid fuels production from biomass is technically feasible. Assuming potential energy crops are used to supply a biorefinery, it would be possible to produce approximately 1.9 million gallons per year of ethanol.[5] Today, most new ethanol refineries are larger than 50 million gallons per year of capacity, thus the Pawnee resource would not play a significant role in supplying a current corn ethanol facility.

An alternative liquid fuel is bio-oil, derived from a fast pyrolysis process. Typically bio-oil is used to displace residual fuels such as #5 or #6 fuel oil. We calculate approximately 5.3 million gallons of bio-oil could be produced on an annual basis.[6] One attractive aspect of bio-oil production facilities is that they can be scaled to match the resource base. Thus a 230 green ton per day plant could conceivably be built to use all of the Pawnee resources.

[5] Assume 25 gallons/green ton, 10 green tons/acre

[6] Assume 70 gallons/green ton, 10 green tons/acre.

**Table 3-2. Preliminary Estimation of Pawnee Nation Biomass Production Potential**

| Land Category | Acres | Rotation (years) | Potential Harvest Acres | Yield/acre (gt) | Annual Yield (gt) | Comment |
|---|---|---|---|---|---|---|
| Cropland | 3,452 | 1 | 3,452 | 5 | 17,260 | Current tillage practice, recover crop residue |
| Native Meadow | 699 | 0 | - | | - | Inappropriate for energy crop |
| Native Pasture/ Timber Pasture | 6,499 | 1 | 6,499 | 10 | 64,990 | Convert to agricultural energy crop |
| Bermuda grass | 1,109 | 1 | 1,109 | 10 | 11,090 | Concert to agricultural energy crop |
| Timber | 6,100 | 25 | 244 | 10 | 2,440 | Conservative 25 year rotation |
| **Total** | **18,666** | | **11,304** | | **95,780** | |

# 3.1.4 Woody Biomass Resources and Opportunities

## Resource Assessment

As mentioned above, the most recent forestry inventory conducted by the USDA Forestry Service for Oklahoma was in 1993. Data concerning the biomass resource of Pawnee County are displayed in Table 3-3.

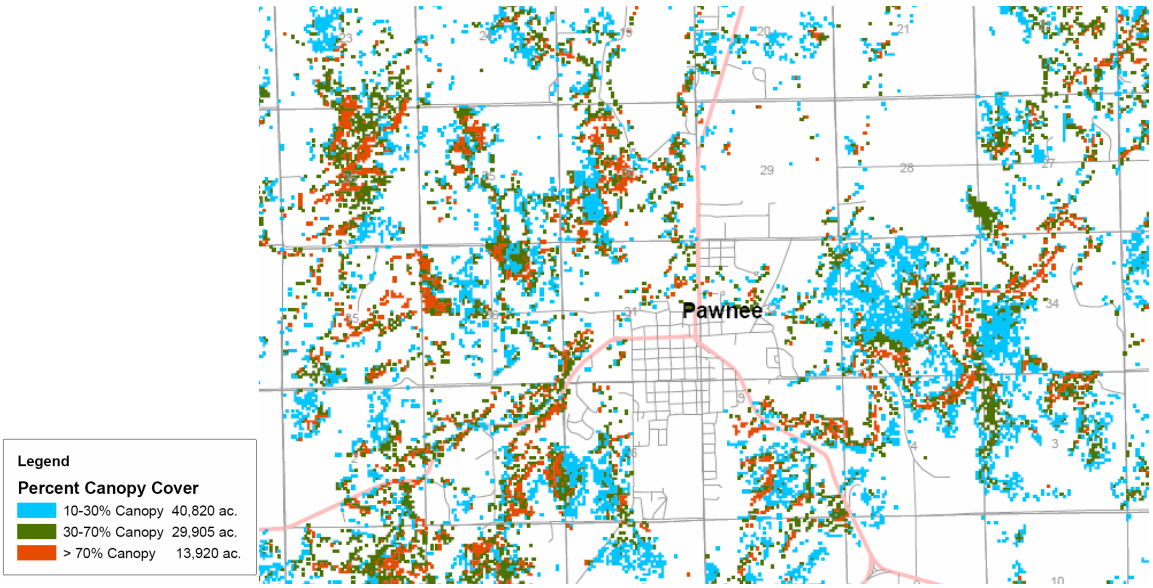
**Table 3-3. Oven Dry - lbs of Hardwood Biomass for Pawnee**

| | Total | Growing Stock | Rough Cull | Rotten Cull |
|---|---|---|---|---|
| Live Biomass | 2,085,617,133 | 1,510,428,126 | 470,589,096 | 104,599,912 |
| Live Merchantable Biomass | 1,443,025,915 | 1,043,232,425 | 345,537,259 | 54,256,231 |

Source: USDA Forest Service – RPA 2002 Tabler/Mapmaker

Figure 3-4 shows the Red Cedar Canopy Cover, provided by the National Resources Conservation Service. While the city of Pawnee is free of Red Cedar, a large portion of the surrounding area is heavily covered. In addition, Pawnee Nation representatives, Monty Matlock and Cecil Riding In, explained that invasive Red Cedar is currently burned for maintenance purposes, and the tribe is interested in understanding whether this waste could be put to use as an energy resource. See the analysis of heating Building #64 with an outdoor wood boiler for use of Red Cedar as an energy source.

**Figure 3-4. Red Canopy Cover for Pawnee, OK**




Source: National Resources Conservation Service – September, 2007

## Physical and Chemical Characteristics of Woody Biomass

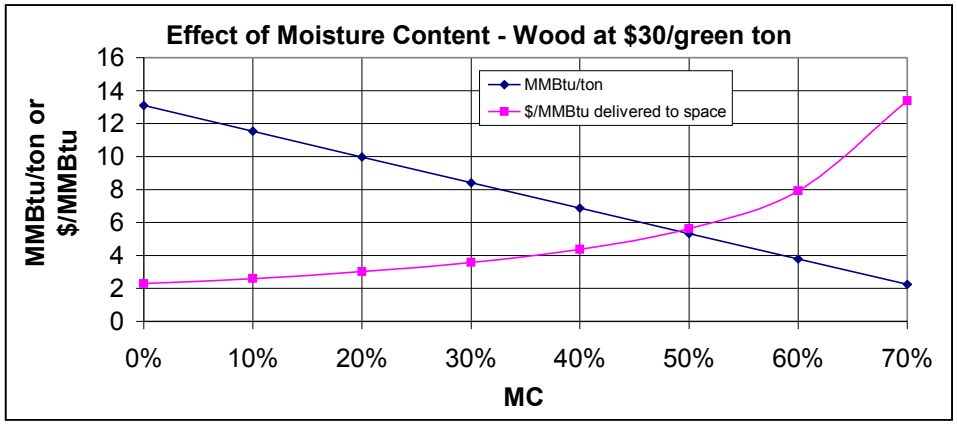
Because the Pawnee resource base includes woody biomass it is important to address physical and chemical characteristics. Wood characteristics impact handling, processing, combustion and gasification processes and, therefore, the choice of conversion technologies.

### *Moisture Content*

As discussed earlier, moisture content greatly affects the quality and energy value of biomass feedstock. Moisture content can be measured on a wet or a dry basis. In engineering calculations, moisture content is expressed as a percent of the total weight. This is the wet basis method. In the dry basis method, the moisture content is expressed as a percent of the dry weight of the wood (weight of water/weight of wood).

Fuel moisture content strongly influences the efficiency of wood-fired combustion. The figure below shows the effect of varying moisture content with a fixed fuel price of $30/green ton on a wood heating system. As shown in Figure 3-5, the energy cost, when accounting for efficiency losses, increases much faster than the moisture content, for MC greater than about 35%. Because of this, it is best to use dryer wood, or to establish a pay scale that accounts for moisture content.

**Figure 3-5 . Wood Moisture Content v. Energy Cost for Wood Heating**




*Heat Content*

Design engineers use heat content values to size a biomass conversion system. The heat content of wood and bark varies considerably among tree species due to differences in the chemical composition of the sample. As a general rule, softwoods contain a higher percentage of volatiles in the form of gums and resins. Because of this, softwoods often have higher heat content per pound than hardwoods.

*Ash Content and Alkalinity*

The most common problems associated with wood combustion are boiler slagging and fouling, erosion and corrosion, combustion instability, and particulate carryover. The amount of slagging and fouling is dependent upon fuel ash fusion temperature. High alkalinity also causes fouling and slagging in stoker type boilers and agglomeration in fluidized bed combustion systems.

Alkali content can be used as an indicator to estimate the potential for biomass fuels to cause boiler slagging and fouling. Research indicates that fuels with alkali contents below 0.4 lb alkali/MMBtu are not likely to cause slagging problems.[7] In general, whole-tree chips are higher than clean chips in alkali content due to the concentration of potassium, sodium salts and other organic compounds in the small branches, twigs and needles of the tree. Sodium and potassium compounds typically have low melting points resulting in increased slagging problems.

Ash content can be analyzed to assess combustion characteristics and determine the quantities of ash that will require disposal.

*Physical Fuel Characteristics*

Physical fuel characteristics such as density and particle size affect combustion and material handling considerations. Changes in fuel density could cause combustion to occur in the wrong place in the boiler, upsetting the heat transfer scheme and therefore the boiler efficiency. Physical fuel characteristics are most often controlled through grinding and screening techniques.

[7] Miles, T.R., et al. Alkali Slagging Problems With Biomass Fuels, In Proceedings of the First Biomass Conference of the Americas, Held August 30 - September 2, 1993. NREL/CP-200-5768 DE93010050. pp. 406

Typically, a one to two inch square chip or smaller with less than 10% fines is the ideal fuel source for biomass heating or power generation. Pellet manufacturing requires bark-free logs, clean chips or sawdust.

### *Wood Quality Issues*

The importance of feedstock quality cannot be stressed too much. Feedstock should be of consistent size and quality, free from contaminants such as rocks, dirt and oversize pieces. For pellets, chips must be free of contaminants and, as stated before, can be accepted in the form of debarked logs, debarked chips or sawdust.

## Potential Applications for Energy Production from Woody Biomass

The following is a discussion of potential biomass applications utilizing hardwood resources. Because Pawnee Nation's priority is to make use of its own biomass resources in its efforts to increase the use of renewable energy, potential applications for Pawnee-owned resources were the focus of the research team's analysis. However, Pawnee Nation could also consider purchasing biomass resources as an additional fuel source for biopower or heating applications.

### *Heating in Commercial Buildings*

The approach for identifying candidate biomass thermal applications is straightforward. The following criteria are used to screen facilities to determine if the building is a logical candidate for more in-depth analysis.

- Buildings with high heating bills. These are typically larger facilities, over 50,000 square feet. The size rationale is predicated on the consideration that it is important to capture economies of scale associated with a new installation.
- Buildings with existing boilers and circulating hot water or steam systems. There is a strong preference for hot water systems because state laws generally require personnel with special certification for operation of a steam system. The research team's experience is that hot air systems are difficult to retrofit with a biomass system.
- Current condition and age of existing boilers. New or well-maintained boilers are rarely candidates for retrofit for economic reasons.
- Future construction plans. A stand-alone project is often more difficult to economically justify than a system that is incorporated into a new construction plan. Construction plans that include expansion or renovation of the HVAC system are particularly favorable.
- Prior biomass utilization history. Support from key maintenance personnel, and past experience with biomass heating systems greatly increase the likelihood for a successful project.

The research team identified Building 64, a Pawnee Nation-owned administrative building, as a potential candidate for using biomass for space heating. Preliminary analysis of this potential application is included later in this section.

### *Residential Heating Applications*

The traditional use of biomass for heating is either a fireplace or a wood stove. Both technologies continue to be used and are often economical solutions. Additionally, fireplaces and stoves have demonstrated increasing efficiency gains over time, and the ability to meet EPA air emission standards.

The supply chain for cord wood is also simple; it can consist of as little as a few laborers and a pickup truck.

A rapidly growing biomass technology is the use of pellet fuel in residential heating applications. Pellets are burned in stoves, furnaces and fireplace inserts and provide an efficient, sustainable and cost-effective method of space heating. Pellet stoves meet all EPA air emission standards.

For Pawnee, *production* of wood pellets for use by members of the tribe, or for sale to others is not advisable at this time. There does not appear to be a mature local wood products industry. As a result, there is little infrastructure for supplying wood to a pellet mill. Furthermore, current market conditions have led to a possible over-capacity situation for the pellet industry, leading to downward price trends.

That being said, the benefits of using pellets as a fuel source for residential applications could be significant. Therefore, Pawnee Nation may wish to explore pellet heating options for members of the tribe, using pellet fuel produced from sources outside the reservation. The average pellet stove is 55% efficient.[8] This is due to the low moisture content (MC) of the pellet fuel (10% to 15%), compared to the 30% to 60% MC of standard cordwood/firewood. In addition, the energy content of wood pellets is 350,000 Btu/cu ft, approximately five times that of cordwood.[9] Pellets are also highly densified to 1/3 the original livestock volume, allowing for greater storage capabilities. As a result, pellet fuel requires less work for more energy production.

Pellet fuel is composed primarily of by-products from commercial applications such as lumber harvesting, furniture and paper mills. In addition, agricultural residues can be used to create pellet fuel, although in practice these residues are not generally employed because of their high ash content. As for particulate emissions, the average pellet stove emits 1.2 grams of particulate per hour, compared to the US EPA mandate of 7.5 grams per hour for wood burning processes.[10] As a result, pellet fuel proves to be a highly sustainable and environmentally friendly resource.

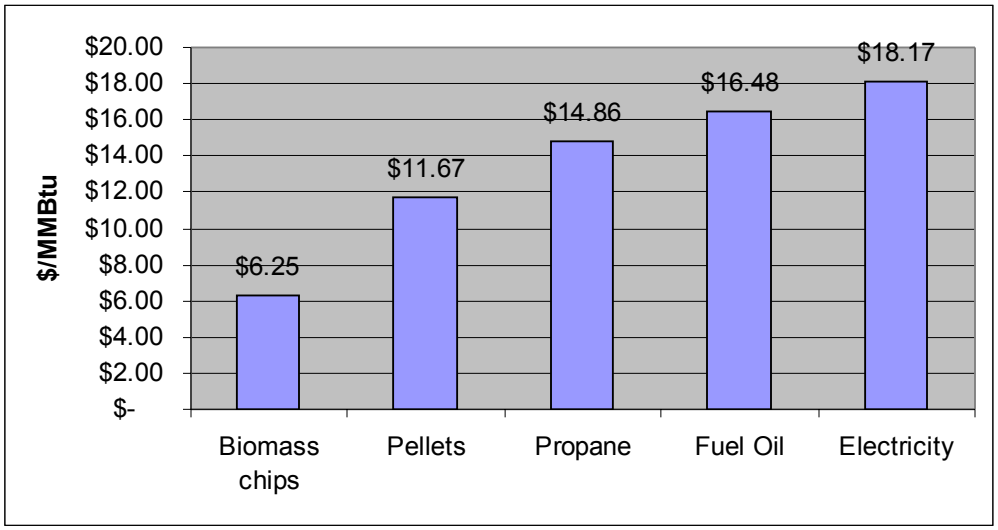
Pellet fuel is often a more cost-effective heating method than most conventional technologies. Figure 3-6 shows the average costs for various fuels on a delivered energy basis. Wood chips are the least expensive. Pellet fuel is widely available across the U.S. in stores such as Home Depot, though seasonal variation in pricing and availability must be taken into consideration.

[8] http://www.oregon.gov/ENERGY/RENEW/Biomass/bioenergy.shtml

[9] http://www.pelletheat.org/2/index/index.html

[10] http://www.pelletheat.org/2/index/index.html

**Figure 3-6 . Pellet Fuel Cost Comparison**




Source: U.S. Energy Information Administration[11]

In conclusion, it is recommended that Pawnee Nation representatives further investigate the potential for using pellet fuel for residential heating applications. Next steps include identifying the nearest pellet fuel supplier, tracking pellet fuel pricing, contacting pellet stove manufacturers to explore pricing and installation options, including potential bulk purchasing benefits, and educating tribal members about the potential to convert to pellet fuel for home heating. Appendix B includes a list of pellet stove manufacturers that may be contacted to determine if they serve Oklahoma, and for more information on local pellet distribution.

### *Power*

Power production from biomass resources represents the largest fraction of renewable electricity generation capacity current in place in the U.S. behind hydroelectric resources. It is uncommon to see wood-fired biopower facilities under 5 MW. Smaller plants may utilize conventional internal combustion engines running on digester gas or another fuel while larger utility-scale plants typically employ steam generator turbine sets. There are size increments associated with differing technologies. Generally internal combustion engines are not seen in installations over a few MW, nor are turbines employed in smaller plants, although the advent of microturbines holds great promise for new facilities. In general, larger plants have higher efficiencies.

When exploring feasibility for a biopower plant, the best case scenario is availability of a large (i.e., >100,000 green tons / year), inexpensive, low-moisture content feedstock, a willing thermal host for thermal sales, a receptive electric utility with an RPS mandate,[12] and favorable financing terms. However it is rare to find such a combination of conditions. Thus the power project decision framework typically involves an iterative analysis of resource costs, power purchase agreement options and project economics. Resource costs, in terms of delivered biomass, needs to be competitive with other fuels on a $/MMBtu basis. Feedstock cost is generally the single largest item in the operating budget and great care must be

[11] Data were obtained in early 2007 and pertain to north-central U.S.; however, they are within an appropriate range to be used for reference purposes for Pawnee Nation.

[12] A Renewable Portfolio Standard (RPS) is a requirement, usually implemented at the state level, that utilities supply a certain percentage of power from renewable energy sources. The requirement creates a market

exercised on a continuing basis to ensure procurement of the least cost supply. It is often prohibitively expensive to procure biomass from a forest when there is no potential for receiving revenue to offset fuel costs, for example, from sources such as fire treatment funds or fuel subsidies. For Pawnee, there are limited funds available from BIA Forestry for some fire mitigation activities for high risk areas.

The Pawnee Nation does not possess sufficient resources for use in a biopower application. As noted above, agricultural resources could technically support a biopower project in the range of 5 MW, however biopower applications of this scale are not economically feasible based on past experience of members of the research team. The Pawnee Nation's woody biomass resource, which equates to less than 1 MW of biopower technical potential, is insufficient to justify project development. Additional discussion of biopower project development potential in general, including fuel conversion technologies and air emissions, is included in Appencix B.

## Non-Energy Producing Applications for Biomass: Specialty Chemicals

A wide variety of chemicals can be derived from the cellulosic and lignin components of wood. It does not appear that there is near-term potential for Pawnee to sell wood products into such a market. However, it is worthwhile to be aware of these potential future market opportunities. This section provides a brief overview of two of many possible chemical derivatives of woody biomass.

### *Levulinic Acid for Manufacturing Chemicals*

Wood biomass can be used as filler for a number of chemicals or chemical intermediaries. Levulinic acid (LA) holds promise as an inexpensive feedstock for producing many industrial chemicals and products. The two chemicals that could significantly increase the market for levulinic acid are methyltetrahydrofuran (MTHF), a fuel additive, and delta-amino levulinic acid (DALA), a biodegradable herbicide/pesticide. The Department of Energy's Lawrence Berkeley National Laboratory (LBNL) recently documented the potential for a new group of processes to produce MTHF and DALA using LA.[13]

### *Specialty Performance Resins from Wood*

Lignin can be separated from other cellulosic components using acid hydrolysis and enzymatic processes that are the focus of research at the National Renewable Energy Laboratory. These natural resins can be substitutes for potentially toxic phenol formaldehyde resins.

With the increasing use of composite materials such as strand board, flake board, and composite lumber, the wood products industry is attempting to increase use of all portions of the tree. The adhesives used for these composite wood products are currently made from petroleum and natural gas. NREL is developing technology to make wood adhesives from biomass. Phenol ($C_6H_5OH$), the primary component of the resin used for the wood adhesives, is made from petroleum. NREL is producing phenol-like extracts from biomass using its fast-pyrolysis vortex reactor that can substitute for about 50% of the phenol in the resin. Researchers expect to be able to make these phenolics for about 50% of the cost of phenol, so net savings for the cost of the resins will be about 25%. Biomass-based resins can also substitute in producing certain molded plastics and foam insulation, with similar savings.

The U.S. used 556 million kilograms (kg) (1.2 billion pounds [lb]) of phenol to make phenolic resins in 1992. About 80% of this was for phenol-formaldehyde (PF) resin used by the wood products industry to

[13] N. Martin, E. Worrell, M. Ruth, L. Price (LBNL) and R.N. Elliott, A.M. Shipley, J. Thorne (American Council for an Energy-Efficient Economy). (October 2000). Emerging energy efficient industrial technologies. LBNL 46990. p. 74. Available online at: http://eetd.lbl.gov/ea/ieua/46990.pdf.

glue together plywood, particle board, strand board, and other composite products. Therefore, the market for these specialty woody biomass-based chemicals could be quite large in the future.

## Preliminary Analysis of Potential Wood Heating Application

*Biomass Heating Analysis of Building #64*

As noted above, biopower applications would not be economically feasible based on Pawnee Nation's biomass resources and the current state of the biopower market. However, a potential biomass application for the Pawnee Nation is the use of an outdoor wood boiler to heat a single or multiple buildings. A potential fuel for such a system is the invasive red cedar trees currently removed and burned for maintenance. According to a representative from the School of Natural Resources at the University of Missouri,[14] a standard cord of Red Cedar dried to 20% moisture can provide 18.9 MMBtu, making it a primary candidate for heating. This analysis evaluates whether Pawnee Nation's Red Cedar resource is sufficient for use in a heating application by determining the acreage necessary to heat Building 64. The benefits of such a system include providing the Pawnee Nation with a renewable heating source, and potential natural gas fuel cost savings.

The following are confirmed characteristics of Building 64, provided in the existing construction survey and usage statistics.

- 14,030 sq ft or 1,300 sq m
- 2 floors
- Functions as a college administration building
- Gas heating (hot water distribution)
- 2005 annual electricity usage was 118,720 kWh

Due to the limited data provided, assumptions were made to complete the analysis. Following is a list of these assumptions. The assumptions were based on information provided in the RETScreen biomass assessment tool.[15]

- Heating Design Temperature = -9.2 °C
- A heating setpoint of 20 °C or 68 °F
- An annual equivalent full load heating hours of 1540
- Average heating load of 58 W/sq m

Based on these assumptions, the annual heating energy consumption is approximately 116 MWh or 400 MMBtu, with a demand of 75 kW or 255,900 Btu/h. The average outdoor wood boiler has an efficiency of 80%,[16] thus requiring an annual energy supply of 495 MMBtu. If a standard cord of Red Cedar equates to 1.23 dry tons or 1.63 green tons, and 15 green tons of Red Cedar can be harvested from one acre (174 MMBtu/Acre), roughly 2.8 acres of Red Cedar would be needed to heat Building 64 each year. Red Cedar growth is estimated at 762 acres/day[17] in the state of Oklahoma, and therefore, availability of 2.8 acres/year of red cedar ready for harvest should be a sufficient heating supply source for Building 64.

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[14] Slusher, John P. "Wood Fuel for Heating." University of Missouri Extension. June 15, 2007 <http://extension.missouri.edu/xplor/agguides/forestry/g05450.htm>

[15] Retscreen is an online assessment tool developed by the Canadian government, www.retscreen.net .

[16] www.greenwoodfurnace.com

[17] Source: National Resources Conservation Center. While the red cedar growth rate seems high, it is equivalent to planting 300,000 acres of Red Cedar each year.

The economic benefits of using a local wood resource to replace natural gas fuel could potentially be substantial. A complete financial analysis was not completed by the research team. However, the 400 MMBtu of natural gas fuel that could be replaced with the local wood fuel source is equal to an annual savings of approximately $3,800 based on recent natural gas prices for Oklahoma.[18]

### *Fuel Collection and Labor Costs*

A primary consideration for proper implementation is developing an infrastructure for harvesting, transporting, drying, and storing the fuel. For Pawnee, the limited forested acreage precludes the investment in mechanized equipment. Rather, employing a small crew with chainsaws, tractors (for hauling) and chippers would be sufficient. If this labor were to be outsourced, current pricing for red cedar removal techniques are $90-$100 per acre for bulldozing, $40 per acre for hydraulic saw utilization, and $25 per acre for use of conventional tools such as chainsaws and other manual equipment.[19] In addition, wood boilers would require daily labor during the heating season for loading, resulting in an increased annual operational cost. However, preliminary conversations with representatives with Pawnee Nation indicate that labor to operate and maintain a wood boiler system would not be a barrier.

### *Air Emissions*

Particulate matter (PM) is the primary air pollutant of concern from wood boilers. Nitrogen oxides ($NO_x$) can also be a concern. Greenhouse gases (carbon dioxide, methane and nitrous oxide) are emitted from wood boilers, but greenhouse gas emissions from biomass are typically not counted since they are assumed to be part of the short-term $CO_2$ cycle. Air emissions are largely a function of the composition the wood product being burned, and the controls in place.[20]

According to manufacturer data, modern wood fired boilers meet EPA emissions standards and many "clean burning" units are available.[21] While claims about how "clean" modern wood fired boilers really are were not confirmed through this research, it is clear from the literature that wood boiler technology has made significant improvements in recent years making air emissions much less of a concern for this technology than it was in the past.

It should also be noted that removing biomass rather than burning it can reduce the smoke emissions impacts of prescribed burning.

### *Other Considerations*

It is necessary that the outdoor wood boiler be hydronic, as this is the current heating system installed in Building #64. In addition, it is recommended that the boiler possess clean burning capabilities, high thermal efficiency (85% or greater), and safety certification.

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[18] Oklahoma commercial natural gas prices averaged ~$12/thousand cubic feet from March through August, 2007. http://tonto.eia.doe.gov/dnav/ng/ng_pri_sum_dcu_SOK_m.htm.

[19] "Cedar Invasion Addressed." Tulsa Today. 19 October 2003. <http://www.tulsatoday.com/index.php?option=com_content&task=view&id=429&Itemid=2>

[20] U.S. EPA. (2003) "*Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources"* (AP 42, Vol 1, Ch. 1.6). Available at http://www.epa.gov/ttn/chief/ap42/ch01/final/c01s06.pdf.

[21] Greenwood Wood Furnace Co. states that Clean Burning furnaces "burn wood completely, leaving no particles to create smoke, creosote or ash." These claims were not confirmed.

*Next Steps*

Pawnee Nation representatives should proceed to the next phase of analysis for pursuing development of an outdoor wood boiler for Building 64, either by retaining additional consulting services or contacting manufacturers and vendors directly. Pawnee Nation representatives should also take steps to identify a funding mechanism for a wood-heating project (i.e., will the tribe self-fund the project, work with a lender, etc.). Vendors and developers will be aware of equipment and labor costs and should be able to assist Pawnee Nation with completion of a cost analysis. A list of outdoor wood boiler manufacturers is included in Appendix C.

### Findings and Recommended Next Steps for Woody Biomass

Current data on availability of woody biomass resources was unavailable to the research team. However, based on data from 1993, the research team determined that there is insufficient resource available to warrant development of biopower at this time, though the resource is sufficient to pursue space heating applications. The research team conducted a preliminary analysis of the potential to use Pawnee Nation's red cedar resource for heating the tribal building with the highest energy production, Building 64. The analysis indicates that the tribes' red cedar resource is a technically viable source for heating Building 64, though a full economic analysis was not completed. The research team recommends that Pawnee Nation representatives retain additional consulting services to complete a comprehensive economic analysis of potential for implementing a wood boiler system at Building 64. As an alternative, Pawnee Nation representatives could proceed to the next phase of analysis on their own by contacting outdoor wood boiler manufacturers directly to obtain pricing information and to get in touch with vendors and/or developers serving the Oklahoma market.

As a means of increasing the tribe's cost-effective use of renewable fuels, the research team also recommends that Pawnee Nation promote the use of pellet fuel in residential wood stoves and furnaces. While the research team's focus in general was on Pawnee-owned fuel resources, given the significant economic and environmental benefits of pellet fuel, and a shortage of other near-term renewable energy options available to the tribe, the research team recommends purchasing off-site renewable fuel in this case. Next steps include identifying the nearest pellet fuel supplier, tracking pellet fuel pricing, contacting pellet stove manufacturers to explore pricing options, including potential bulk purchasing benefits, and educating tribal members about the potential to convert to pellet fuel for home heating.

## 3.1.5 Agricultural Resources and Opportunities

### Resource Assessment

Agriculture data for crops grown in Pawnee County can be found in Table 3-4. Soybean and wheat crops occupy the largest area of land, however sorghum has the highest yield. An initial review of these numbers shows that soybeans are the primary energy crop, useful for applications such as biodiesel. According to Jerry Skidgel at the Bureau of Indian Affairs, soybeans are grown primarily for livestock feed. However, due to increased costs in fuel and fertilizer, agricultural lands are being converted to grasslands, as seen in the decrease of "Planted All Purpose" acres for soybeans between 2005 and 2006. These lands may prove to be valuable as soybean growth for energy purposes has become competitive with cultivation for food purposes. The data in Table 3-4 is for all of Pawnee County, accounting for lands not owned by the Pawnee Nation. Once specific information is obtained from BIA regarding Pawnee Nation agriculture, a more conclusive analysis can be completed.

**Table 3-4. Pawnee County Agriculture**

| Commodity | Year | Planted All Purposes (acres) | Harvested (acres) | Yield (bushel) | Production (bushel) |
|---|---|---|---|---|---|
| Wheat Winter All | 2005 | 19500 | 12500 | 25.6 | 320000 |
| Wheat Winter All | 2006 | 19500 | 10000 | 20 | 200000 |
| Wheat All | 2005 | 19500 | 12500 | 25.6 | 320000 |
| Wheat All | 2006 | 19500 | 10000 | 20 | 200000 |
| Sorghum For Grain | 2005 | 900 | 800 | 43.8 | 35000 |
| Soybeans | 2005 | 7500 | 7000 | 25 | 175000 |
| Soybeans | 2006 | 6300 | 4800 | 12.9 | 62000 |
| Hay Alfalfa (Dry) | 2005 | N/A | 2100 | 3.6 | 7500 |
| Hay Other (Dry) | 2005 | N/A | 18000 | 1.7 | 30000 |
| Hay All (Dry) | 2005 | N/A | 20100 | 1.9 | 37500 |

Source: USDA National Agricultural Statistics Service

## Applications

The following is a discussion of potential uses for agricultural biomass resources. Potential for use of these applications in the context of Pawnee Nation's resources is discussed as part of the key findings and recommendations for this section.

### *Liquid Fuels*

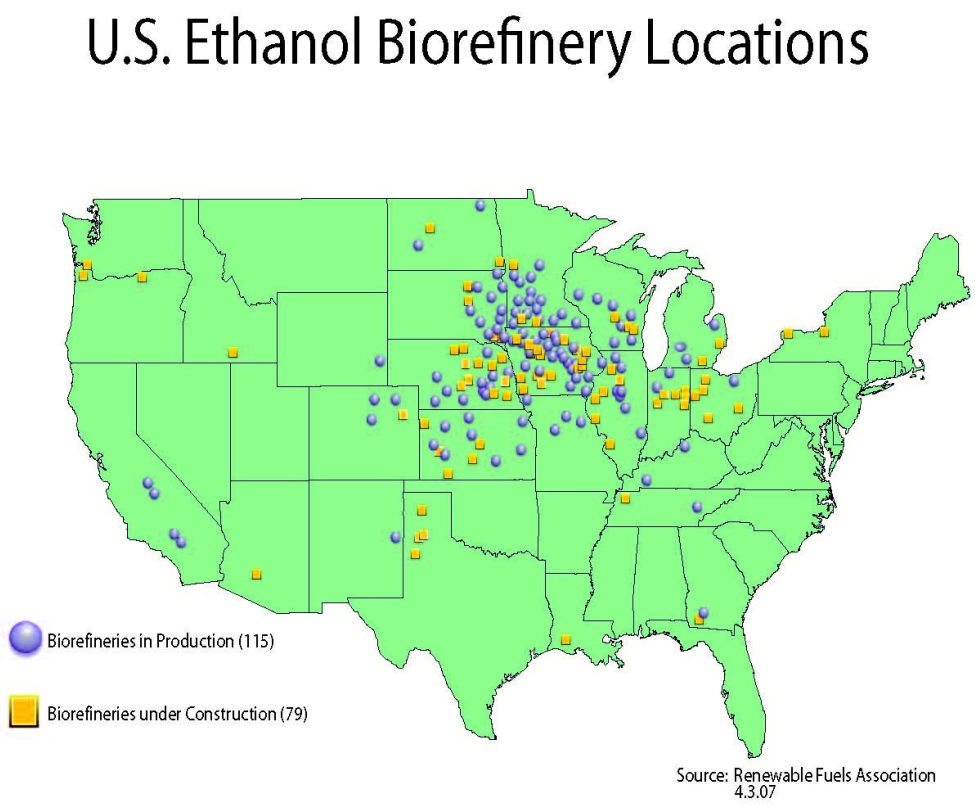
It is possible to produce a range of liquid fuels from biomass, including ethanol, biodiesel and bio-oil.

### Ethanol

Ethanol is most commonly blended into gasoline for use as an oxygenate to increase combustion efficiencies thereby reducing emissions. As of January 2007, 110 ethanol refineries were online in 21 states with 5.5 billion gallons of annual production capacity.[22] U.S. imports of ethanol were 653 million gallons in 2006. The U.S. imposes a 2.5% ad valorem tax on imported ethanol and there is also a secondary tariff to blenders to offset the tax credit they receive for blending ethanol. Figure 3-7 shows the locations of ethanol production facilities (blue) and those under construction (yellow).

[22] http://www.ethanolrfa.org/industry/statistics/

**Figure 3-7 . Map of U.S. Ethanol Production Facilities**




Source: Renewable Fuels Association, Ethanol Industry Outlook 2007

Nearly all refineries in production use corn as the feedstock, but other feedstocks include barley, cheese whey, waste beer and wheat starch. Most of the mills in production and all under construction are dry mills. This is due to standardization of design which led to a reduction in capital costs ranging between $1.93 per gallon of installed capacity for a 10 million gallon plant to $1.04 for an 85 million gallon plant.[23] There is one demonstration cellulosic ethanol facility in Canada but none located in the U.S. Due to a lack of experience with cellulosic ethanol production, it is difficult to anticipate both the capital and operating costs. It is expected, however, that due to novel technology cellulosic ethanol will require more capital on a capacity basis and production costs are anticipated to exceed those of corn based production.

Ethanol is not transported in pipelines due to an affinity for water and other physical properties. Roughly 75% of ethanol is distributed by rail with the remainder being delivered by truck. Barges or ships are also used as intermediaries to move ethanol to rail or truck.

[23] R. Dale, W. Tyner, *Economic Analysis of Dry-Milling Technologies,* Purdue University

## Biodiesel

Biodiesel is produced through a chemical engineering process referred to as transesterification, in which a fat or oil is combined with an alcohol and a catalyst to produce an ester (biodiesel, B100) and glycerol. Neat (100 percent) biodiesel has been designated as an alternative fuel by the US DOE. Biodiesel has lower energy content (Btu/gallon), but significantly higher cetane and lubricity versus standard diesel fuel. Biodiesel contains no inherent nitrogen or aromatics and is virtually sulfur-free. Biodiesel is registered as a fuel and fuel additive with the EPA, and is approved as an Energy Policy Act (EPAct) compliance strategy.

The latest production figures available from the National Biodiesel Board for 2006 were believed to be approximately 250 million gallons and plant production capacities for 2007 totaled nearly 1.4 billion gallons. Production occurs at some 148 plants in the U.S., at scales ranging from less than one million gallons per year to greater than 25 million gallons per year. In addition, another 1.89 billion gallons per year is under construction or proposed.

## Bio-Oil

The fast pyrolysis process produces bio-oil and char along with gases. Bio-oil is a dark brown liquid composed of a complex mix of highly oxygenated compounds (see Figure 3-8). Depending on fuel production parameters and quality, bio-oil may mimic fuel oil #6. Bio-oil production technology may be considered a commercial product for a limited but growing market. Until 2005, all commercial installations produced specialty food chemicals. The sole commercial installation worldwide producing bio-oil for energy use came online in February of 2005 in West Lorne, Ontario Canada.[24] This facility produces bio-oil from wood wastes at a flooring manufacturer which in turn uses the bio-oil to provide energy for the manufacturing process.

### Figure 3-8 . Bio-oil

Bio-oil is manufactured through a process called pyrolysis. Pyrolysis is the irreversible, thermal degradation of organic matter to produce gas, liquid and char products. The process occurs at lower

[24] The plant was manufactured by Dynamotive, a Canadian firm located in Vancouver, BC.

temperatures than combustion or gasification without an oxidizing agent. Controlling the temperature and reaction rate determines product composition. Research and development in pyrolysis focuses on maximizing liquid (bio-oil) yields due to the ability to transport and store liquid fuels.

Bio-oil has limited market presence and does not presently enjoy the popularity of other biofuels such as ethanol and biodiesel. Bio-oil applications include thermal uses (e.g., for heating buildings, water, industrial processes), power generation either with slow-speed diesels or co-fired in utility-scale boilers, and ultimately transportation fuels. Recently, successful tests were conducted producing syngas through gasification of bio-oil which can be further processed into syndiesel. Syndiesel can be used in all diesel end use devices without modification.[25] Beyond energy products, bio-oil can be refined into a range of specialty chemicals including flavor enhancers, and fuel additives. A co-product is char which has a range of applications such as pellets, fertilizer transport mechanism, and briquettes.

## Key Findings and Recommended Next Steps for Agricultural Biomass

Of all the biomass resources available to the Pawnee Nation, agricultural biomass holds the greatest potential for development over the next decade. We forecast that soybean production, crop residue collection and finally energy crop production will have development potential for Pawnee.

The growth in domestic demand for renewable fuels will create market opportunities that Pawnee needs to monitor. In the immediate future it is likely the demand for soybean will continue to increase for biodiesel production. The existing channels of distribution for current soybean production will experience growth and it is likely that additional soybean acreage will need to be planted to meet demand. While soybean is presently sold exclusively for animal feed, anticipated growth in demand for biofuels will likely make the fuel market a more lucrative choice for soybean growers. It is possible a biodiesel production facility will locate near (within 100 miles) Pawnee, further increasing demand for soybean. Without major technology changes, we do not see the potential for Pawnee to develop a biodiesel refinery, rather we see the Pawnee opportunity as a resource supplier.

Both ethanol and bio-oil will also experience increasing demand and the search for feedstocks will make it economic to collect residues associated with traditional crop harvests. The cellulose to ethanol technology is rapidly maturing with no clear market leader at this point. Without strong technological leadership by Pawnee, we do not advocate investment in a cellulosic ethanol facility at this time. Furthermore, because of economy of scale considerations, we believe ethanol production will be of such a large scale relative to the Pawnee Nation's resource base that a refinery is not practical.[26] We do recommend closely monitoring developments in the technology through regular attendance at trade meetings or review of the literature.

Bio-oil holds limited promise for Pawnee over the intermediate term. It is clear the technology exists that scales well to the Pawnee resource base. However, it is not clear there is sufficient market demand for the product. Bio-oil is in its infancy, well behind both biodiesel and ethanol in terms of market acceptance. We thus recommend that Pawnee monitor the bio-oil development status but not commit to a bio-oil refinery without a compelling end-use market / application in hand.

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[25] Dynamotive Press Release, September 22, 2005 *Successful Conversion of DynaMotive's BioOil to Synthetic Gas Demonstrates Potential for Production of Synthetic Diesel and other Advanced Fuels*.

[26] This observation is predicated on the notion that Pawnee owns and operates a facility that is mostly supplied by resources from the reservation. We have not examined resources in the nearby county and thus the potential may be such to justify further consideration of a Pawnee cellulosic ethanol facility.

Within the next few years, the market potential for using Pawnee's agricultural land base for cultivation and harvest of energy crops will likely become clearer. We can readily envision a scenario within the next five to ten years in which crop land that is marginal for food production has considerable value for energy production. Pawnee has sufficient acreage that can be dedicated to energy crop production that can provide economic returns well above existing levels. For the energy crop vision to be realized there needs to be development of demand for the feedstock by one or more biorefineries in the region. Because of Oklahoma's oil production heritage, we see a natural evolution of the oil industry to capture the biomass resource via a thermochemical pathway. Furthermore, as discussed in Section 3.5.1, the 2007 Farm Bill, which was approved by the Senate Agriculture Committee in late October, includes a number of incentives to boost the market for biofuels and use of renewable energy resources on agricultural lands. This legislation could jump start the market for biofuels, significantly improving the economic feasibility of using Pawnee lands for biofuel production. Our recommendation is for Pawnee to work with the state energy office, the Oklahoma Bioenergy Center, BIA and local Resource Conservation Districts to determine how best to position its agricultural lands for energy crop production.

## 3.1.6 Methane Capture

### Overview of Methane Use for Energy Production

Methane is primarily produced through the anaerobic decomposition of organic matter occurring in biological processes. Agricultural processes such as rice cultivation, enteric fermentation in animals, and the decomposition of animal wastes produce methane. Methane is also produced during the production and distribution of natural gas and petroleum, coal mining operations, and from the incomplete combustion of fossil fuels. Methane gas is a primary component of landfill gas (LFG). LFG's composition is approximately 50% methane, 50% carbon dioxide, and less than 1% non-methane organic compounds. Municipal solid waste (MSW) landfills are the most significant producer and emitter of methane in the U.S. LFG is also considered to be a health and environmental concern.

According to the US EPA, atmospheric levels of methane have dramatically increased by an estimated 143% since the year 1750 from 722 PPB to 1,756 PPB in 2004. The change in the level of methane in the world's atmosphere is anthropogenic, attributed to agriculture-related activities, fossil fuel use, and waste disposal. Methane is widely recognized as a green house gas and estimated to be over 20 times as potent in terms of warming effects when compared to carbon dioxide.

Methane recovery from solid waste, landfills, and wastewater operations for energy use is increasing in utilization for municipalities and communities. Landfill gas-to-energy (LFGTE) operations are accepted as a reliable renewable energy resource. According to the U.S. EPA, MSW landfills are the largest anthropogenic source of methane in U.S. contributing to 24% of the total U.S. methane emissions in 2005. Both the availability and reliability of methane recovery makes LFGTE projects an attractive option for communities looking for sustainable and renewable energy resources to invest in and capitalize on.

Other benefits of methane recovery/energy options for the Pawnee Nation include the following:

- Methane and additional organic compounds are destroyed and prevented from entering the atmosphere as green house gas contributors
- Using recovered methane for energy offsets non-renewable fossil fuel-based energy sources
- Methane is a recognized renewable energy resource
- Methane from LFG is generated continuously and has an accepted online reliability of 90%

- Use of recovered methane for energy can act as a price and volatility hedge against fossil fuels
- Methane recovery actively reduces local air pollution and can decrease incidents of respiratory health problems for the community
- Methane recovery can generate new revenue streams for the community
- A methane recovery project can create local job opportunities and stimulate the local economy.

## Landfill Gas to Energy (LFGTE)

### *Resource Availability from Landfills*

According to the US EPA information for 2005, landfills were the largest source of anthropogenic methane emissions figuring in at an estimated 24% of total US methane emissions. Landfill emitted methane results from low oxygen content conditions coupled with the presence of anaerobic bacteria. The anaerobic bacteria decompose organic materials such as grass clippings, yard waste, food waste, and paper products to produce biogenic methane and carbon dioxide. Carbon dioxide is water soluble and thus more likely to exit as liquid state leachate from the landfill site. Methane being less water soluble than carbon dioxide is more prone to remain in gas state and exit the landfill site as a component of LFG.

LFG is approximately 50% methane, with the remainder of the gas being predominately carbon dioxide and an inconsequential amount of non-methane organic compound gas. The volume of LFG from methane emitted from a landfill depends on many physical characteristics of the landfill site itself. The prime factor directly affecting the volume of emitted methane is the amount of organic material present. From the years 1990 to 2005, overall landfill methane emissions decreased due to the increasing amount of landfill gas being collected and combusted. LFGTE development is an accepted practice with a general consensus online energy reliability of 90%.

### *Pawnee Nation Landfill Energy Options*

Pawnee Nation's solid waste is collected by a private contractor and transported approximately 18 miles to the Payne County Landfill where methane recovery LFGTE operations are in place. Data pertaining to the amount of methane collected and the amount of energy produced (kWh) from the LFG is unavailable.

Pawnee Nation has the potential to develop LFGTE resources in two ways: 1) the tribe could develop a solid waste landfill for its community with LFGTE incorporated into the design; 2) the tribe with the neighboring city of Pawnee and develop a joint MSW LFGTE project. The second option would likely be more feasible because it would reduce costs while yielding more organic material for use in producing LFG for electricity generation. Also, a landfill serving only Pawnee Nation may not be capable of producing an adequate amount of biogas to make a LFGTE project feasible.

While the energy potential of a landfill varies depending on its content, an acceptable LFG production value estimate for an actively producing landfill under optimal conditions is 450,000 cubic feet of LFG per day for 1 million tons of municipal solid waste (MSW). This volume of LFG translates to 0.8 MW of electricity per day yielded from every 1 ton of MSW.

Also of significant consideration is the organic activity of the landfill in terms of biogas production. New landfills produce and emit more LFG and thus more methane, and older sites produce significantly less LFG and methane. This is directly related to the organic decomposition process. The organic decomposition process rates are much higher in new landfills than in older more organically stabilized sites.

Other considerations that Pawnee Nation must take into account are the intangible facets that a methane/biogas to energy project could present. Aside from reusing 'free' waste decomposition methane gas and producing non-fossil fuel based electricity for the tribe's community, there are aspects of a LFGTE project that cannot be quantified. For example:

- Methane and other LFG organic compounds are destroyed and their emission avoided;
- Offset of sulfur dioxide (SO2) emission which contributes to acid rain;
- Offset of NOx compound emission which contributes to ozone and smog;
- Offset of particulate matter (PM) emission which cause respiratory health concerns;
- Offset of carbon dioxide (CO2) emission which is a green house gas.

The success of a LFGTE project for the Pawnee Nation would depend on the following parameters:

- The LFGTE project is a joint or cooperative energy development venture;
- The physical characteristics of the MSW landfill provide for optimal LFG and methane recovery conditions;
- The organic load level to be deposited in the MSW landfill is high and expected to be continuous and long-term.

### *Key Findings and Recommended Next Steps for Methane Capture*

Pawnee Nation should further explore the potential to collaborate with the city of Pawnee to develop a joint MSW LFGTE project. This would involve a review of: existing contractual relationships with the current waste management provider; potential sites for locating a facility; potential for leveraging funding sources available to the Pawnee Nation and the city of Pawnee, among other considerations.

## Methane Capture from Wastewater Operations

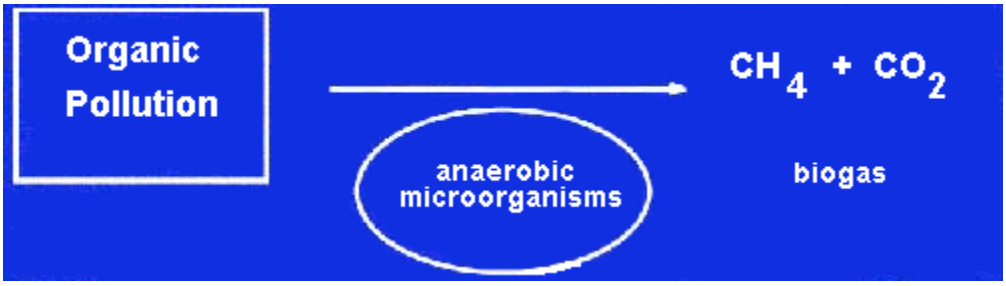
### *Methane Recovery Options from Wastewater Treatment*

Wastewater contains organic matter and solids that must be broken down and stabilized in order to produce properly treated effluent water.[27] The standard treatment for many communities in the U.S. is to have, at minimum, "secondary treatment" with chlorination. Secondary treatment includes mechanical filtering, screening, and removal of solids through settling, followed by biological oxidation of the wastewater's organic matter. Secondary treatment is expected to remove 90% of the BOD and 90% of the suspended solids. This type of treatment commonly employs anaerobic processes in a number of varying configurations.

Anaerobic treatment processes decompose and stabilize organic matter without using elemental oxygen or air. Organic material and pollutants are converted by anaerobic microorganisms to gas which is predominately methane and carbon dioxide (Figure 3-9). This resultant gas is commonly referred to as biogas. It is the methane component of biogas that can directly be used for energy production. Methane typically makes up 70-90% of natural gas and can be readily and easily used for energy purposes. Anaerobic treatment processes could be utilized during activated sludge digestion as part of secondary treatment. Also, anaerobic activity will obviously occur with an anaerobic lagoon.

[27] Domestic wastewater is typically 99.9% water and approximately 0.03-0.06% solids.

**Figure 3-9. Anaerobic Decomposition of Organic Material**




*Pawnee Nation Options for Generating Energy from Wastewater Treatment Operations*

Domestic wastewater for the Pawnee Nation community is currently handled and treated using an anaerobic lagoon system (See Figures 3-9 and 3-10). The two cell anaerobic lagoon system provides secondary biological treatment of the community's sewage, removing most solids and organic matter through biological processes. Secondary treatment of raw sewage is commonly capable of removing approximately 90% of Biochemical Oxygen Demand (BOD) and 90% of suspended solids. The Pawnee anaerobic lagoon performance is unknown at this time but its performance should be consistent with that of typical secondary treatment operations.

**Figure 3-10. Pawnee Nation Two Cell Anaerobic Lagoon**

The Pawnee Nation's existing anaerobic lagoon system is sized for a single community's domestic wastewater treatment. Currently, this lagoon system is estimated to be at maximum operating capacity. To accommodate any future development, the Pawnee Nation must consider improvements, upgrades, or additional facilities for their future sewage treatment needs. Also, the Pawnee Nation should evaluate any cooperative options available with the neighboring City of Pawnee.

This need to improve upon and expand wastewater treatment operations presents Pawnee Nation with the opportunity to explore energy production options. The research team did not examine the economic feasibility of incorporating the energy generating technology as part of an improved or expanded wastewater treatment system, nor did the team confirm whether the volume of waste produced by the tribe would be sufficient to warrant an investment in energy generation at the wastewater treatment facility. However, from technical perspective, the team identified two primary paths the Pawnee Nation could pursue in order to capture methane from wastewater treatment processes, in preparation for pursuing energy generating opportunities. The tribe could create an energy opportunity with minimal improvement and cost or it could take a more involved route including a change in treatment technology. The primary energy producing wastewater operations opportunities available to Pawnee Nation are: 1) secondary treatment with anaerobic digestion of activated sludge; and 2) methane recovery using a lagoon cover.

## Secondary Treatment with Anaerobic Digestion of Activated Sludge

Methane-producing anaerobic digestion can be incorporated into secondary wastewater treatment. If the treatment process utilizes activated sludge, then the biosolid sludge can be decomposed using digester technology to produce methane. An anaerobic digester is an airtight container that serves as a mesophilic or thermophilic reactor. Many wastewater treatment plants use anaerobic digestion to reduce the volume of these biosolids. Anaerobic digestion also stabilizes the wastewater sludge and destroys pathogens. According to the U.S.D.O.E., sludge digestion commonly produces biogas containing 55-75% methane, with an energy content of about 600 Btu per cubic foot. Also, according to the U.S.D.O.E., state-of-the-art high efficiency digesting systems can yield biogas with methane levels of 95%.

Many wastewater treatment plants that use anaerobic digesters utilize the methane content of the biogas for heat to maintain digester temperatures and to heat building space. Digester gas can also be utilized to fuel and generate electrical power onsite using the following methods:

- Engine generator
- Reciprocating engines
- Gas turbines
- Steam turbines
- Microturbine
- Fuel cell technology

In order for Pawnee Nation to utilize this methane producing option, the community must switch wastewater treatment technologies. The Pawnee Nation's existing system would need to be replaced with a secondary treatment technology that incorporates the production and anaerobic digestion of activated sludge. Because this option would involve complete system replacement, it would come at a significant cost. Other considerations are:

- Evaluating the need to accommodate future growth and accompanying wastewater treatment requirements;
- Seeking a successful cooperative partnership with the City of Pawnee to integrate wastewater treatment needs.

## Lagoon Cover/Methane Recovery Option

The most cost effective and least risk option for the Pawnee Nation, in terms of methane production, is to add a synthetic cover to the community's existing lagoon. The addition of a cover coupled with a methane recovery system could potentially collect enough methane to produce a moderate amount of electricity. The main advantages with this option are:

- The lagoon cover/biogas recovery system would "piggyback" on an already existing system;
- The synthetic cover would not affect the anaerobic treatment performance of the lagoon cells;
- The methane recovery system would make use of an existing renewable energy resource.

The synthetic cover or membrane would trap the rising biogas from the lagoon water and capture the gas via a series of floating collectors. The biogas would then be conveyed to a pipeline at the lagoon perimeter where it could be treated and directly used like natural gas for energy generation.

The lagoon cover design would likely incorporate a high density polyethylene (HDPE) cover or membrane. HDPE would be the logical option for a cover material because of the wide band of temperatures at which the material can be welded, it is a lightweight material and floats on water, is puncture resistant, and it has thermal expansion properties that are significantly less than other materials. HDPE contains no plasticizers, and therefore remains flexible even after long-term exposure to the weather.

The cover could be attached to the embankments or it could float depending on design. The cover could direct rainfall to one edge of the lagoon, drain rainfall into the lagoon, or prevent rainfall from entering the lagoon by accumulating rainfall and pumping it to rainfall discharge structures or to rainwater storage cisterns. In addition to the cover, the design could include:

- New sludge withdrawal lines;
- New pumping station;
- New force main to convey the sludge to another lagoon.

The decision to utilize this cover and collection method for energy has a number of considerations. Methane is the product of a biological process and there are many variables that could affect the rate of production. The physical characteristics of the waste stream and the temperature are the most critical because they both significantly affect the rate of bacteria growth. More important, a new lagoon requires a number of cycles before the bacterial colony is sufficiently developed to produce the predicted volume of biogas. It is not unreasonable to wait one to two years for the lagoon to mature and methane production to reach predicted levels. Also, to yield an adequate volume of biogas to make the project economically feasible, the organic and volatile solids loading rate would need to reach a specific pre-designed level.

The benefits of this methane energy option for the Pawnee Nation include:

- Control of foul ambient odors;
- Reduction in wastewater pathogens through anaerobic processes;
- Use of the existing lagoon as an anaerobic digester to reduce sludge volume;
- Generation of renewable energy from methane-producing anaerobic processes.

*Findings and Recommended Next Steps for Energy Production from Wastewater Operations*

Pawnee Nation's wastewater treatment lagoon is at capacity and the tribe will need to pursue expansion opportunities in the near-term. New investment in wastewater treatment infrastructure presents an ideal opportunity to explore the economic feasibility of capturing methane and incorporating energy generating capacity at the treatment facility. The research team did not explore the economic feasibility of incorporating energy generating technologies into an expanded wastewater treatment facility, but did identify two paths the tribe could take to build methane capture into its improved or expanded wastewater treatment system. As Pawnee Nation explores options for expanding the capacity of its wastewater treatment infrastructure, it should incorporate a thorough examination of opportunities to incorporate energy generating technologies.

## 3.1.7 Summary of Biomass Key Findings and Recommendations

Pawnee Nation has the potential to harvest roughly 95,000 green tons/year of woody and agricultural biomass. Given current market conditions, this resource presents near-term opportunities for using local red cedar to heat Pawnee-owned buildings with outdoor wood boiler systems. The research team recommends that Pawnee Nation conduct an economic feasibility assessment to further explore the potential for using a wood boiler system at Building 64. If Building 64 is deemed a suitable application and a biomass-fueled heating system can be successfully deployed there, the tribe may consider additional installations at other non-residential buildings.

The research team also recommends that Pawnee Nation encourage the use of pellet fuel for residential heating applications. While Pawnee Nation is not well-positioned to provide its own pellet supply, pellet fuel (purchased from outside vendors) used in stoves and furnaces can be a cost-effective and environmentally friendly heat source, and can help tribal members protect themselves from rising and volatile natural gas costs. Pawnee Nation representatives should locate the nearest pellet fuel supplier,

track pellet fuel pricing, get in touch with pellet stove manufacturers to explore bulk purchasing options, and inform tribal members of pellet fuel heating options.

Agricultural biomass ("biofuels") is a resource category with substantial technical potential given the significant amount of cropland in the Pawnee reservation and surrounding areas. While current market potential appears to be limited, great potential may exist within the next few years, in particularly in the area of soybean growth for use in producing biodiesel. Pawnee Nation representatives should monitor developments in the biofuels industry by attending trade shows and establishing communications with Oklahoma's Bioenergy Center.

Two primary options exist for capturing methane for use in generating energy. Landfill gas to energy is a proven cost-effective means of generating renewable energy. Pawnee Nation's waste is currently taken 18 miles away to a landfill where LFGTE is taking place. The tribe should explore the potential to collaborate with the city of Pawnee to develop a joint MSW LFGTE project. Another option for methane capture is at the tribe's wastewater treatment facility. As Pawnee Nation explores options for expanding the capacity of its wastewater treatment infrastructure, it should incorporate a thorough examination of opportunities to incorporate energy generating technologies.

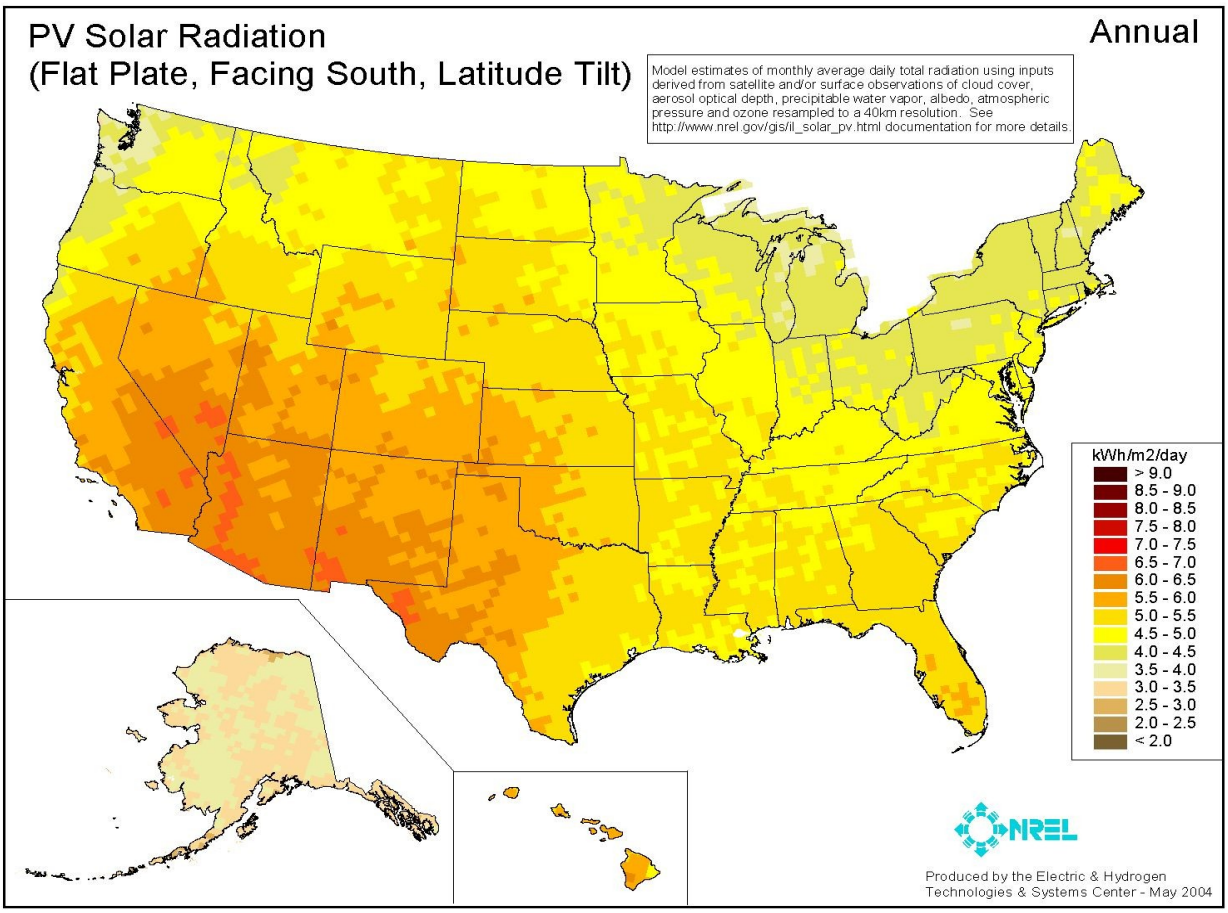
## 3.2 Solar

The three main solar energy applications in buildings are photovoltaics (PV), solar domestic hot water (SHW) and solar space heating. PV converts sunlight to electricity, typically using building or ground mounted panels/modules made up of crystalline cells. Solar hot water systems in climates like Oklahoma typically heat water by circulating a heat transfer fluid through a rooftop solar collector and transferring that heat to the domestic water through a heat exchanger. Solar space heating can use either passive (i.e., requiring no mechanical equipment) or active (i.e., using fans and other mechanical equipment) techniques. For the purposes of this assignment, the research team focused on assessing the feasibility of PV and SHW.

### 3.2.1 Data Sources and Resource Availability

Oklahoma's solar resource (4 - 4.5 kWh/sq. m-day) is above average for the U.S., as shown in Figure 3-11, a map of solar radiation produced by the National Renewable Energy Laboratory.

**Figure 3-11 . U.S. Solar Resource Map**



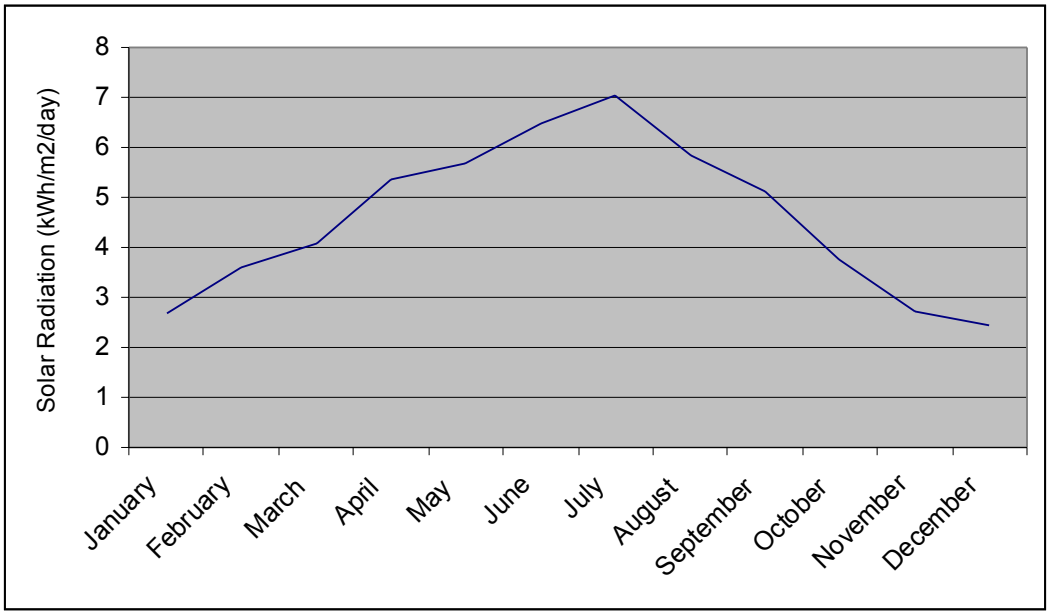

Source: National Renewable Energy Laboratory

The solar data used for this project was taken from Mesonet tower measurements. The Oklahoma Mesonet is a world-class network of environmental monitoring stations. The network was designed and implemented by scientists at the University of Oklahoma (OU) and at Oklahoma State University (OSU).

The Oklahoma Mesonet network consists of over 110 automated stations covering all of Oklahoma. There is at least one Mesonet station in each of Oklahoma's 77 counties. At each site, the environment is measured by a set of instruments located on or near a 10-meter-tall tower. The Oklahoma Climatological Survey (OCS) at OU receives the observations, verifies the quality of the data and provides the data to Mesonet users and the website (Oklahoma mesonet website, http://www.mesonet.org/overview/). These data is goes through 4 stages of quality checks to confirm the validity of the data.

The solar data presented below is an average of the data collected from the past two years (June 2005 to June 2007). During this period, the average solar resource was:

**Figure 3-12. Average Incident Solar Radiation on Pawnee Nation (2005-2006)**




Source: Oklahoma Mesonet

## 3.2.2 Photovoltaics

Photovoltaic (PV) cells convert sunlight to electricity. PV cells are arranged into larger solar collector modules which are usually roof mounted. Pole mounted systems with solar tracking devices can also be used to maximize power production. PV modules produce direct current (DC) electricity which must be converted to alternating current (AC) electricity using an inverter. The PV modules, mounting equipment, and the inverter are the primary components of most PV systems. Batteries can be included in the system to provide power storage, but batteries add a substantially to system costs. PV systems have no moving parts, they require very little maintenance, and they are among the simplest renewable energy technologies to implement. The amount of electricity produced by PV systems is directly proportional to the amount of available sunlight. As stated above, Pawnee's solar resource is slightly above average for the U.S. radiation per square meter in Pawnee is 4.58 kWh. PV is one of the more favorable renewable resources available to Pawnee Nation from a technical perspective, however the system costs a very high and there are no major funding sources available to make a PV system more affordable for the tribe. The research team analyzed the potential power production and economics of a PV system located on a Pawnee Nation building, described in the following section.

### System Siting Considerations

It is important to select a site where a solar system will perform at its optimum level to maximize economic feasibility. A PV system will have a faster payback if it is installed on a building that has the ability to consume all the electricity produced, as the avoided energy cost (retail value) is much greater than the value of net excess generation (wholesale value). Therefore, buildings with high electric loads are ideal candidates for PV installation.

Initially, Pawnee representatives identified Building 64, an administrative building, as the best candidate for a PV project given that building's critical role in Pawnee Nation operations. Pawnee Nation has

experienced power reliability problems in the past and was interested in the potential for a PV system to provide emergency backup power for the building. However, Building 64 is a historic building and must adhere to historic preservation standards for building aesthetics due to its use of federal funds. The building has a sloped roof and installation of standard, more cost-effective PV modules would likely violate historic preservation requirements. The fire / police building was identified as the next best candidate for locating a PV system. This is a flat-roofed modern building, also providing critical services to Pawnee Nation.

## Research Methods

The analysis was completed using RETScreen, an industry accepted tool for analysis of renewable energy systems.[28]

### *Cost and Revenue Assumptions*

Cost inputs for all system components (collectors, inverter, labor, electrical equipment, etc.) were based on default RETScreen assumptions. All system cost assumptions are shown in the cost summary table. The project revenue sources factored into the economic analysis included the following:

- Net Metering– Electric utilities in Oklahoma are required to allow customers to "net meter." This means that an electricity customer's monthly bill will be reduced by the retail value associated with the electricity generated from their PV system. When the PV system produces less than the customer needs, electricity from the grid is automatically supplied, and any excess electricity produced by the PV system would automatically flow into electric grid. In some cases, a PV system will produce more electricity than the electric customer uses in a monthly billing cycle, or during the course of a year. Oklahoma utilities are not required to purchase this excess generation. But if the utility chooses to do so, it will purchase the electricity at the utility's avoided cost of electricity, which is assumed to be the wholesale electricity cost; approximately $0.015/kWh.[29] However, for the purposes of this analysis, it is assumed that all electricity produced by the PV system would be used on-site.

- Avoided cost of electricity – For electricity produced by the PV system that is used to serve building loads, a value of 9.5 cents/kWh was assumed. This is consistent with retail electricity rates paid by Pawnee Nation.

- Renewable Energy Production Incentive - The Renewable Electricity Production Incentive (REPI) is a per kilowatt-hour federal financial incentive for electricity generated by PV and other qualified energy resources. At present the value of this credit is $0.02/kWh. This credit is only valid for 10 years for solar and wind resources, and funding availability is subject to annual congressional appropriations.[30]

Since a major barrier to PV development is its high initial cost, most states offer rebates or other financial incentives to encourage investment in PV technology. However, the state of Oklahoma does not offer

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[28] RETScreen International is managed under the leadership and ongoing financial support of Natural Resources Canada's (NRCan) CANMET Energy Technology Centre - Varennes (CETC-Varennes).

[29] Oklahoma's net metering rules state, *"Utilities are not allowed to impose extra charges for customers signed up for net metering, nor are they allowed to require new liability insurance as a condition for interconnection. Utilities are also not required to purchase net excess generation (NEG) from customers. However, a customer may request that the utility purchase NEG. In the utility agrees, then NEG will be purchased at the utility's avoided-cost rate."*

[30] Database of State Incentives for Renewable Energy (www.dsireusa.org).

citizens any such incentives for PV systems smaller than 1 MW. Another potential revenue source considered by the research team was Renewable Energy Certificates (RECs). RECs represent the environmental benefits associated with the electricity produced by renewable energy systems. The most substantial REC markets exist in states with minimum renewable energy supply requirements ("Renewable Portfolio Standards," or "RPS requirements.")

In addition, a comparatively small but growing "voluntary" REC market exists in the U.S. REC values are generally much lower in the voluntary market than in the RPS compliance markets. However, as discussed in a later section focusing on financial incentives for renewable energy, a REC broker called Native Energy focuses on matching tribal renewable energy projects with REC revenue sources. A Native Energy representative quoted the research team a value of $0.003/kWh to $0.005/kWh for solar RECs.[31] This value is too low to make PV cost effective without being combined with other much more substantial financial incentives. Due to the relatively small scale of the project being considered for the purposes of this analysis, the Native Energy REC revenue would not make a substantial impact on the revenue stream and was not factored into the analysis. However, it should be noted that this revenue source is available and would make PV economics slightly more favorable than the results of the analysis presented here.

### *Installation Assumptions*

The following installation characteristics were assumed for the analysis:

- Solar Azimuth Angle – Solar panels get maximum exposure if they face south. This results in an azimuth angle of zero degrees. An azimuth angle of zero degrees was used for this analysis.

- Solar Tilt Angle - To maximize solar gain, solar panels are usually installed at an angle which is equal to the latitude of the location. Hence a tilt of 36.2 degrees was assumed.

- Grid Connection – As noted above, Oklahoma allows net metering, but does not require utilities to purchase net excess generation. It was assumed for the purposes of this analysis that all the electricity produced by the solar system is used by the building on which it is located.

- System Size – Given the economic benefits of sizing a system that will produce an amount of electricity that does not exceed the amount used by the building on which it is located (i.e., to take advantage of the ability to avoid high retail electricity costs), a 5 kW PV system size was assumed for the analysis.

- Collector Specifications – A typical silicon collector with an average efficiency of 11.7 percent is used for this analysis. As noted earlier, the collector price assumption was based on RETScreen standard assumptions. A price of $5,750/kW was assumed.

- Inverter Specifications – An inverter with a capacity of 0.36 kW (DC to AC) is used. This figure was suggested by the software (RETScreen) after taking the kWp rating of the solar array into account. The inverter is priced using the database built in the software.

- Capacity Factor – A capacity factor of 18% was assumed. The capacity factor represents the portion of the total hours in a year in which the system is producing at its full rated capacity.

[31] Personal communication with Bill Kallock, Native Energy, August 2007.

## Table 3-5. Assumed System Characteristics

| System Characteristics | Units | Estimate |
|---|---|---|
| Application type | - | On-grid |
| Grid type | - | Central-grid |
| PV energy absorption rate | % | 100.0% |
| PV Array | | |
| PV module type | - | mono-Si |
| PV module manufacturer / model # | | BP solar |
| Nominal PV module efficiency | % | 11.7% |
| NOCT | °C | 45 |
| PV temperature coefficient | % / °C | 0.40% |
| Miscellaneous PV array losses | % | 5.0% |
| Nominal PV array power | kWp | 5.00 |
| PV array area | m² | 42.7 |
| Power Conditioning | | |
| Average inverter efficiency | % | 95% |
| Suggested inverter (DC to AC) capacity | kW (AC) | 4.8 |
| Inverter capacity | kW (AC) | 4.8 |
| Miscellaneous power conditioning losses | % | 0% |

## Table 3-6. System Cost Assumptions

| Energy Equipment | Unit | Number of Units | Price per unit | Total Cost |
|---|---|---|---|---|
| PV module(s) | kWp | 5.00 | $ 5,750 | $ 28,750 |
| Transportation | Project | 0 | $ - | $ - |
| Other - Energy equipment | Cost | 0 | $ - | $ - |
| Credit - Energy equipment | Credit | 0 | $ - | $ - |
| Sub-total : | | | | $ 28,750 |
| Balance of Equipment | | | | |
| _ Module support structure | $M^2$ | 42.7 | $ 100 | $ 4,274 |
| _ Inverter | kW AC | 4.8 | $ 1,000 | $ 4,800 |
| _ Other electrical equipment | kWp | 5.00 | $ - | $ - |
| System installation | kWp | 5.00 | $ 1,500 | $ 7,500 |
| Transportation | project | 0 | $ - | $ - |
| Other - Balance of equipment | Cost | 0 | $ - | $ - |
| Credit - Balance of equipment | Credit | 0 | $ - | $ - |
| Sub-total : | | | | $ 16,574 |
| Miscellaneous | | | | |
| Training | p-h | 6 | $ - | $ - |

| | | | | | |
|---|---|---|---|---|---|
| Contingencies | % | 0% | $ 45,324 | $ | - |
| Sub-total : | | | | $ | - |
| | | | | $ | 45,324 |

## PV Findings and Recommendations

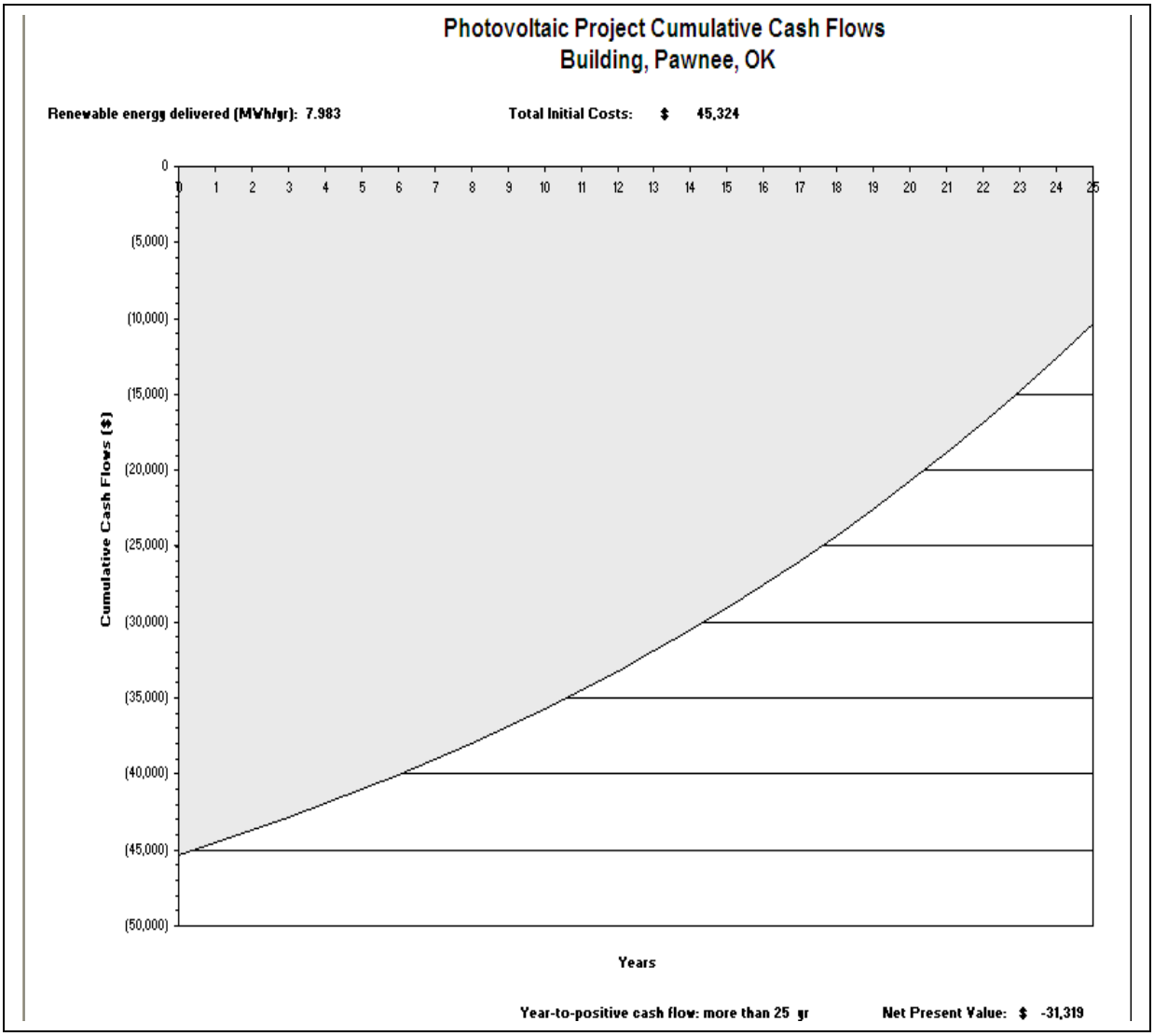
In the absence of additional financial incentives or creative financing, PV would not be a cost effective option for Pawnee Nation. The 5 kW system that was modeled through the RETScreen analysis would have a total upfront cost of approximately $45,000 and would produce approximately 8,000 kWh per year. Assuming Pawnee Nation were to own the system (as a tribe rather than as a private enterprise) the simple payback on the project would be on the order of 30 years, and the net present value of the investment would be approximately -$31,000. However, this does not mean that a PV system is out of the question for Pawnee Nation.

Project economics would be somewhat more favorable if Pawnee Nation were to build a PV system through its own private business enterprise (i.e., the Tribal Development Corporation), as this would make the project eligible for more financial incentives (i.e., USDA grant and federal investment tax credit). However, the project economics would still be poor, with a simple payback on the order of 22 years. This is based on a preliminary analysis which did not involve an in-depth analysis of the tax treatment of a private tribal business enterprise.

Another alternative that could present an opportunity for PV system investment is for the tribe to borrow funds, potentially at below-market interest rates (see summary of financial incentives in a later section). As long as the value of the power produced by the system exceeds the interest costs on the loan, Pawnee Nation will see a positive cash flow and the system will provide value as an example of the tribe's commitment to the environment, as an educational tool, and potentially as a means of improving reliability of electricity supply for the fire / police station.

Another financing option that can make development possible for some tribal projects is a Power Purchase Agreement with a private entity that would actually own and operate the system. This enables the private entity to take advantage of substantial federal tax incentives and greatly simplify the financing and logistical burdens faced by the tribe. However, companies offering PPAs are not interested in small scale projects because they are not as profitable as larger projects (i.e., 250 kW and larger), and therefore, this does not appear to be an option for Pawnee Nation.

**Figure 3-13. Photovoltaic Project Cumulative Cash Flow Chart**




## 3.2.3 Solar Hot Water

Solar water heating systems (SHW) are generally composed of solar thermal collectors, a fluid system to move the heat from the collector to its point of usage, and a reservoir or tank for hot water storage. The systems may be used to heat domestic hot water, swimming pool water, or for space heating (though this is typically less cost-effective). In some climates, the heat can also be used for industrial applications or as an energy input for other uses such as cooling equipment. In many climates, a solar heating system can provide a very high percentage (50 to 75%) of domestic hot water energy. Because they tend to be so cost effective, solar hot water systems are already very popular in many European countries and in other parts of the world. This section describes the research team analysis of the feasibility of installing a solar hot water system on a Pawnee-owned facility.

## System Siting Considerations

Solar hot water systems perform better, and are more economically feasible in buildings with a sizeable and consistent demand for hot water. Through discussion with Pawnee Nation representatives, the gym was identified as the best candidate for a solar hot water system, as its locker room uses a great deal of hot water, and the building has adequate roof space for located solar collectors. The gym is used throughout the year, though heaviest use is during the winter basketball season. Locker room usage can range from 60 – 100 people per day. The solar hot water system simulated here only takes the shower loads into account; it does not take hand washing and laundry-related hot water loads into account.

## Research Methods

All analysis was completed using RETScreen, the same tool used for completing PV system analysis. The RETScreen analysis factored in a full range of equipment and labor costs, as well as project revenues in the form of avoided energy costs. Default RETScreen assumptions were used for equipment and labor costs. These costs are built into the RETScreen tool as either per unit costs or costs based on the ratio of system cost and system size. For project revenues, an avoided energy cost of $12.85 per thousand cubic feet.[32] No other project revenues were included in the analysis, as no other financial incentives exist for solar hot water systems. Additional assumptions used in the analysis include the following:

- *Type of system used* – Given that the temperature in Pawnee falls below freezing in the winter (Mesonet data), a water heating system with freeze protection is used. The system used here is an indirect system with a heat exchanger and a mixture of water and glycol as the working fluid. Hence the system has other requirements such as a pump, heat exchanger and a storage tank. All these systems will be sized to optimize the system for the gymnasium on the Pawnee nation land.

- *Load on the system* – The load on the system represents the average daily load on the system. This will be the total volume of hot water consumed by the system. Understanding system load is important for determining system size. The daily load for the gym was determined on the basis of number of people that shower on an average and the national average usage of water per person per shower (12 gallons per person per day).[33] Pawnee Nation representatives reported that the locker rooms are used by 60 – 100 people per day; most of them use the showers and there is also a lot of hand-washing. Assuming that the maximum possible hot water load would occur with 100 people a day using the gym shower, the building would have a total daily hot water load of 1,200 gallons.

- *Base system* – The existing water heating system is fueled with natural gas. The system efficiency was assumed to be 70 % (RETSCREEN-3 manual).

- *Storage tank volume (m3)* – Annual system performance remains relatively insensitive to storage capacity once storage capacity is more than 50 liters per square meter of collector. Here storage volume is assumed to be 75 liters/ square feet.[34]

- *Collector number and size* – The optimum collector size is automatically determined by RETScreen as one of its standard outputs. The suggested collector size here is 61 square meters which equates to 27 collectors.

[32] Energy Information Administration: national average, August 2007.
[33] From AWWARF Residential End Uses of Water study.
[34] Duffie and Beckman. (2006) *Solar Engineering of Thermal Processes*, Third edition.

- *Pump* – As the system modeled is an indirect system with a heat exchanger, a pump is required. The pump sizing is based on information given in the RETScreen-3 user manual. The suggested collector area for the given load is 61 square meters, hence a pump of 205 watts is chosen for this system.

- *Piping and solar tank losses* – These losses account for heat lost from the pipes and the solar tank. Losses are assumed to be around 5% for the system used in this analysis.[35]

- *Collector orientation* – To optimize the collection of incident radiation, it is advised that the collector faces south, this assumption has been used for the purpose of this analysis.

- *Collector slope* – The slope of the collector can be adjusted to maximize the incident solar radiation on a collector in a given location. However, this is dependent on the slope of the roof, keeping the slope of the collector equal to the slope of the roof makes installation easy and is aesthetically more pleasing than a collector which has a different slope than the roof. Here collector slope is assumed to be equal to latitude (36.2 degrees).

[35] Based on data from RETScreen-3 user manual.

**Table 3-7. Cost Inputs for Solar Hot Water Analysis**

| Energy Equipment | Unit | Number of units | Cost per unit | Total Cost of component | % of total |
|---|---|---|---|---|---|
| Solar collector | M² | 61.0 | $ 65 | $ 3,966 | |
| Solar storage tank | L | 4,050 | $ 1.40 | $ 5,670 | |
| Solar loop piping materials | M | 41 | $ 6.00 | $ 248 | |
| Circulating pump(s) | W | 189 | $ - | $ - | |
| Heat exchanger | kW | 32.4 | $ - | $ - | |
| Transportation | project | 1 | $ 100 | $ 100 | |
| Other - Energy equipment | Cost | 0 | $ - | $ - | |
| Sub-total : | | | | $ 9,984 | 80.2% |
| Balance of System | | | | | |
| Collector support structure | M² | 61.0 | $ - | $ - | |
| Plumbing and control | project | 1 | $ 300 | $ 300 | |
| Collector installation | M² | 61.0 | $ 10 | $ 610 | |
| Solar loop installation | M | 41 | $ 2.00 | $ 83 | |
| Auxiliary equipment installation | project | 1 | $ 50 | $ 50 | |
| Transportation | project | 1 | $ 50 | $ 50 | |
| Other - Balance of system | Cost | 0 | $ - | $ - | |
| Sub-total : | | | | $ 1,093 | 8.8% |
| Miscellaneous | | | | | |
| Training | p-h | 4 | $ 60 | $ 240 | |
| Contingencies | % | 10% | $ 11,317 | $ 1,132 | |
| Sub-total : | | | | $ 1,372 | 11.0% |
| Initial Costs - Total | | | | $ 12,448 | 100.0% |

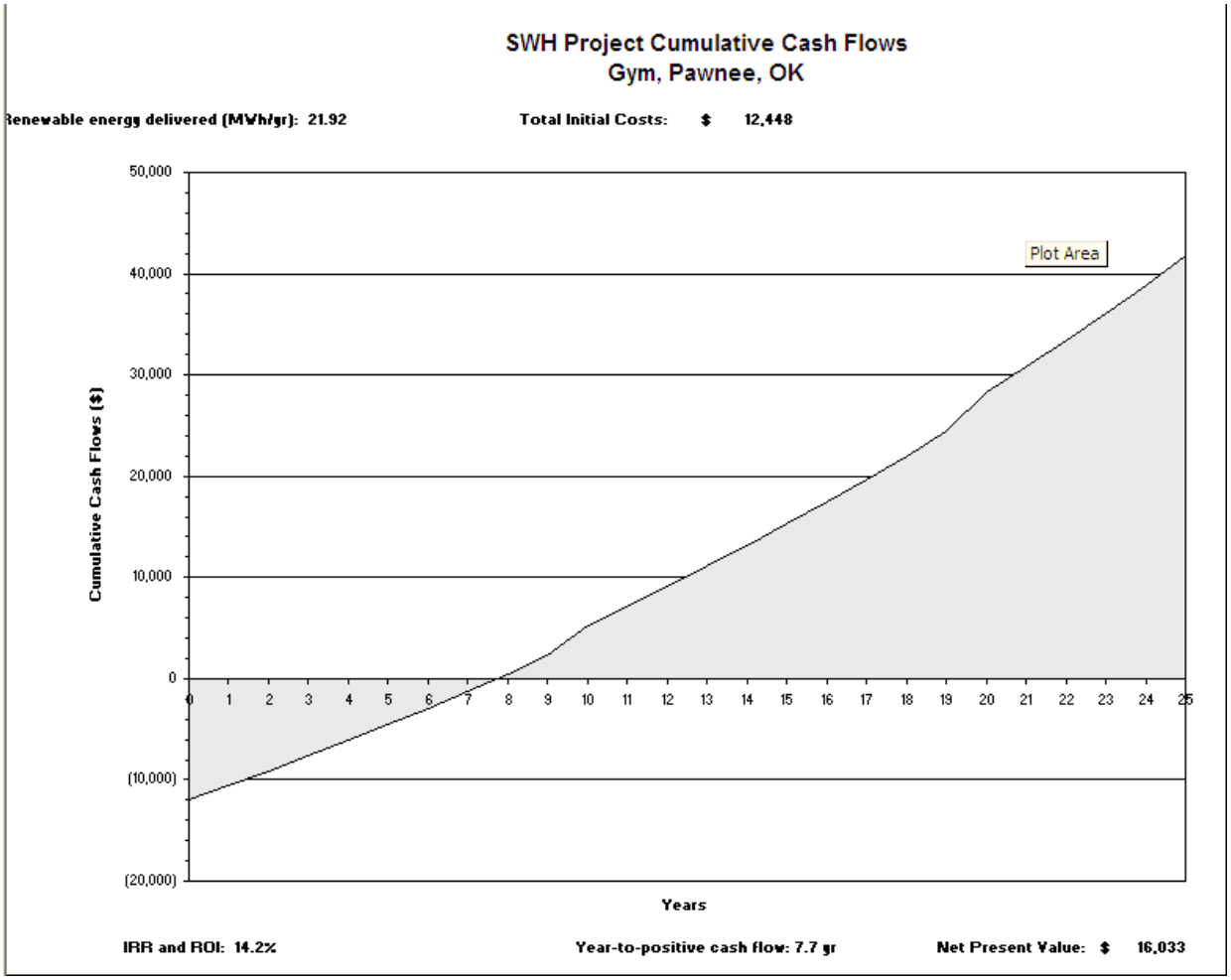
## Solar Hot Water Findings and Recommendations

Based on the assumptions used by the research team, the system would have a total upfront cost of $12,500 and would produce the equivalent of 45 MWh per year. The system is projected to have much more favorable economics than the PV system. It will pay for itself in savings in less than four years, after which time it will start "earning" money for Pawnee Nation. Information provided by the Pawnee nation suggests that the water heating system is used predominantly in the winter months and underused in the summer. Accounting for dominant winter usage, the payback would increase to 7.7 years. This total comes up to $42,000.00. Given these favorable economics, the research team recommends that Pawnee Nation pursue installation of a solar hot water system.

Using an online tool, FindSolar.com, the research team identified three solar developers providing solar hot water installation services to Pawnee County. These companies include Harvest Solar Energy

(location: Tulsa; Website: HTTP://WWW.HARVEST-ENERGY.COM), SEI Systems (location: Bixby; Website: HTTP://seisystems.net), Sun City Solar Energy Inc (location: Tulsa; Website: HTTP://www.suncityenergy.com).

**Figure 3-14. Solar Hot Water System Cumulative Cash Flow Projections**




## 3.2.4 Solar Findings and Recommendations

Pawnee Nation's solar resource is slightly above average for the U.S., and is one of the most favorable renewable energy resources available on the reservation. Preliminary analyses of economic feasibility were conducted for both PV and solar hot water systems. Based on current availability of financial incentives, a PV system owned by Pawnee Nation would not be economically feasible, and there is insufficient revenue available to attract an outside investor. Pawnee Nation may see somewhat more favorable economics if it were to develop a PV project through its own private business enterprise, as this would increase access to some incentives. However, project economics would still be unfavorable, with an expected simple payback on the order of 22 years. Installation of a PV system may be economically feasible for Pawnee Nation as well if favorable lending terms are secured. If PV system installation is a

priority for Pawnee Nation, the Energy Committee should pursue below market interest-rate borrowing opportunities available through BIA or USDA.

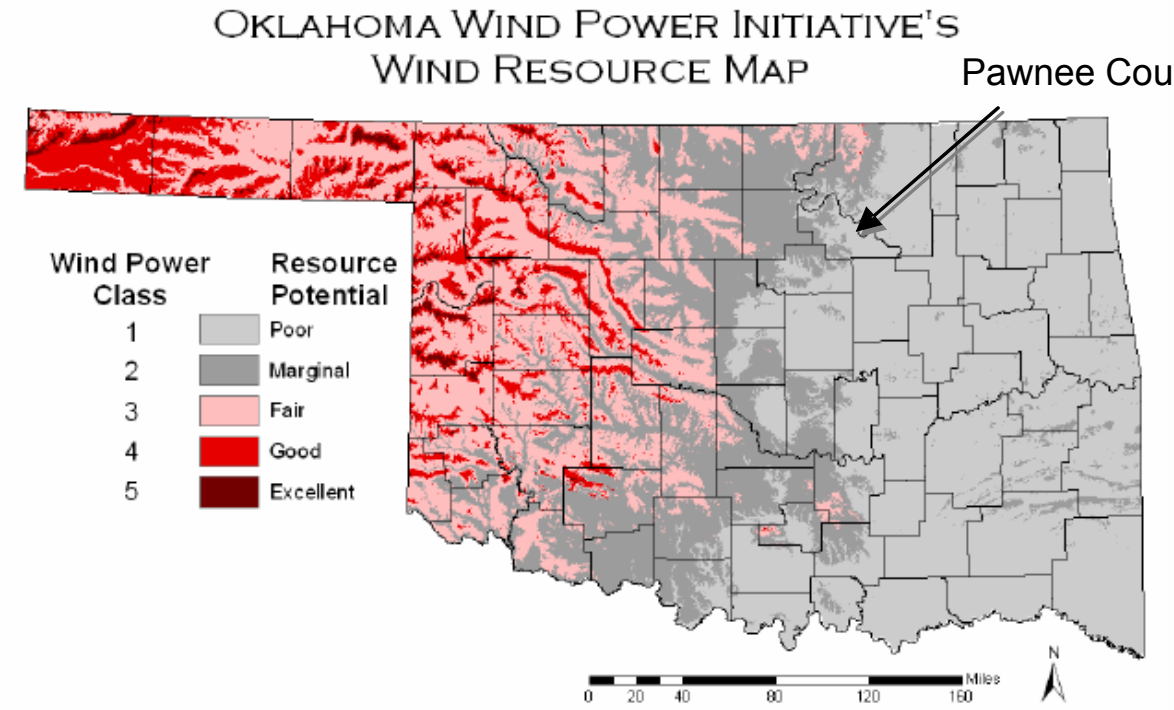
Solar hot water appears to possess highly favorable economics, with a payback period in the range of 8 years, and a net present value over $16,000. Given the favorable economics of a solar hot water system, the research team recommends that that Pawnee Nation pursue development of a solar hot water system for the gymnasium. Pawnee Nation's Energy Committee should first identify the appropriate sources to gain approval for installation of the system, and to determine whether the system's upfront cost of $12,500 would require assistance from a lender (either government subsidized or through a conventional lender). Three solar developers serving Pawnee County were identified, and Pawnee Nation should contact these developers to begin the process of solidifying project costs and moving toward project completion.

## 3.3 Wind

Wind power is one of the nation's most rapidly growing sources of new electric generating capacity, second only to natural gas-fired power plants in 2005 and 2006. Wind turbines provide an emission-free source of electricity, and when cited in a location with a strong wind resource and financial incentives, installation of wind turbines can be highly cost effective. Across much of Oklahoma, the wind resource is strong. However, as described below, the wind resource is relatively poor on the Pawnee Nation. This, combined with a lack of ideal net-metering opportunities and a lack of state-level financial incentives makes wind an unfavorable renewable energy development option for Pawnee Nation. It was clear to the research team from an early stage in the project that the wind resource is insufficient to warrant development of large-scale wind turbines (i.e., over 500 kW). However, to explore the economic feasibility of pursuing small-scale wind development, the research team completed a high level economic feasibility analysis.

### 3.3.1 Data Sources and Resource Availability

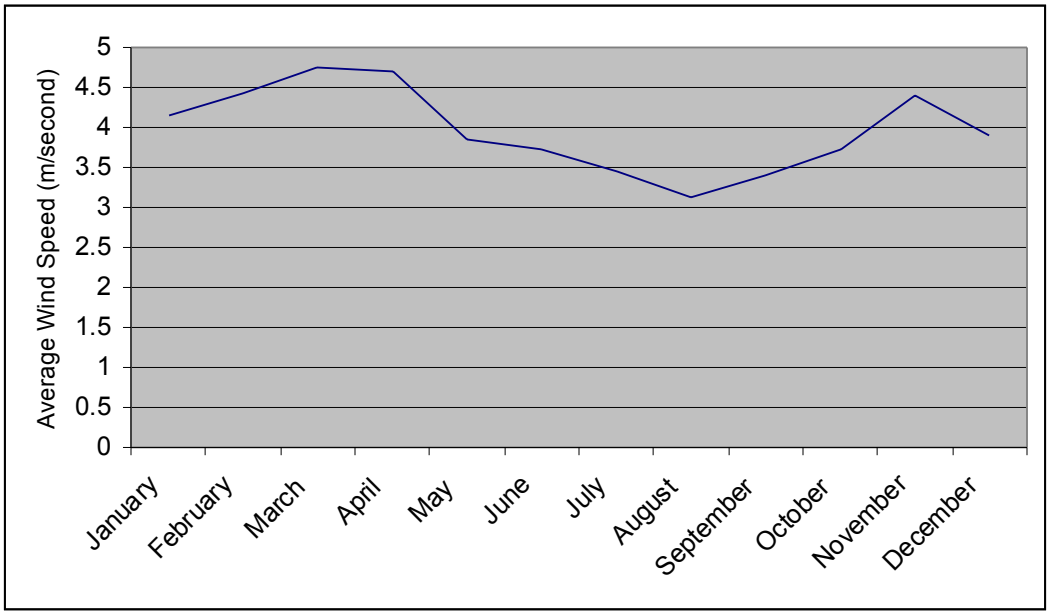
With portions of the state possessing excellent wind resources, Oklahoma has seen substantial growth in wind power development in recent years. The Oklahoma Wind Power Initiative provides data on the state's wind resource, and resources to assist in wind power development.




Source: OWPI, Wind Resource Map, 2000
www.ocgi.okstate.edu/owpi

The wind data used in this analysis was taken from Mesonet tower measurements. As noted in the solar resource discussion, the Oklahoma Mesonet is a system of environmental monitoring stations designed and implemented by scientists at the University of Oklahoma and Oklahoma State University. The 10 meter measurement tower used as the data source for this analysis is located on the Pawnee reservation four miles north of the city of Pawnee. The wind data presented in Figure 3-15 is an average of the data collected from the past two years. (June 2005 to June 2007).

**Figure 3-15. Average Wind Speeds, Pawnee Nation (2005-2006)**




The wind resource is Class 1 for the majority of the year, but reaches the Class 2 level (above 4.4 meters / second) in February, March, April and November. Power production from a wind turbine is highly sensitive to wind speed. According to the National Renewable Energy Laboratory, "*areas designated class 3 or greater are suitable for most utility-scale wind turbine applications, whereas class 2 areas are marginal for utility-scale applications but may be suitable for rural applications. Class 1 areas are generally not suitable, although a few locations (e.g., exposed hilltops not shown on the maps) with adequate wind resource for wind turbine applications may exist in some class 1 areas."*[36] Therefore, the research team analyzed small wind turbines (size ranging from 10 to 150 kW), as the wind resources can not support turbines of a higher capacity.

[36] (http://www.nrel.gov/gis/wind.html)

Wind speeds and resource class categories are summarized in Table 3-8.

**Table 3-8. Wind Speeds and Resource Class Categories**

| Class | Speed at 10 m in m/s |
|---|---|
| 1 | < 4.4 |
| 2 | 4.4 - 5.1 |
| 3 | 5.1 - 5.6 |
| 4 | 5.6 - 6.0 |
| 5 | 6.0 - 6.4 |
| 6 | 6.4 - 7.0 |
| 7 | > 7.0 |

## 3.3.2 System Siting Considerations

Recognizing that wind speeds can vary depending on the microclimate of a particular location, the research team worked with Pawnee Nation representatives to identify potential sites that would possess maximum wind speeds and minimal turbulence from surrounding obstacles, and would be close to existing building loads and distribution system tie-in points to facilitate the more favorable project economics associated with net metering.[37] Sites discussed as having potential for small wind development include:

- Travel Plaza—This site, located south of reservation at the junction of I-412 and Hwy 18, is the site of a small casino. The facility is not owned by Pawnee Nation, presenting a barrier to the potential for development. However, Pawnee representatives noted that an owner of land near the site is interested in selling property.

- Northern Hilltop—Land on a hilltop on the northern portion of reservation was also discussed, but this site does not appear to be located near an existing building load that could enable a wind project to take advantage of net metering.

- Twin Mountains—This is a 10 acre site where an old burial ground is located. It is not currently owned by Pawnee, but Cecil Riding In thought Pawnee members would be open minded to wind

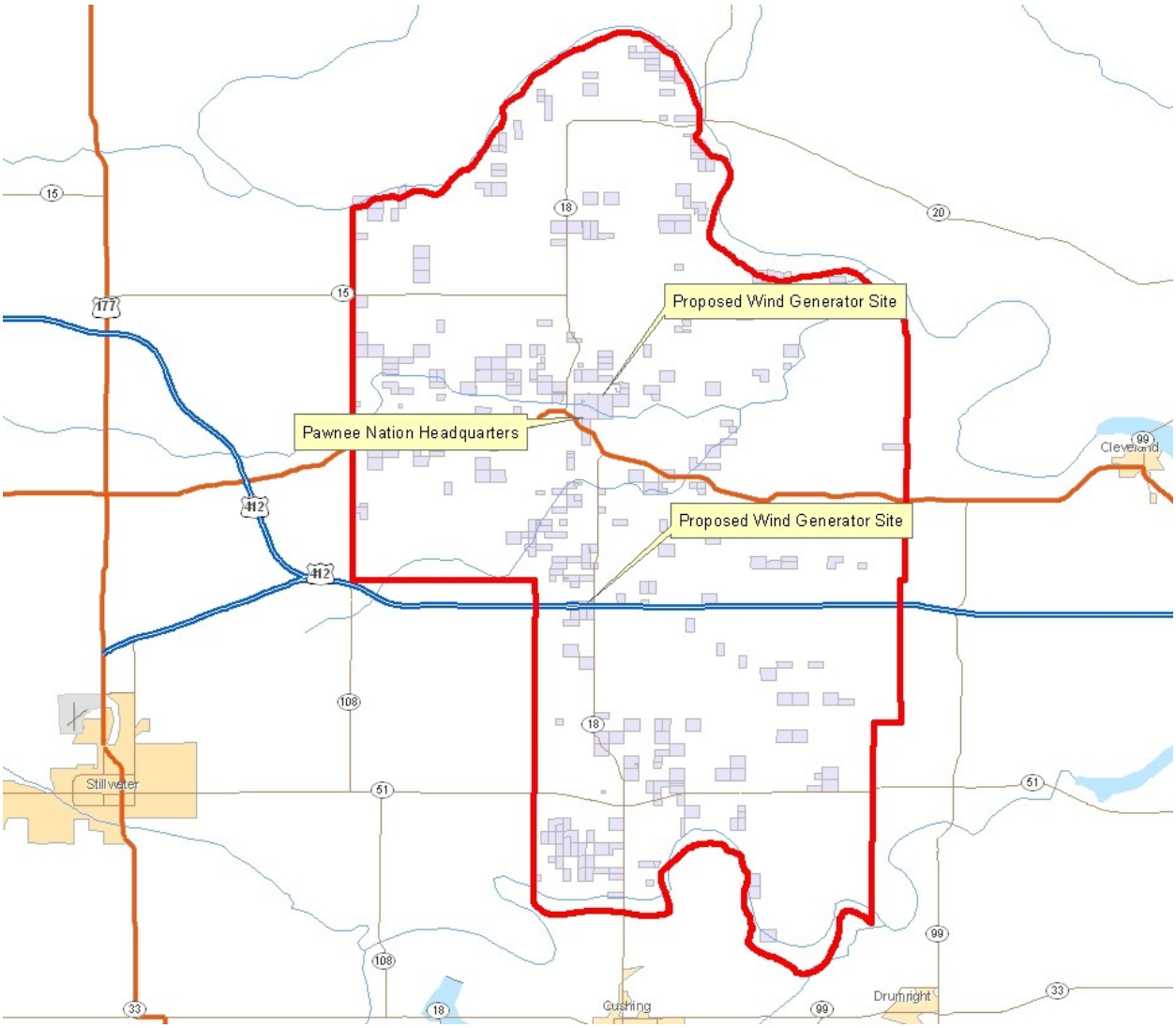
[37] When a project is net metered, the revenue stream from power production is the retail electricity rate rather than the wholesale rate, which has significant implications for project economics.

development there if the site were purchased. This site does not appear to be located near an existing building load that could enable a wind project to take advantage of net metering.

- Chilocco School Site—This is the site where construction of a large casino is planned. The site is located 4 miles south of Kansas state line on Hwy 77. Pawnee owns land there, along with other tribes including the Kaw and other tribes. A portion of the land is jointly owned by these tribes and is being developed in collaboration with Kaw Nation. Kaw Nation has researched on the site for wind potential and found that only a low to moderate resource exists. Kaw Nation did not receive funding to build upon past wind feasibility work there, however, the research team learned that the Cherokee Nation is now pursuing wind development at the site.

Figure 3-16 shows the Travel Plaza (southern point) and Northern Hilltop (northern point) locations.

**Figure 3-16. Sites Discussed as Potential Wind Turbine Locations**




Due to Pawnee land ownership or lack of existing building loads to facilitate the use of net metering, none of the sites discussed appears to have strong enough potential to warrant development. Given that the Travel Plaza does have a large exiting building load and potential for net-metering a wind turbine,

Pawnee Nation could potentially consider options to purchase the site. Assuming the wind resource is consistent with the data from the Mesonet measurement tower, even with net metering, the project economics would still be very poor, as discussed below. However, it is possible that the site could have a wind resource that is moderately better than the Mesonet site.

## 3.3.3 Research Methods

As with the solar systems analyzed, the research team used the RETScreen tool to analyze projected performance and economic feasibility of small wind systems.

### System Characteristics and Costs

Table 3-9 presents the range of wind turbines that were included in the analysis. All these turbines with the exception of the last turbine fall in the "Small turbine" category. The total installed cost is assumed to consist of turbine cost, tower cost and installation cost. In addition, there are some operation and maintenance (O&M) costs also associated with a turbine.

**Table 3-9. Wind Turbines Included in Analysis**

| Installed Capacity (kW) | Turbine Manufacturer | Turbine Cost ($) [1] | Tower Cost ($)[2] | Installation Cost ($)[3] | Total Installed Cost ($/kW)[4] | O&M ($/kW/yr) [5] |
|---|---|---|---|---|---|---|
| 1 | | 2,300 | 1,600 | 1,100 | 5,000 | 19 |
| 10 | Bergey Windpower Company | 28,900 | 9,200 | 11,400 | 4,950 | 16 |
| 50 | Entegrity Wind Systems Inc. | 135,000 | 35,000 | | 3,400 | 18 |
| 100 | Fuhrlander | | 380,000 | | 3,800 | 22 |

Project costs included turbine costs provided by manufacturers (shown in Table 3-9), as well as default assumptions for the cost of spare parts, and balance of plant costs. For small wind farms, the cost of spare part can amount to up to 30 % of the cost of a single turbine.[38] For our analysis, we assume spare parts to be 15 % of the cost of a single turbine. The balance of plant of a wind plant includes wind turbine foundation, erection, road construction, transmission line, control and transportation costs. For a small wind farm these costs typically fall between 13 and 22 % of total project costs.[39] For our study we assume a value of 13 % since only a single turbine is being analyzed.

A range of system characteristics were factored into the analysis (i.e., wind shear exponent, degradation and downtime losses). RETScreen default assumptions were used. A capacity factor of 12% was assumed, given the predominantly Class 1 resource available on Pawnee lands.

## Project Revenue Assumptions

The same project revenues were assumed for wind as were assumed for the PV analysis described above. The assumptions include the following.

- Avoided cost of electricity – For electricity produced by the PV system that is used to serve building loads, a value of 9.5 cents/kWh was assumed. This is consistent with retail electricity rates paid by Pawnee Nation.

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[38] Lynette, R. and Associates. (1992) *Assessment of Wind Power Station Performance and Reliability*.

[39] (RETScreen-3 User Manual)

- Renewable Energy Production Incentive - The Renewable Electricity Production Incentive (REPI) is a per kilowatt-hour federal financial incentive for electricity generated by PV and other qualified energy resources. At present the value of this credit is $0.02/kWh. This credit is only valid for 10 years for solar and wind resources, and funding availability is subject to annual congressional appropriations.[40]

The state of Oklahoma does not offer any incentives for wind systems smaller than 1 MW. Another potential revenue source considered by the research team was Renewable Energy Certificates (RECs). RECs represent the environmental benefits associated with the electricity produced by renewable energy systems. The most substantial REC markets exist in states with minimum renewable energy supply requirements ("Renewable Portfolio Standards," or "RPS requirements").

In addition, a comparatively small but growing "voluntary" REC market exists in the U.S. REC values are generally much lower in the voluntary market than in the RPS compliance markets. However, as discussed in a later section focusing on financial incentives for renewable energy, a REC broker called Native Energy focuses on matching tribal renewable energy projects with REC revenue sources. A Native Energy representative quoted the research team a value of $0.003/kWh to $0.005/kWh for solar RECs.[41] This value is too low to make PV cost effective without being combined with other much more substantial financial incentives. Due to the relatively small scale of the project being considered for the purposes of this analysis, the Native Energy REC revenue would not make a substantial impact on the revenue stream and was not factored into the analysis. However, it should be noted that this revenue source is available and would make PV economics slightly more favorable than the results of the analysis presented here.

## Results

[40] Database of State Incentives for Renewable Energy (www.dsireusa.org).

[41] Personal communication with Bill Kallock, Native Energy, August, 2007.

**Figure 3-17. Financial Summary for 10 kW Turbine**

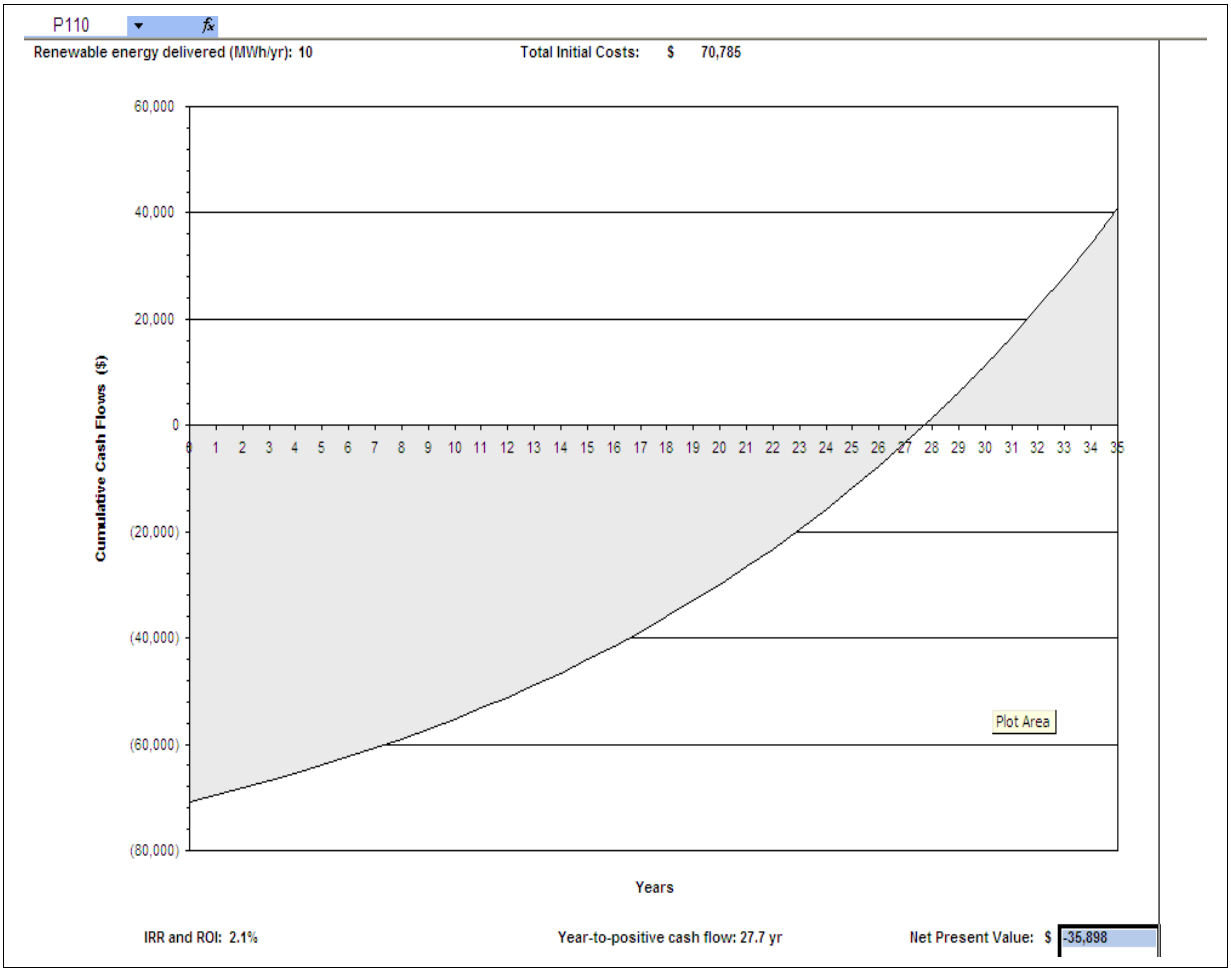
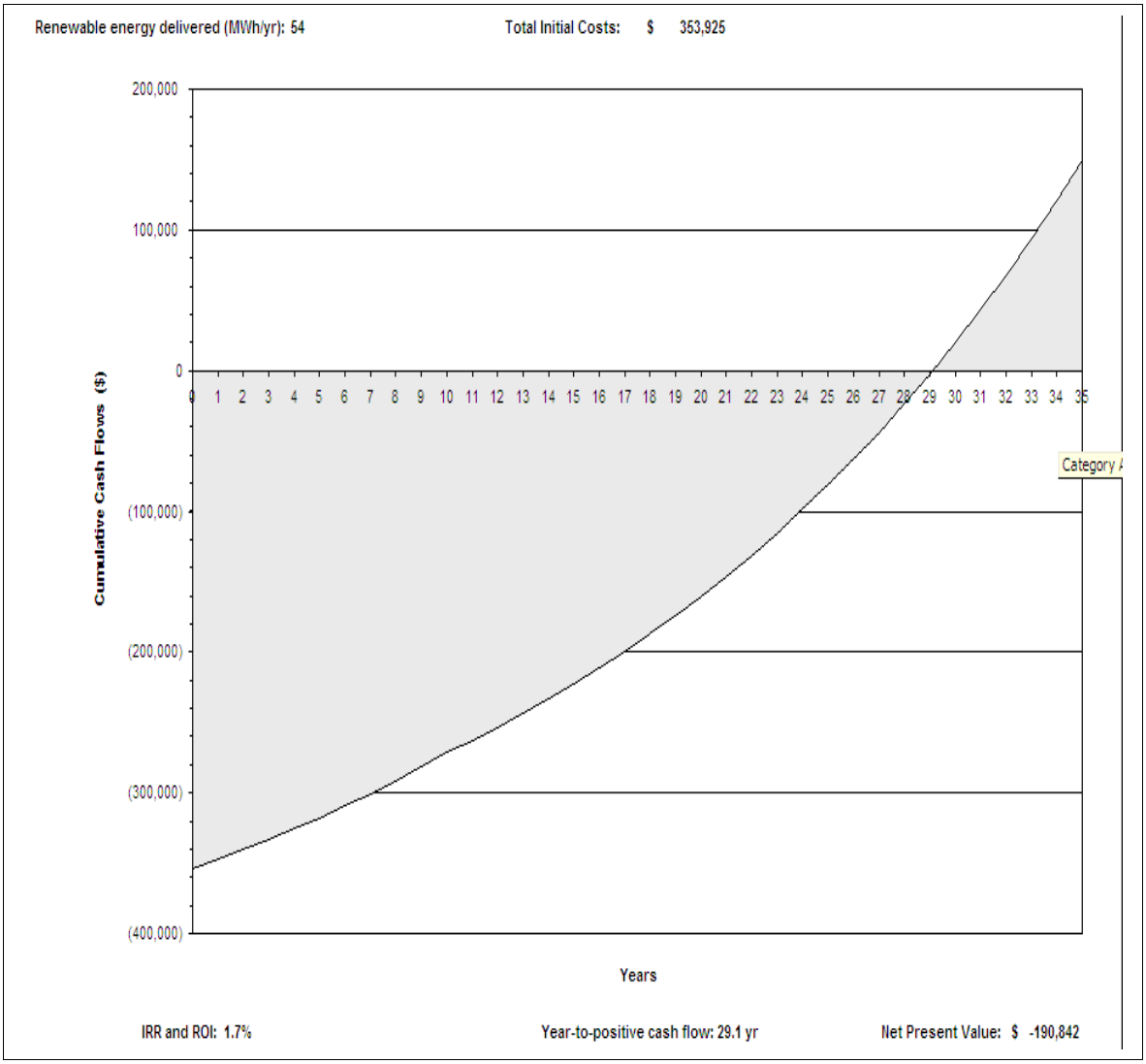


**Figure 3-18. Financial Summary for 50 kW Turbine**




## 3.3.4 Wind Findings and Recommendations

Due to a poor wind resource, a lack of availability of ideal sites for net metering, and a lack of state financial incentives, the economics of a small wind would be insufficient to warrant investment by Pawnee Nation. Financial summary graphs are presented for the 10 and 50 kW turbines. For the 10 kW turbine, the simple payback period is 27 years. Usually technologies with a payback of greater than 15 years are not considered financially viable. The payback period for the 50 kW turbine is 29 years while the 100 kW turbine takes longer than 35 years for return in investment. This analysis assumes that the wind system would be owned by Pawnee Nation (as a tribal entity).

As was discussed in the PV findings and recommendations, a wind project owned by a private tribal business enterprise may have somewhat more favorable project economics. While the research team did not conduct an in-depth assessment of the tax treatment of tribal business enterprise, which may affect the outcome, it is likely that but the investment would still be a poor business proposition with a simple payback period greater than 20 years.

As was also noted in the discussion of PV feasibility, if Pawnee Nation can identify additional financial resources, project economics could change substantially. In addition, if Pawnee Nation wishes to borrow money, loan guarantees, or subsidized lending opportunities may be an option, as discussed further in Section 3.5.

It is possible that the wind resource could be more favorable at a particular site than the one used as the basis for the assessment (a Mesonet 10 meter data collection tower located in the northern section of the reservation). The site that appears to have the greatest economic potential among those discussed with Pawnee Nation is the Travel Plaza. However, the site is not currently owned by Pawnee Nation. Pawnee Nation may wish to explore purchase or leasing arrangements with the property owner, and could obtain an anemometer through either an Oklahoma or DOE anemometer loan program to gather site specific data.

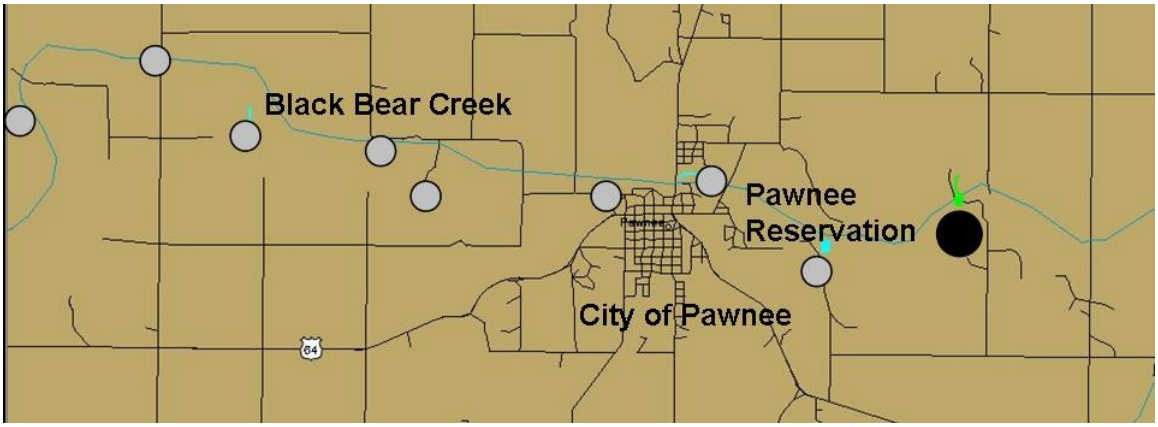
## 3.4 Hydro Power

### 3.4.1 Data Sources and Resource Availability

The primary resource used for determining the hydropower potential was an online GIS tool developed by the Idaho National Laboratory, known as the Virtual Hydropower Prospector (VHP).[42] This tool identifies the existing and potential hydropower sites for a specific region, based on factors such as hydraulic head, annual mean flow rate, and estimated power generating potential. Eighteen small microhydro (<100 kW) resource sites were identifies for the Pawnee region, as well as three low power conventional (10-30 ft hydraulic head, < 1MW) resource sites. In addition to resource sites, the VHP displays potential projects based on a set of feasibility criteria including site accessibility, transmission capabilities, load requirements, and environmental factors. The sites identified as feasible for development in the Pawnee region are presented in Figure 3-19. Potential microhydro sites are shown with grey circles, and the low power conventional hydro power generation site is shown with a larger black dot. A few of these locations appear to be close enough in proximity to the Pawnee reservation to potentially be owned by the reservation or by a member of the tribe, however, a determination of land ownership was not included in the study.

[42] The technical potential data in the Virtual Hydropower Prospector are based on a study published in 2004 by Hall et al. The study involved analytic assessments of water energy resources for the 20 hydrologic regions of the U.S. using state-of-the-art digital elevation models and geographic information system tools. According to Hall, "The assessments were made by estimating the power potential of all the stream segments in a region, which averaged 2 miles in length. These calculations were performed using hydrography and hydraulic heads that were obtained from the U.S. Geological Survey's Elevation Derivatives for National Applications dataset and stream flow predictions from a regression equation or equations developed specifically for the region." Further information on the VHP is available at http://hydropower.inel.gov/prospector/index.shtml.

**Figure 3-19. Potential Hydroelectric Project Sites**




Source: Idaho National Laboratory – Virtual Hydropower Prospector

### Table 3-10. Microhydro Projects

| Rec | Power (mW) | Power Class | Prime Candidate | State | County |
|---|---|---|---|---|---|
| 1 | 0.021 | Microhydro | Y | Oklahoma | Pawnee |
| 2 | 0.039 | Microhydro | Y | Oklahoma | Pawnee |
| 3 | 0.016 | Microhydro | Y | Oklahoma | Pawnee |
| 4 | 0.017 | Microhydro | Y | Oklahoma | Pawnee |
| 5 | 0.092 | Microhydro | Y | Oklahoma | Pawnee |
| 6 | 0.013 | Microhydro | Y | Oklahoma | Pawnee |
| 7 | 0.033 | Microhydro | Y | Oklahoma | Pawnee |
| 8 | 0.013 | Microhydro | Y | Oklahoma | Pawnee |

Source: Idaho National Laboratory – Virtual Hydropower Prospector

### Table 3-11. Low Power Projects

| Rec | Power Class | Prime Candidate | Power (mW) | Working Flow Rate (cfs) | Working Head (ft) | State | County |
|---|---|---|---|---|---|---|---|
| 1 | Low Power, Conventional | Y | 0.108 | 87.49 | 14.567 | Oklahoma | Pawnee |

Source: Idaho National Laboratory – Virtual Hydropower Prospector

In addition, monthly mean flow rate data were obtained from the USGS for Black Bear Creek.[43] These data are displayed in Table 3-12. The values are averaged from October 1944 to June 2007. The mean data shows a relatively flat flow rate with peaks in the spring and early summer.

### Table 3-12. Mean Monthly Flow Rates for Black Bear Creek

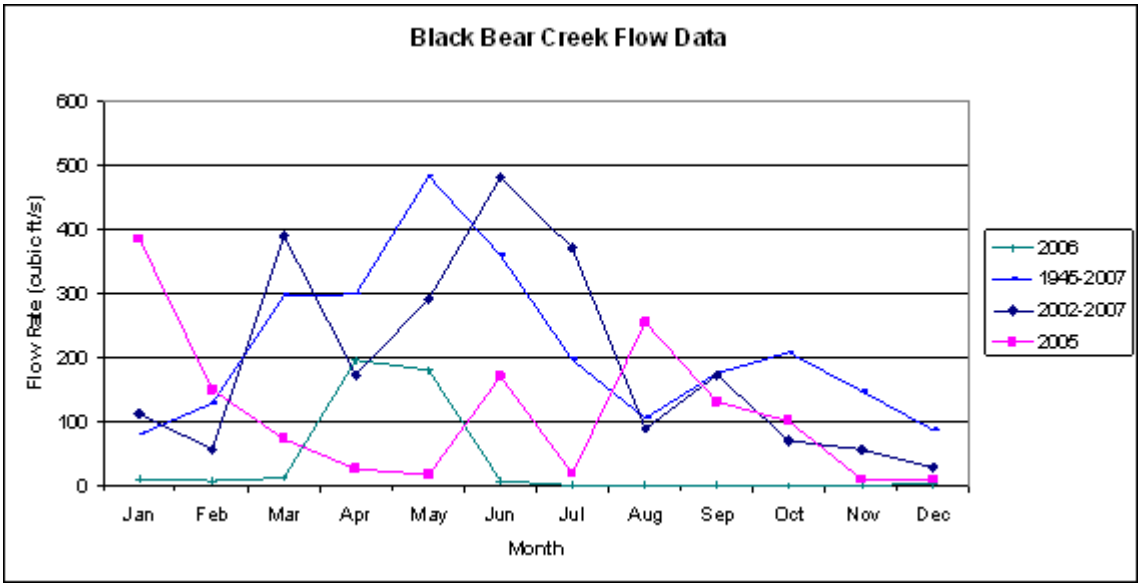
| | January | February | March | April | May | June | July | August | September | October | November | December |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cfm | 81 | 130 | 298 | 295 | 471 | 331 | 167 | 105 | 168 | 211 | 152 | 94 |

Source: United States Geological Survey

The data are inconsistent with reports from Pawnee Nation representatives who explain that Bear Creek is often dry during parts of the year, and flows at low levels for the remainder of the year. To determine whether this inconsistency is due to recent changes in flow rates, the research team looked at flow rates for the past five years. The measurements seem fairly erratic without a real pattern; 2006 shows practically zero flow rate, which corresponds to observations from Pawnee representatives, however, 2007 values show flow rates in 1000's of cfs. This indicates that data may be skewed due to environmental effects such as flash floods or inaccurate data readings. Further, it makes it difficult to accurately assess small scale hydropower development potential.

[43] http://waterdata.usgs.gov/nwis/sw

**Figure 3-20. Black Bear Creek Flow Rate Data**




Source: U.S. Geological Survey

In addition to the small scale hydropower development potential reviewed by the research team, the Arkansas and Cimarron rivers are close in proximity to Pawnee lands, and may prove to be a valuable resource for hydropower development. However, due to water rights and access issues, and the resources available for this project, potential for hydropower development on those rivers is outside the scope of this project.

## 3.4.2 Potential for Development

The data presented above shows that the majority of projects within the Pawnee region are micro-hydro sites with a power potential between 10-30 kW. Micro-hydro power can be delivered to sites up to a mile a way. Project costs range anywhere from $1000-$20,000 per location, depending on site characteristics, and carry low operational and maintenance costs relative to other power generating technologies.[44] However, power generated by micro-hydro will fluctuate seasonally, and may have environmental impacts due to rerouting of stream water. These factors must be considered when investigating project development. While each individual site listed above may not provide enough power to function independently, coordinated development of multiple sites may be more cost effective. The total power generating potential for the "feasible" projects listed above is approximately 350 kW.

While VHP data indicate that potential exists for the development of small-scale hydro power resources within the Pawnee region, the research team does not possess sufficient data to determine whether development of these sites is economically feasible at this time. Given anecdotal data from Pawnee Nation representatives, and a lack of financial incentives for renewable energy development in Oklahoma, it is unlikely that the sites would be economically feasible for development.

## 3.4.3 Hydro Findings and Recommendations

[44] http://www.alternative-energy-news.info/micro-hydro-power-pros-and-cons/

It is clear that a limited amount of small-scale hydro power development exists in the area surrounding the Pawnee reservation. However, more detailed analysis would be necessary to determine the whether development of these small scale resources would be economically feasible.

Next steps could include physical measurement of flow data for specific sites, examination of recent shifts in flow rate along Black Bear Creek, discussions with small scale hydro equipment vendors and project developers, and a complete financial analysis of potential development sites.

## 3.5 Funding Opportunities for Renewable Energy Resource Development

Accessing upfront capital to fund a tribal energy project is one of the key challenges associated with project development. A variety of grants have been made available in the past to fund renewable energy and energy efficiency-related activities on tribal lands. In general, grant opportunities should be maximized since they provide access to funds with no requirement for paying back the funding agency. However, very little grant funding for equipment and construction costs is currently available. Therefore, loans, loan guarantees, third party financing and other creative sources of project revenue must be considered in order to make an energy project viable. Following is a summary of potential funding opportunities of relevance to Pawnee Nation.

### 3.5.1 Federal Resources

#### Department of Energy

The **DOE Tribal Energy Program** has offered grants to tribes in the past for project construction, but no grant opportunities are currently available through this program. Pawnee Nation representatives should monitor the future availability of grants through the DOE Tribal Energy Program by checking the following website http://www.eere.energy.gov/tribalenergy/government_grants.cfm and subscribing to the DOE Tribal Energy Program list serve (contact Program Manager Lizana Pierce to subscribe: lizana.pierce@go.doe.gov).

DOE is currently accepting proposals for research grants to explore plant **feedstock genomics for bioenergy**. Grant funds will support research leading to the "improved use of biomass and plant feedstocks for the production of fuels such as ethanol or renewable chemical feedstocks. Pre-applications are due November 13, 2007 and final applications are due January 23, 2008. Further information by contacting: SCbiomass.genomics@science.doe.gov ; or visiting https://e-center.doe.gov/iips/faopor.nsf/UNID/1A749FE781C1AA8C8525736F00611D99?OpenDocument. This schedule does not provide sufficient time for Pawnee Nation to consider whether it would like to partner with a research entity to pursue such an opportunity, but the availability of the grants does indicate increased increase in biofuels by DOE, and further reason for Pawnee Nation to monitor future opportunities in this area.

The **Renewable Energy Production Incentive (REPI) Program** provides payments to tribes and other qualifying entities, based on the amount of electricity produced by an eligible renewable energy system. Eligible ***electricity producing*** renewable energy systems include solar, wind, geothermal, or biomass (except for municipal solid waste combustion), landfill gas, livestock methane, ocean (including tidal,

wave, current, and thermal) generation technologies, and fuel cells using hydrogen derived from eligible biomass facilities. Payments are made for the first ten years a renewable energy system is in operation, subject to availability of program funding. Participating entities currently receive a payment of 2 cents / kWh of production (indexed to inflation, based on 1.5 cents/kWh 1993 dollars).

The REPI program is a valuable source of revenue, but is unlikely to make a project (particularly a photovoltaic project) economically feasible without additional funding resources. Also, since the REPI is paid over time and is subject to budget appropriations, Pawnee Nation cannot depend on it as a source of upfront capital, or as a consistent source of funding over time. Additional information is available from:

Christine Carter
U.S. Department of Energy
Golden Field Office
1617 Cole Blvd.
Golden, CO 80401-3393
E-Mail: christine.carter@go.doe.gov
Web site: http://www.eere.energy.gov/

## Department of Interior, Division of Capital Investment (DCI) / Bureau of Indian Affairs

The **Loan Guaranty and Interest Subsidy Program** helps tribes obtain loans for economic enterprises that would not otherwise be approved without a guaranty. The program can also provide an interest subsidy, which is a rebate to the borrower for the difference between the lender's interest rate and the rate set for Indian loans by the U.S. Treasury. DCI will only guaranty the minimum amount necessary in order for the tribe to obtain financing. In addition, the borrower must have 20% equity in the business being financed immediately after the loan is funded. For individuals, the maximum loan amount that can obtain a guaranty is $500,000. Loan amounts can be higher for tribes and tribal enterprises.

A loan guaranty may be particularly relevant for an energy project in which lenders may not feel confident enough in the project revenue stream to issue the loan without the additional securitization provided by a guaranty. To obtain a loan guaranty, Pawnee Nation would contact a standard lender. The lender would determine whether the guaranty is necessary and would process the application. Additional information is available at http://www.eere.energy.gov/tribalenergy/loans.cfm.

## Small Business Innovation Research and Small Business Technology Transfer Programs

**Small Business Innovation Research (SBIR)** and **Small Business Technology Transfer (STTR)** grants are issued by 11 different federal agencies including DOE and USDA. These federal agencies set aside a portion of their Research and Development (R&D) budgets to support SBIR small businesses' technology innovation and commercialization activities. Projects funded under the STTR program must involve substantial research collaboration with a non-profit research institution. Different federal agencies define different priorities for their SBIR and STTR funds. Both the DOE and USDA have emphasized renewable energy-related topics in recent years.

The grant programs are broken into three phases: Phase I funds feasibility studies of innovative concepts, Phase II provides additional funds for research and development (R&D) activities, and Phase III provides ongoing support for an entity's commercialization efforts. Phases II and III are only open to recipients of Phase I grants.

These programs would probably be most applicable for Pawnee Nation if the tribe were interested in pursuing a biomass-related growth and harvest R&D project in collaboration with an Oklahoma university (i.e., using Pawnee lands to grow experimental crops, or to test experimental growth / harvest techniques). If interested, Pawnee Nation should coordinate with representatives from the Oklahoma Bioenergy Center (see description under state-level funding discussion) who would likely wish to leverage that program's own funding resources (see below for more information on the Oklahoma Bioenergy Center). General information on SBIR grant programs across all federal agencies can be found at http://www.sbirworld.com/solicitations/solicitations.asp. Proposals for DOE SBIR Phase I grants are due on November 27, 2007. Further information DOE SBIR grants is available at www.science.doe.gov/sbir, telephone (301-903-1414) or e-mail (sbir-sttr@science.doe.gov).

## Department of Housing and Urban Development

Through its **Indian Home Loan Guaranty Program**, HUD offers loan guarantees to facilitate home ownership and home rehabilitation for Native American individuals and tribally-designated entities such as housing authorities. The primary purpose of the program is to improve access to private mortgage financing. Additional information is available at http://www.eere.energy.gov/tribalenergy/loans.cfm.

Through its Tribal Housing Activities Loan Guaranty Program, HUD provides loan guarantees for Indian Housing Block Grant recipients needing access to additional funding. Further information is available at http://www.eere.energy.gov/tribalenergy/loans.cfm.

## Department of Interior, Division of Energy and Mineral Development

The **Division of Energy and Mineral Development (DEMD)** issues annual solicitations for proposals from tribes interested in conducting feasibility assessments for energy resource development, both renewable and non-renewable. Grants can be used to hire BIA or an independent consultant to conduct the assessment. Funds are only available for feasibility assessment, not for actual project construction. DEMD issued a solicitation for the fiscal year 2008 round of funding in September 2007 and will accept applications through mid-January 2008. Based on information from the program's contact, Robert Anderson, project funding can range from $10,000 to $200,000 for very large-scale projects.

Pawnee Nation may consider applying for a grant for a more detailed assessment of biomass development options related to harvesting crops for bioenergy. This may also be a good opportunity for Pawnee Nation to explore mineral development opportunities, as members of the Energy Committee explained that this is another priority for the tribe.

## US Department of Agriculture (USDA)

USDA makes grants and loan guarantees available to rural small businesses, ***not*** directly to tribes. However, Jody Harris, USDA's energy coordinator for Oklahoma, noted that there is some discussion about making USDA funds available to tribes.[45] Therefore, Pawnee Nation should maintain communications with USDA's Native American Coordinator for Oklahoma, David Moore, and the energy coordinator, Jody Harris, to monitor future developments related to USDA funding for rural small businesses. Contact information is provided below:

David Moore
Native American Coordinator, OK

Jody Harris
USDA Rural Energy Coordinator, OK

[45] Personal communication with Jody Harris, USDA Rural Energy Coordinator for Oklahoma, August, 2007.

Phone: (918) 423-7602 (ext. 114)
Email: david.moore@ok.usda.gov

Phone: (405) 742-1036
Email: jody.harris@ok.usda.gov

USDA makes **Rural Business Enterprise Grants (RBEG) and Rural Business Opportunity Grants (RBOG)** available to tribes as well as public entities and non-profit organizations located in rural areas for the purposes of facilitating development of private business enterprises.[46] Under the RBEG Program, there is no limit to grant funds, though smaller projects are preferred. Grant funds can be used for a wide range of activities including technical assistance and training, building construction and renovation, the purchase of machinery and equipment, and capitalization of a revolving loan fund that will make loans to startups.

The RBOG program targets communities with exceptional needs. Grants serving a single state are limited to $50,000. The program focuses on funding training and technical assistance activities.

If members of the Pawnee Nation are interested in developing an energy services-related business that would provide energy efficiency and/or renewable energy-related services, this program may be a good source of funding. **Rural Business Opportunity Grants** are targeted to communities with exceptional needs. Applications must be made through Oklahoma's Rural Development State Office. The relevant contact for tribes is:

USDA's **Renewable Energy Systems and Energy Efficiency Improvements Program** provides grants and loan guarantees to small businesses and agricultural producers purchasing renewable energy equipment and making energy efficiency improvements. Grants can cover up to 25% of a project's cost, not to exceed $500,000. Loan guarantees can support up to 50% of a project's cost. According to Jody Harris, USDA prioritizes combination grant / loan guarantee applications. The combination of the grant and loan guarantee can support a maximum of 50% of a project's cost. Applications must be made through the Oklahoma USDA Rural Development Office. The contact there is David Moore. Jody Harris, Rural Energy Coordinator for Oklahoma, is another helpful source of information.

USDA's Electricity Program offers a **High Energy Cost Grant Program** in which entities within rural communities with home energy costs that are greater than 275% of the national average qualify for grants to pay for energy efficiency, generation, transmission or distribution related projects. The current funding solicitation closed on October 1, but it appears that Pawnee Nation would not have qualified given that energy costs are not 275 percent of the national average. However, Pawnee Nation should monitor funding availability through this program going forward the tribe's eligibility may change in the future. See http://www.usda.gov/rus/electric/hecgp/overview.htm for more details on the program and its eligibility requirements.

USDA's **Value Added Producer Grants** can be used for "planning activities and for working capital for marketing value-added agricultural products and for farm-based renewable energy." This could potentially fund biomass cultivation and harvest-related activities. The application deadline for the fiscal year 2007 funding cycle was May 16, 2007. However, Pawnee Nation should monitor availability of funds through this program under future budget cycles. Further information is available at http://www.rurdev.usda.gov/rbs/coops/vadg.htm.

## 2007 Farm Bill, the Food and Energy Security Act

Existing opportunities available through the USDA and other federal agencies would be enhanced substantially with passage of the **2007 Farm Bill, the Food and Energy Security Act,** which was

[46] Rural is defined as "any area other than a city or town that has a population of greater than 50,000 inhabitants and the urbanized area contiguous and adjacent to such a city or town."

approved by the Senate Committee on Agriculture in late October and will next be considered by the full Senate. The bill would provide $6 million per year in federal grants and subsidies to promote education and awareness of biofuels and expand federal procurement initiatives; it includes nearly $1billion in incentives to promote and establish infrastructure for production of biofuels; and over $300 million in funds to promote rural development of and research into biofuels. The bill also includes funding for woody biomass-related research and development. Further information on the status of the bill is available at http://agriculture.senate.gov/.

## Environmental Protection Agency

Tribes are eligible to apply for **Source Reduction Assistance Grants** which provide funds for energy conservation activities, among other pollution prevention-related strategies. For fiscal year 2007 funding, EPA Region 6, the region serving Oklahoma, was among the Region's offering funds through the program. EPA Region 6 sought proposals in the following areas:

- Pollution prevention opportunities with hospitals;
- Environmentally preferable purchasing;
- Greening the government or the supply chain;
- National Environmental Performance Track;
- Pollution prevention-based environmental management systems;
- Developing pollution prevention projects of interest to States, regions, Indian Tribes and intertribal consortia that meet the requirements for treatment in a manner similar to a State as noted in 40 CFR 31, and/or sensitive populations; and
- Energy conservation and/or water conservation.

Up to $163,000 was available per EPA region for the 2007 fiscal year, and five percent cost share was required of applicants. Proposals for the 2007 round of funding were due on June 18, 2007. The program could potentially fund energy efficiency-related activities at a building, or further research should explore whether funds could be used to construct a wind or solar project.

Pawnee Nation should monitor availability of future funding through this program. Further information available at: www.epa.gov/p2/pubs/grants/srap07.htm.

## Clean Renewable Energy Bonds

Another federal financial incentive available to renewable energy projects is the Clean Renewable Energy Bonds (CREBs). Enacted under the Energy Tax Incentives Act of 2005, CREBs enable state and local governments, cooperative electric companies, and tribal governments to issue bonds, borrowing at a zero percent interest rate. Bondholders receive tax credits instead of interest payments from the bond issuer. CREBs share similarities with tax-exempt bonds, but differ from them in two key ways: 1) tax credits resulting from a CREB are treated as taxable income for the bondholder. The logistical effort associated with use CREBs to finance a renewable energy project would only be warranted for a large-scale effort, such as a potential future biorefinery project, or something of that scale. There are no current development opportunities available to Pawnee Nation that would warrant use of CREBs.

## New Markets Tax Credits

New Markets Tax Credits (NMTC) were introduced as part of the Tax Relief Act of 2000 as a means of spurring development and economic growth in low-income communities. The Community Development Financial Institutions Fund of the Treasury Department can allocate up to $19.5 billion per year in Tax

Credit Authority. Tax Credit Authority is "the amount of investment for which investors can claim a tax credit at rates that total, over the 7 years they can claim the credit, 39 percent of their investment. In return for the tax credit, investors supply capital to the Community Development Entities, which, in turn, make investments in qualified low-income communities."[47] Management of Tax Credit Authority and implementation of NMTCs is managed by Community Development Entities (CDEs). NMTCs may hold opportunity for Pawnee Nation, most likely for larger project development opportunities. This may be particularly relevant for future biofuel development activities. Further information is available at http://www.epa.gov/swerosps/bf/mmatters.htm and http://www.novoco.com/new_markets/index.php.

## 3.5.2 State Level Resources

### Net Metering

While Oklahoma recently introduced a corporate production tax credit program, the state does not provide any direct financial incentives for tribal renewable energy projects. Electricity generating projects that interconnect with the electric distribution system can take advantage of Oklahoma's **net metering** rules. Renewable energy facilities that are 100 kW or less in size, or that produce up to 25,000 kWh/year (whichever is less), can receive monthly credits on their electric bills for electricity produced during the previous month. Utilities are not required to purchase net electricity generation (net amount produced over and above amount used during a month), though utilities may choose to pay for this net generation in an amount equal to the utilities' avoided costs. Only investor owned utilities and utilities regulated by the Oklahoma Corporation Commission are required to allow net metering. Further information is available from:

George Kiser
Oklahoma Corporation Commission
Public Utility Division
Phone: (405) 521-6878
E-Mail: g.kiser@occemail.com
Web site: http://www.occ.state.ok.us

[47] U.S. Government Accountability Office (2007) "Tax Policy: New Markets Tax Credits Appears to Increase Investment by Investors in Low-Income Communities, but Opportunities Exist to Better Monitor Compliance." GAO-07-296

### Oklahoma Bioenergy Center

In January 2007, Governor Henry announced an initiative to establish an **Oklahoma Bioenergy Center**. The objectives of the Center are to develop crops and crop systems for Oklahoma, educate agricultural producers, establish an industry in Oklahoma, improve opportunities for federal funding, and improve opportunities for partnering with industry. The initiative has been funded at $40 million over 4 years. During the first year, activity will be focused only on core founders of the Center (University of OK, OK State and the Noble Center), but in future years they could possibly look to Pawnee lands for crop growth for research purposes. The research team has notified Cassie Gillman of the Oklahoma Secretary of Energy's Office of Pawnee Nation's interest in potential development of bioenergy resources on Pawnee lands. Pawnee Nation representatives should maintain communications with the Center and monitor future opportunities for bioenergy development in collaboration with the Center. Pawnee Nation could potentially be a valuable partner to a state university looking to leverage R&D funding from the Federal government's **Small Business Innovation Research (SBIR)** and **Small Business Technology Transfer (STTR)** grant programs. Further information is available from:

Cassie Gillman
Office of Secretary of Energy, Oklahoma
Telephone: 405-285-9213
Email: cassie.gillman@doe.ok.gov

## 3.5.3 Other Resources

Most federal funding programs are intended to supplement and leverage traditional project financing. Given the high upfront cost of renewable energy project investments, it will most likely be necessary for the Pawnee Nation to obtain project financing from a private lending institution, or to enter into a **power purchase agreement (PPA)** with a third party financer. Under a PPA, the host site for the renewable energy system does not actually own the project. Instead, the project is owned by a corporate entity that is able to take advantage of tax incentives. The project owner and the host site negotiate the terms of the agreement, but it typically involves the project owner selling the electricity and renewable energy certificates (RECs) to the host site at pre-determined prices. For tribes as well as public and non-profit entities, the PPA structure can make renewable energy projects economically feasible, facilitating project development that might not otherwise occur.[48] A number of financial institutions are familiar with the unique issues associated with renewable energy projects and support project financing either through standard lending, or through alternative project ownership arrangements such as the PPA. However, the PPA structure is typically only an option for larger projects (i.e., >250 kW). The American Council on Renewable Energy (ACORE) published a **Renewable Energy Financing Directory** in 2004 which provides a list of many financial entities that serve the renewable energy market. The directory can be accessed at http://www.acore.org/programs/refin.php.

### Renewable Energy Certificates

**Renewable Energy Certificates (RECs)** represent the environmental attributes associated with renewable energy. RECs are used by several states to demonstrate compliance with renewable energy purchasing mandates, and many companies and individuals purchase RECs to demonstrate environmental

[48] Note that for projects that don't need the PPA structure in order to be viable, it is preferable to pursue a standard ownership structure so that the tribe or entity can take advantage of potential increases in the value of RECs and electricity production.

stewardship. A national market has emerged for the trade of RECs, though it is a fairly immature market, particularly in states that do not use RECs for compliance with a state renewable energy purchasing mandate.

**Native Energy** is a company whose mission is to improve tribal energy independence and facilitate renewable energy development on tribe-owned lands by purchasing and selling RECs from tribal renewable energy projects. Native Energy will purchase RECs for prices in the range of $3 to $5 per REC (MWh). This payment can either be made as a one-time upfront payment, or can be paid over time based on project production. The upfront payment option is attractive since it will eliminate risks associated with the REC revenue stream. However, $3-$5/MWh is a very low price for RECs compared to what they are selling for in other markets (i.e., $15-$50/MWh for wind and >$300/MWh for solar), and this REC value would make only a small dent in upfront project costs if sold at this price (i.e., $400 over 10 years for a 5 kW PV project). Sale of RECs at this price also limits the potential to sell them at a higher value in the future when the REC market might become more mature. For example, REC values would increase if an Oklahoma or Federal renewable energy purchasing mandate (Renewable Energy Portfolio Standard "RPS") were to be passed in the future. Further information about Native Energy is available at www.nativeenergy.com and a contact there is Bill Kallock, bill.kallock@nativeenergy.com.

A number of other companies may also be interested in purchasing RECs from a Pawnee project including 3 Phases Energy, Bonneville Environmental Foundation, and Sterling Planet. In addition, a variety of electric utilities, including the Kay Electric Cooperative purchase RECs from wind projects for resale to utility customers. Links to utilities and companies that market RECs for sale in Oklahoma is available at http://www.eere.energy.gov/greenpower/buying/buying_power.shtml?state=OK. There are also a number of potential large purchasers of RECs including federal agencies, universities and corporations. Two excellent sources of information on REC markets and large purchasers of RECs are the DOE Office of Energy Efficiency and Renewable Energy's Green Power Network: http://www.eere.energy.gov/greenpower/buying/customers.shtml and the EPA's Green Power Partnership Program: http://www.epa.gov/greenpower/. However, sale of RECs in the near future is unlikely to change the economics presented in the earlier discussion due to the current low market value for RECs in Oklahoma.

### 3.5.4 Funding Opportunity Findings and Recommendations

Very little grant funding is currently available to support the construction of renewable energy projects. Most federal funding programs are intended to supplement and leverage traditional project financing, and the state of Oklahoma offers only offers renewable energy project support in the form of net metering for small projects, and a tax credit for very large (>1 MW) renewable energy projects. The only grant funding that may be available for project construction appears to be through USDA's Rural Business Enterprise Grant program, Renewable Energy Systems and Energy Efficiency Improvements Program, or Value Added Producer programs. Further, it appears that Pawnee Nation would need to form a business enterprise in order to qualify for any of these grants.

As discussed earlier, solar and biomass resources hold the greatest technical potential for development on Pawnee lands, with solar hot water and wood-based biomass space heating holding the greatest near-term potential for development. Solar PV and small wind applications hold great symbolic value as renewable energy production sources, and they could be pursued with financing assistance from a conventional lender with the assistance of a BIA or USDA loan guaranty, but project economics would be very poor. RECs could be sold from PV or wind projects, but the market value for RECs from these projects is currently so low that this additional revenue stream would not have a substantial impact on project

economics. Given the small scale development potential and poor economics of potential solar and wind applications, the projects would not be candidates for additional investment arrangements such as Clean Renewable Energy Bonds or Power Purchase Agreements.

Pawnee Nation's best strategy appears to be a focus on partnerships with large research institutions to explore bioenergy development opportunities, using Pawnee Nation land for the research initiatives. Research partnerships are eligible for funding through DOE's feedstock genomics for bioenergy grant program, the Small Business Innovative Research grants available through several federal agencies, and potentially Oklahoma's own Bioenergy Center. In addition, Pawnee Nation could apply for funding through the Department of Interior to conduct a more detailed assessment of biomass development opportunities, either in partnership with a research institution or independently. Pawnee Nation is open-minded to the concept of partnering with research institutions, as the tribe is in discussions with a state university in the region about the possibility of applying for funds to conduct research into the use of algae growth for energy production.

## 3.6 Summary of Renewable Energy Development Opportunities

Based on Pawnee Nation's renewable energy resources and availability of financial incentives, only limited renewable energy development opportunities exist at this time. Near-term opportunities exist to use red cedar as a fuel source for an outdoor wood boiler at the Pawnee Nation administrative building, and to develop a solar hot water system on the gym. Significant opportunities will likely exist in the area of biofuels development within the next few years, and most certainly within the next decade. Table 3-13 provides a summary of development opportunities and factors affecting future changes in these opportunities.

## Table 3-13. Summary of Renewable Energy Resource Development Opportunities and Next Steps

| | Biomass | Solar | Wind | Hydro |
|---|---|---|---|---|
| **Resource Availability (+ = favorable; +/- = mediocre; - = poor) based on available data** | + | +/- | +/- | +/- |
| **Should conduct further research to better understand resource availability?** | Y | N | Not Recommended as Near-Term Priority | Not Recommended as Near-Term Priority |
| **Economically Viable Development Opportunities Currently Exist?** | Likely for wood-fired boiler system (more detailed assessment recommended); possibly for methane capture if wastewater treatment facility improvements take place and/or pursue landfill potential with City of Pawnee | Yes, solar hot water on gym | Not on Pawnee land, though possibly on Chilocco School Site | Not likely |
| **Would financial incentives make development economically viable?** | Most likely | Yes | Not likely, due to poor resource on Pawnee lands, but potentially for Chilocco School Site | Resource issue is larger factor, though financial incentives would improve if resource is sufficient |
| **Key Next Steps** | Conduct economic analysis of wood boiler system; make contacts with Oklahoma Bioenergy Center; monitor biofuel market developments; explore potential for methane capture as part of potential future landfill / wastewater treatment facility development | Pursue solar hot water development on gym (see solar installer contact info provided) | Explore opportunities for coordination with other tribes for wind development on Chilocco School Site | Determine whether it's a priority for the tribe to better understand hydro resource availability. |

# 4 ENERGY EFFICIENCY OPPORTUNITIES

Building energy use accounts for 34% of the total energy consumption in the United States.[49] This is around 30 quads.[50] The majority of buildings in the U.S. are inefficient and, with continued new construction, buildings contribute to the nation's steady increase in energy demand. Apart from consuming more energy and having higher utility bills, increasing energy demand also takes its toll on the environment. A number of simple energy efficiency measures can be implemented to help curb the growing energy demand from U.S. buildings. This section presents a brief overview of a variety of common and well-proven energy efficiency measures ranging from those that are very simple low-cost solutions, to those that are more complex or costly. The section also presents a summary of a high level analysis conducted to examine the feasibility of replacing air conditioning units at Pawnee Nation's main administrative building, Building #64. Finally, the section includes a recommendation for the adoption of a building energy code to help maximize energy efficiency in new construction.

## 4.1 Overview of Common Energy Efficiency Measures

The recommended energy efficient measures have been broken into four categories: envelope measures, lighting, appliances and HVAC measures. It makes sense to pursue envelope and lighting measures first, as they affect both appliance and HVAC system performance. Also, the amount of heat generated by lighting and appliances affects HVAC system requirements.

### 4.1.1 Envelope Measures

The building "envelope" consists of all those elements of construction that are exposed to the environment: the walls, façade, roof and doors. In short it consists. Following are the common envelope efficiency measures.

#### Air Sealing

The main purpose of air sealing measures is to reduce air infiltration into the building. Infiltration occurs when outside air enters the buildings through cracks and replaces conditioned air. This results in higher energy use than necessary since the outside air must be conditioned. Air sealing can usually be done fairly easily as a retrofit measure. Calking and weatherstripping can be purchased at a low cost and a low level of skill is required to complete air sealing measures. The most critical places to focus air sealing measures are around doors and windows and doors, and any visible cracks.

[49] U.S. Department of Energy

[50] One quad is equal to $10^{15}$ Btu's.

### Insulation

Roofs and exterior walls should be insulated to keep the building from losing or gaining heat from the environment. A well insulated building is one that keeps the heat in during heating season and does not gain heat from the outside during cooling season. Roof insulation is particularly important. Increasing roof insulation can decrease heating costs by over 10%.[51] The higher the "R-value" of insulation, the more effective it is.

### Windows

Pawnee has approximately 1,900 cooling degree days and 3,900 heating degree days.[52] This means that heating needs in Pawnee far outweigh its cooling needs. Hence the windows should ideally have a high solar heat gain coefficient and a high U value. This means that the windows let sunlight/ solar heat in but do not lose heat at night time. This will result in energy savings. There are usually two ways to achieve this, the first method is to replace the existing façade with a more energy efficient façade, the second is to coat the windows with film. The latter is much less expensive, but this will only affect the solar heat gain properties of the window. Also it is useful to note that replacing windows with energy efficient ones typically only cost effective in the case of commercial buildings; because these buildings have large window area, and high daytime usage, this results in much greater savings per square foot and faster payback periods than for residential buildings.

## 4.1.2 Lighting

The step with the highest initial cost, but also the greatest life cycle savings is lamp and/or fixture replacement. In spaces with fluorescent ceiling fixtures, ensure that T-8 or T-5 lamps and electronics are being used rather than T-12 lamps and magnetic ballasts. All incandescent light bulbs should be replaced with compact fluorescent lamps (CFLs). CFLs use only about 25% of the energy while giving the same lighting output as incandescent bulbs. Lighting retrofits greatly reduce the energy consumption of buildings and typically have payback periods within two or three years. Another advantage of efficient lighting is that it does not generate as much heat as less efficient equipment. This results in lower cooling loads, and associated air conditioning savings during the summer months.

During the course of their lifetimes, all lighting systems gradually show a decrease in efficiency. Some efficiency losses, such as a reduction in light output, are simply due to the aging of lighting equipment and are unavoidable. However, a timely tune-up can avoid unnecessary efficiency losses due to improperly functioning controls, or accumulation of dirt on fixture lenses and housings. Cleaning fixtures and replacing burned-out lamps and ballasts periodically can considerably increase fixture light output. This is a simple first step that can help restore lighting levels to their design value. Making sure all lights are working at their optimum level ensures that only the required number of lights will be on at all times, and people will not use inefficient task lights where they would not otherwise be needed.

Use of automatic lighting controls is another key strategy for reducing lighting energy use. Many buildings use automatic controls which are time-based, occupancy-based, or lighting level-based. Installation of lighting controls is most cost-effective in spaces that are often unoccupied, such as bathrooms, conference rooms or kitchen areas. In spaces that already use lighting controls, there is a good chance that the controls were never properly calibrated during installation, or that they have been

[51] U.S. Department of Housing and Urban Development, http://www.hud.gov/offices/pih/programs/ph/phecc/strat_B6.cfm .

[52] Oklahoma Mesonet data.

subsequently tampered with by occupants. Adjusting these controls and associated sensors will ensure maximum energy savings.

## 4.1.3 Appliances and Electrical Power Systems

### Energy Efficient Appliances

The average American home spends around $2,000 annually on electricity for appliances. By using efficient "ENERGY STAR" rated appliances, homes have been found to save a minimum of 4% on their utility bills. ENERGY STAR is a joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy, with the aim of reducing electricity usage through energy efficient products and practices (www.energystar.com). These energy efficient appliances save energy without sacrificing performance. Their energy savings typically result in short payback periods, and they often have lower lifecycle operating costs than traditional appliances.

### Electrical Power Systems

Electrical power systems also hold potential for energy and money savings. There are a number of opportunities within a facility's distribution system to save energy, increase equipment life, and reduce unscheduled outages. These opportunities include evaluating and correcting voltage imbalances, voltage deviations, poor connections, undersized conductors, poor power factors, insulation leakage, and \ or harmonics. Components to check in a building tune-up include transformers, conductors, switchgear, distribution panels, and connections at loads and elsewhere. The annual cost penalty for operating a 100 horsepower motor with a 4 percent voltage imbalance is approximately $830 per year. This cost is due to reduced motor life, energy charges, and electrical demand charges. (This assumes continuous operation, utility rates of $0.04/kWh, and demand charges of $4.00/kW.) This shows the importance of analyzing power systems.

## 4.1.4 HVAC Measures

These measures deal with making the heating, ventilating and air conditioning (HVAC) systems more efficient. Listed below are some easy to implement retrofit measures to help reduce HVAC energy use.

### Testing Adjusting and Balancing

Proper distribution of air and water in an HVAC system is critical to the proper functioning of the system and to create comfortable conditions within a given space. Excessive room air temperature fluctuations, excessive draft, and improper air distributions will lead to occupants' discomfort and can increase energy consumption. Testing, adjusting, and balancing (TAB) involves investigation of the current system, and evaluating and making adjustments to bring the HVAC system as close as possible to its original design specifications. The TAB process helps identify and make the necessary adjustments, hence improving occupant comfort and reducing energy costs. In short this process generally includes (Step 1) evaluating the performance of the equipment in its current state and making recommendations for improvements, (step 2) regulating flow rates of air or water for the purpose of balancing the system and (Step 3) proportioning the air or water flows throughout a building to match the loads. Savings from TAB measures differ, and are based on many factors related to the building including heating and cooling system types, construction, geographical location, and internal heating, cooling, and electrical loads. Heating and cooling cost savings can be as high as 10%.

### Heat Exchanger Maintenance

This equipment usually consists of heating and cooling coils installed in air handlers, fan coil terminal units, or baseboard radiators. The air-side of heating and cooling coils should be cleaned, whether in an air handler or in a rooftop unit, to reduce deposit buildup. Methods for cleaning may include compressed air, dust rags/brushes, and power washes. Also, baseboard heating systems should be checked for dust build up and cleaned if necessary. Savings associated with this measure depend on the current state of the building. Timely cleanups ensure that HVAC equipment run on design conditions and minimize energy consumption.

### Duct Sealing

It is common for leakage to occur through cracks in air ducts. This usually results in supply air getting mixed with air at room temperature. This makes the HVAC system work harder and consumes more energy. Duct sealing with tape is an easy, low cost solution to this problem.

### HVAC Equipment Addition / Replacement

Replacing HVAC systems with newer equipment can dramatically reduce operating costs, but with high upfront costs, it is typically only cost-effective if the existing unit is older. Cooling equipment with a Seasonal Energy Efficiency Ratio (SEER) rating of 13 and higher, and heating equipment with an efficiency of greater than 0.85 (for gas) are considered efficient. Other options include installation of a heat recovery system or an economizer. These types of equipment help further decrease energy consumption, but should only be installed after all other measures have been implemented.

## 4.2 Analysis of Potential for Building #64 Air Conditioner Replacement

Building #64 functions as an administration building for the Pawnee Nation and is equipped with four rooftop (RUUD) 3-ton units (model # UAKA-037JAZ) with a SEER rating of 10. Replacing the existing RUUD units was viewed as a potential energy and money saving opportunity. A high-level energy and cost analysis of replacing these units with higher efficiency models was conducted to determine annual energy and cost savings, simple payback period, and total lifecycle costs for each system.

In order to provide an accurate evaluation, certain parameters integral to the analysis needed to be researched or assumed. First, since the specific cooling load was unknown, the Annual Full Load Operating Hours of 1,200 provided by ARI (American Refrigeration Institute) was used to calculate approximate energy usage for each unit. Second, the average cost of energy ($/kWh) was calculated from the utility data for January, 2005-November, 2006 provided by Pawnee Nation for Building 64. The resulting average was $.0821/kWh. In addition, the utility data for 2005 was used to calculate the Percent Energy Savings in Table 4-14. Third, the estimated installation costs for each unit were sourced from the 2005 DEER (Database of Energy Efficient Resources). Using an inflation rate of 3.2% for 2006, and 2.0% for 2007[53], these costs were converted to 2007 values. Finally, the lifecycle costs were calculated based on an effective discount rate of 4% and a lifetime of 15 years,[54] with $100 annual operation and maintenance cost for the existing units and $50 for the replacement units.[55] Based on these assumptions, the results from Table 4-14 were calculated, displaying the energy and cost savings for higher efficiency models over the existing RUUD units.

[53] http://www.minneapolisfed.org/research/data/us/calc/hist1913.cfm

[54] Energy Star Air Conditioner Savings Calculator Assumptions

[55] "Making your air conditioner last longer", http://www.high-performance-hvac.com/air-conditioning/air-conditioning/making-your-air-conditioner-last-longer.html

The results show that it is not cost effective to replace the existing units before the end of their useful lives. This is supported by the long simple payback periods calculated, as well as the $2,300 to $3,100 additional costs over the lifetime of the unit. The existing models were installed in 2000, and will most likely need to be replaced within 7 to 10 years. At that time, the research team recommends installing a model with a 13 SEER (Seasonal Energy Efficiency Ratio) efficiency rating, as a model with that low efficiency rating will have lower lifecycle cost than other alternatives.

**Table 4-14. AC Analysis Results**

| Rooftop Unit | Demand Savings | Energy Savings | Percent Energy Savings | Total Installed Cost (2007) | Annual Cost Savings | Payback | Life Cycle Costs |
|---|---|---|---|---|---|---|---|
| | kW | kWh | % | $ | $/yr | yrs | $ |
| Baseline | 0.00 | 0 | 0% | 0 | $ 0.00 | 0.0 | $ 4,990.57 |
| 13 SEER | 0.62 | 925 | 3% | 3007 | $ 75.96 | 39.6 | $ 6,597.53 |
| 14 SEER | 0.77 | 1162 | 4% | 3300 | $ 95.45 | 34.6 | $ 6,673.28 |
| 15 SEER | 0.91 | 1368 | 5% | 3592 | $ 112.34 | 32.0 | $ 6,777.93 |
| 16 SEER | 1.03 | 1548 | 5% | 3885 | $ 127.13 | 30.6 | $ 6,906.06 |
| 17 SEER | 1.14 | 1707 | 6% | 4177 | $ 140.17 | 29.8 | $ 7,053.52 |
| 18 SEER | 1.23 | 1848 | 6% | 4470 | $ 151.76 | 29.5 | $ 7,217.10 |

## 4.3 Energy Code

The research team recommends that the Pawnee Nation adopt an energy code to ensure that all new buildings incorporate design elements and equipment that meet the latest industry standards for quality and energy efficiency. Two options for model energy codes include ASHRAE (American Society of Heating, Refrigerating and Air Conditioning Engineers) 90.1-2004 or the International Energy Conservation Code (IECC). The two codes are similar in many respects and adoption of either holds the potential to result in vast improvements in energy efficiency of new buildings. Both codes lay out minimum requirements for a building's envelope, electrical power systems and equipment, lighting, heating, ventilating and air conditioning, service, water heating, and energy management.

The research team submitted a memo to Pawnee representatives in August recommending the adoption of a building code, focusing on ASHRAE as the recommended code. The team later learned that Oklahoma's energy code is the IECC. The 2003 IECC is currently in effect in Oklahoma (adopted in 2004), but the state is on a three-year review cycle and may adopt the latest (2006) IECC when Oklahoma's 2007 energy code review occurs. As a result, the research team recommends adoption of the 2006 IECC to improve consistency with Oklahoma standards.[56]

[56] Further information on the IECC is available at http://www.iccsafe.org/e/prodshow.html?prodid=3800S06.

The review of energy and building codes by the Pawnee Nation has also included the development of a Water Resource Management code for Bio-fuel production with the protection of Cultural Resources. Adopting an energy code will benefit Pawnee Nation by ensuring that all new construction is constructed to high standards of quality and energy efficiency.[57] Furthermore, adoption of a code is one of the simplest ways for the Tribe to further its goals of saving energy and money which improving the environment and increasing the energy independence. Pawnee Nation will also set a positive example for other Tribes and the state of Oklahoma.

## 4.4 Energy Efficiency Findings and Recommendations

A variety of well-proven measures can be implemented to improve the energy efficiency of Pawnee Nation buildings, resulting in both utility savings and environmental improvements. These measures range from those that are low-cost and simple to implement, to more complex and costly measures. Envelope and lighting measures should be implemented first, followed by appliances and HVAC equipment. The steps described in this section should be incorporated into a regular building maintenance program. All equipment should be checked periodically, and manuals should be consulted while dealing with equipment or making adjustments. Ideally, an O&M (Operation and Maintenance) manual should be developed and used as a guide for a maintenance program for all commercial buildings. Benefit of installing efficient equipment in buildings is not realized if proper maintenance is not performed.

Based on an assessment of air conditioning units at Building #64, it was determined that replacement of these units is not cost-effective at this time. Rather, Pawnee Nation should focus first on the more basic measures described in this section first.

Pawnee Nation should make every effort to maximize the energy efficiency of new construction. A first step toward this end is the adoption of a building energy code. The IECC is recommended for consistency with the Oklahoma energy code. Pawnee Nation should also seek out architect and engineering firms with demonstrated knowledge and experience in the construction of highly energy efficient buildings. Hiring professionals that are "LEED-certified" is one way to ensure that building design team is informed and committed to energy and environmental issues.[58]

[57] An alternative code used in some jurisdictions, the International Energy Conservation Code (IECC) was updated in 2006, and is quite similar in most respects to AHSRAE 90.1

[58] LEED stands for Leadership in Energy and Environmental Design, a program of the U.S. Green Buildings Council. More information is available at http://www.usgbc.org/DisplayPage.aspx?CMSPageID=222.

# 5 Overview of Current and Expected Future Electricity Consumption

To effectively assess the feasibility of renewable energy projects for the Pawnee Nation, it is important to understand existing and future energy needs. Given the resources available for the project, and the amount of data provided, the research team conducted a limited, high level overview of existing and future electricity use at facilities owned by Pawnee Nation.

## 5.1 Data Collection

Pawnee Nation representatives provided electricity usage data for the time period of January, 2005 to November, 2006 for buildings owned by Pawnee Nation. To increase the value of these data, the research team developed a building inventory file to gather additional data on the buildings' function, heating system, square footage, and codes and standards. The main goal of the inventory was to identify the function, energy usage, heating system type, and square footage of each building. Pawnee Nation representatives, James Rice and Cecil Riding In, provided information for over 20 existing buildings, and limited information on new construction projects was gathered through conversations with Cecil Riding In, Monty Matlock and other Pawnee Nation representatives.

The following assumptions were made to account for missing data for some buildings:

- December, 2006 usage was estimated by taking the average increase of the surrounding months (i.e. January and November), for all buildings except the New Fitness Center.
- August, 2005 usage for the New Fitness Center was estimated by taking the average percent change of July and September and applying it to the 2006 August value.
- November and December, 2006 usage was estimated by carrying forward the 24% decrease seen in October 2006 for the New Fitness Center.
- For the Tribal Water Well, January, 2005 usage was estimated by taking the average of February and December, 2005 usage levels.

## 5.2 Existing Buildings

The top energy consumers identified through the inventory were Building #64 (Administration Building), the Wellness Gym, the New Fitness Center, the Wellness Center, the Northern Tribal Water Well, and the Fire/Police Station.[59]

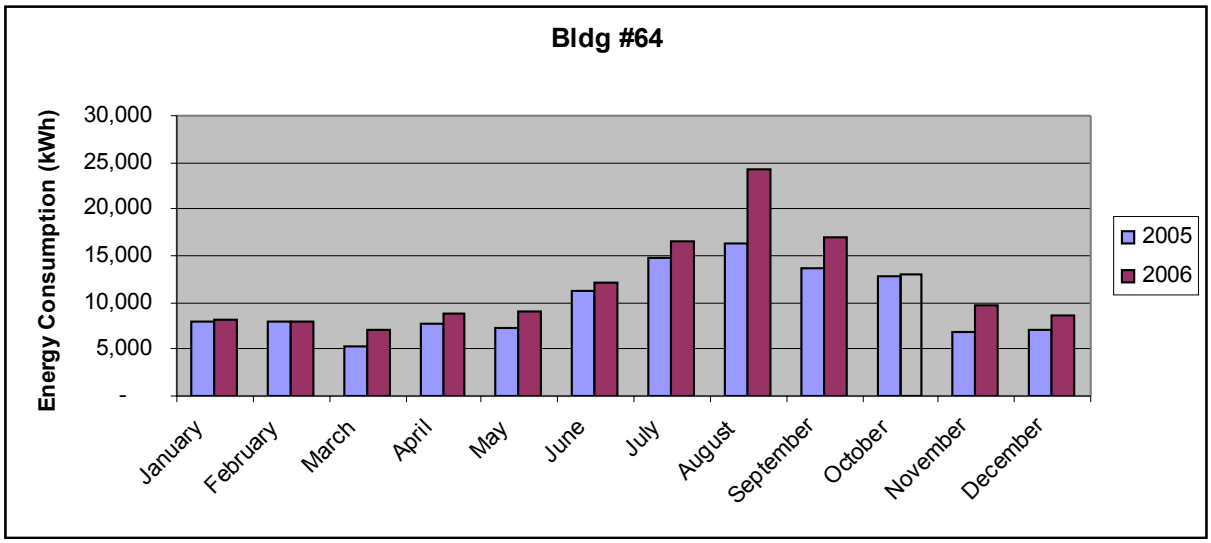
Peak electricity usage occurs during the summer months in the three buildings with the highest levels of electricity consumption. Pawnee Nation representatives provided no indications that usage patterns will change at these existing buildings in the coming years. Therefore, based on existing use patterns it

[59] The Wellness Gym, the New Fitness Center and the Wellness Center share similar names but are different facilities according to information provided to the research team.

appears that Pawnee Nation should focus any energy efficiency efforts on reducing summer air conditioning loads, as these appear to be the largest contributors to building electricity consumption.

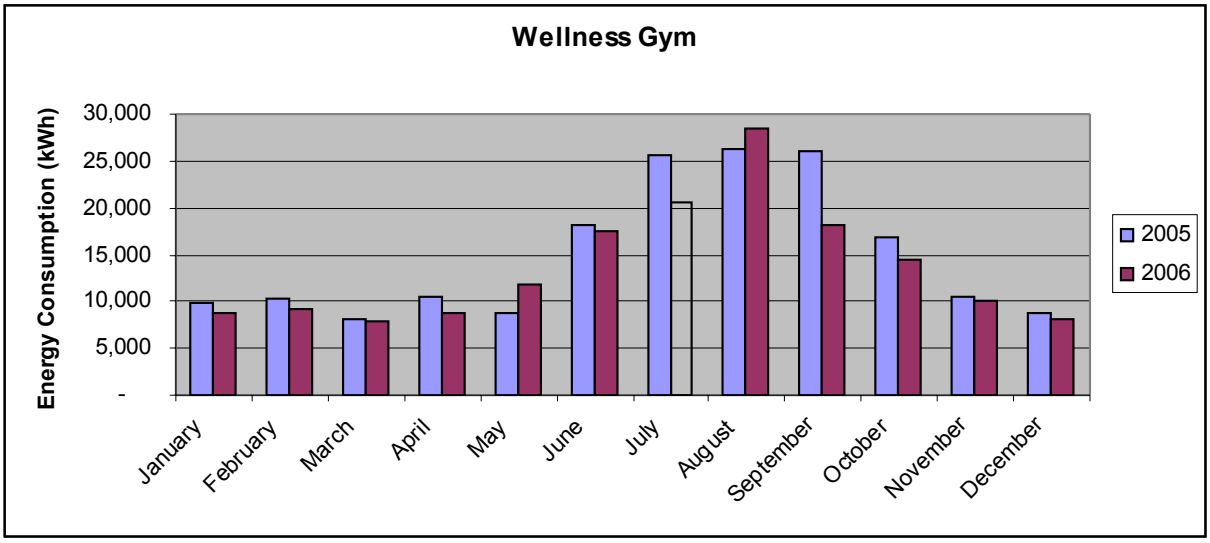
The Tribal Water Well was also among the top four electric accounts in terms of usage levels. The peak demand occurs during the winter months for this electric account. Electricity usage data for the top four energy users, is presented in the following figures.

**Figure 5-21. Energy Usage Building #64**



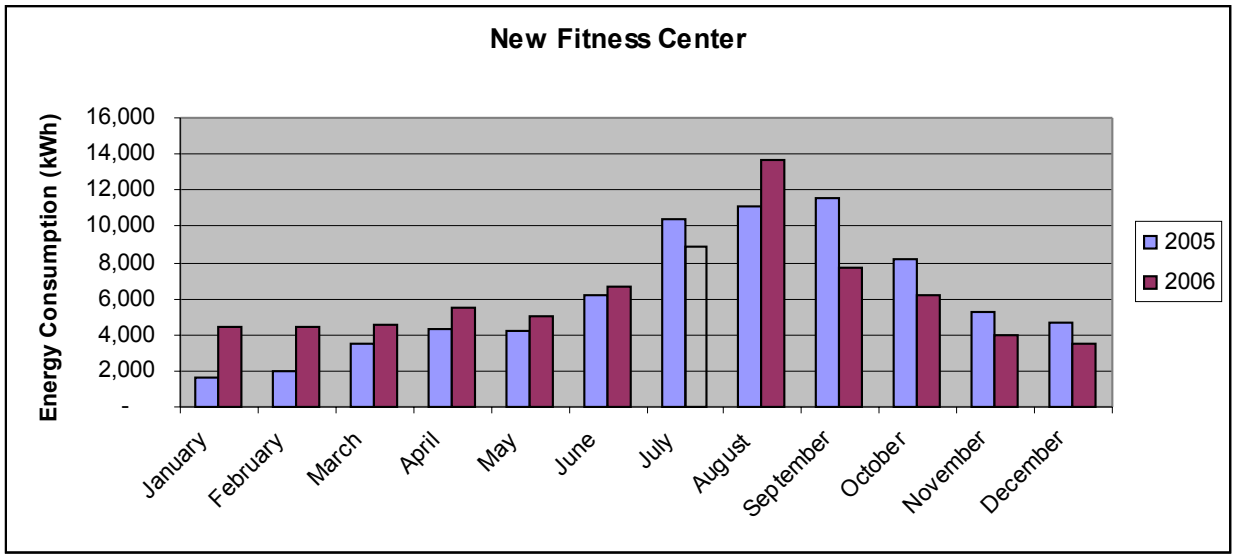

Source: Pawnee Nation utility data

**Figure 5-22. Energy Usage Wellness Gym**



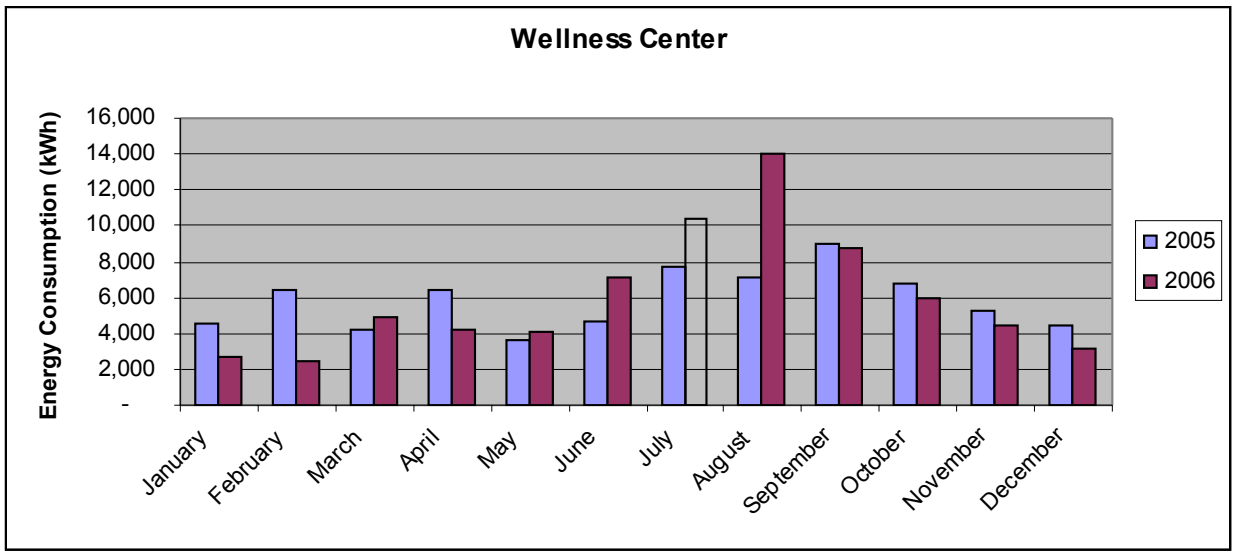

Source: Pawnee Nation utility data

## Figure 5-23. Energy Usage New Fitness Center



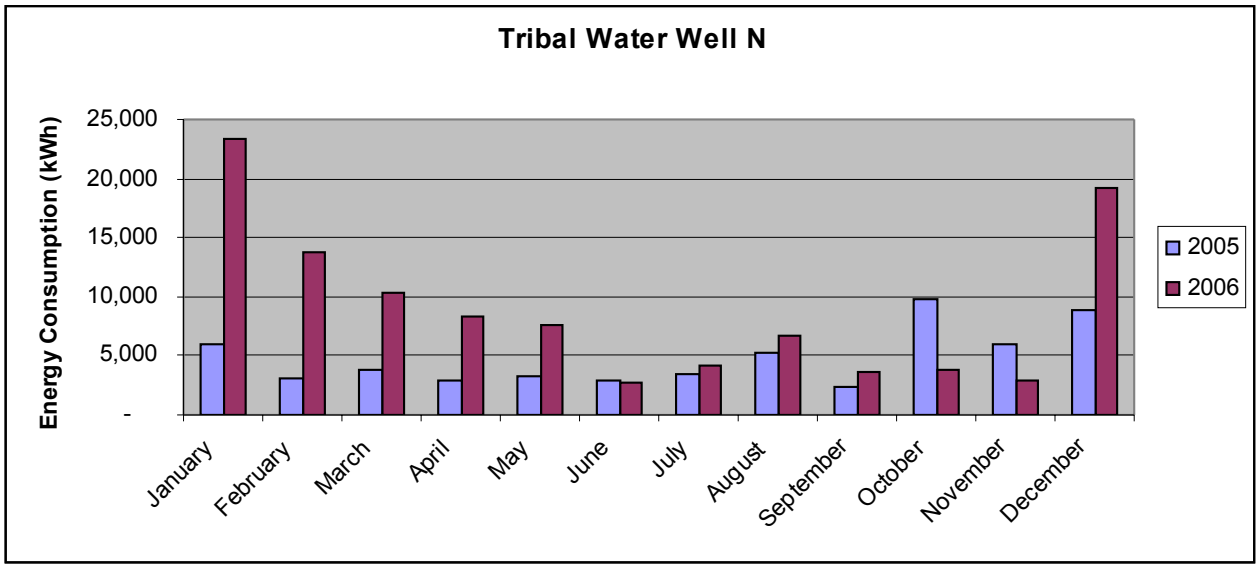

Source: Pawnee Nation utility data

## Figure 5-24. Energy Usage Wellness Center



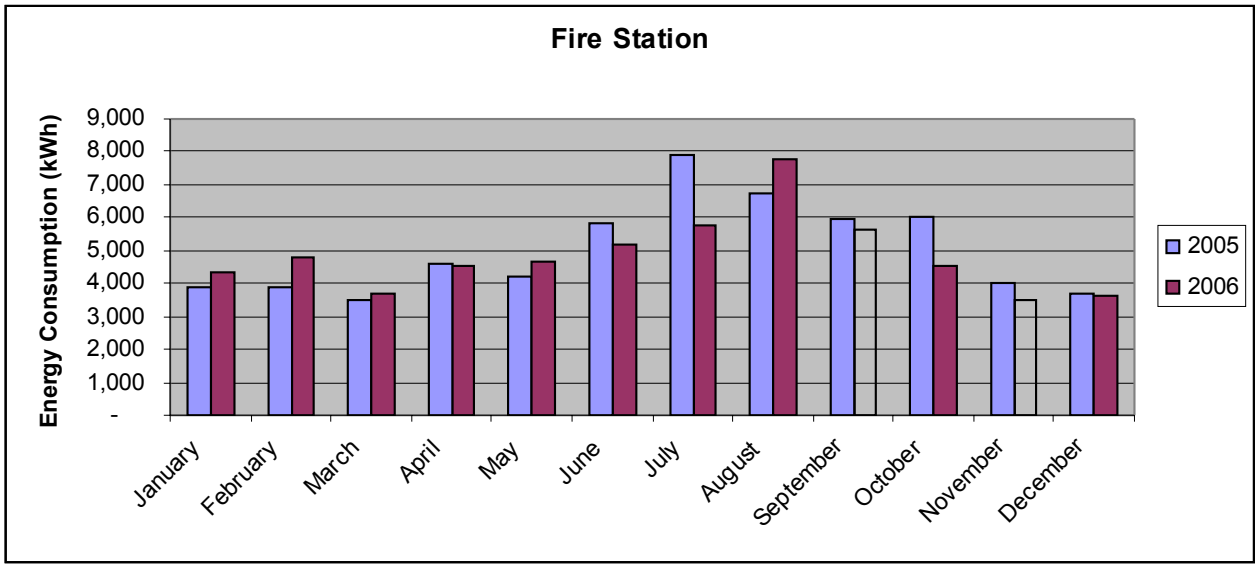

Source: Pawnee Nation utility data

**Figure 5-25. Energy Usage Tribal Water Well N**




Source: Pawnee Nation utility data

**Figure 5-26. Energy Usage Fire Station**




Source: Pawnee Nation utility data

## 5.3 New Construction

Pawnee Nation representatives provided a limited amount of information on new construction projects both underway, and planned for the future. The following are four new construction projects that will affect Pawnee Nation's future energy demands.

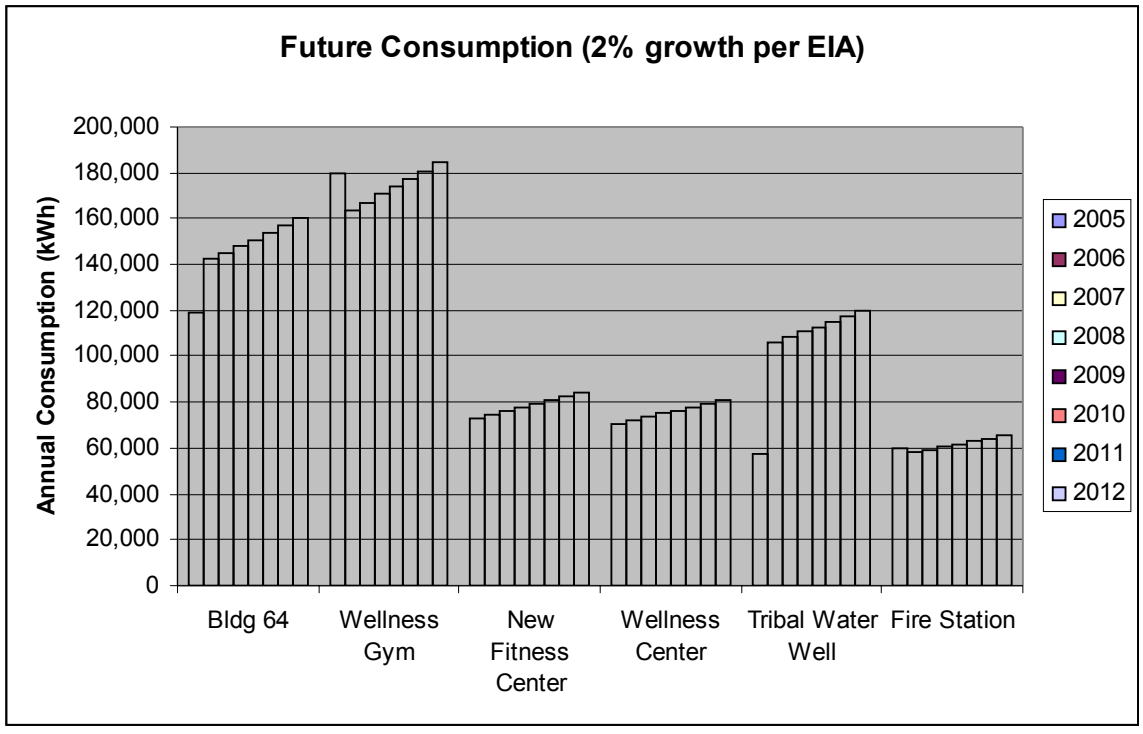
- Dining Hall – As of July, 2007, architectural drawings had been developed for the renovation of a campus dining hall.
- Boys Dormitory – This building, also located in the campus area, is currently undergoing renovation.
- Old hospital – This three-story building is undergoing renovated for multi-purpose use as an office and clinic.
- Chilocco Casino- A new casino, currently in the architectural design phase, is planned for the Chilocco site. The Chilocco site, located four miles south of the Kansas state line on Hwy 77, includes land owned by the Pawnee, Kaw and other tribes. A portion of the land is jointly owned by the three tribes and is being developed in collaboration with Kaw Nation. Pawnee Nation's involvement in the project is being overseen by the Pawnee Nation Tribal Development Corporation. The project was in the architectural design phase as of the July, 2007, but was later put on hold. The research team is not aware of the schedule for moving forward with the project, however the team has learned that a top priority for the Development Corporation is to minimize upfront project costs. For example, use of a ground source heat pump was evaluated and deemed too expensive. Although further consideration should be examined as technology advances in geo-thermal and ground source heat pump development and installation.

# 5.4 Potential Load Growth

## 5.4.1 Existing Construction

Without specific building construction information and usage patterns, it is difficult to make an accurate prediction of future energy uses for existing buildings. Therefore, the research team has based load growth assumptions on data from the U.S. Energy Information Administration's Annual Energy Outlooks for residential, commercial, and industrial buildings. For the time period of 2007-2030, EIA expects commercial energy consumption to increase at a rate of approximately two percent each year.[60] While EIA projections are based on broad factors affecting the U.S. energy economy as a whole, the research team has chosen to use the EIA estimate as a conservative proxy to account for potential growth in the level of electricity usage of Pawnee buildings. Assuming Pawnee Nation energy use grows at a rate of two percent per year, the highest electricity consuming buildings among Pawnee Nation's existing building stock will be consuming approximately 65,000 kWh of *additional* electricity by 2012. Figure 5-27 shows potential growth.

**Figure 5-27. Load Growth[61]**




## 5.4.2 New Construction

[60] Energy Information Administration –2007 Annual Energy Outlook, http://www.eia.doe.gov/oiaf/aeo/pdf/trend_3.pdf.

[61] Note that both 2005 and 2006 are based on actual utility data. Therefore, the change from 2005 to 2006 is not necessarily consistent with the two percent growth estimate.

Unfortunately, an accurate prediction of future energy use due to New Construction cannot be made due to incomplete construction data. However, using the following assumptions, a rough estimate for future energy impact was developed for the Dining Hall (Figure 5-28), Boys Dormitory, Old Hospital, and Casino projects.

**Figure 5-28. Dining Hall**

Source: http://www.native.brokenclaw.net/articles/pawnee.html

According to the Pawnee Nation Casino's website the new casino is expected to contain the following "The master plan includes a large first class dynamic casino, hotel, meeting space, multiple restaurants and bar venues, an entertainment and event center, a golf course and various other casino resort amenities. The first phase of the project is planned to include approximately 1,200 gaming devices, various restaurants and bars, a 150 room deluxe hotel, approximately 24 table games with additional poker tables."[62] See below for estimated area of each casino section.

Using these values, as well as assumed values for square footage, was constructed for predicted energy use. Therefore, it can be assumed that Pawnee Nation's energy use will increase by 702,123 kWh per year due to additional development. Combined with future growth for existing construction, approximately 765,000 kWh of additional energy consumption can be expected for Pawnee Nation.

**Table 5-15. Predicted Energy Use for New Construction**

| Building | Area (sq ft) | Energy Intensity[63] (kWh/sq ft) | Annual Energy Usage (kWh) |
|---|---|---|---|
| Dining Hall | 2,400 | 37 | 89,760 |
| Dorm | 16,87 | 12 | 200,813 |

[62] www.pawneenationcasino.com

[63] Energy Information Administration – 2003 Commercial Building Study

| | | | |
|---|---|---|---|
| | 5 | | |
| Hospital | 5,000 | 24 | 120,000 |
| Casino – hotel | 4,500 | 12 | 53,550 |
| Casino - restaurant | 5,000 | 37 | 187,000 |
| Casino - gaming | 5,000 | 5 | 25,500 |
| Casino - event center | 5,000 | 5 | 25,500 |
| TOTAL | | | 702,123 |

## 5.4.3 Findings and Recommendations

Based on available information, it is clear that Pawnee Nation's electricity loads, and associated expenses will increase substantially as a result of new construction plans. For the dining hall, boys dormitory and office / clinic renovation projects underway on the Pawnee Nation campus, the tribe will see increases in building electricity usage with little or no increase in associated revenues from these new building uses. This could present financial challenges for the tribe. Pawnee representatives indicated that federal funding for current renovation projects was contingent on incorporating basic energy efficiency features (i.e., high efficiency windows and insulation) into the buildings, but additional information on the level of energy efficiency incorporated into these renovation projects was not made available to the research team. Some opportunities may remain to improve the energy efficiency at these new facilities, particularly with regard to lighting and equipment used in the buildings (i.e., refrigeration equipment in the dining hall and use of compact fluorescent lighting and other high-efficiency lighting throughout). Pawnee Nation should implement all cost-effective energy efficiency measures discussed in Section 4, and should take steps to maximize energy efficiency at new buildings by adopting an energy code and hiring architectural and engineering professionals that are experienced in the design of high efficiency buildings.

# 6 ELECTRIC UTILITY ISSUES

Pawnee Nation electric utility options were analyzed through a four-phase process, which included: 1) summarizing the relevant utility background information; 2) gathering relevant utility assessment data; 3) developing a set of realistic Pawnee electric utility service options, and 4) analyzing the various Pawnee electric utility service options for the Pawnee Energy Team's consideration.

Due to the sensitivity of the issues, and the typically adversarial nature of outside consultants' efforts to assist Tribes with their utility system and service issues with their service providers, all of the data gathered for this analysis was from public information sources. No substantive discussions took place between the consultant team with any of the electric service providers. The only contact made with any utility provider was to request information that was considered public, but may not have been available through public information sources.

## 6.1 Relevant Utility Background and Framework

The relevant utility background provided and gathered included descriptions of Pawnee land and development, residential buildings, non-residential buildings, and projected construction activity. In addition, a summary of current Pawnee Nation utility providers was provided and/or gathered. Pawnee concerns regarding risings cost of electric service were shared with the team.

The majority of Pawnee tribal administration activities are located adjacent to the city of Pawnee (as noted in the map below). For the purposes of this discussion, this area will be referred to as Pawnee Nation Facilities. A discussion of current and expected future energy use by Pawnee-owned buildings (existing and new construction) is included in Section 5. Residential construction includes a small number of homes on reservation lands, which were built approximately 50-55 years ago. In addition, the Tribal Housing Authority maintains roughly 100-150 homes of newer construction.

The Pawnee Nation is currently served by two electric utilities: the City of Pawnee and Indian Electric Rural Electric Cooperative. The City of Pawnee provides power for the tribe's government offices and Indian Electric serves the electricity needs for the Travel Plaza and Casino. The Pawnee Nation currently has no energy codes in place and does not formally follow any energy efficiency guidelines.

Currently, the Pawnee Nation has access to natural gas supply lines and electric transmission lines. The tribe's drinking water needs are met by groundwater wells (on tribal land) and there is supplementary access to City of Pawnee water supply lines (off-reservation sources). There is no agreement in place for water transfer between City of Pawnee and the tribe.

The Pawnee Nation also owns approximately 800 acres of Chilocco Indian School lands near Newkirk, OK. Pawnee is currently pursuing a Class III gaming compact, and has plans to build a casino on its land. The Chilocco Indian School is located just south of the Kansas border, and if a casino were ultimately built, it would be served by Kay Electric Cooperative. Ownership of the Chilocco Indian School property is shared by five Tribes.

# 6.2 Relevant Utility Assessment Data

Relevant utility assessment data gathered and developed include a set of Electric Usage data for Pawnee Nation Facilities, Utility Service Area maps of the Oklahoma electric transmission system, data about Pawnee Nation current service providers, identification of nearby electric service providers, and calculated Pawnee Nation Facility electric costs under various electric provider scenarios, rate applications and wholesale providers.

## 6.2.1 Electric Usage Data

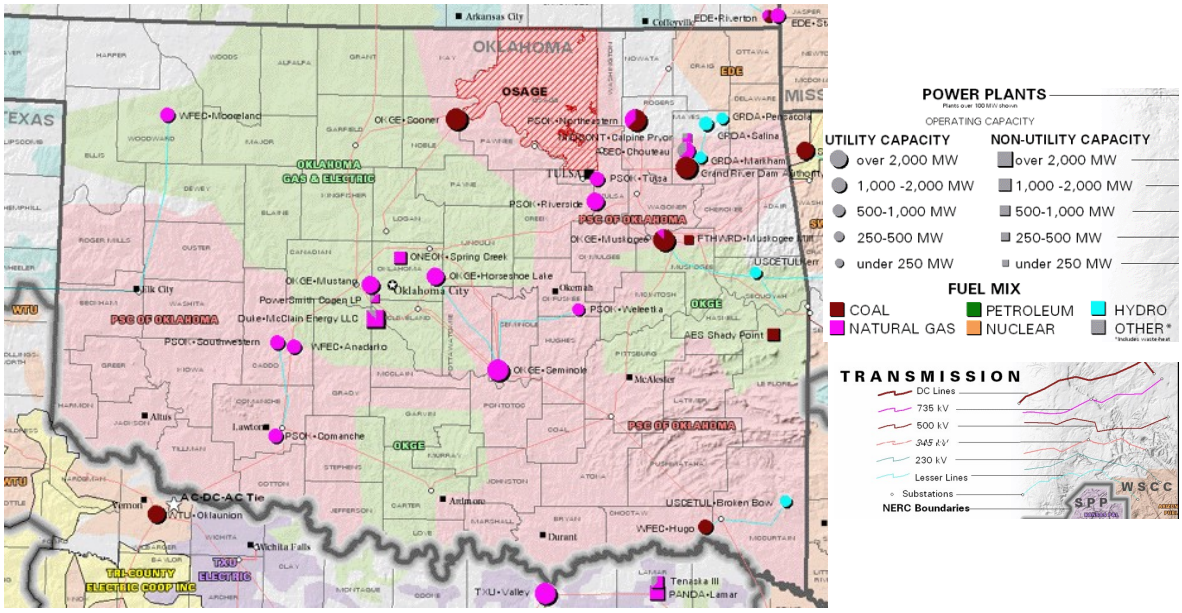
Electric usage data was collected for the period from January 2005 through November 2006. Summary data is presented in Section 5. Annual usage during that period totaled 1,081,199 kilowatt hours, and annual electric costs were just under $96,800.

## 6.2.2 Utility Service Area Maps

*Oklahoma Transmission System and Power Generation*

Pawnee Nation is located in close proximity to several electric transmission lines, and large coal and natural gas generation, as shown in Figure 6-29. Pawnee appears to have multiple options to access power supply through 345kV and 230kV lines in the Pawnee area.

**Figure 6-29. Oklahoma Transmission System and Power Generation**



*Current Service Provider: City of Pawnee*

The city of Pawnee serves customers within the boundaries of the city, as well as customers that are within 4 miles of city boundaries, at the city's option. Pawnee Nation Facilities are located primarily to the north and east of the center of the city. Typically, the key driver for electric utility costs is the cost of purchased or generated power supplies. The city purchases wholesale power supplies from the Grand River Dam Authority (GRDA), a non-appropriated agency of the state of Oklahoma which serves as the conservation and reclamation district for waters of the Grand River.

GRDA provides electric service to nearly seven million customers in a 500,000-square-mile region through three customer classes: municipals, electric cooperatives and industries. GRDA sells wholesale power to 15 municipalities in Oklahoma, and two cities along state border, as well as to the Oklahoma Municipal Power Authority. GRDA maintains approximately 2,000 miles of electric transmission lines and 200 electric substations across its service area.

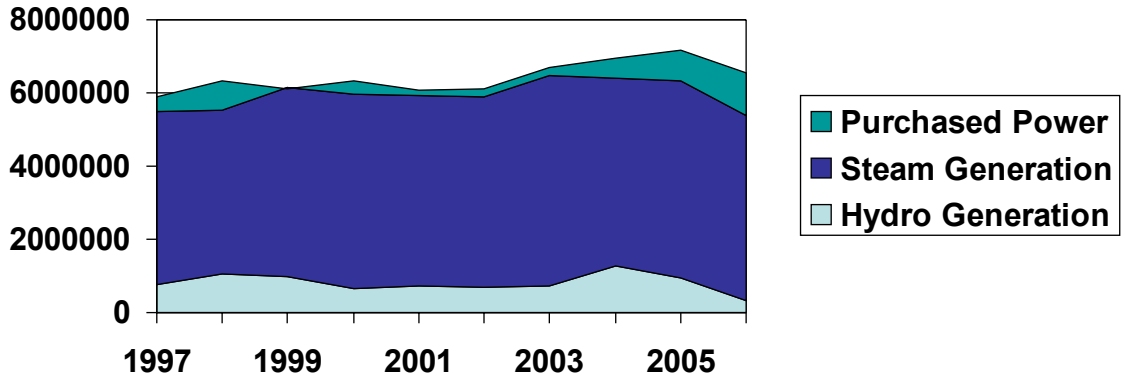
GRDA operates three hydroelectric facilities and manages two lakes along the Grand River system. These facilities, along with the GRDA Coal-Fired Complex (thermal generation), combine for a total generation capability of 1,480 megawatts (MW). GRDA transmits and delivers this wholesale electricity across its 24-county service area in Northeast Oklahoma.

GRDA is a not-for-profit, cost-of-service public power utility, whose rates consistently rank in the lowest 20% nationwide. GRDA established a power cost adjustment (PCA) to help stabilize rates, which is computed twice a year, and adjusts base rates to reflect actual cost of fuel used in electrical generation.

GRDA is a member of the Southwest Power Pool, whose interconnected power grid stretches across parts of eight states including New Mexico, Texas, Oklahoma, Kansas, Missouri, Arkansas, Louisiana and Mississippi. Members of the power pool, in times of emergency, can receive power across this grid from other power pool members. GRDA is also a member of the Western Systems Power Pool (WSPP), whose members joined together to leverage power marketing opportunities. As a member, GRDA can make surplus power marketing transactions via computer.

GRDA's historical power generation mix is illustrated below in Figure 6-30.

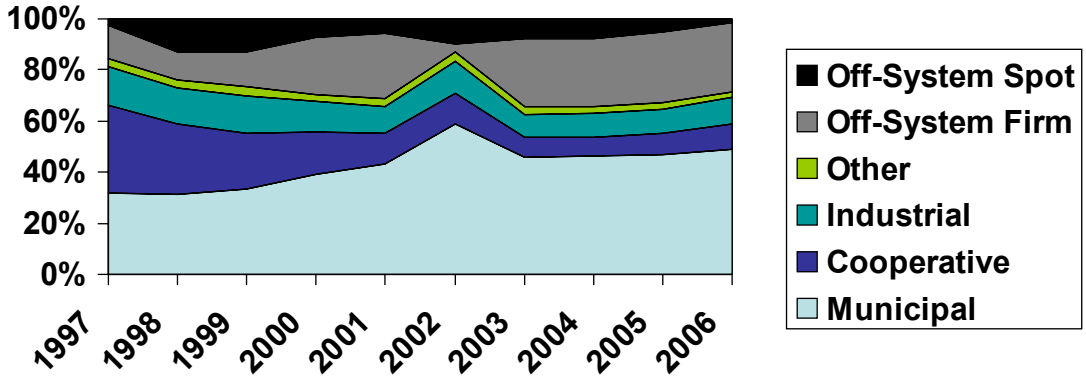
**Figure 6-30. Grand River Dam Authority Generation Mix**



Pensacola Dam was the first hydroelectric facility constructed in Oklahoma, completed in 1940. The six units at Pensacola Dam have a combined generation capacity of approximately 120 MW. The Robert S. Kerr Dam is the second hydroelectric facility constructed by GRDA. Constructed in 1964, Kerr Dam's powerhouse houses four, 28.5-megawatt generators that combine to produce 114 total megawatts of electricity. The third hydroelectric project constructed by GRDA, Salina Pumped Storage Project (SPSP) is located in the hills southeast of Salina, Oklahoma, along the Saline Creek arm of Lake Hudson. GRDA's coal-fired facility nearly tripled GRDA's total generation capabilities.

GRDA's power is sold to a variety of purchasers, as illustrated below in Figure 6-31. In recent years, GRDA has focused on increasing diversity of its power sales and has consistently increased sales to municipals.

**Figure 6-31. Grand River Dam Authority Power Purchasers**




Based on the description of its generation facilities and business model, GRDA appears to provide relatively low-cost power supplies to its municipal customers.

The City of Pawnee signed a long-term power supply contract with GRDA in August 2007. The contract calls for the city to purchase Full Requirements Wholesale Supply Service from GRDA. Wholesale electric rates specified in this contract are listed in Table 6-16 below:

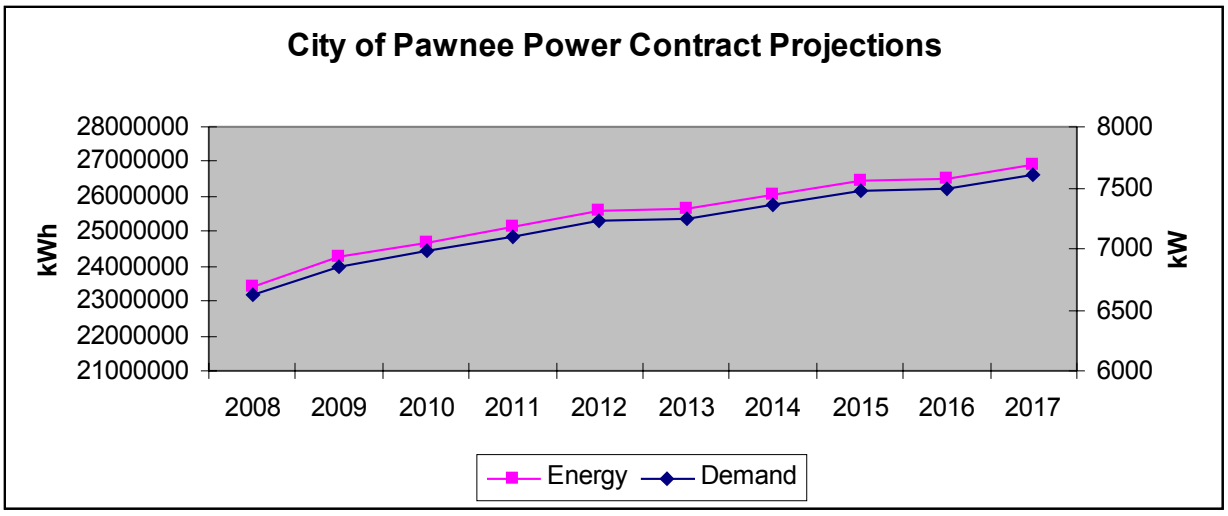
**Table 6-16. Rates Specified in City of Pawnee Contract with Grand River Dam Authority**

| Charges | Generation Bus | Transmission | Distribution Primary |
|---|---|---|---|
| Basic charge, per Meter | $50 | $50 | $50 |
| Capacity Charge, per Capacity Billing Demand (kW) | $5.76 | $5.76 | $5.88 |
| Delivery Charge, per Delivery Billing Demand (kW) | $3 | $3.56 | $4.21 |
| Energy Charge, per Billing Energy (kWh) | $.021 | $.021 | $.021 |

Based on the energy charge component of the City of Pawnee rates, which appears to be quite competitive, one could surmise that that the City has relatively high electric distribution service rates. This could be due to a number of factors: high overall electric distribution service costs; possible subsidization of other City services, or subsidization within electric customer classes. Without additional information about the rate development process, and recent cost of service studies from the City, it is difficult to identify which is the case.

One other consideration for the City of Pawnee power supply contract is its terms, such as the projected Energy or Demand levels shown in Figure 6-32. The chart below represents the contract projections, for which the City of Pawnee is responsible to pay for, regardless of its actual power takes. These projections are to be updated annually.

**Figure 6-32. City of Pawnee Power Contract Projections**

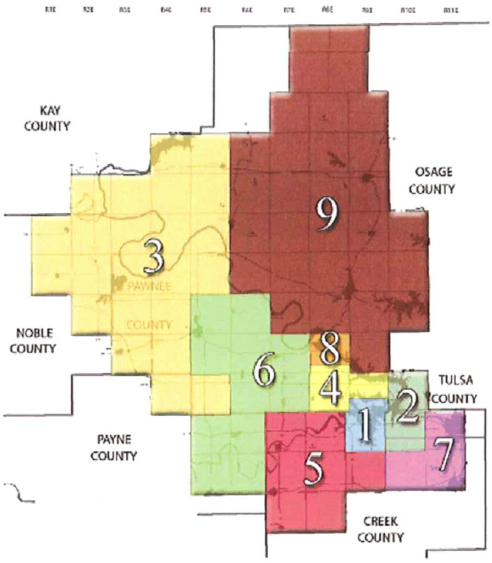


*Indian Electric Cooperative*

Indian Electric Cooperative, Inc. (IEC) provides power to one Pawnee customer – the Travel Center, which is located south of the City of Pawnee, adjacent to Highway 412. IEC is a member-owned, non-profit distribution cooperative that supplies electric service in seven north-central and northeastern Oklahoma counties including Pawnee, Osage, Creek, Payne, Noble, Kay and Tulsa.

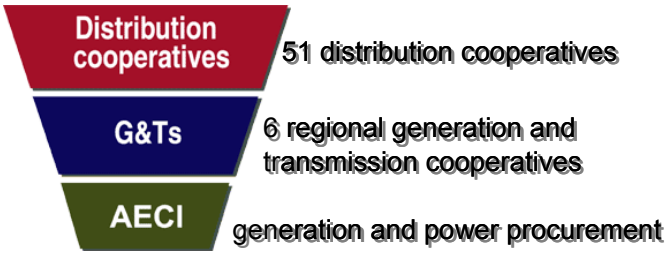
IEC serves 18,245 homes and businesses through 3,451 miles of distribution line covering a service territory of 2,500 square miles in Fairfax and a warehouse in Pawnee. IEC's service territory is comprised of nine districts, as illustrated in Figure 6-33 below.

**Figure 6-33. Indian Electric Cooperative Service Territory**



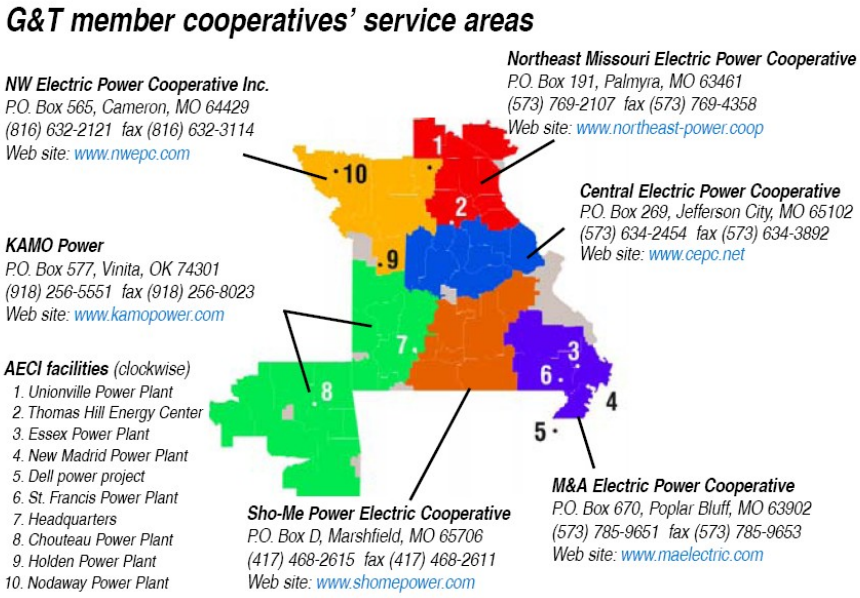

IEC purchases power from KAMO Power, one of six regional Generation and Transmission Cooperatives, of the Associated Electric Cooperative, Inc. (AECI), which is structured as indicated in Figure 6-34.

**Figure 6-34. Structure of Associated Electric Cooperative, Inc.**




AECI is owned by, and provides power to six regional and 51 local distribution cooperative systems in Northeast Oklahoma, Missouri and Southwestern Iowa. KAMO Power provides power to distribution cooperatives in northern Oklahoma and southern Missouri, indicated in green in Figure 6-35 below.

**Figure 6-35. KAMO Power Distribution Cooperatives**




AECI's transmission system consists of 9,217 miles of line, and related substations. The cooperative has 152 interconnections and 21 interconnection agreements, as well as 77 interchange agreements with investor-owned and municipal utilities, electric cooperatives, power marketing firms and regional transmission organizations.

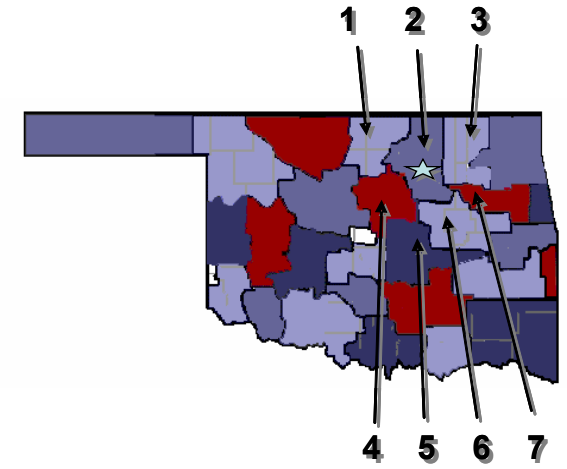
AECI has a diversified mix of generation resources, including baseload generation supplied by two coal-based plants; intermediate generation provided by two combined-cycle natural gas plants; and four peaking plants that provide power when demand rises to peak levels on cold winter or hot summer days. AECI also has contracted power sources, including renewable hydropower and wind energy from northwest Missouri's first utility-scale wind farms. AECI's owned and contracted coal-based resources make up about 55% of capacity, but produce about 81% of AECI's energy. AECI's gas-based resources provide intermediate and peaking power. AECI member energy sales are projected to grow 2.3% annually during the next 10 years. At this pace, AECI's resource plan shows the system will need more generation for both year-round energy needs and peak demand periods that typically occur in summer and winter when energy use increases.

From Pawnee Nation's perspective, IEC also seems able to provide reasonably-priced power supplies, should it choose to, and be able to contract for service with IEC.

## Nearby Service Providers

Since Pawnee Nation Facilities are located adjacent the city boundaries, the City of Pawnee electric department has traditionally provided electricity service. However, as indicated by the map below, Pawnee Nation Facilities also fall within Indian Electric Cooperative service territory, as noted by the blue star in the section indicated by a 2 in Figure 6-36.

**Figure 6-36. Electric Utility Service Territories**




Oklahoma Electric Coops:

1. Kay Electric
2. Indian Electric
3. Verdigris Valley Electric
4. Central Rural Electric
5. Canadian Valley Electric
6. East Central Electric
7. Lake Region Electric

For comparison purposes, rate schedules were summarized for four of the nearby Oklahoma electric cooperatives, along with rates from the City of Pawnee:

### Table 6-17. Electric Rates Schedules for Potential Electricity Suppliers

| Utility | Rate Schedule Type | Customer Charge | Minimum Charge | Schedule Type | $ Per kWh | |
|---|---|---|---|---|---|---|
| Central Rural | Non-Residential & Small Commercial | $25.00 | $25.00 | Summer: April-Oct | 0.076491 | |
| | | | | Winter: Nov-March | 0.076491 | first 2000 kWh |
| | | | | | 0.056491 | above 2000 kWh |
| East Central | General | $12.25 | $12.25 | Summer: May 1- Sept 30 | 0.070900 | all kWh |
| | | | | Winter: Oct 1- April 30 | 0.070900 | first 2000 kWh |
| | | | | | 0.048900 | above 2000 kWh |
| Indian Electric Cooperative | General | $29.00 | $19.00 | | 0.073700 | all kWh |
| Kay | General | $15.00 | $20.00 | Summer: May 1- Nov 1 | 0.087900 | all kWh |
| | | | | Winter: Nov 1- May 1 | 0.087900 | first 1000 kWh |
| | | | | | 0.067900 | above 1000 kWh |
| City of Pawnee | Commercial | $15.65 | $15.65 | | 0.093900 | first 500 kWh |
| | | | | | 0.085700 | 501-2000 kWh |
| | | | | | 0.080100 | 2001 kWh and above |
| | Public School and Hospital | $0.00 | $0.00 | | 0.093900 | first 500 kWh |
| | | | | | 0.085700 | 501-1500 kWh |
| | | | | | 0.080100 | 2000 kWh and above |

## Comparative Retail Electric Costs

Since total electric cost is a more relevant comparison than individual utility electric rates, each utility's rates were applied to the most recent twelve months of Pawnee Nation Facilities' electric usage, to calculate a hypothetical annual electric cost for each. For each utility, the most likely applicable rate structure was assumed, and rates selected from each utility's tariff. However, no demand information was available for any Pawnee accounts, so rate selection was limited to non-demand rate structures. Also, any purchase power adjustments in place were also not reflected, due to limited data available.

The average retail electric per kWh charge for commercial customers for each of the five utilities are compared in the table below:

### Table 6-18. Average Retail Electric Rates for Potential Electricity Suppliers

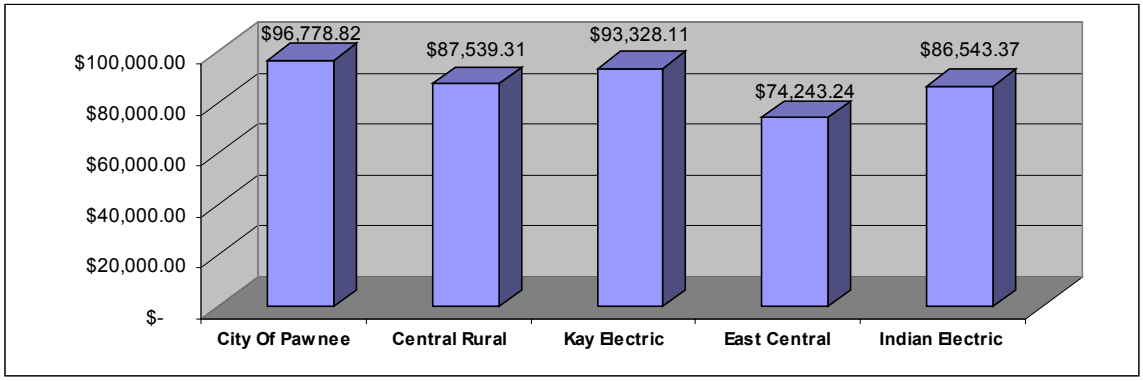
| Electric Service Provider | Average Commercial Customer $ / kWh charge | Percent Lower than City of Pawnee |
|---|---|---|
| City of Pawnee | 0.0895 | N/A |
| Central Rural Cooperative | 0.0810 | 10.6% |
| East Central Cooperative | 0.0687 | 30.4% |

| | | |
|---|---|---|
| Indian Electric Cooperative | 0.0800 | 11.8% |
| Kay Electric Cooperative | 0.0863 | 3.7% |
| State of Oklahoma | 0.0557 (2006) | 37.8% |
| United States | 0.0578 (2006) | 35.4% |

In comparison, according to EIA, Average retail electricity cost for Commercial customers in Oklahoma for 2006 was 5.57 cents per kWh; compared with average of 5.78 percent across U.S.

Results of the cost comparison are shown in Figure 6-37.

**Figure 6-37. Cost Comparison Results**




As initially indicated by the Pawnee team, the highest electric costs were reflected for electric service provided by the City of Pawnee. The total annual cost calculated for the Pawnee team's preferred electric service provider, Indian Electric Cooperative, was $86,543.37. The difference between the two providers was over $10,000 annually.

## 6.2.3 Electric Utility Service Options

Based on the Pawnee background information initially provided, and the utility assessment data identified, a set of electric utility service options was identified and reviewed with the Pawnee energy team. The electric utility service options included:

- Business as usual
- Consider alternative supply options
- Negotiate lower rates with City of Pawnee
- Focus on reducing energy usage
- Develop electric utility organization

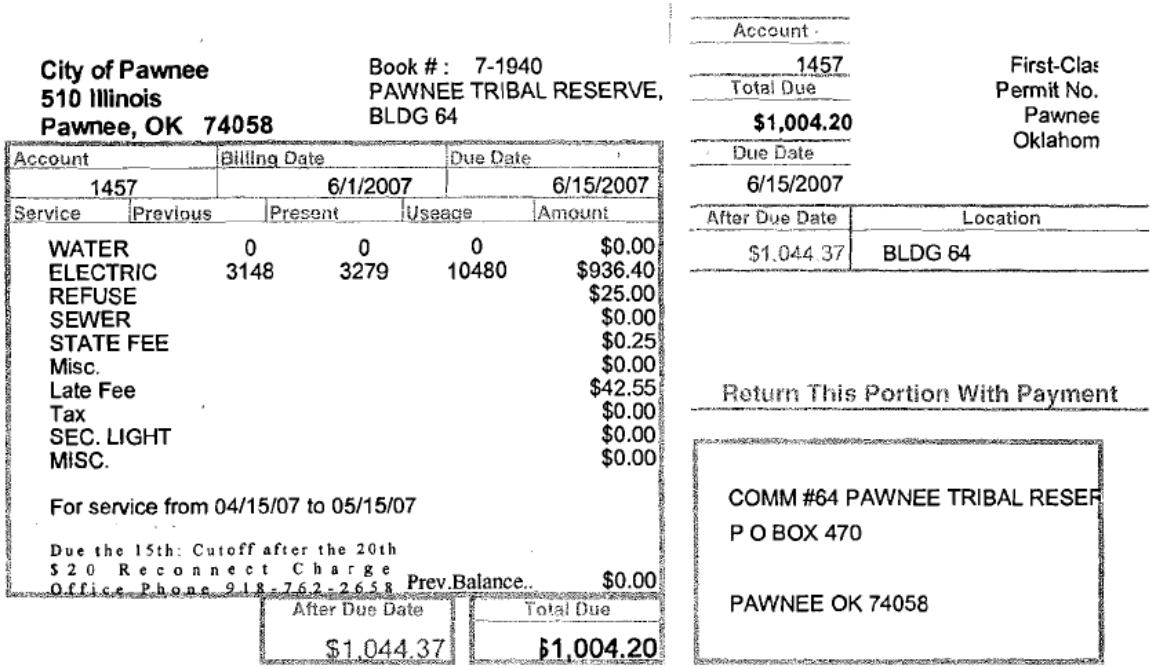
### Business as Usual

In the business as usual option, the Pawnee Nation was assumed to take no significant action to improve its situation, despite the potential for significantly higher electric costs, with its anticipated new facilities.

However, some relatively minor steps could help reduce City of Pawnee utility costs, such as focus on avoiding all late fees.

As indicated in the representative billing statement below, bills are issued on the 1st of the month, are due on the 15th of the month, and service can be shut off on the 20th of the month. This is a very short window for payment, which can create a situation where late fees are often applied, as in the example below in Figure 6-38.

**Figure 6-38. Sample Pawnee Electric Bill**



City of Pawnee
510 Illinois
Pawnee, OK 74058

Book # : 7-1940
PAWNEE TRIBAL RESERVE,
BLDG 64

| Account | Billing Date | Due Date |
|---|---|---|
| 1457 | 6/1/2007 | 6/15/2007 |

| Service | Previous | Present | Useage | Amount |
|---|---|---|---|---|
| WATER | 0 | 0 | 0 | $0.00 |
| ELECTRIC | 3148 | 3279 | 10480 | $936.40 |
| REFUSE | | | | $25.00 |
| SEWER | | | | $0.00 |
| STATE FEE | | | | $0.25 |
| Misc. | | | | $0.00 |
| Late Fee | | | | $42.55 |
| Tax | | | | $0.00 |
| SEC. LIGHT | | | | $0.00 |
| MISC. | | | | $0.00 |

For service from 04/15/07 to 05/15/07

Due the 15th: Cutoff after the 20th
$20 Reconnect Charge
Office Phone 918-762-2658

Prev.Balance.. $0.00

| After Due Date | Total Due |
|---|---|
| $1,044.37 | $1,004.20 |

| Account |
|---|
| 1457 |
| Total Due |
| $1,004.20 |
| Due Date |
| 6/15/2007 |

First-Clas
Permit No.
Pawnee
Oklahom

| After Due Date | Location |
|---|---|
| $1,044.37 | BLDG 64 |

Return This Portion With Payment

COMM #64 PAWNEE TRIBAL RESER
P O BOX 470

PAWNEE OK 74058

If late fees were applied to all accounts, each month, this would total $4,000, and increase Pawnee Nation Facilities' electric bills by another 4%. With this knowledge, and an agreed-upon strategy to review, approve, and pay all City bills on time, the City could help reduce its utility cost burden considerably.

## Consider Alternative Power Supply Options

### *Contract with Other Nearby Electric Cooperative*

A logical option for Pawnee is to consider contracting with IEC for electric utility service, if it were physically possible to do so. Pawnee is squarely within IEC territory, and, as a sovereign nation, Pawnee has the ability to choose it as its electric supplier. According to City of Pawnee tariffs, service is furnished "to persons desiring to use the same within the corporate limits of said City, and at the City's option to those within a radius of four miles of the City, at the rates and subject to the conditions, rules, regulations and requirements." However, the system serving Pawnee Nation Facilities is the property of the City, and would likely need to be acquired by IEC, if the City were willing to sell it. Also, without more discussion with IEC, it is difficult to assess the physical ability to interconnect with IEC facilities.

### *Direct Wholesale Power Supply Purchases*

Key drivers for consideration of Direct Wholesale Power Supply Purchases include:

- Authority to purchase from other suppliers
- Ability to contract with the City of Pawnee for delivery service only
- Availability of wholesale supply options

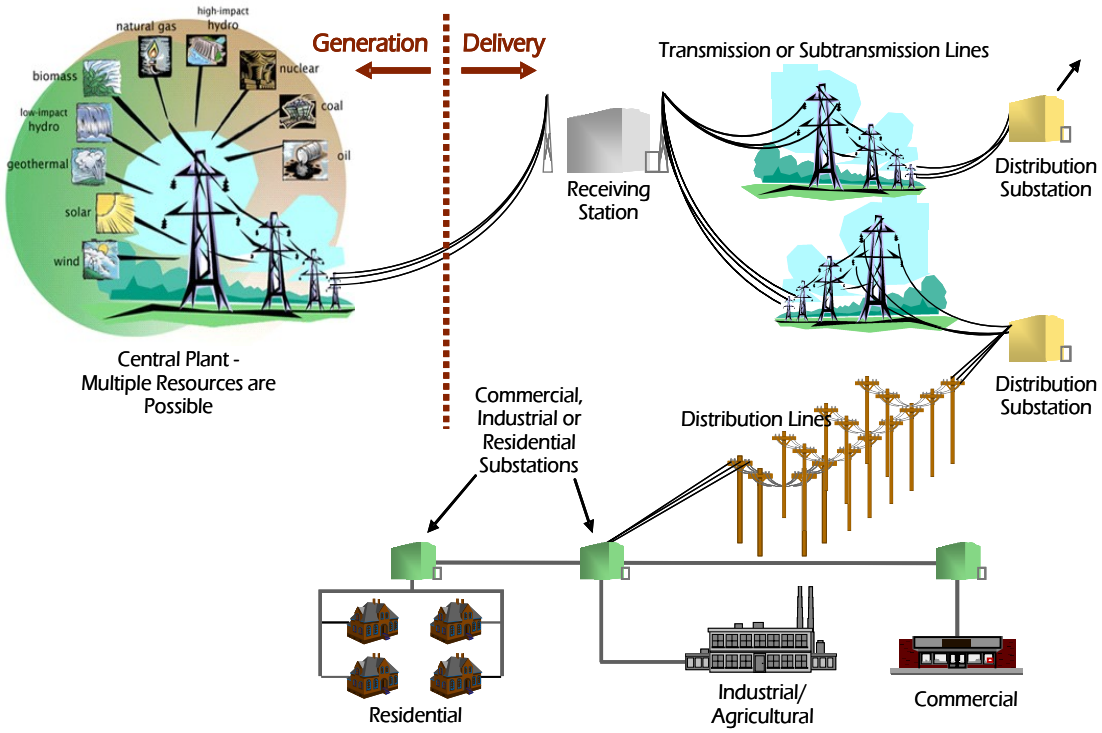
Pawnee Nation's authority to purchase Wholesale Power from other suppliers has its basis in several areas, the most important of which is tribal sovereignty. As a federally recognized tribe, the Pawnee Nation is able to make decisions, and take actions for the benefit of the Tribe, without concern about local, county, or state jurisdiction.

The state of Oklahoma has also taken steps to provide for a choice of wholesale electric providers. 1997 legislation set the framework for retail electric competition to begin by July, 2002, and directed the Oklahoma Commerce Commission to figure out the details. However, the state never did implement rules that allowed electric customers to select their own power suppliers, due in part, to concerns stemming from the California Energy crisis, and relatively low consumer electric rates in Oklahoma.

A third driver for Pawnee to consider is its ability to contract for delivery service through existing City of Pawnee lines. If Pawnee Nation were to maintain service with the City, and purchase its wholesale power separately, it would need to come to agreement with the City of Pawnee on the amount of delivery service rates. That could be a long and involved process, and ultimately not result in significant cost savings for the Pawnee Nation.

Electric service is made up of two primary components: Power Supply Service, and Electric Distribution Service, as illustrated in Figure 6-39.

**Figure 6-39. Schematic Overview of Power Generation and Delivery System**




One concern expressed by the Pawnee Energy Team was the limited ability for its electric utility service providers (either the City of Pawnee, or IEC) to be able to meet needs of future Pawnee Nation Facilities.

It was not clear whether this was a physical limitation of the City's electric system or substation, or capacity limitations of electric transmission lines. But, since no information was available to define that limitation, Pawnee may prefer to consider evaluating the requirements of developing its own utility service, and provide a physical interconnection to bypass the City in order to directly serve Pawnee Nation facilities.

If it is City of Pawnee that is limited in capacity, in order to gain access to additional power supplies, either the City system would need to be upgraded, or Pawnee would need to contract for service with another provider. If it is IEC that is capacity constrained, the Pawnee Nation could not likely contract with IEC for service, and its best option would be to contract with another provider for wholesale supply service, and with the City of Pawnee for distribution service.

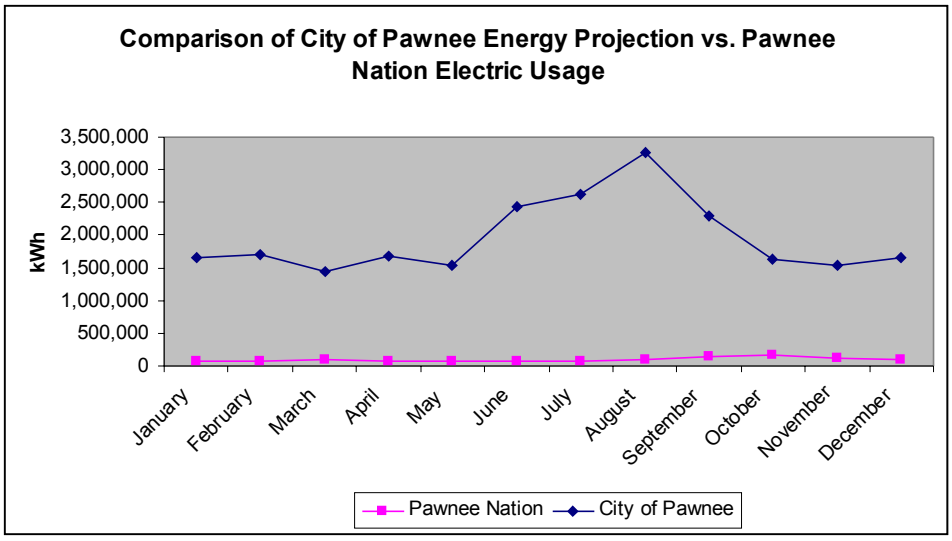
*Wholesale Supply Options*

Three options are most appropriate for the Pawnee Nation to consider if it chooses to pursue wholesale power delivery service to serve Pawnee Nation Facilities. These include: 1) power supply service from GRDA; 2) wholesale power supply service from other suppliers, such as Indian Electric Cooperative, or its supplier, KAMO Power; or 3) pursuing a hydro allocation from the Southwestern Power Administration, similar to actions taken by many Western Tribes through the Western Area Power Administration.

It appears that Pawnee Nation could conceivably contract directly with GRDA for wholesale power supply, since that is GRDA's primary business focus. One important consideration is whether GRDA is allowed only to contract with other state-chartered entities, or whether it has the ability to contract with a tribal government.

It is likely that the City of Pawnee and GRDA would need to renegotiate their recently signed contract, to reduce deliveries by the amount of anticipated Pawnee Nation electric load, and the Pawnee Nation would contract with GRDA directly for wholesale power supply service. The Pawnee Nation electric load appears to be a fairly small percentage of the City of Pawnee electric load in most months (Figure 6-40), ranging from a low of 3% in June, July and August, to a high of 10% in October.

**Figure 6-40. Comparison of City of Pawnee Electric Load v. Pawnee Nation Electric Load**



It is not clear whether the Pawnee Nation could contract with IEC for wholesale power supply service. No information about the IEC distribution and transmission system was available publicly, and it is unknown what physical connections are available. Also, IEC's tariff includes only retail electric distribution service, and does not indicate whether wholesale electric supply is available. However, if physical connectivity was possible, and IEC were willing and able to do so, it is feasible that the Pawnee Nation could contract with IEC for wholesale power supply to be delivered through City of Pawnee lines.

KAMO Power does provide wholesale power supply service, but, based on available public information, it is not clear whether physical connections to KAMO Power transmission systems are available.

Numerous tribes in the Western U.S. have benefited from low-cost power available through hydropower allocations from the Western Area Power Administration. The comparable organization in the Oklahoma area where Pawnee Nation Facilities are located is the Southwest Power Administration.

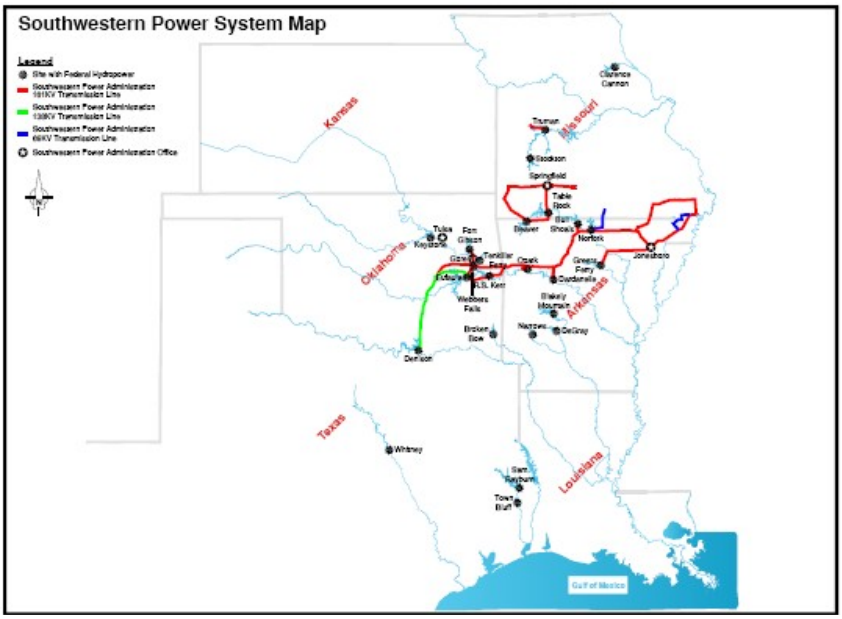
The Southwest Power Administration ("Southwestern") markets hydroelectric power in Arkansas, Kansas, Louisiana, Missouri, Oklahoma, and Texas from 24 U.S. Army Corps of Engineers multipurpose dams. Southwestern's power is marketed and delivered primarily to public bodies such as rural electric cooperatives and municipal utilities. Southwestern has over one hundred such "preference" customers, and these entities ultimately serve another seven million end-use customers. Southwestern operates and maintains 1,380 miles of high-voltage transmission lines, substations, and a communications system that includes microwave, VHF radio, and state-of-the-art fiber optics.

Today, Southwestern provides power to a group of municipalities, which includes the Oklahoma Municipal Power Authority (OMPA) based in Norman, Oklahoma.

The Oklahoma Municipal Power Authority is a state governmental agency, created to provide wholesale electricity to cities and towns that own their electric systems. OMPA currently serves 35 municipals in Oklahoma and four in Kansas.

The Southwestern Power System is located east of the Pawnee area, and from public information available, such as the map in Figure 6-41, its system does not appear to reach Pawnee Nation Facilities.

**Figure 6-41. Southwestern Power System Map**



At this time, no Indian Tribes have allocations from the Southwest Power Administration, and, as is true throughout the country, the system is fully subscribed, which means that no low-cost hydro power is available for delivery. However, GRDA wholesale power supply rates are very competitive, and an excellent option for the Pawnee Nation, and appear very comparable to preference power rates available to Tribes in other parts of the U.S.

## Negotiate Lower Rates with City of Pawnee

Another possible approach for the Pawnee Nation is to work to negotiate lower rates with the City of Pawnee. A logical leverage point for the Nation is that, as a federally recognized Indian Tribe, the Pawnee Nation can select its electric suppliers. Also, it currently has no contracts currently in place with the City. And, as discussed previously, service appears to be provided to the Pawnee Nation at "the City of Pawnee's option." The Pawnee Nation could approach the City to establish lower-cost contracts, which would ultimately protect the City in the future, but with the goal of reducing current electric rates.

Several alternatives were modeled in this analysis that could possibly be considered reasonable by the City, depending on its financial situation, and funding sources. The cost of electric service for various customer classes, and political considerations often results in subsidization of one or more customer classes, but there is no public information available that would provide enough data to determine whether that is the case. A summary of several rate application alternatives, and their financial impacts, is included in Table 6-19.

### Table 6-19. Rate Application Alternatives

| Negotiation Approach | Rationale | Rate Application | Potential Pawnee Savings |
|---|---|---|---|
| **Industrial Rate** | Volume of power used by Pawnee Nation Facilities | 11.40 monthly charge; $.071 per kWh | $19,660 |
| **Economic Development Rate** | Additional facilities<br>Level of usage | To be negotiated | To be negotiated |
| **Public Schools/Hospital Rate** | Public/non-profit entity | No monthly charge; tiered rates beginning at $.0939 | $485 |

According to the Pawnee Energy Team, the Pawnee Nation, and the City of Pawnee have traditionally had a strong connection and positive relationship. Rather than create an adversarial situation, the Nation could find several opportunities to allow the Nation and the City to partner to identify solutions. As the Nation and City work through a variety of utility service-related challenges, they could benefit from partnering on such projects as provision of water service, utilizing Pawnee Nation water rights and supplies, developing joint wastewater management and facility options, or other possible City-Tribe relationships.

Other Tribes and cities have developed a Memorandum of Understanding for a variety of joint efforts, and, depending on the current relationships, could be a possible avenue for Pawnee to pursue activities that would benefit the Tribe, as well as the City.

## Develop a Pawnee Electric Utility Organization

### *Regulatory or Oversight Authority*

The Pawnee Nation could establish a separate Pawnee Electric Utility Authority, or create a sub-entity of its existing Pawnee Nation Utility Authority, with a focus on coordination or oversight of energy utility services, costs, and programs. The Electric Utility Authority could take on a coordination role for the Nation, charged with the responsibility to work with the City to improve service and lower costs; establish energy efficiency programs, requirements and codes; and to provide better access to existing energy-related programs, such as LIHEAP home energy assistance, and DOE-funded weatherization/payment assistance programs. This would benefit Pawnee Nation by establishing a central point of contact, and focus for its electric utility issues and implementation steps.

If the Electric Utility Authority took on a more regulatory role, it could establish its authority to oversee and set energy rates and services on reservation; set standards of service, such as reliability requirements, outage penalties, power quality requirements, and require certain elements of customer services. The Authority could assess penalties for violations, as well as negotiate rates for Tribal facilities. This would benefit Pawnee Nation by establishing its voice in the electric utility world, and by ensuring compliance with service standards that are meaningful and necessary to the Pawnee Nation's ongoing tribal administration activities, and future economic development.

### *Operating Electric Utility*

As a sovereign nation, the Pawnee Nation is empowered to charter, operate and regulate an electric utility as an authority or agency of Tribe, affording it sovereign immunity and other benefits. With this action, the Tribe could and would be responsible for power lines and poles, a substation for interconnection, electric meters and billing systems; staffing and contracts, establishing rate structures, facility construction contracts, and identifying and contracting for wholesale power supplies. Tribal utilities are not subject to state regulation, and are not subject to Federal Energy Regulatory Commission authority.

Its electric utility options include, among others:

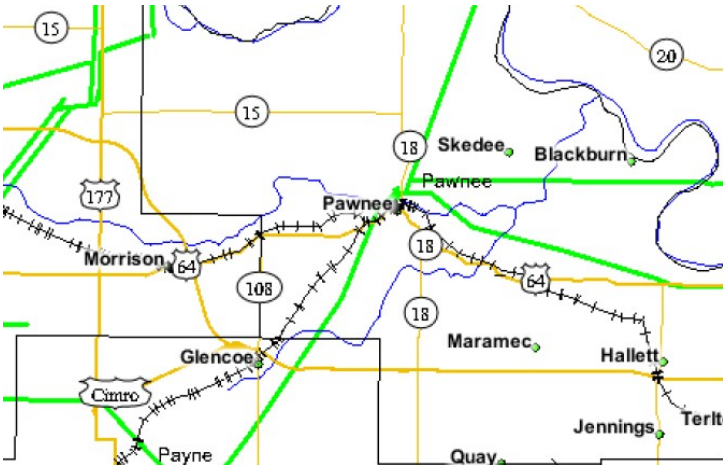
- Acquiring the existing electric distribution system and contracting operations;
- Acquiring the existing electric distribution system and developing internal capacity to operate its system in the future;
- Developing a parallel system which could serve to support growth on the reservation.

With its existing Utility Authority in place, Pawnee Nation has the advantage of the governance and organization already having been established. It would need to study the electric system structure, work to estimate the value of the system, and develop a feasibility analysis to determine the impact of acquisition costs, improvements, power supply options, and rate structures on the Pawnee community and Pawnee Nation Facilities. Some important considerations in its studies would include wholesale power supply options, which include Pawnee's proximity to a transmission system, its proximity to the existing City substation and cost of lines to serve Pawnee, and the cost of building a new substation on the Pawnee reservation.

Once it decided on its course of action, the Pawnee electric utility organization could focus on the development, construction, or negotiations to purchase its existing electric utility system from the City, and work to contract for wholesale power supplies to meet its needs.

The map shown below in Figure 6-42 provides some indication of the proximity of Pawnee Nation Facilities to electric transmission facilities. The green lines represent electric lines greater than 69 kV.

**Figure 6-42. Location of Transmission Facilities in Close Proximity to Pawnee Nation Facilities**




The nearest electric substation, assumed to be owned/operated by the City of Pawnee is estimated to be within 2 miles of Pawnee Nation Facilities.

Understanding the distance from the substation is helpful in estimating costs of electric line construction to connect with Pawnee Nation Facilities. Another potential route would be construction of an interconnection with nearby transmission lines, and construction of a substation on Pawnee Nation lands.

Table 6-20 provides some guidance on costs for transmission and substation construction. These figures were provided by a Southwestern investor-owned utility in mid-2007 in support of an RFP for renewable energy. While not specific to Oklahoma, the costs of power-related construction activity should be indicative of costs Pawnee could anticipate in its exploration of this option.

**Table 6-20. Transmission and Substation Construction Costs**

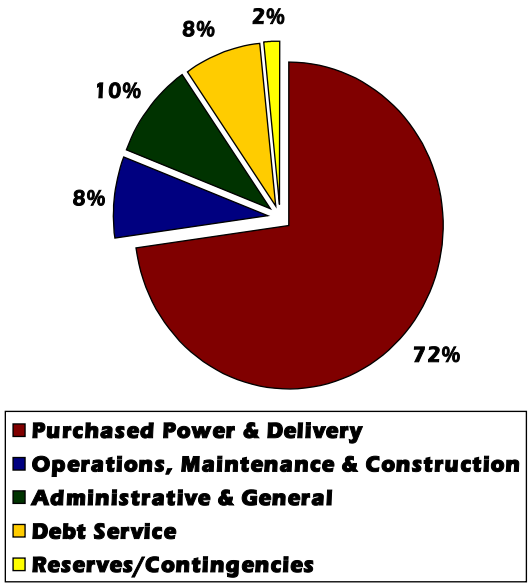
| | $M/mile of transmission line* (single circuit) | Cost of substation to interconnect into existing line** ($M) |
|---|---|---|
| 500kV | $2.6 | $10.5 |
| 345kV | $1.7 | $5.7 |
| 230kV | $1.6 | $4.1 |
| 69kV | $0.4 | $2.4 |

Source: Southwestern investor-owned utility RFP.

A more detailed study of electric operations feasibility would be based on specific system-related data, costs of wholesale power supplies in the region, and costs of recruiting, hiring and training field operations staff in the region.

Depending on Pawnee's interest in contracted operations vs. operating personnel, costs would vary considerably. The chart below in Figure 6-43 indicates the relative costs of electric utility operations, assuming a contracted field operations staff, and utilization of an existing utility administration organization.

**Figure 6-43. Relative Costs of Electric Utility Operations**




For a Pawnee electric utility, if one assumes it is able to contract with GRDA for wholesale power supply, it is likely that Pawnee electric utility service costs could be lower than are currently experienced. Using the relationship illustrated above to overall electric rates, and estimating that per kWh wholesale power costs of roughly $.04 are 72% of Pawnee Nation electric rates, Pawnee Electric Utility Authority rates could potentially be in the $.065 to $.075 range, rather than $.0895 as they are at this time with the City of Pawnee as a provider. This potential decrease in rates could reflect savings of $20,000 to $30,000 over current Pawnee Nation Facilities electric costs.

## 6.2.4 Electric Utility Options Analysis

*Option Analysis*

Each of the electric utility options described previously was analyzed within the context of potential value to the Pawnee Nation, resource requirements, potential funding resources, regulatory and legal considerations, and anticipated energy cost impacts.

## Table 6-21. Option Impacts on Pawnee Nation

| Option | Description | Pros | Cons | Potential Value |
|---|---|---|---|---|
| Business as usual | No major Pawnee action; some focus on prompt payment to avoid late fees | Little effort or focus required | Subject to continuing energy cost increases | Some reduction in total electric costs due to avoidance of late payments - $xxxxx per year? |
| City owns system | Pursue wholesale alternative supply options<br>Negotiate lower rates<br>Reduce energy usage | Progress can be made without significant changes that are dependent on significant cost expenditures | Remain subject to outages, concerns about ability to serve; limited ability to build knowledge and capacity | Long-term reduction in energy costs; as much as $xxxxx annually |
| Pawnee Utility Organization | Develop regulatory authority<br>Develop oversight authority | Greater control over energy matters; develop more knowledge/ involvement in energy matters | Remain subject to outages, concerns about ability to serve | Potentially less financial value |
| Pawnee acquires system | Outside contract operations<br>Develop internal capability | Opportunity to develop knowledge/ capability<br>Greater control | Significant resources required; potentially adversarial situation? | Dependent on acquisition cost; cost of improvements needed |
| Pawnee develops parallel system | Outside contract operations<br>Develop internal capability | Opportunity to develop knowledge/ capability<br>Greater control over energy costs | Significant resources required; adversarial? | Dependent on cost of new facilities; |

## Table 6-22. Option Relative Costs of Electric Utility Operations

| Option | Description | Expertise | Education Required | Financial Requirements |
|---|---|---|---|---|
| Business as Usual | No Pawnee action; some focus on prompt payment to avoid late fees | None | None | None |
| City owns system | Pursue alternative supply options<br>Negotiate lower rates<br>Reduce energy usage | Power generation<br>Energy efficiency | Administration<br>Community<br>Operators | $$ |
| Pawnee Utility Organization | Regulatory authority<br>Oversight authority | General utility matters<br>Other utility systems | Administration<br>Governing organization | $ |
| Pawnee acquires system | Outside contract operations<br>Develop internal capability | Utility operations<br>Utility governance<br>Utility economics/ rates | Administration<br>Operating personnel | $$$$ |
| Pawnee establishes system | Outside contract operations<br>Develop internal capability | Utility operations<br>Utility governance<br>Utility economics/ rates | Administration<br>Operating personnel | $$$$ |

## Table 6-23. Option Funding Resources

| Option | Description | Tribal Resources Required | State/Local Resources | Federal Resources |
|---|---|---|---|---|
| Business as Usual | No Pawnee action; some focus on prompt payment to avoid late fees | Minimal | None | None |
| City owns system | Pursue alternative supply options<br>Negotiate lower rates<br>Reduce energy usage | Administrative Time<br>Supply contract oversight<br>Community Education $ | Weatherization $<br>Payment Assistance | Weatherization $<br>Payment Assistance $ |
| Pawnee Utility Organization | Regulatory authority<br>Oversight authority | Administrative Time<br>Governance Time | Weatherization $<br>Payment Assistance $<br>Community Energy Education Program | Weatherization $<br>Payment Assistance $ |
| Pawnee acquires system | Outside contract operations<br>Develop internal capability | Administrative Time<br>Technical Expertise | State USDA RUS | ANA<br>DOE<br>USDA |
| Pawnee establishes system | Outside contract operations<br>Develop internal capability | Administrative Time<br>Technical Expertise | State USDA RUS | ANA<br>DOE<br>USDA |

## Table 6-24. Option Regulatory / Legal Considerations

| Option | Description | Regulatory | Legal | Level of Complexity |
|---|---|---|---|---|
| Business as Usual | No Pawnee action; some focus on prompt payment to avoid late fees | None | None | None |
| City owns system | Pursue alternative supply options<br>Negotiate lower rates<br>Reduce energy usage | OK deregulation status<br>OK building energy codes | Power supply contract negotiations<br>Fairness re: other Pawnee customers | Moderate |
| Pawnee Utility Organization | Regulatory authority<br>Oversight authority | Tribal governance | Would Pawnee authority be recognized? | Moderate |
| Pawnee acquires system | Outside contract operations<br>Develop internal capability | Potential adversarial situation | Contract negotiations<br>Potential system liabilities | High |
| Pawnee establishes system | Outside contract operations<br>Develop internal capability | Access to land/ownership | Contract negotiations<br>Potential system liabilities | High |

**Table 6-25. Relative Costs of Electric Utility Operations**

| Option | Description | Individual Members | Community | Tribe |
|---|---|---|---|---|
| Business as Usual | No Pawnee action; some focus on prompt payment to avoid late fees | None | None | Modest |
| City owns system | Pursue alternative supply options<br>Negotiate lower rates<br>Reduce energy usage | Modest | Modest | Modest |
| Pawnee Utility Organization | Regulatory authority<br>Oversight authority | Modest | Modest | Modest |
| Pawnee acquires system | Outside contract operations<br>Develop internal capability | Unknown; assume some savings by decision to proceed | Unknown; assume some savings by decision to proceed | Unknown; assume some savings by decision to proceed |
| Pawnee establishes system | Outside contract operations<br>Develop internal capability | Unknown; assume some savings by decision to proceed | Unknown; assume some savings by decision to proceed | Unknown; assume some savings by decision to proceed |

The relative merits of each possible strategy are still under consideration by the Pawnee energy team.

## 6.3 Findings and Recommendations for Review of Utility-Related Issues

The Pawnee Nation has multiple options it can pursue to reduce its electric utility cost burden and could conceivably take action on all five options. Brief discussion of each follows:

- **Business as usual:** While generally not a good approach if the Pawnee Nation is serious about minimizing impacts of higher electric costs, there are specific actions it could take to reduce its power costs re: avoidance of late fees. We recommend that the Pawnee Nation focus some attention on this issue.

- **Consider alternative supply:** Pursuing self generation that makes economic sense is a win-win for the Pawnee Nation. Researching options for wholesale power supply purchases also is an approach that is a win-win for Pawnee. In addition, we believe Pawnee Nation should initiate some focused discussions with the City of Pawnee, with GRDA, and with IEC to discuss its wholesale supply purchase options.

- **Negotiate lower rates with City of Pawnee:** In the context of considering alternative supply, Pawnee could raise this issue with the City of Pawnee. Depending on the existing relationship, and Pawnee Nation's comfort level with applying pressure on the City, it could suggest that the City consider application of other rate schedules, which could help Pawnee Nation overall electric costs. Also, as previously discussed with the Pawnee energy team, working toward partnership opportunities with the City, such as for water supplies or wastewater services, is a win-win.

- **Focus on reducing energy usage:** This is an effort that makes sense for Pawnee Nation under any scenario. The best of all worlds is to reduce electric usage, and completely avoid those costs of service.

- **Develop electric utility organization:** With an existing Utility Authority already in place, Pawnee Nation could identify a resource to focus on electric utility coordination, at a minimum. If it felt it necessary to do so, the Utility Authority could move forward on efforts to regulate its utility services. Forming an electric utility, however, is a serious step, which requires further analysis of the system, and costs of electric utility operations. We don't recommend that the Pawnee Nation pursue this option until it has exhausted its other options.

# 7 FINDINGS AND RECOMMENDATIONS

This section includes an overall summary of findings and recommendations, as well as specific discussion of lessons learned, implications for Pawnee Nation's strategic energy plan, and next steps.

## 7.1 Overall Findings and Recommendations

Due to a lack of financial incentives for renewable energy, particularly at the state level, combined mediocre renewable energy resources, renewable energy development opportunities are limited for Pawnee Nation. However, near-term potential exists for development of solar hot water at the gym, and an exterior wood-fired boiler system at the tribe's main administrative building. Pawnee Nation should also explore options for developing LFGTE and/or anaerobic digester electric generating capacity in collaboration with the City of Pawnee. Significant potential may also exist for development of bioenergy resources within the next decade. Pawnee Nation representatives should closely monitor market developments in the bioenergy industry, establish contacts with research institutions with which the tribe could potentially partner in grant-funded research initiatives.

In addition, a substantial effort by the Kaw and Cherokee tribes is underway to pursue wind development at the Chilocco School Site in northern Oklahoma where Pawnee is a joint landowner. Pawnee Nation representatives should become actively involved in these development discussions and should explore the potential for joint investment in wind development at the Chilocco site.

Financial incentives for project development are generally structured to provide tribes with access to conventional financing mechanisms. Grant opportunities are rare. Pawnee Nation could increase its chances of obtaining financial incentives by partnering with a research entity in pursuing research activities related to biomass or other renewable energy resources; or by applying for funds through a tribe-affiliated business enterprise. Given that energy efficiency appears to be Pawnee Nation's most cost-effective resource development opportunity, and given that funding is available to support rural energy-related business enterprises, members of the Pawnee tribe should consider establishing an energy services business focused on implementing energy efficiency improvements at buildings owned by Pawnee Nation and its members. Establishing an energy services business also furthers the goals set forth in Pawnee Nation's strategic energy vision in that it would empower tribal members with education and greater energy independence, and it would build energy-related employment opportunities. It would also provide the Tribe and its members with substantial energy and cost savings.

Another key recommendation is for Pawnee Nation to adopt a building energy code. Adopting an energy code will ensure that new facilities meet minimum standards for energy conservation and quality construction. Architects and engineers are familiar with energy codes, and it is a simple, no-cost way to further the Nation's goals for sustainable energy use. Adoption of the latest International Energy Conservation Code (IECC) would be consistent with the code in place in Oklahoma.

A review of potential alternatives to Pawnee Nation's current electricity supply scenario revealed that a range of options could be viable. These include the following scenarios: business as usual, alternative supply, negotiate lower rates with City of Pawnee, focus on reducing energy usage, and develop electric utility organization. Under any circumstances, Pawnee Nation should purse strategies to reduce energy usage, as this is the simplest means of reducing electric costs and environmental impacts. The research team also recommends that Pawnee Nation initiate some focused discussions with the City of Pawnee, with GRDA, and with IEC to discuss its wholesale supply purchase options. These discussions will better

inform the Pawnee Energy Team of the specific pros and cons of its wholesale power supply options, and will assist the Team's broader decision-making on utility-related issues. The ultimate path chosen by Pawnee Nation will depend on further consideration of priorities and potential barriers by Pawnee Nation's Energy Team.

## 7.2 Lessons Learned

Through the first steps project, Pawnee Nation learned about the potential for developing specific renewable energy resources and identified areas best-suited for pursuing further research or actual development activities. The renewable energy resource assessment clarified the critical role of both resource and funding availability in determining project feasibility. The assessment helped Pawnee Nation identify the scale of cost savings that could result from changes in electricity service providers, and helped identified the practical and strategic issues to consider in the next phase of decision-making. The assessment also provided Pawnee Nation with a better understanding of the energy industry and energy markets, and helped the Energy Team determine which markets and technologies should be closely monitored in the future.

## 7.3 Next Steps and Implications for Strategic Energy Plan

In 2003, Pawnee Nation established a strategic energy vision and the basic framework for developing a strategic energy plan. A more comprehensive and structured energy plan would provide the tribe with greater focus as it pursues future energy-related decision-making. A comprehensive strategic energy plan would include a well structured planning document that would comprehensively address both current and future energy requirements for a community. An energy plan would also lay out a method to incrementally move away from certain energy sources, while at the same time, investing in and relying on more financially beneficial and secure resources.

The energy plan for the Pawnee Nation as a sovereign and modern tribal government must ensure economic security and vitality. The Pawnee Nation must take every step practical to preserve their integrity as a self-reliant tribe and to develop as a robust economic entity. The tribe must also have the ability to make well-informed decisions so that opportunities and options which align with the tribe's energy vision can be successfully analyzed and pursued. Pawnee Nation's energy plan should also motivate the tribe to utilize new energy technologies, reduce the overall annual cost of energy for the tribe, diversify the Pawnee Nation's economic base, attract capital investment on tribal land, and create new and reliable revenue streams when possible.

Available and reliable energy on Pawnee Nation tribal land is a fundamental necessity for the tribe to develop economically. Reliable energy can anchor existing needs and requirements for the tribe, while at the same time, attract business and development that is both beneficial to and compatible with the Pawnee Nation's energy vision.

Pawnee Nation should take into consideration all possible issues pertaining to the development of its existing strategic energy vision. The results of this first steps project assessment indicate that Pawnee Nation's strategic energy plan should emphasize:

- Energy Efficiency:
  - Implement energy efficiency measures at existing buildings
  - Establish an energy services company run by members of Pawnee Nation to facilitate implementation of energy efficiency measures
- Bioenergy:
  - This should be the primary renewable resource category of focus for the next decade.
  - Monitor bioenergy market developments
  - Pursuit of collaboration with research institution
  - Develop of biomass heating system at Building #64
  - Discuss with City of Pawnee the potential for collaborating on landfill gas to energy project
  - Incorporate exploration of incorporating anaerobic digester electric generating capacity into an expanded wastewater treatment facility.
- Solar:
  - Pursue development of solar hot water system on gym
  - Monitor future reductions in equipment costs and availability of financial incentives for solar installations, as these changes would make photovoltaic installation economically feasible.
- Wind
  - Explore options for Pawnee Nation participation wind development on Chilocco School Site
  - Monitor future reductions in equipment costs and availability of financial incentives for solar installations, as these changes would make photovoltaic installation economically feasible.
- Utility Issues
  - Discussions with nearby electric service providers contractual options and pricing, and potential for pursuing wholesale supply alternatives.
  - Discussions within Pawnee regarding the tribe's interest in establishing its own electric utility.

## 7.4 Conclusion

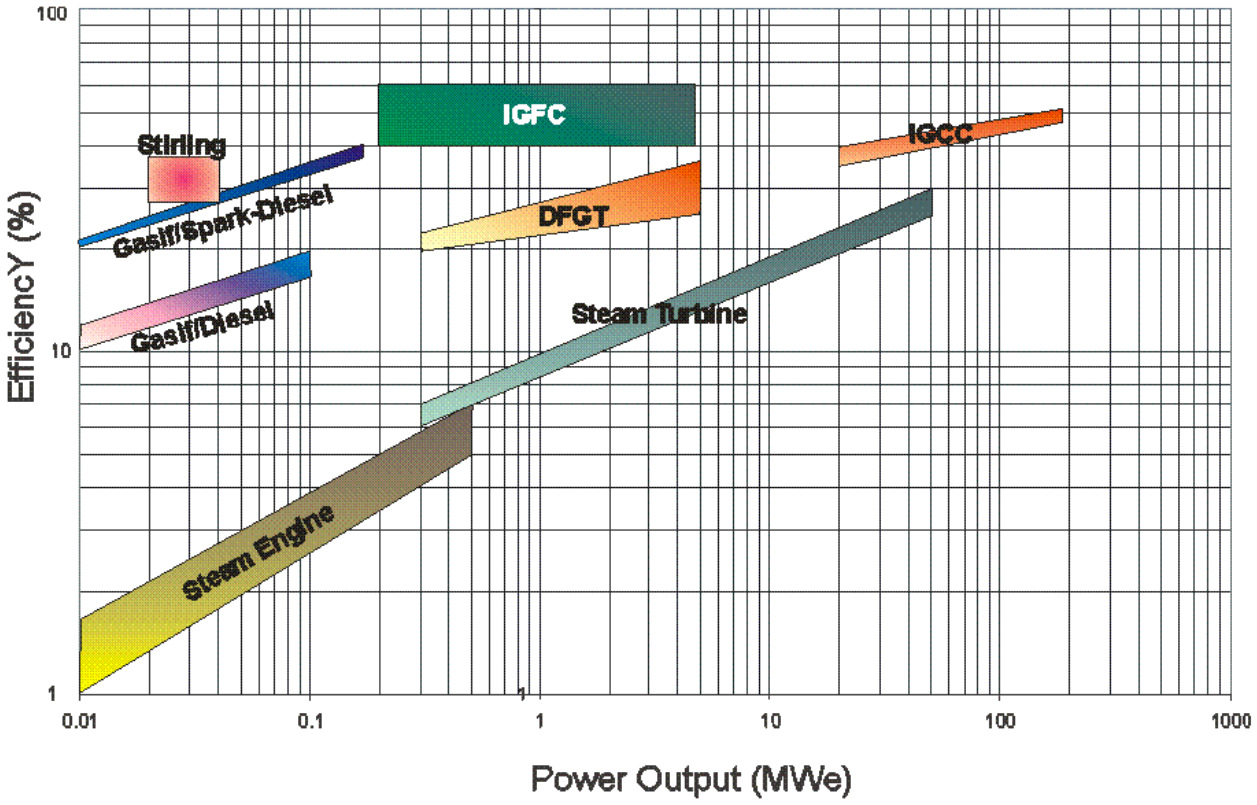
To date, as a result of this First Steps Project the Pawnee Nation has establish a profile of its existing energy supply, demands, and future needs. It has identified Energy Conservation as a priority to immediately integrate into its governmental operations. Creation of additional sustainable energy supply is limited with some opportunity in wind, solar, and bio-fuel production. The Pawnee Nation is in the process of developing its "Energy Code" and is looking at adopting the 2009 International Energy Code. In addition, the Pawnee Nation is updating its existing Natural Resource Laws to promote effective Bio-Fuels" production in the future. However, the most rewarding feature of this project is the overall change or modified behavior which has resulted from the involvement of the tribal participants and stakeholders of this project. The participants are Pawnee governmental decision makers and policy makers are effectively integrating energy conservation into their areas of responsibility. The utilization of geo-thermal, solar, and wind technologies are discussed and evaluated regularly as energy options. The Pawnee Nation is currently trying to install some of these technologies for its facilities. This modified behavior was certainly not expected at this point and was not a directive under the project.

# APPENDIX A: BIOPOWER BACKGROUND INFORMATION

Power purchase agreements (PPA) vary widely and are a major determinant for securing financial backing for a biopower project. Under a PPA, a third party owns and maintains the generation equipment that is located on the property of the project host. The third party would be a commercial business that is well-positioned to take advantage of federal tax incentives for renewable energy development. Securing a PPA is a time consuming effort involving technical experts from various disciplines. Negotiations for a PPA may require in excess of one year and are thus costly in terms of labor hours. However, a power project cannot proceed without a PPA and thus it is important to plan for the budget.

The project pro forma will vary to reflect changing economic conditions as well as deal structure and financial terms. The marketplace is fluid and one can anticipate the pro forma analysis to be flexible in response to fluctuations in the project. As a general observation, the pro forma should be conservative because most projects tend to be more expensive than the initial capital and operating cost estimates, for a variety of reasons.

**Figure A-44. Illustrative Biopower Technologies, Sizes and Efficiencies**



**Technology**

The following is an overview of technological requirements for the applications listed above.

*Biomass Conversion to Power*

Combustion

Direct combustion involves the oxidation of biomass with excess air,[64] producing hot flue gases, which are (generally) used to produce steam in the heat exchange sections of a boiler. The steam can be used to produce electricity in a steam cycle (Rankine cycle). Direct combustion boilers include pile burners, stokers and fluidized bed combustors.

Pile burners stack the wood fuel on a stationary grate. New fuel is fed from the top, or from underneath by an auger. Pile burners are simple and reliable, but they have low efficiency and, generally, high emissions. To remove the ash, they have to be shut down and allowed to cool periodically.

Stoker combustors incorporate a moving grate, which permits continuous ash discharge, thus eliminating the cyclic operation characteristic of traditional pile burners. In addition, the fuel is spread more evenly, normally by a spreader stoker, and in a thinner layer in the combustion zone, giving more efficient combustion.

In the basic stoker design, the bottom of the furnace is a moving grate which is cooled by underfire air. More modern designs include the Kablitz grate, a sloping reciprocating watercooled grate. Reciprocating grates are efficient, fuel-flexible, able to handle load swings well and typically have low fly-ash carryover.

There are hundreds of stoker systems installed and operating in the U.S., in both heating and power generation applications, and the technology is scalable from as small as residential heating to as large as power plants up to 80-MW in capacity.

Bubbling fluidized bed (BFB) and circulating fluidized bed (IFB) combustors have high efficiencies and good fuel flexibility, but are higher in both capital and operating costs than stoker systems.

The primary type of turbine used for central power generation is the condensing turbine. Steam exhausts from the turbine at sub-atmospheric pressures, maximizing the energy extracted from the steam to produce useful work. Back-pressure turbines are less efficient than condensing turbines, however, they are less expensive and do not require a surface condenser. An extraction turbine has openings in its casing for extraction of steam. The extraction pressure may or may not be automatically regulated depending on the turbine design. Regulated extraction permits more steam to flow through the turbine to generate additional electricity during periods of low heating demand by the thermal system.

[64] Approximately 6 pounds of air is required for complete combustion of one pound of dry wood. In order to ensure complete combustion within the space and time available, *excess air*, usually about 50%, is added to the combustion chamber. Therefore, the air emissions are approximately 9 to 10 pounds per pound of fuel burned.

Gasification

Thermal gasification of biomass produces biogas, also known as wood gas, producer gas (produced with air) or syngas (produced in the absence of air). Biogas is produced at temperatures of about 1300°F, by the reaction of carbon with steam or a limited amount of air. Biogas is typically composed of carbon monoxide (CO), hydrogen ($H_2$), methane ($CH_4$), and carbon dioxide ($CO_2$). With the exception of $CO_2$, all of these components are combustible. In addition to these gases, gasification produces nitrogen, oxygen, water vapor, char (carbon), tar, ash and small amounts of other chemicals.

Producer gas can be used for heating, power generation and liquid fuel applications. In air-based gasification cycles, biomass is partially oxidized to provide energy for thermal conversion of the remaining biomass to gases and vapors.

When air is used for gasification, the product gases generally have an energy content of 125 to 150 Btu per dry standard cubic foot (Btu/dscf). This is considered a low-Btu gas (as a comparison, natural gas has an energy content of about 1,000 Btu/dscf). If oxygen is used instead of air in the gasification process, the energy content of the gas can be increased to about 350 Btu/ scf.

In indirect gasification, instead of air or oxygen, an external heat source is used to provide the heat for high-temperature steam gasification of the biomass. Indirect gasification produces a gas with an energy content of about 500 Btu/scf, which is considered a medium-Btu gas.

Emissions from Wood Combustion

Emissions from any combustion appliance are best-determined using test results specific to a given technology in a particular application. In many cases, these data are not readily available. In such cases, the U.S. EPA provides emissions factors that can be used to estimate emissions from wood-fired boilers that use mechanical particulate collection systems in AP-42 (see table).[65]

[65] U.S. EPA. Introduction to AP-42, Volume I, Fifth Edition. January 1995. On-line: http://www.epa.gov/ttn/chief/ap42/c00s00.pdf Washington, DC. p. 2

**AP-42 US Federal Government AP-42 emission factors**

| Pollutants | Emission Factors [lb/MMBtu] |
|---|---|
| Total Particulates* | 0.22-0.3 |
| Oxides of Nitrogen | 0.49 |
| Carbon Monoxide | 0.6 |
| Total Organic Compounds | 0.06 |
| Sulfur oxides | 0.025 |

* Emission factors for systems utilizing mechanical particulate collection devices

Some of the biomass may come from wood that would be pile burned and thus there are considerable environmental benefits if the wood were utilized in a controlled environment. The table below shows the emissions due to burning wood in piles, in prescribed burns, in uncontrolled forest fires, and in a gasifier. Due to the controlled conditions in the gasifier, and the emissions control equipment, the level of emissions of CO (carbon monoxide), PM10 (particulate matter smaller than 10 microns) and VOCs (volatile organic compounds) are greatly reduced when these materials are burned in the gasifier. The level of $NO_x$ (oxides of nitrogen) is also reduced, but not as significantly.

**Comparison of different wood-burning alternatives**

| | lbs/green ton | | | |
|---|---|---|---|---|
| **Disposal method** | **PM10** | **NOx** | **VOC** | **CO** |
| Pile burning (1) | 19 to 30 | 3.5 | 8 to 21 | 54 to 312 |
| Prescribed burn (2) | 24 | 4.0 | 13 | 224 |
| Forest fire (2) | 15 | 4.0 | 21 | 140 |
| **Biomass boiler (3)** | **2.1** | **2.8** | **0.6** | **1.7** |
| ***Average Reduction*** | ***89%*** | ***30%*** | ***96%*** | ***99%*** |

(1) Patrick Gaffney, California Air Resource Board, 916-332-7303
Available at www.gisc.berkeley.edu/~jscar/agburn/agburnefs.html
(2) Environment Australia. Emissions Estimation Technique Manual for Aggregrated Emissions from Prescribed Burning and Wildfires, Version 1.0. September 1999.
(3) Based on Chiptec gasifier - other systems similar

The data in the table above are given in terms of pound of pollutant per ton of wood burned.

# APPENDIX B: PELLET STOVE MANUFACTURERS

| COMPANY NAME | PHONE | BRAND NAME | URL |
|---|---|---|---|
| American Energy Systems | 320/587-6565 | Country Side | www.hearthdirect.com |
| APR Industries, Ltd. | 204/452-9907 | Kozi | www.kozistoves.com |
| Bixby Energy Systems | 612/916-0642 | | www.bixbyenergy.com |
| Breckwell Hearth Products | 972/606-8444 | Breckwell | www.breckwell.com |
| Country Stoves Inc. | 714/921-6100 | | www.LennoxHearthProducts.com |
| Dansons Group, Inc. | 877/303-3134 | Glo Boy | www.dansons.com |
| Dell Point Technologies | 514/331-6212 | | www.pelletstove.com |
| Empire Products, Inc. | 909/399-3355 | Easyfire | www.empireproductsinc.com |
| England's Stove Works, Inc. | 434/929-0120 | Englander | www.englandsstoveworks.com |
| Even Temp Inc. | 402/728-5255 | St. Croix | www.eventempinc.com |
| Harman Stove Company | 717/362-9080 | Harman | www.harmanstoves.com |
| Invensys Climate Controls | 310/638-6111 | | www.invensys.com |
| Lennox Hearth Products | 714/921-6100 | Whitfield/Country Collection | www.LennoxHearthProducts.com |
| Mendota Hearth Products | 319/365-5267 | | www.mendotahearth.com |
| NU-TEC Incorporated | 401/738-2915 | | www.nutec-castings.com |
| Quadra Fire | 509/684-3745 | Quadra-Fire | www.quadrafire.com |
| Sherwood Industries | 250/652-3223 | EnviroFire | www.envirofire.biz |
| Stove Builder International (SBI) | 418/527-3060 | | www.drolet.ca |
| Tarm USA | 603/795-2214 | | www.woodboilers.com |
| Thelin Co. Inc. | 530/273-1976 | | www.thelinco.com |
| Traeger Industries, Inc. | 503/845-9234 | Traeger | www.traegerindustries.com |
| Travis Industries | 425/609-2500 | Avalon/Lopi | www.travisproducts.com |
| United States Stove Company | 423/837-2100 | American Harvest | www.usstove.com |

Source: Pellet Fuels Institute

# APPENDIX C: OUTDOOR WOOD BOILER MANUFACTURERS

| Manufacturers | Air furnace | Hydronic Furnace/Boiler | Clean Burning[66] | Thermal Efficiency | Safety Certified |
|---|---|---|---|---|---|
| Greenwood Technologies | | 3 models | Yes | 85% | Yes |
| Tarm USA | | 6 models | Yes | 80-85% | Yes |
| Garn | | 3 models | Yes | 85% | Yes |
| Alternate Heating Systems | | 8 models | Yes | 85% | No |
| Hud-Son Products | | 3 models | No | No Claim | No |
| Central Boiler | | 5 models | No | No Claim | Yes |
| Free Heat Machine | | 3 models | No | No Claim | (1) |
| Gefco Hydronics | | 3 models | No | No Claim | No |
| Northwest Manufacturing | | 4 models | No | No Claim | No |
| The Wood Doctor | | 5 models | Yes | No Claim | Yes |
| Hardy Manufacturing | | 7 models | No | No Claim | Yes |
| Empyre | | 4 models | No | No Claim | Yes |
| Heatmor | | 6 models | No | No Claim | Yes |
| Mahoning | | 4 models | No | No Claim | No |
| Royall | 3 models | 3 models | No | No Claim | No |
| Kerr Heating | 5 models | 1 model | No | No Claim | No |
| Charmaster | 4 models | 1 model | No | No Claim | No |
| Valley Comfort/Blaze King | 3 models | - | No | No Claim | No |
| Yukon Eagle | 6 models | - | No | No Claim | Yes |

Notes:
(1) Control panel is UL-listed.
(2) US distributor claims units are certified to UL 391-1955 and CSA B366.1-M91 but test lab name and report number have not been provided.

(Source: Greenwood Wood Furnace – Wood Boiler 15 September 2007)

[66] Greenwood Wood Furnace Co. states that Clean Burning furnaces "burn wood completely, leaving no particles to create smoke, creosote or ash." These claims were not confirmed.