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KAW NATION ENERGY EFFICIENCY AND CONSERVATION STRATEGY

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3.5.1 Overview 43
3.5.2 Geothermal Heat Pump 43
3.5.2.1 Data Sources and Resource Availability 44
3.5.2.2 Design Analysis 44
3.6 Overall Renewable Energy Summary 46
Chapter 4. Energy Audits and Retrofits 47
4.1 Overview 47
4.2 Energy Auditing Strategy 48
4.3 Energy Efficiency Improvements 50
4.3.1 Envelope Measures 50
4.3.2 Roof and Wall Insulation 53
4.3.3 Window Insulation 53
4.3.4 Air Leakage 54
4.3.5 Insulation of Kaw Nation Facilities 54
4.4 Lighting 56
4.4.1 Lighting Bulb Improvements 56
4.4.2 Lighting Controls 57
4.5 Appliances and Electrical Power Systems 58
4.5.1 Energy Star Label Appliances 59
4.5.2 Life Expectancy of Appliances 60
4.6 HVAC (Heating, Ventilation, Air-Conditioning) 61
4.6.1 Replacement of Air-Conditioner in Day Care Center, Newkirk 61
4.7 Energy Code 64
Chapter 5. Electric Energy Audit and Recommendations 65
5.1 Data Collection 65
5.2 Electricity Usage and Recommendation for Existing Buildings 65
5.2.1 EPA Building and Garrett Dental Clinic 65
5.2.2 Administrative Building 67
5.2.3 Kanza Museum 69
5.2.4 Mehojah Resource Center 71
5.2.5 Social Services Center 72
5.2.6 Health Center 74

5.2.7 Wellness Center 76
5.2.8 Community Center and Gymnasium 78
5.2.9 Day Care Center 80
5.2.10 SouthWind Parking Lot 82
5.3 New Construction 84
5.3.1 Education and Learning Center 84
5.4 Overall Analysis 85
Chapter 6. Education and Outreach 86
6.1 Overview 86
6.2 Raising Public Awareness 86
6.3 Local Environmental Programs and School Programs 86
6.3.1 Energy Saving Class 86
6.4. Energy Saving Activity Participation 87
Chapter 7. Conclusions and Recommendations 88
7.1 Conclusions 88
7.2 Recommendations 89
Appendix A:Biomass 91
Appendix B: Funding Opportunities for Renewable Energy Resource 99
Appendix C: Energy Auditing Tips 101
Appendix D: Transportation 105
Appendix D: Waste Management 110
Appendix E: Budgeting 115
References 117

Figures

Figure 1 Kaw Nation area 11
Figure 2 United States Energy Consumption and Renewable Energy Consumption 14
Figure 3 Oklahoma Energy Status 16
Figure 4 U.S Solar Energy Resources 17
Figure 5 Oklahoma State Solar Radiation 18
Figure 6 Solar Radiation in Newkirk, 2008 19
Figure 7 Solar Radiation in Blackwell, 2008 19
Figure 8 Photovoltaic system 20
Figure 9 Cumulative Cash Flow Graph for PV system 24
Figure 10 Solar Hot Water System Configuration 25
Figure 11 Cumulative Cash Flow for Solar Water Heating System 29
Figure 12 Wind Turbine System 30
Figure 13 Oklahoma and Projected Area Wind Resources 31
Figure 14 Wind Velocity in Newkirk, 2008 32
Figure 15 Wind Velocity in Blackwell 32
Figure 16 Cumulative Cash Flow Chart for Wind Turbines for the SouthWind Parking Lot, Newkirk 35
Figure 17 Cumulative Cash Flow Chart for Wind Turbines at the Kanza Health Center, Newkirk 36
Figure 18 Cumulative Cash Flow Chart for Wind Turbines at the Day Care Center, Newkirk 37
Figure 19 Cumulative Cash Flow Chart for Wind Turbines at the JRM Community Building, Newkirk 38
Figure 20 Cumulative Cash Flow Chart for Wind Turbines at the Wellness Center, Newkirk 39
Figure 21 Hydro Resources in the Kaw Nation area 40
Figure 22 Cumulative Cash Flow Chart for a 300 kW Micro-hydropower system 42
Figure 23 Geothermal Heat Pump Diagram 43
Figure 24 Geothermal Resources in the U.S 44
Figure 25 EPA Tracked Sites in Oklahoma with Geothermal Binary Power Plant Facility Siting Potential 44
Figure 26 US Energy Consumption 47
Figure 27 Residential Buildings Total Energy Use in 2006 48
Figure 28 Commercial Buildings Energy Use 48
Figure 29 Conventional Air Leakage in the Residence 51
Figure 30 Recommended R-Values in the United States 52
Figure 31 Cumulative Cash Flow Chart for Day Care Center 64
Figure 32 EPA Building Energy Consumption in 2008 67
Figure 33 Energy Consumption for the Administrative Building 69
Figure 34 Electricity Consumption in the Kanza Museum 70
Figure 35 Electricity Consumption for the Mehojah Resource Center in 2008 72
Figure 36 Electricity Consumption by the Social Services Center 74
Figure 37 Electricity Consumption for the Health Center 76
Figure 38 Electricity Consumption for the Wellness Center in Newkirk 78
Figure 39 Electricity Consumption for the Community Center and Gymnasium 80
Figure 40 Electricity Consumption in the Day Care Center, Newkirk 82
Figure 41 Electricity Consumption and Expected Savings in the SouthWind Parking lights 83
Figure 42 Moisture Effect on Heating Value 92
Figure 43 Gasification Process 94
Figure 44 Combustion Process 95
Figure 45 Pyrolysis Process 95
Figure 46 Biofuel Extraction Process from Biomass 96
Figure 47 Co-Firing Process 97
Figure 48 Biomass Resources Available in the United States 97
Figure 49 Oklahoma Biomass Resources 98
Figure 50 U.S. Greenhouse Gas Emissions by Sector, 1990-2006 105
Figure 51 Percentage of U.S. Greenhouse Gas Emissions, 2006 105
Figure 52 Total MSW Generation in the U.S., 2008 110

Figure 53 The Solid Waste Management Hierarchy 110
Figure 54 Waste Disposal in 2008 112
Figure 55 Electricity Providers near Kaw Nation 115

Tables

Table 1 Information on Major Kaw Nation Facilities 12
Table 2 Electricity Net Generation from Renewable Energy by Energy Use Sector and Energy Source, 2003 – 2007 15
Table 3 System Design Assumptions 22
Table 4 System Cost Assumptions 23
Table 5 Solar Hot Water Design for the Wellness Center in Newkirk 27
Table 6 Cost Estimation for Solar Hot Water System in Newkirk 28
Table 7 Wind System Efficiency Assumptions 33
Table 8 Wind Turbine Cost 34
Table 9 Wind System Cost Assumptions for Lights in the Parking Lots of the SouthWind Casino, Newkirk 35
Table 10 Wind System Cost Assumptions in the Kanza Health Center, Newkirk 36
Table 11 Wind System Cost Assumptions for the Day Care Center, Newkirk 37
Table 12 Wind System Cost Assumptions in JRM Community Building, Newkirk 38
Table 13 Wind System Cost Assumptions in Wellness Center, Newkirk 39
Table 14 Arkansas River Flow Rates 41
Table 15 Necessary Flow Rate Design 41
Table 16 Micro-hydro System Design 42
Table 17 Ground-Source Heat Pump Design 45
Table 18 Ground Heat Pump Cost Estimation 46
Table 19 Summary of Renewable Energy Resource Development 46
Table 20 Procedures of Commercial Building Auditing 49
Table 21 Feasible Kaw Nation Buildings for Installation of Insulation 53
Table 22 Effective Methods of Window Insulation 54
Table 23 Types of Insulation Recommended for Kaw Nation Facilities 55
Table 24 Recommended lighting levels 56
Table 25 Energy Savings with Occupancy Sensor Retrofits 58
Table 26 Appliance Electricity Consumption 58
Table 27 Comparing Energy Star Product Operating Costs 59
Table 28 Lifespan of Appliances 61
Table 29 Air Conditioning System Design for Day Care Center in Newkirk 62
Table 30 Cost estimation of Cooling System in Day Care Center, Newkirk 63
Table 31 Energy Audit for the EPA building 66
Table 32 Energy Audit for the Administrative 68
Table 33 Energy Audit for the Kanza Museum 70
Table 34 Energy Audit for the Mehojah Resource Center in Kaw City 71
Table 35 Energy Audit for the Social Services Center in Kaw City 73
Table 36 Energy Audit for the Health Center in Newkirk 75
Table 37 Energy Audit for the Wellness Center in Newkirk 77
Table 38 Energy Audit for the Community Center and Gymnasium in Newkirk 79
Table 39 Energy Audit for the Day Care Center in Newkirk 81
Table 40 Energy Audit in the SouthWind Parking Lot 82
Table 41 Energy Audit for the Education and Learning Center 84
Table 42 Summary of Electricity Consumption and Savings 85
Table 43 Typical Solid Fuel Properties 92
Table 44 Biomass Power Technology in Commercial/Demonstration Phase during 2000-2006 93
Table 45 Generation and Recovery of Products in MSW, 2008 113
Table 46 Electricity Rates from Feasible Providers 116

Executive Summary

Energy efficient usage and conservation are major issues in the United States. To reap the benefits from energy efficient usage and conservation, the Kaw Nation requested this study on renewable energy resources, funding options, energy auditing and retrofit, transportation, waste management, and education. These issues are all analyzed within this report. Finally, solutions for each topic are recommended.

This report is divided into four categories based on possible energy savings for the Kaw Nation.

1. Renewable Energy resources

Solar, wind, hydropower, biomass, and geothermal energy were considered as feasible renewable energy resources. Each resource was evaluated to find the best energy combination for the Kaw Nation.

- Solar
  Solar photovoltaic (PV) and solar hot water systems were evaluated as renewable energy resources. The solar PV system was designed for the office building next to the SouthWind Casino by the RETScreen Method and resulted in a 16 year payback period. The solar hot water system was evaluated for the Wellness Center in Newkirk and found a 13.5 year payback period.
- Wind
  100kW wind turbine systems were evaluated for the SouthWind parking lot, the Kanza Heath Center, the Kaw Nation Day Care, the JRM Community Building, and the Wellness Center in Newkirk. Installation of turbine systems in facilities of Newkirk resulted in more than a 25 year payback period. This payback period is very long, so wind turbines cannot be justified based solely on economics.
- Hydropower
  A micro-hydropower system was evaluated for the facilities in the Kaw City due to resource availability. The Arkansas River is the only feasible hydro resource for the Kaw Nation. A 350kW micro-hydropower system was evaluated and resulted in a 6 year payback period. However, this option requires that the Kaw Nation obtain rights to use the Arkansas River, which may not be possible.
- Biomass and Biofuels
  Biomass and biofuels were not estimated due to poor economics. Information on these resources are included in Appendix A.
- Geothermal Energy
  A geothermal system was evaluated for the Day Care Center in Newkirk. A payback period was estimated at longer than 25 years.

2. **Energy Audits and Retrofits**

The easiest and most efficient way to improve energy usage within the Kaw Nation is to audit the existing facilities. An audit was performed and is evaluated in four categories: envelope measures, lighting, appliances, and heating and cooling.

- Envelope measures
  Most Kaw Nation facilities were built after 1990 and were designed with modern envelope measures. However, window insulation and blocking of sunlight could save energy.
- Lighting
  All facilities of the Kaw Nation were inspected to analyze their lighting systems. The recommended lighting to maintain optimum brightness for types of use is shown in Table 24. An appropriate lighting control system tied to work hours would further conserve energy.
- Appliances
  Many electrical appliances could be economically replaced with Energy Star Labeled equipment. Reducing appliance use would contribute an additional 5 to 10% to energy efficiency.
- Heating and Cooling
  Several Kaw Nation facilities were determined to have inefficient heating and cooling loads. Equipping programmable thermostats for all facilities would help save on heating and cooling loads.

3. **Electricity Usage and Recommendation for Existing Buildings**

Current electricity data and site inspections were used to evaluate energy consumption of Kaw Nation facilities. All major facilities were inspected and recommendations provided.

4. **Education and Outreach**

This chapter includes education and outreach programs for the Kaw Nation. Educational programs for both students and adults are recommended to obtain buy-in from tribal members.

Chapter 1. Introduction

1.1 Project Objective

This report evaluates facilities of the Kaw Nation for energy efficient usage and makes recommendations for the retrofit of energy systems to improve energy efficient usage and conservation.

Detailed goals are to:

- Assess the existing energy infrastructure and energy consumption.
- Examine possible cost saving and renewable energy resources that could fit the capacity and needs of the Kaw Nation.
- Analyze the various Kaw Nation facilities that the Nation owns and operates.
- Prioritize Kaw Nation current and future energy consumption to increase energy efficiency and reduce energy cost.
- Recommend the procurement and installation of energy-efficient appliances and other items of equipment.

Most of the report is based on the following steps:

- Review of renewable energy options.
- Analysis of renewable energy options.
- Energy auditing options.
- Energy demand forecasts and characterization.
- Review of demand-side options.
- Prioritization of options.

During the project meeting, the Kaw Nation representative requested that the focus of the report be the development of renewable energy resources and the determination of possible energy savings by auditing the facilities. This report concentrates on the renewable resource use and auditing. More detailed information is included in the Appendices.

1.2 Document Organization

The report is organized as follows:

- Chapter 1 provides background information on the Kaw Nation and energy use.
- Chapter 2 introduces facilities of the Kaw Nation and energy improvements at the facilities.
- Chapter 3 overviews renewable energy resources such as solar, wind, hydro, biomass, biofuel, and geothermal energy in the Kaw Nation area and feasible renewable resources to be adopted for the Kaw Nation facilities.
- Chapter 4 contains current electricity consumption and energy-saving recommendations for major facilities of the Kaw Nation.
- Chapter 5 discusses the public participation and energy education of Kaw Nation residents.
- Chapter 6 finalizes the overall report and recommends better options for the Kaw Nation.
- Appendices provide more information for energy efficient use and conservation. The appendices also include funding opportunities for the Kaw Nation.

Chapter 2. Background

2.1 Overview of the Kaw Nation

The Kaw Nation (Nation) has 3,177 tribal members scattered across the United States. Most of the members live in Kay County, Oklahoma, where the Nation is one of the largest employers for Kaws. The Kaw Nation also controls 1400 acres of tribally-owned and federal trust lands, as shown in Figure 1, and operates several facilities such as the SouthWind Casino, a Health Clinic, a Wellness Center, and a Daycare Center. The Nation provides several services for local or Kaw people, such as child support services, educational and social services, emergency management, environmental programs, human resources, administration of the ICDBG (Indian Community Development Block Grant) program, health care, and Kaw language education.

Most of the energy used in Kaw Nation facilities is provided by two utilities: Kay Electric and OGE Energy Corp. Kay Electric provides the electricity used by the Kaw Nation, and OGE Energy provides natural gas.

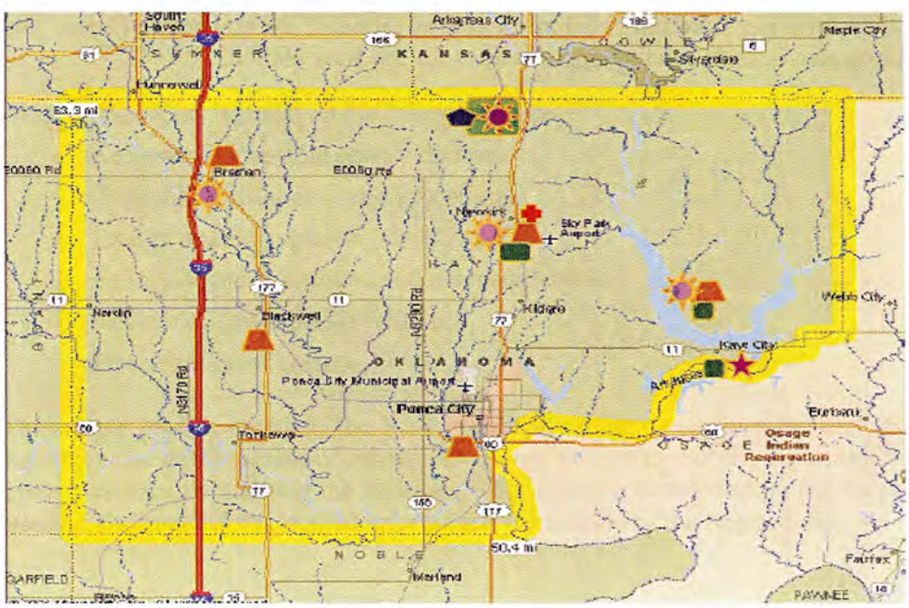


Figure 1 Kaw Nation area

2.2 Facilities Information

The Kaw Nation possesses 41 facilities around Kay County. Most of the facilities consuming large amounts of energy are located in Kaw City and Newkirk, Oklahoma. Table 1 shows a summary of characteristics of major facilities in the Kaw Nation area. Based on this information, analyses will be performed and economic possibilities will be determined.

Table 1 Information on Major Kaw Nation Facilities

Buildings	Old Loc #	Year Built	Floor Area, Sq. Ft.	2008 Electric Usage (kWh)	Yearly Electric Cost ($)	Yearly Water Cost ($)	Type of usage
Kaw City, OK - North of Hwy 11							
Administration Building	1	1985	7,600	67,240	8259.96	272.9	Offices
Garrett/EPA Building	2	1979	3,500	59,132	7549.31	530.53	Offices
Museum / Multifunction	10	1993	7,180	34,120	4393.11	214.32	Museum
Mehojah / Title VI	21	2001	6,016	67,114	8259.96	259.2	Offices
Accounting Storage	8	2006		-			Warehouse
Kaw City, OK - South of Hwy 11							
Social Services Building	24	2006	5,900	41,560	5195.62	246.86	Offices
Learning Center	33	2009	4,205	NA	NA	NA	
KEDA Newkirk, OK							
Kaw SouthWind Casino			55,000	5,425,200	353056	524.92	Casino
SouthWind Signage				6,678	811.19	--	
Casino Office Bldg- #2				976	233.41	119.38	Office
Maintenance Bldg				24,574	2368.88	106.95	Maintenance
SouthWind Parking Lights				120,360	10913.9	1518.85	
New Office Bldg				68,240	6554.7		Office
Newkirk, OK							
Clinic	16	1998	12,315	114,680	10718.01	449.8	Clinic
Community Center and Gymnasium	15	1997	12,967	131,640	11761.67	0	Meetings
Wellness Center	17	1998	11,010	255,600	20846.25	543.91	Gym
Day Care Center	19	2002	3,520	89,000	8631.92	203.41	Day Care
Maintenance Building	26	2007	2,520	10,501	1170.54	187.07	Shop
Daycare Storage	20		300	-			Warehouse

2.3 Tribal Energy Vision

The Kaw Nation Environmental Department (KNED) was established in 1996 by the Kaw Nation to preserve, protect, and improve the quality of natural resources for the benefit of the people of the Kaw Nation and their descendants. Since 1996, KNED has made an effort to improve air quality, tribal lands, water, wildlife, plants, and the health and quality of life for the Kaw Nation people.

This project is one of the programs to improve an existing energy efficiency and conservation strategy (EECS). The project can generate benefits of the Kaw Nation in the following ways:

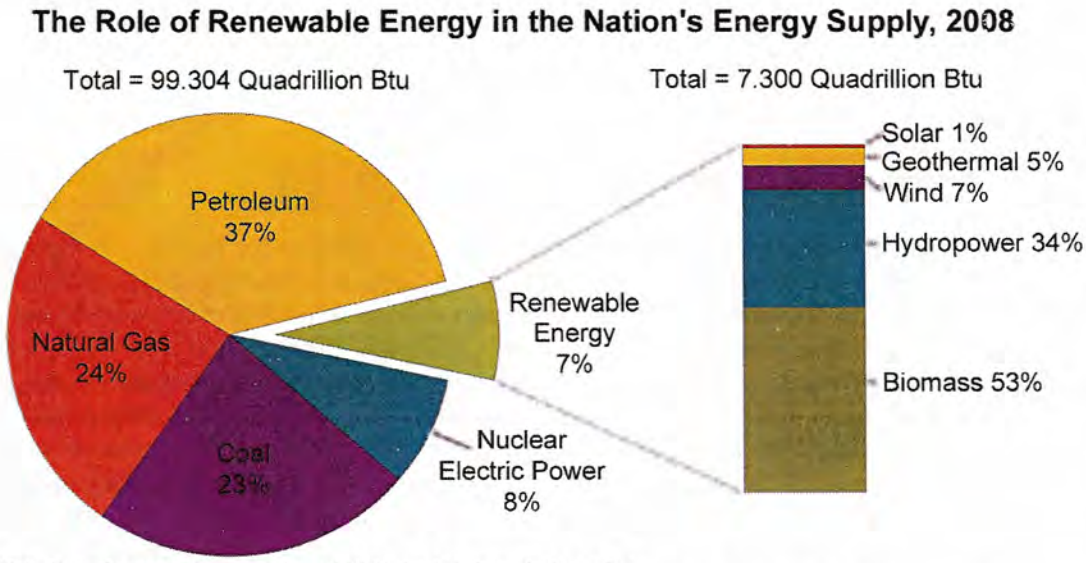
- Reduce energy usage in residential houses and commercial facilities of the Kaw Nation.
- Reduce greenhouse gas (GHG) emission and use clean energy.

- Establish better local job markets and educational training programs for energy savings.
- Recognize the importance of energy savings and environmental protection to the Nation's people.
- Provide opportunities for funding for renewable resources for the Kaw Nation.

Chapter 3. Renewable Energy Resources

3.1 Overview

This chapter provides an overview of the different types of renewable energy resources which might be adopted by the Kaw Nation. Many countries try to use renewable energy to improve energy savings and to protect the environment. In the United States, renewable energy provided about 9% of total energy usage and more than 7% of electrical supply in 2008[3]. The generation of renewable energy has increased at a high rate due to environmental friendliness and a desire to find substitutes for limited fossil fuel supplies. Figure 2 and Table 2 show the increase in the use of renewable resources since 1949. Biomass and wind power show the highest rates of increase in the U.S market. Oklahoma is well-situated to take advantage of both biomass and wind power. These resources also have potential for the Kaw Nation.



Note: Sum of components may not equal 100% due to independent rounding.
Source: U.S. Energy Information Administration, *Annual Energy Review 2008*, Table 1.3, Primary Energy Consumption by Energy Source, 1949-2008 (June 2009).

Figure 2 United States Energy Consumption and Renewable Energy Consumption

Table 2 Electricity Net Generation from Renewable Energy by Energy Use Sector and Energy Source, 2003 – 2007 (Thousand Kilowatt-hours)

Sector/Source	2003	2004	2005	2006	2007
Electric Power	320,992,669	317,391,910	323,693,336	352,187,707	320,547,239
Biomass	23,335,310	22,798,191	23,600,971	24,268,913	25,005,592
Waste	13,807,633	13,061,787	13,031,084	13,927,432	14,294,304
Landfill Gas	4,829,632	4,836,377	4,811,325	5,475,664	5,928,117
MSW Biogenic	7,553,146	7,175,417	7,342,938	7,487,120	7,301,560
Other Biomass	1,424,854	1,049,993	876,822	964,648	1,064,627
Wood and Derived Fuels	9,527,677	9,736,404	10,569,886	10,341,481	10,711,288
Geothermal	14,424,231	14,810,975	14,691,745	14,568,029	14,637,213
Hydroelectric Conventional	271,511,659	265,063,848	267,039,777	286,253,922	245,842,714
Solar/PV	534,001	575,155	550,294	507,706	611,793
Wind	11,187,467	14,143,741	17,810,549	26,589,137	34,449,927

Source: U.S. Energy Information Administration, Annual Energy Review 2008.

3.1.1 Oklahoma Renewable Energy Resources

Oklahoma has been largely dependent on the oil and gas industry for decades, though this sector has declined due to limited production rates and State and Federal policies. Now, state agencies and private companies are examining clean energy. Wind power has been found to be particularly valuable, especially in the west of Oklahoma. Between 2003 and 2005, wind power increased from 175 MW to 474 MW. Oklahoma also has significant potential for the development of micro hydroelectric power generation. The United States Department of Energy estimates that there exists 542 MW of undeveloped hydroelectric generation in the State of Oklahoma [(6)]. This includes upgrading existing power sites, adding generation to existing non-power dam sites, as well as undeveloped sites. Oklahoma has significant potential for the development of bio-resources in its many farms. Recently, the Rural Energy for America Program grants provided funding under the new Farm Bill. Figure 3 shows energy usage and potential energy resources in Oklahoma.

In this project, feasible renewable resources for the Kaw Nation were evaluated for the potential to reduce energy usage. Potential energy resources were divided into five categories: solar, wind, hydropower, biomass, biofuel, and geothermal energy.

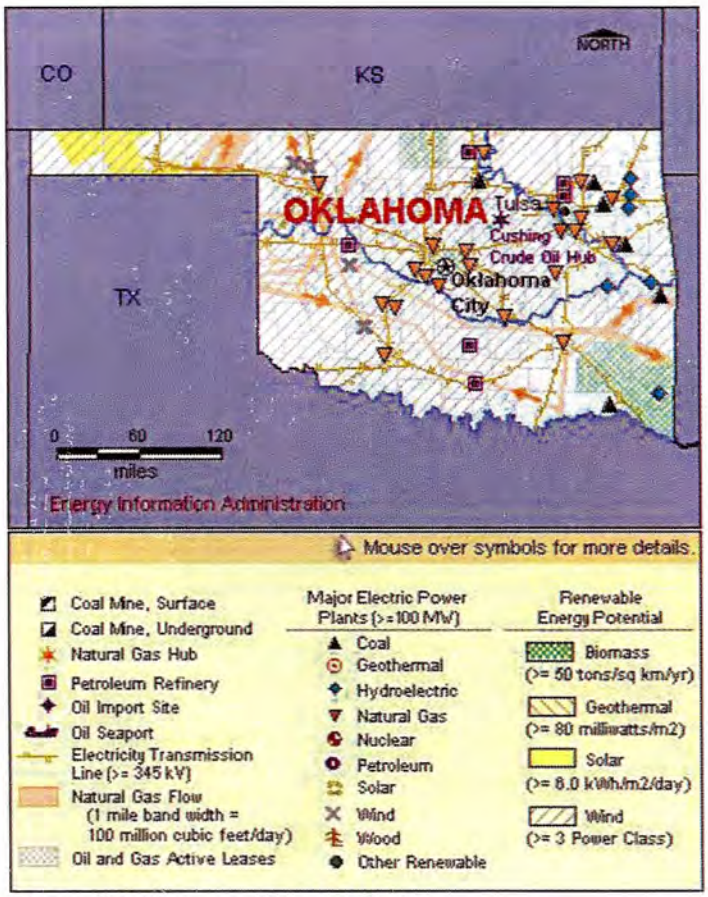


Figure 3 Oklahoma Energy Status
Source: U.S. Energy Information Administration, 2010

3.2 Solar Energy

3.2.1 Overview

Solar energy is one of the fastest-growing energy resources today, due to its ability to provide a permanent source of clean energy as well as contributing to the reduction of greenhouse gas (GHG) emissions. Technologies using solar energy for commercial and domestic buildings are solar electric power generation, solar water heating, solar space heating, cooling and ventilation. Solar power is defined as sunlight that is directly converted into electricity using photovoltaics (PV), or indirectly using concentrating solar power (CSP). PV technology, which is normally used in small buildings, will be evaluated in this report. CSP technology requires a solar power station and generates large amounts of electric power. A solar hot water system, which uses sunlight to heat water by the use of semiconductor photovoltaic (PV) cells, will be analyzed as a feasible option for Kaw Nation facilities. Other systems such as solar heating, cooling and ventilation (HVAC) systems have fewer opportunities to be adopted for the facilities of the Kaw Nation. However, the report will consider all feasible applications for solar energy usage in the Kaw Nation.

3.2.2 Data Sources and Resource Availability

The Florida Solar Energy Center has cataloged solar radiation information for the United States. Figure 4 below shows solar power availability for the entire United States in kilowatt-hours per day.

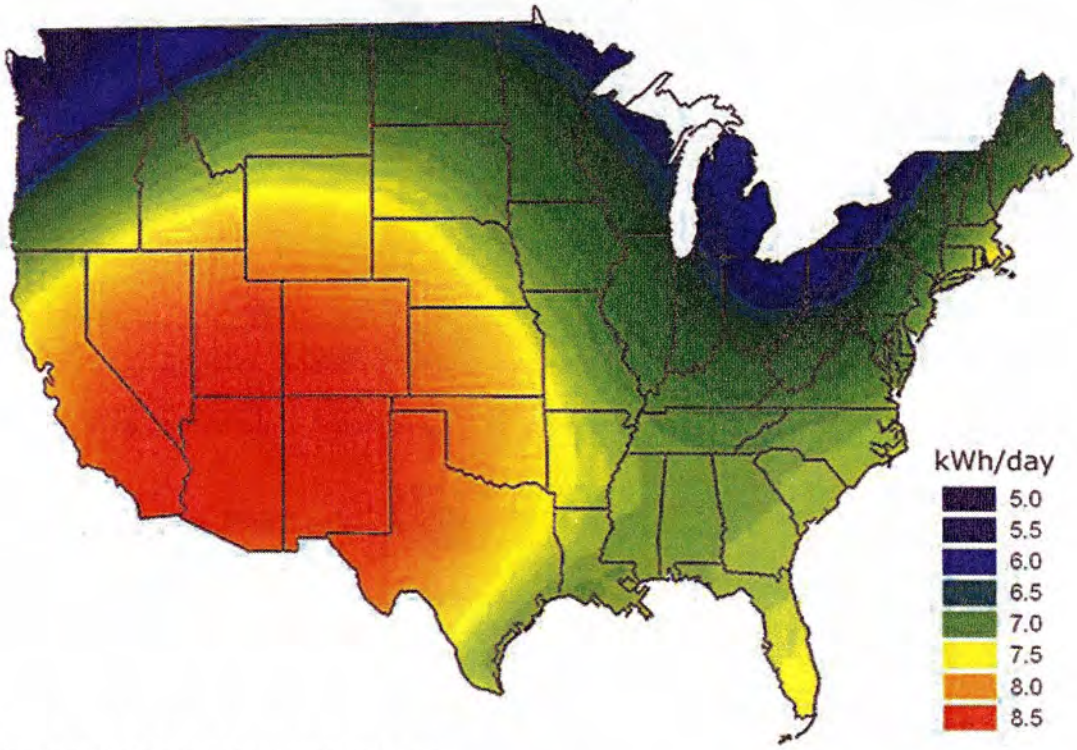
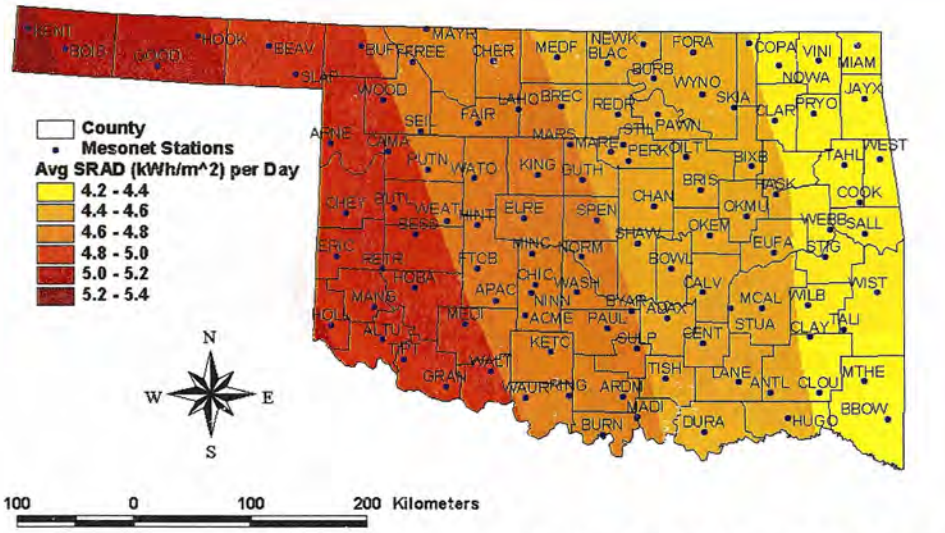


Figure 4 U.S Solar Energy Resources
Source: Florida Solar Energy Center, Solar resource information, 2007

Figure 4 indicates that Oklahoma has high availability of solar radiation, around 7.5 kWh/day per m^2 to 8.0 kWh/day per m^2 during the summer season. This suggests that solar energy systems might be a feasible option for the Kaw Nation. For more detail inspection, an Oklahoma Solar Map provided by the University of Oklahoma is shown below in Figure 5.



(c) 2002 Environmental Verification and Analysis Center, University of Oklahoma - All Rights Reserved

Figure 5 Oklahoma State Solar Radiation
Source: Environmental Verification and Analysis Center, University of Oklahoma, 2002

The Oklahoma solar radiation map indicates that the project area has an average solar radiation of 4.4 to 4.6 kWh/m^2 per day. These values differ somewhat from the U.S Solar map information provided in Figure 4. The reason for this variance is that values on the U.S solar map are based on the maximum solar energy, and the Oklahoma solar radiation map is based on average solar energy.

For more precise solar energy availability in the Kaw Nation area, solar radiation data from the Oklahoma Mesonet station at Newkirk and Blackwell were obtained for 2008. Figure 6 and 7 below give graphical results from those data sets. The Mesonet system has more than 110 automated stations to verify specific weather information all over Oklahoma [10].

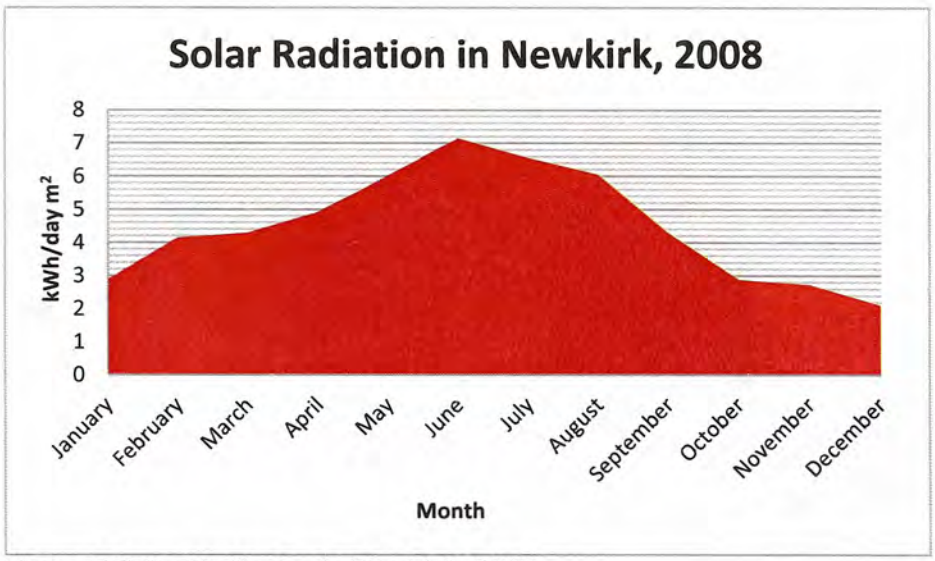


Figure 6 Solar Radiation in Newkirk, 2008
Source: Oklahoma Mesonet

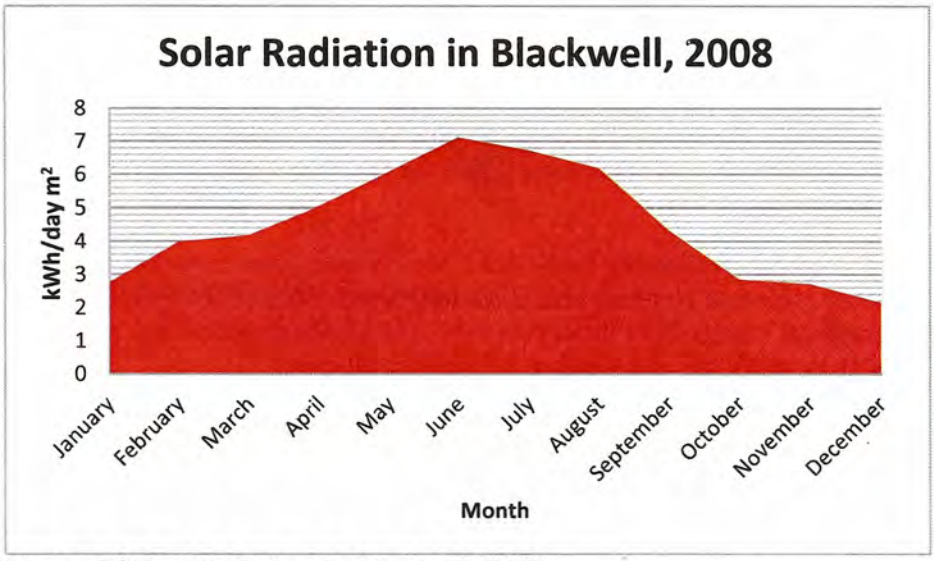


Figure 7 Solar Radiation in Blackwell, 2008
(Blackwell is not in the Kaw Nation, but it is the closest monitoring station for the Kaw Nation area.)
Source: Oklahoma Mesonet

In 2008, the maximum solar radiation in the area was 7kWh/day per m^2, the minimum solar radiation was 3kWh/day per m^2 and the average solar radiation was 4.5kWh/day per m^2. Typically, photovolaitics (PV) systems or solar hot water systems installed in areas with more than 5kWh/day m^2 of solar radiation are considered economically viable. The average value of 4.5kWh/day m^2 will be used for the analysis of PV systems.

3.2.3 The Photovoltaic System

A photovoltaic (PV) system uses semiconducting materials such as mono-crystalline silicon, polycrystalline silicon, microcrystalline silicon, cadmium telluride and copper indium selenide, to convert sunlight directly into electricity. Figure 8 shows a system diagram.

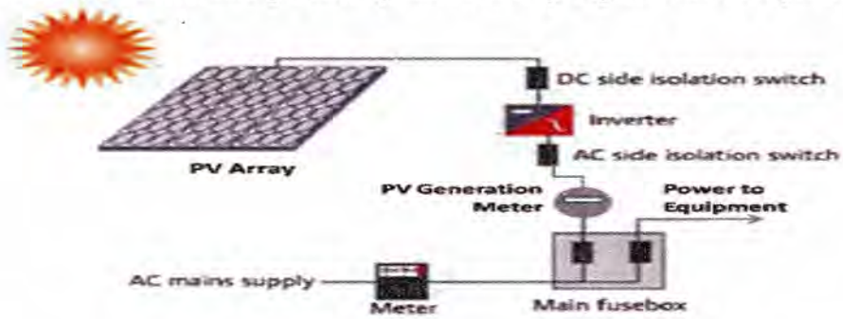


Figure 8 Photovoltaic system
Source: Alternative-Heating-Info.com, http://www.alternative-heating-info.com/Solar_Energy_for_Homes.html

The PV array directly assimilates sun light, and direct current electricity is then converted to alternating current using an inverter. Then, the AC goes to a main fuse box which includes batteries to store the power. Electricity is provided from the main fuse box to the AC main supply.

3.2.3.1 Cost Estimation for a PV System

Two solar cost estimation programs (Solar Estimator by the Solar-Estimate Organization, http://estimator.solar-estimate.org/[12], and RETScreen 4[13] by Canada's CANNMET Energy Technology Centre) were used to design the photovoltaic system. Once the programs were run, it was found that the two methods provided very similar results. Some energy-saving practices such as Net-Metering, Tiered billing rates, and Time-Of-Use (TOU) metering were also evaluated to provide for a better design. These practices can help reduce electricity usage and allow for installation of a smaller solar system. An explanation of these practices follows in the next paragraph.

Net-Metering: Net-Metering is a process whereby surplus electricity generation by your renewable energy system will be credited back to you. In Oklahoma, Net-Metering has been allowed for all customers by all electric utilities since 1988. Most reusable energy systems such as solar thermal electric, photovoltaics, wind, biomass, hydroelectric, geothermal, and CHP/Cogeneration can be adapted to use a net meter. Many electric cooperatives around the United State charge the user 7% to 10% of the retail price (approximately \$0.012 - \$0.19/kWh[14]) to administer their net metering program.

Tiered Rates: A tiered rate is a system for charging a higher rate for electricity when a customer uses more electricity than an allocated amount. Installation of a solar system can reduce the peak electric demand on a utility, which will reduce the need for a tiered rate system.

TOU Metering: A time-of-Use (TOU) meter indicates variation of electricity price by time of day and by season. This meter changes electricity costs for peak and off-peak periods. This equipment is usually provided by electric utilities.

3.2.3.2 Siting and System Consideration

The installation location of a PV system is a significant decision, because it can greatly affect the performance of the system. The following factors were considered to make a better choice of the system location.

- Location to maximize energy efficiency
- South facing solar panel installation
- Feasible off roof installation
- Enough space for solar panels

Two options (near the Casino and near the Health Center and Gymnasium in Newkirk) were found to be viable locations for PV systems. The office building next to the casino was selected as having the best potential for a PV system.

3.2.3.3 Design

The design for the PV system in the office building was evaluated using RETScreen and Solar Estimator. Several design assumptions and cost assumptions were used to evaluate the system design for the office building.

Design Assumption

- Radiation of solar resources was averaged at 4.46 kWh/sq-m/day based on Mesonet information.
- A non-battery system was estimated due to lower installation cost.
- DC and AC rating assumptions were adopted from National Renewable Energy Laboratory (NREL). Source: http://www.nrel.gov/rredc/pvwatts/version1.html [15]
- A PV module type was chosen from RETScreen and was conformed to provide an economical system.
- A system capacity of 23 kW PV was used based on electricity needs.
- A general capacity factor of 15% was assumed [16].
- Inverter efficiency was assumed to be 90% based on DC and AC ratings [16].

A complete list of design assumptions is given below in Table 3.

Table 3 System Design Assumptions

Factor	Assumption
Solar resources	Based on Mesonet information
Soiling or contamination of the PV panels	Clean, washed frequently: 100% design sunlight transmission
PV module type	a-Si - BP Millenia MST 50 MV by BP solar
Capacity factor	15%
System configuration (battery or non-battery)	Non-battery
Orientation to the sun	Array tilted at 35.4 latitude, full sun Array azimuth at 180 South
Shading	None
PV Energy delivered as % of manufacturer's rating	95%
DC rating (kW)	4.0
DC to AC derating factor	0.77
AC rating (kW)	3.1
Soiling, wiring & power point tracking losses	9% (91% delivered)
Inverter Efficiency	90%

3.2.3.4 Cost Assumptions

Several engineering assumptions were made in order to provide cost data for the design. These assumptions include

- Annual price inflation rate of electricity of 3%, which is conservative based on past information.
- PV panels are product module BP Millenia MST 50 MV.
- Inverter and labor costs are recent market prices [17].
- Payback period estimation considers all factors such as inflation, net metering, and total costs.

A complete list of system cost assumptions and the results of the analysis are presented in Table 4.

Table 4 System Cost Assumptions

Solar Energy Rating	4.46 kWh/sq-m/day
Solar System Capacity Required	23 kW of peak power (DC watts)
Roof Area Needed:	214 sq-m
Equivalent Annual Production	32,612 kWh electricity
Price installed per Watt DC	$8 [97]
Electricity providing by solar PV	50%
Annual inflation	3.00%
PV panels	$114,080
Inverter	$18,400
Labor	$27,232
Balance of System	$27,600
Total installation amount	$184,000
Payback	16 years
Installation cost with Federal Incentives	$128,800
Payback with Federal Incentive	13 years
PV Energy conversion	95%
Greenhouse Gas (CO2) Saved	660 tons/year

3.2.3.5 Cost Analysis

Annual electricity usage was calculated at 32,612 kWh, which yielded a total cost of installation of $184,000 dollars with the 16 years payback period, as shown in Figure 9. Even when a thirty percent Federal incentive is applied, the payback period is still a relatively long 13 years. However, the PV system provides an impressive view, which might attract customers and provides a visual sign of the Kaw Nation's regard for the environment and sustainability.

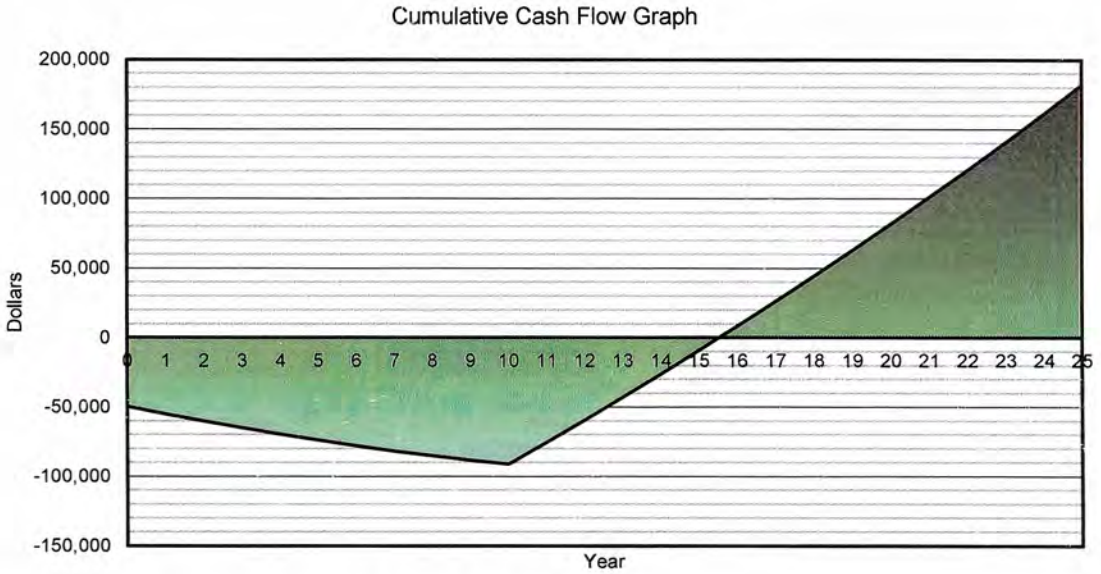


Figure 9 Cumulative Cash Flow Graph for PV system

3.2.4 Solar Hot Water

Facilities with a high demand for hot water use a high percentage of their energy dollars for natural gas or electricity for water heating. In the United States, domestic electricity consumption of hot water in 2001 was 9% of total electricity consumption, according to the EIA. [86] The Kaw Nation runs a Wellness Center facility, which has high electricity consumption for water heating. Therefore, a more efficient water heater would be expected to save energy for the Wellness Center. The solar hot water heater was evaluated to develop a feasible application for the Wellness Center in Newkirk.

Figure 10 shows a general solar hot water system.

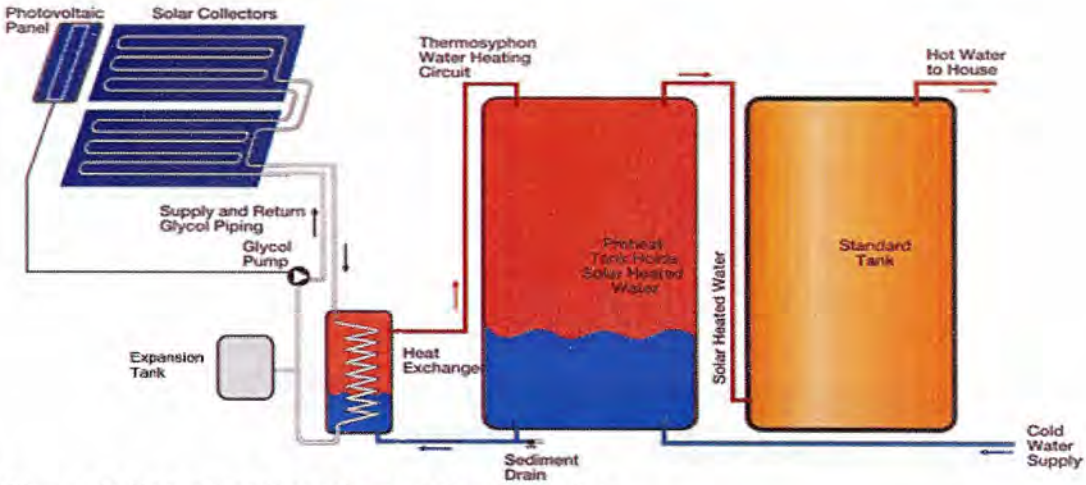


Figure 10 Solar Hot Water System Configuration
Source: Alternative-Heating-Infor.com, Solar Hot Water Heaters, 2010

A solar hot water system contains four major equipment items: solar thermal collectors, a glycol pump, a heat exchanger, and a standard tank. Solar collectors receive solar energy from the sun, and the heat moves to the heat exchanger to heat water. The heated water is supplied to the storage tank.

3.2.4.1 Siting and System Considerations

For economical application of solar hot water systems, the installation location must be carefully selected. This project considered the following factors:

- Location with a high demand for hot water.
- Water currently heated using electrical energy.
- Enough spaces for solar panels.
- A gym with pool and showers would be the best choice.
- A site view for customers.
-

The Wellness Center in Newkirk was selected because it satisfied the above factors.

3.2.4.2 System Design

The average water usage of the Wellness Center in winter is 720 gallons/day, which should yield an annual average of approximately 600 gallons of hot water per day. A normal installation cost of a solar hot water system ranges from approximately $9,000 to $15,100 for a demand of 600 gallons/day. Maintenance costs, including all component replacements during system life, were estimated for each system, depending on which components were included. The range of estimated maintenance costs was $40-$140 annually.

The system design was mainly based on major equipment items: collectors, heat exchanger, piping and a storage tank. Moreover, a glycol system with heat exchanger and holding tank was used due to freezing climates in the winter in Oklahoma. Also, a drain back system was

used for the same reason.

The system design analysis was based on the two methods (Solar Estimator by Solar-Estimate Organization, http://estimator.solar-estimate.org/, RETScreen 4 by Canada's CANNMET Energy Technology Centre).

3.2.4.3 Design Assumptions

Most of assumptions were taken from the RETScreen Solar Hot Water Manual, and the selected system model was configured to provide high efficiency with reasonable costs. Table 5 shows the design elements of the solar hot water system for the Wellness Center in Newkirk.

Assumptions
RETScreen Assumptions [19]

- Water heater thermostat is set at 120°F (48.9°C)
- Solar collector type: 3 sq-meter. Glazed flat-plate type.
- Solar collector slope and azimuth: Set at Latitude of installation, South facing
- Shading: None
- Ambient air temperature: 59 °F (same temperature assumed for each month)[19]
- Cold-water temperature: Same as average ambient temperature
- Fraction of each month when solar heating should be available: 100%
- A thermal storage volume is provided at a rate of 80 liters per m^2 of collector area (2 gallons per ft^2),
- Storage tank insulated to achieve a UA of 4 W/°C[19]
- Pipe heat loss based on a UA of 2.64 W/°C for the inlet and the outlet piping [19]
- The heat exchanger effectiveness is assumed to be 70%

Table 5 Solar Hot Water Design for the Wellness Center in Newkirk

Solar Water Heater Design	Unit	Value
Type	Glazed	
Manufacturer	Themo Dynamics	
Model	G32-P	
Gross area per solar collector	m^2	2.98
Aperture area per solar collector	m^2	2.78
Fr (tau alpha) coefficient		0.70
Fr UL coefficient	$(W/m^2)/°C$	4.93
Number of collectors		10
Solar collector area	m^2	29.82
Miscellaneous losses	%	4.0%
Balance of system & miscellaneous		
Storage capacity / solar collector area	L/m^2	100
Storage capacity	L	2,783.0
Heat exchanger	kW	18.0
Heat exchanger efficiency	%	70.0%
Miscellaneous losses	%	3.0%
Pump power / solar collector area	W/m^2	100.00
Electricity rate	$/kWh	0.093

3.2.4.4 Cost Assumptions

Table 6 provides cost information for the solar hot water system in the Wellness Center. Details include:

- The costs of solar equipment were calculated as the median price of commercial products.
- Installation costs were minimized considering current economics.
- Cost estimations between RETscreen and Solar calculator have small differences.

Table 6 Cost Estimation for Solar Hot Water System in Newkirk

Energy Equipment	Price
Solar Collector	$6,000
Solar Storage Tank	$4,000
Solar Loop Piping Materials	$180
Circulating pump	$200
Heat Exchanger	-
Transportation	$100
Sub-total	$13,800
Balance of System	
Collector Support Structure	
Plumbing and Controls	$300
Collector Installation	$230
Solar Loop Installation	$60
Auxiliary Equipment Installation	$50
Transportation	$50
Sub-Total	$690
Other- Balance of System	
Labor	$1,543
Miscellaneous	
Training	$596
Contingencies	$1,491
Sub-Total	$2,087
Total without Federal Incentives	$14,800
Payback	13.5 years
RETScreen Cost	$14,910
Total with Federal Incentives	$9,870
Payback with Federal Incentives	10 years

3.2.4.5 Cost Analysis

As seen in Table 6, the cost of a solar hot water system in the Wellness Center, Newkirk totaled $14,800 dollars. The payback period was calculated as 13.5 years. If federal incentives could be applied, costs dropped to $9,870 with a payback period of 10 years. While the payback period will be long in either case, the solar panels would provide an impressive view for visitors of the Wellness Center. A graph of cumulative cash flow is shown in Figure 11.

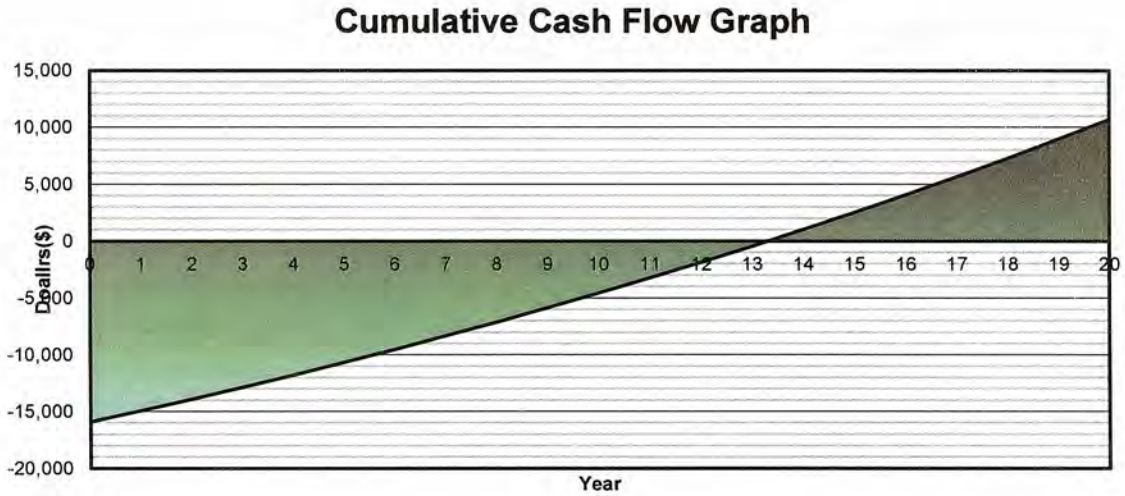


Figure 11 Cumulative Cash Flow for Solar Water Heating System

3.2.4 Solar Findings and Future Recommendations

3.2.4.1 PV systems

Installation of a PV system in the office building, Newkirk was evaluated for the Kaw Nation. The 23kW system was designed based on RETScreen and Solar Estimator, which estimated a 32,612 kW yearly production and 660 tons of greenhouse gas savings. A total cost of system installation was estimated at $128,800, which would have a payback period of 16 years.

Economically, the PV system installation is not a high pay-back for the Kaw Nation, though federal incentives would improve the economics. However, other reasons such as reducing greenhouse gas emissions, providing impressive views for visitors, and the status of the Kaw Nation as a pioneer of clean energy should all factor into the decision making.

Grants may be available for installation of solar energy systems. Recently, many federal and state governments and agencies have offered grants related to renewable energy projects. The Kaw Nation should periodically search for grant funding to cover some of the costs to install the PV system.

3.2.4.2 Solar Hot Water

The 600 gal per day solar hot water system was designed using RETScreen and Solar Estimator analyses. A total installation cost of $14,800 dollars with a 13.5 years payback period was calculated. As with the PV system, a solar water heating system could provide benefits such as impressive views to attract more visitors and visually demonstrating the commitment of the Nation to sustainable practices.

3.3 Wind Energy

3.3.1 Overview

Wind can generate electricity and mechanical power through the use of a wind turbine. Higher wind velocity generates more energy. Since Oklahoma ranks as the 5th highest wind state in the United States for wind power potential, wind power will be scrutinized and analyzed for the facilities of the Kaw Nation.

A diagram of a wind turbine system is shown in Figure 12. Rotating blades operates a generator, which provides energy to a controller. Then, the controller connects to an inverter to transform D.C. power to A.C. Wind turbine capacities vary from 1kW to 5000 kW. Wind turbines of 50 kW and 100 kW capacity will be evaluated for this project, since these are adequate for the demands being evaluated.

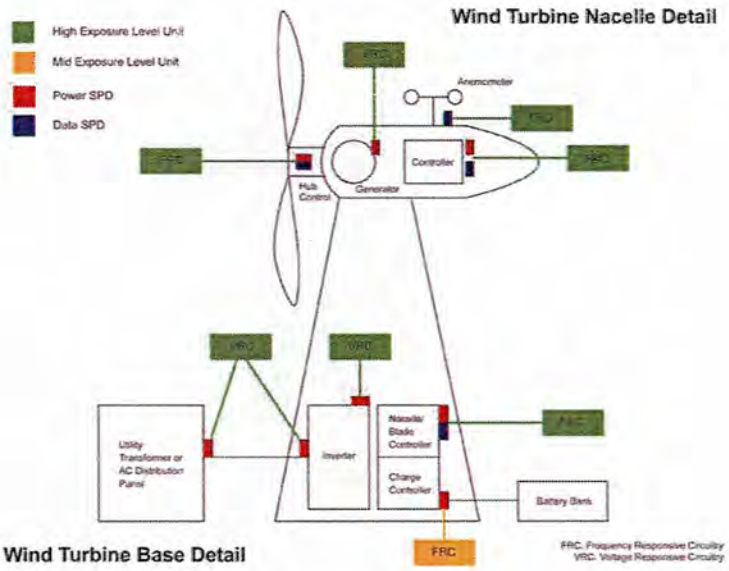


Figure 12 Wind Turbine System
Source: Alltec Corporation Solutions: Wind Farms, http://www.allteccorp.com/apps_windfarms.php

3.3.2 Data Sources

Oklahoma has recently installed a large amount of wind generating capacity. Figure 13 shows the State wind generation potential in 2002, as well as the projected area wind generation in 2009. Data are from the Oklahoma Wind Power Initiative.

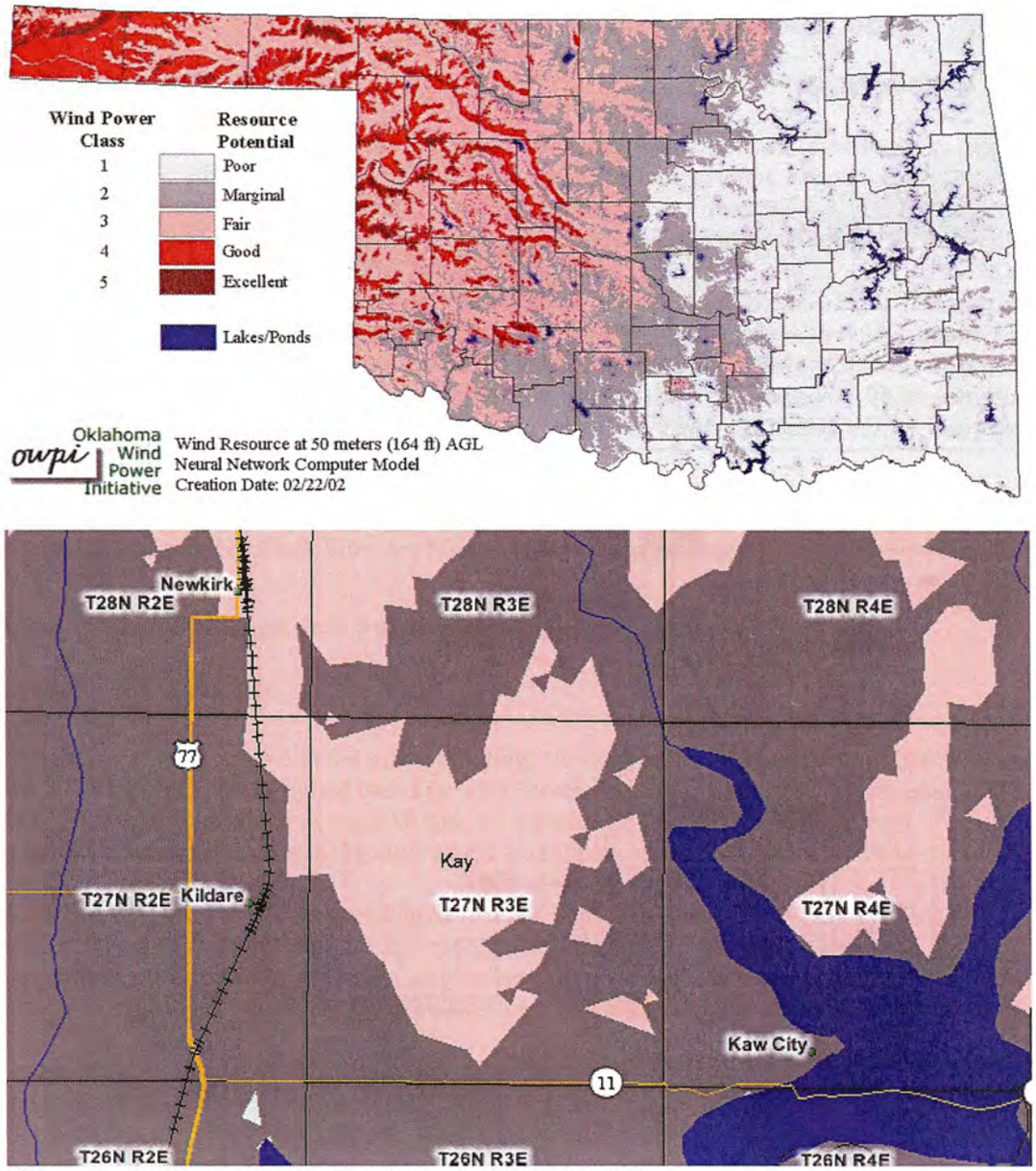


Figure 13 Oklahoma and Projected Area Wind Resources
Source: Oklahoma Wind Power Initiative

The most favorable wind power generation is located in the west of Oklahoma. Kay County is not located in the most favorable area for wind resources. However, the projected areas still have enough wind to apply for the wind turbine design. For more exact wind information, Figure 14 and 15 were drawn from Mesonet information in 2008.

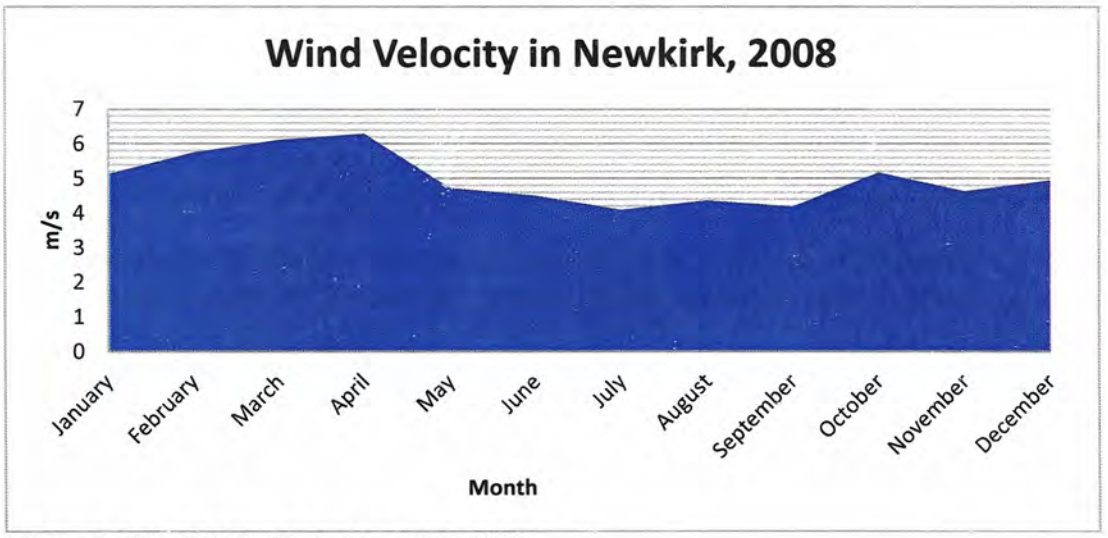


Figure 14 Wind Velocity in Newkirk, 2008
Source: Mesonet

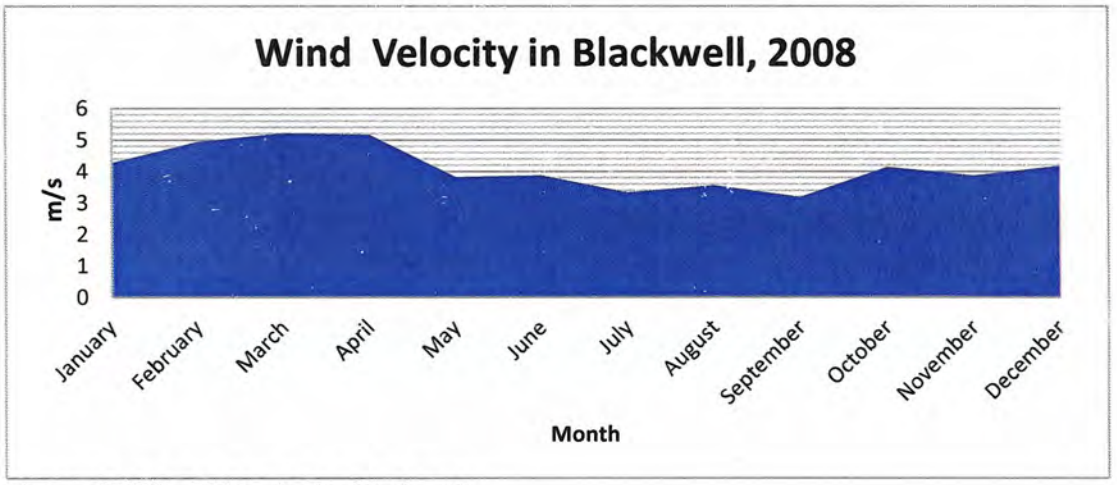


Figure 15 Wind Velocity in Blackwell
Source: Mesonet

According to Figure 13, 14, and 15, wind velocities in the projected area vary between 4.0 to 6.2 meter per second. Average wind velocity was calculated to be 5 m/s. This velocity, while it will not result in highly efficient and economical wind generation systems, will yield realistic results for consideration by the Kaw Nation.

3.3.3 System Siting Considerations

The Kaw Nation is planning to install a 100kW wind turbine for the facilities in Newkirk. The following factors were considered to make a better choice of the system location.

1. Location to maximize energy efficiency.
2. Open location away from mountain or any barricade.
3. Enough space for a wind turbine system.

The feasible facilities for the 100kW turbine system are the SouthWind Casino parking lots, the Kanza Heath Center, the Kaw Nation Day Care, the JRM Community Building, and the Wellness Center. Among these, facilities except the outh Wind Casino were analyzed to estimate wind turbines feasibility, due to their electricity demands and accessibility.

3.3.4 System Design

A RETScreen method and a wind energy estimator by the Solar Estimate organization were applied to evaluate wind turbine design and cost. The result from the RETScreen method was unrealistic due to low turbine prices as compared to a recent commercial price. So, all calculations were based on factors from the Solar Estimate wind estimator. The analyses of design and cost are shown in Table 7 and 8, based on the following assumptions.

3.3.4.1 Design Assumptions [22]

A general system design was used, since most wind turbine prices are not very different. The system was configured for maximum efficiency.

- Wind velocity was chosen as 4.995m/s based on 2008 Mesonet information.
- A non-battery system and a grid-tied system were assumed to lower installation costs.
- DC and AC rating assumptions were adopted from National Renewable Energy Laboratory (NREL). Source: http://www.nrel.gov/rredc/pvwatts/version1.html
- Total energy Delivered was 86%

Table 7 Wind System Efficiency Assumptions

Factor	Assumption
Turbine Energy Curve	Common turbines in each power class were chosen for extracting energy curve data.
System configuration	Grid-tied, Non-battery
Availability	98%
Air foil soiling/icing, wiring & other power losses	12%
Total Energy Delivered	98% x 88% = 86%

3.3.5 Cost Analysis

Wind turbine cost data were obtained for commercially available turbines from 400 W to 100kW. These costs are listed in Table 8. As the cost of turbines is still high in the U.S. and the world markets, wind turbine systems in the Kaw Nation area (with less than 6 m/s wind velocity) are not currently economically favorable. Cost assumptions used in this project are listed below.

3.3.5.1 Cost Assumptions

- Inflation rate was selected as 2% of general economic growth.
- Total costs of turbine installation are extracted from recent wind turbine pricing.
- Wind velocities were taken from annual averages at nearest Mesonet sites.
- Wind turbines generate 100 % of their capability.

Table 8 Wind Turbine Cost
Source: Solar-Estimate.org, Your Wind Turbine Estimate, The cost to go with the wind

Turbine Specifications	**400 W**	**1 kW**	**5 kW**	**10 kW**	**20 kW**	**50 kW**	**70 kW**	**100kW**
Typical Power Rating	400 W	1 kW	5 kW	10 kW	20 kW	50 kW	70 kW	100kW
Swept Area	1.2 m^2	4.9 m^2	32 m^2	50 m^2	121 m^2	177 m^2	195 m2	265 m2
Rotor Diameter	1.2 m	2.5 m	6.4 m	8.0 m	12.4 m	15 m	17.6	19.4
Tower Height	14 m	19 m	24 m	24 m	24 m	30 m	30 m	35 m
Assumed Total	$2,400	$5,000	$24,500	$48,000	$92,000	$225,000	$320,000	$450,000
Cost range:	expect +/- 20% for "normal" installations							

3.3.5.2 SouthWind Parking Lot in Newkirk

A 100kW wind turbine installation in the SouthWind parking lots was evaluated as part of this project. As shown in Table 9, a 43 year payback period was estimated. The long payback is due to both the low cost of electricity in Oklahoma and the relatively low wind velocities in the Kaw Nation area. The RETScreen estimation resulted in a10 year payback period, though this is unrealistic due to low prices used by the program. The 43 year payback reduces to 33 years if federal incentives can be applied. A graphical presentation of project economics is shown in Figure 16.

Table 9 Wind System Cost Assumptions for Lights in the Parking Lots of the SouthWind Casino, Newkirk

Wind Speed	4.995 m/s
Wind Turbine Size	100 kW
Number of Wind Turbines	1
Electricity Generation	110508 kW/year
Portion of Electricity Generation	92%
Electric Rate($/kWh)	$0.065/kWh
Inflation Rate	2%
Total Cost	$450,000
Greenhouse Gas (CO_2) Saved:	1720 tons
Payback without Federal Incentives	43years
Payback with Federal Incentives	33 years

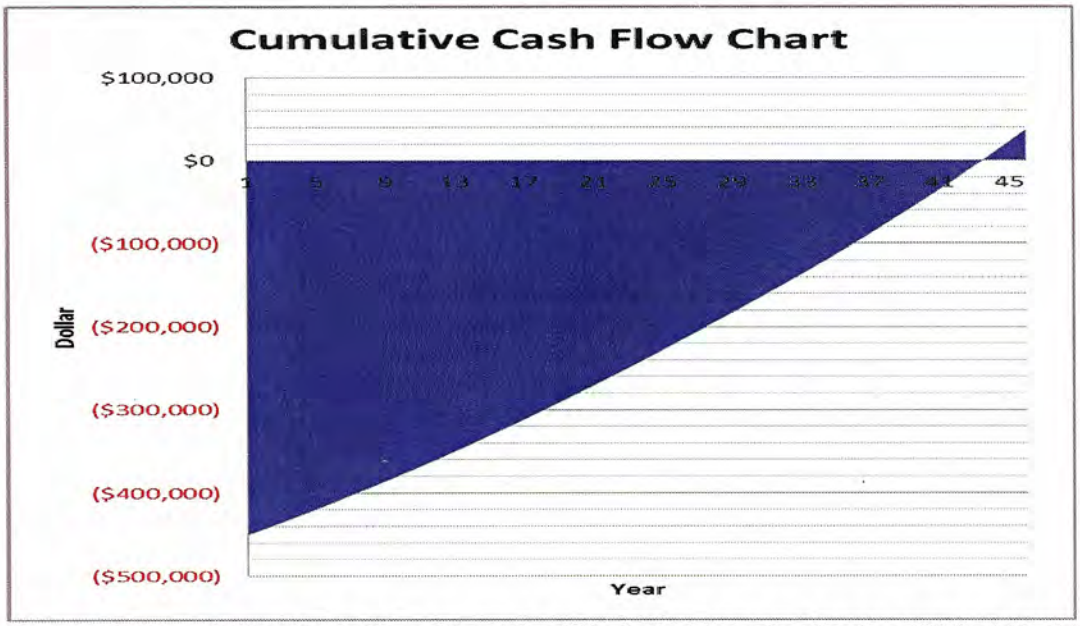


Figure 16 Cumulative Cash Flow Chart for Wind Turbines for the SouthWind Parking Lot, Newkirk

3.3.5.3 Kanza Health Center

A 100 kW wind turbine installation was evaluated for the Kanza Health Center. The evaluation yielded a 30 year payback period, as shown in Table 10 and Figure 17.

Table 10 Wind System Cost Assumptions in the Kanza Health Center, Newkirk

Wind Speed	4.995
Wind Turbine Size	100 kW
Number of Wind Turbines	1
Electricity Generation	110508 kW/year
Portion of Electricity Generation	96%
Electric Rate ($/kWh)	$0.093/kWh
Inflation Rate	2%
Total Cost	$450,000
Greenhouse Gas (CO_2) Saved	1720 tons/year
Payback	33 years
Payback with Federal Incentives	23 years

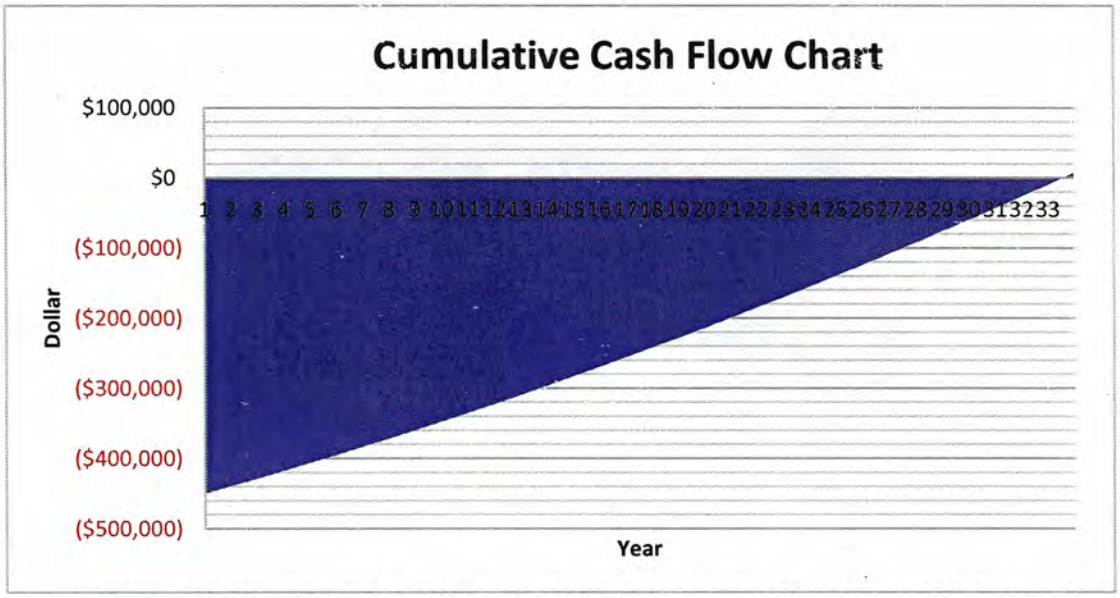


Figure 17 Cumulative Cash Flow Chart for Wind Turbines at the Kanza Health Center, Newkirk

3.3.5.4 Day Care Center

A 50 kW wind turbine was evaluated at the Day Care Center in Newkirk. The analysis showed a payback period of 31 years as shown in Table 11 and Figure18.

Table 11 Wind System Cost Assumptions for the Day Care Center, Newkirk

Wind Speed	4.995 m/s
Wind Turbine Size	50 kW
Number of Wind Turbines	1
Electricity Generation	55254 kW/year
Portion of Electricity Generation	62%
Electric Rate($/kWh)	$0.097/kWh
Inflation rate	2%
Total cost	$225,000
Greenhouse Gas (CO_2) Saved:	860 tons/year
Payback	31 years
Payback with Federal Incentives	22 years

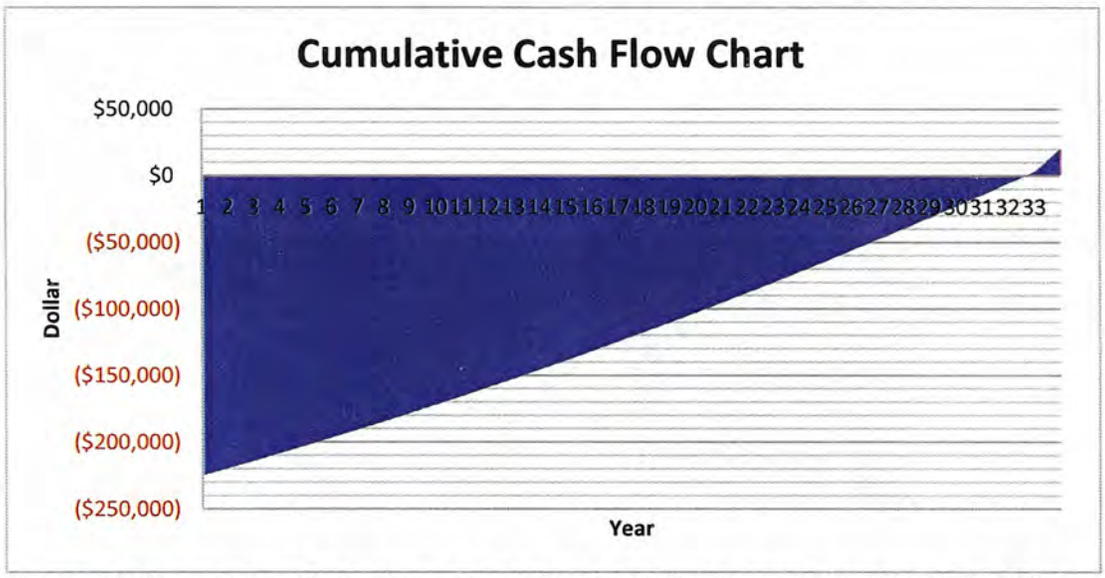


Figure 18 Cumulative Cash Flow Chart for Wind Turbines at the Day Care Center, Newkirk

3.3.5.5 JRM Community Building

A 100 kW wind turbine installation was evaluated at the JRM Community Building. It resulted in a payback period of 34 years, as shown in Table 12 and Figure 19.

Table 12 Wind System Cost Assumptions in JRM Community Building, Newkirk

Wind Speed	4.995 m/s
Wind Turbine Size	100 kW
Number of Wind Turbines	1
Electricity Generation	110508 kW/year
Portion of Electricity Generation	84%
Electric Rate($/kWh)	$0.089/kWh
Inflation Rate	2%
Total Cost	$450,000
Greenhouse Gas (CO_2) Saved:	1720 tons/year
Payback	34 years
Payback with Federal Incentives	25 years

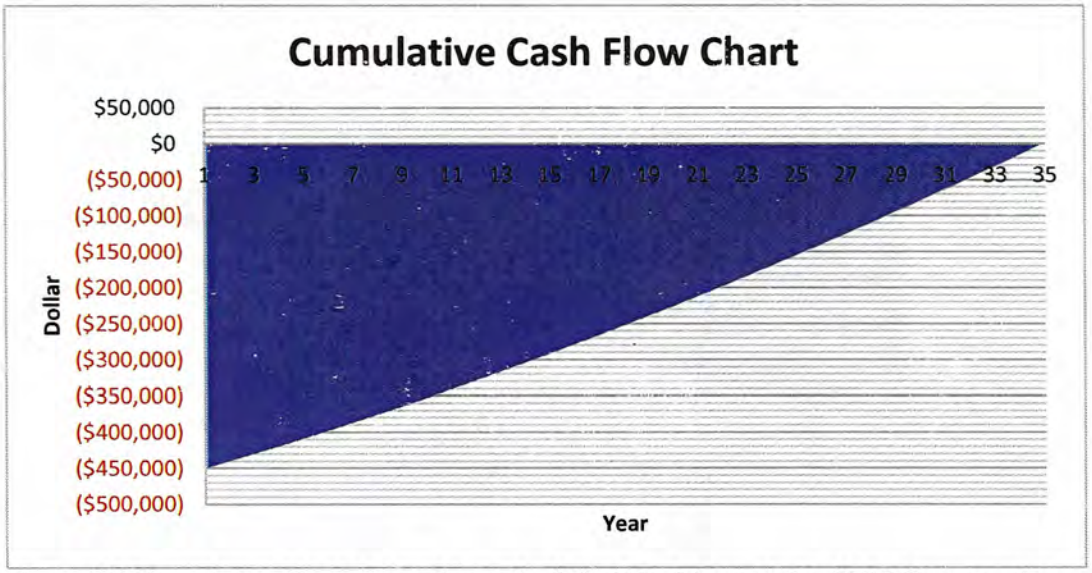


Figure 19 Cumulative Cash Flow Chart for Wind Turbines at the JRM Community Building, Newkirk

3.3.5.6 Wellness Center

The installation of a wind turbine in Wellness Center, Newkirk was evaluated. The payback period was 37 years, as shown in Table 13 and Figure 20.

Table 13 Wind System Cost Assumptions in Wellness Center, Newkirk

Wind Speed	4.995 m/s
Wind Turbine Size	100 kW
Number of Wind Turbines	1
Electricity Generation	110508 kWhr/year
Portion of Electricity	43%
Electric Rate($/kWh)	$0.082/kWh
Inflation Rate	2%
Total cost	$450,000
Greenhouse Gas (CO_2) Saved:	1720 tons/year
Payback	37 years
Payback with Federal Incentives	26 years

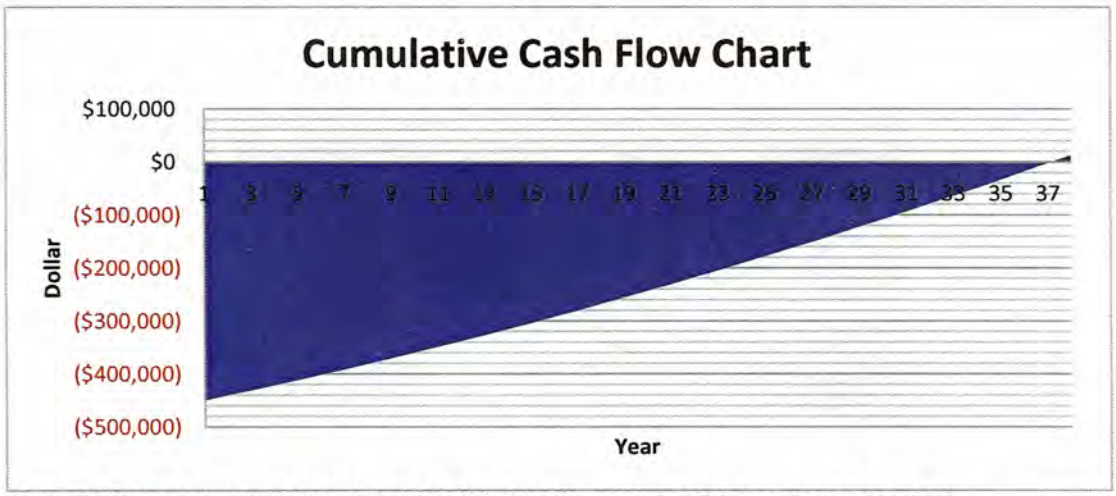


Figure 20 Cumulative Cash Flow Chart for Wind Turbines at the Wellness Center, Newkirk

3.3.6 Findings and Recommendations

Neither 100 kW nor 50 kW wind turbine installations can be recommended options for the Kaw Nation, when evaluated strictly on the basis of economics. The 100 kW and 50 kW wind turbine systems examined in this project had extremely long payback periods due to the low cost of electricity in the area and the relatively low wind speeds. The total costs of wind turbine systems are about $450,000 for a 100 kW system and $225,000 for a 50 kW system. However, if factors other than economics make wind generation attractive, the Nation should seek grants or other funding to defray part of the installation costs.

3.4 Hydropower

3.4.1 Overview

A feasible hydropower system for the Kaw Nation is a micro-hydropower system which produces power up to 500 kW and is used to provide power to small communities. Most

micro-hydropower systems can be installed in small rivers or streams without much environmental effects. The process of micro hydro system consists of eight steps [24] in detail:

1. Intake: this is a simple box to transfer air-free water to a pipeline.
2. Pipeline: it carries the water to the turbine by usually PVC pipe and must be large enough to handle the design flow.
3. Turbine: it converts the water energy into electricity.
4. Charge controller: it sends excess energy to a secondary load.
5. Dump load: it is consist of electrical resistance heater, which is sized to handle the full generating capacity of the micro-hydro turbine.
6. Storage battery: it stores surplus energy.
7. Meters: it measures micro-hydro systems.
8. DC inverter: it transforms DC to AC electricity for residential and commercial use.

3.4.2 Small Scale Hydropower Siting and Installation

The only hydro-resource near the Kaw Nation area is the Arkansas River, which has a sufficient flow rate to generate power and is situated less than a mile from Kaw City. Figure 21 and Table 14 show hydro resource availability and flow rates near the Kaw Nation.

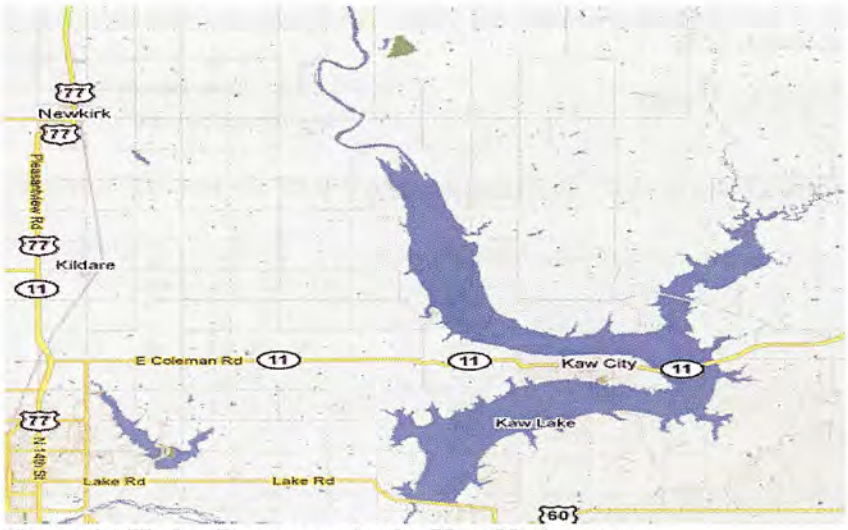


Figure 21 Hydro Resources in the Kaw Nation area
Source: Google Map Search

YEAR	Monthly mean in cfs (Calculation Period: 2008-01-01 -> 2008-12-30) Period-of-record for statistical calculation restricted by user										
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
2008	321.5	640	568.4	1,044	1,821	4,896	560	121	7,170	2,585	792.9
Mean of monthly Discharge	322	640	568	1,040	1,820	4,900	559	121	7,170	2,590	793

Table 14 Arkansas River Flow Rates
Source: USGS http://waterdata.usgs.gov/nwis/sw

3.4.2.1 Design Analysis

In this project, a 350kW micro-hydro system was evaluated to check economic feasibility to provide electricity in Kaw City. The evaluation was performed using the RETScreen Method. Assumptions and design parameters are shown below and in Tables 15 and 16.

Assumptions [27]

- Maximum hydraulic losses are 7%
- Miscellaneous losses are 2%
- Generator Efficiency is 95%

Table 15 Necessary Flow Rate Design

%	Flow m³/s	Turbine efficiency	Number of turbines	Combined efficiency
0%	10.00	0.00	0	0.00
5%	8.00	0.00	1	0.00
10%	6.00	0.00	1	0.00
15%	5.00	0.08	1	0.08
20%	4.00	0.41	1	0.41
25%	3.50	0.63	1	0.63
30%	3.50	0.76	1	0.76
35%	3.50	0.84	1	0.84
40%	3.50	0.88	1	0.88
45%	3.50	0.90	1	0.90
50%	3.50	0.91	1	0.91
55%	3.40	0.91	1	0.91
60%	3.30	0.91	1	0.91
65%	3.20	0.91	1	0.91
70%	3.10	0.91	1	0.91
75%	3.00	0.91	1	0.91
80%	2.90	0.91	1	0.91
85%	2.80	0.91	1	0.91
90%	2.70	0.91	1	0.91
95%	2.60	0.91	1	0.91
100%	2.50	0.91	1	0.91

Table 16 Micro-hydro System Design

Micro-hydro system Design	Unit	Value
Design flow	ft^3/s	106
Gross head	ft	49.2
Manufacture		Alstom
Model		Kaplan
Residual flow	ft^3/s	17.657
Firm flow	ft^3/s	70.63
Design coefficient		4.5
Turbine peak efficiency	%	91%
Flow at peak efficiency	ft^3/s	79.5
Number of turbines		1
Maximum tailwater effect	ft	6.6
Power capacity	kW	346
Net annual GHG emission reduction	tCO_2	524

3.4.2.2 Cost Estimation

A cost estimation was performed using the following assumptions:

- 2 percent rate of inflation
- 25 years project life

Results of the analysis show a payback period of 6.5 years, as shown in Figure 22.

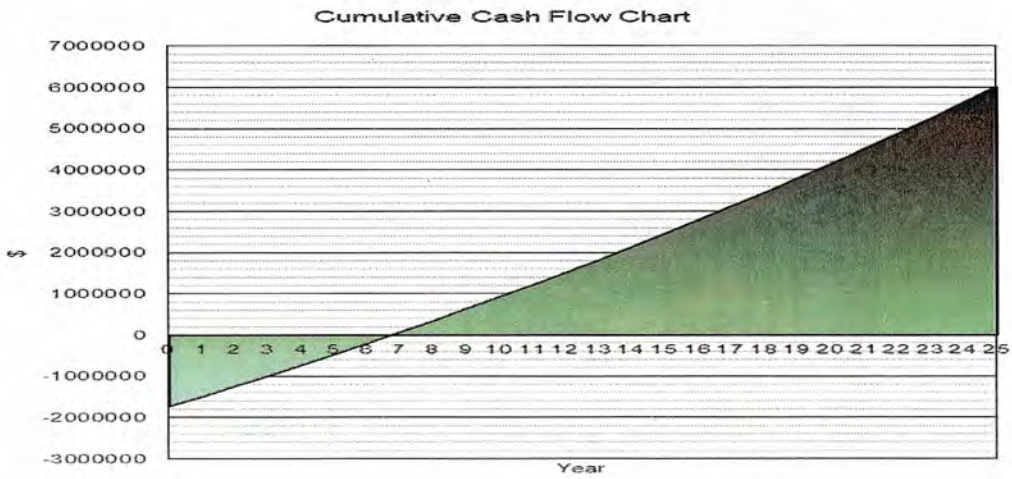


Figure 22 Cumulative Cash Flow Chart for a 300 kW Micro-hydropower system

3.4.3 Hydro Findings and Recommendations

The installation of a 350 kW micro-hydro system in the Arkansas River near Kaw City was evaluated a payback period of 6.5 years shown in Table 16 and Figure 22. This option would require the Kaw Nation to negotiate rights to Arkansas water river, which may not be feasible.

3.5. Geothermal Energy

3.5.1 Overview

Geothermal energy is a clean and sustainable energy source that uses heat from the Earth. Geothermal energy is the fourth largest renewable energy source (behind biomass, hydropower and wind power), which in 2007 accounted for 4% of renewable energy-based electricity consumption in the U.S. It provides about 30% of the world total energy usage[(90)]. As interest in geothermal energy grows, many Native tribes in the U.S are considering the use of geothermal energy. The Kaw Nation also needs to consider geothermal energy as a potential renewable resource.

3.5.2 Geothermal Heat Pump

A geothermal heat pump, also called a Ground Source Heat Pump (GSHP), is used for a heating and/or cooling system for buildings. It gains natural heat from the Earth through pipes which carry heat to the building in winter. The system draws excess heat from the building and carries it to be absorbed into the Earth in summer. This system provides 30 percent to 40 percent lower bills according to the U.S. EPA[(97)]. Geothermal heat pumps are not yet widely used due to a lack of awareness on the part of the public, as well as a relatively high cost of installation. Figure 23 shows how a ground source heat pump works.

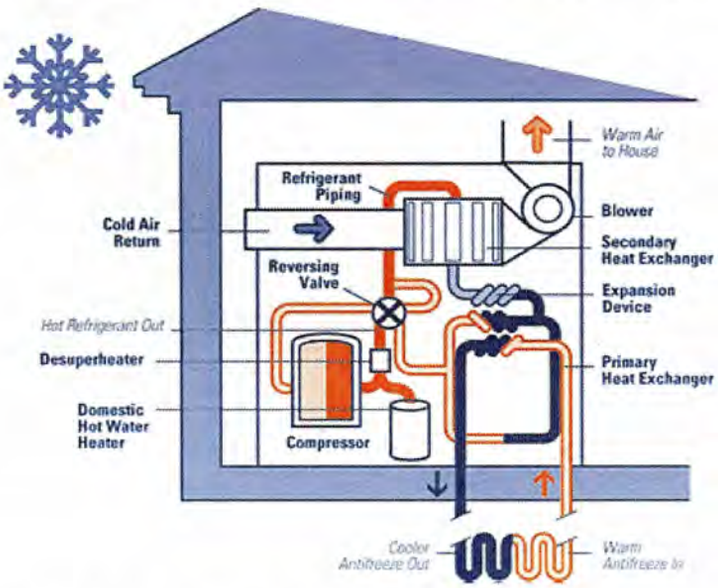


Figure 23 Geothermal Heat Pump Diagram
Source: Natural Resources Canada, Heating and Cooling With a Heat Pump

3.5.2.1 Data Sources and Resource Availability

Available geothermal resources in the U.S and Oklahoma are shown in Figure 24 and Figure 25. The Kaw Nation is in an area of moderate geothermal resource potential, according to these figures. The maps were produced by the National Renewable Energy Laboratory in 2009, and are provided by the U.S. EPA.

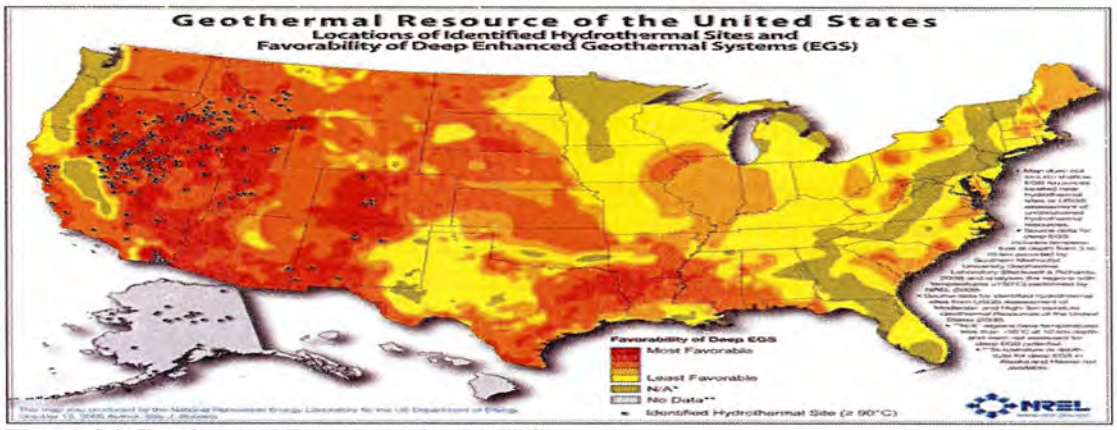


Figure 24 Geothermal Resources in the U.S
Source: Tester, J., et al. 2006.

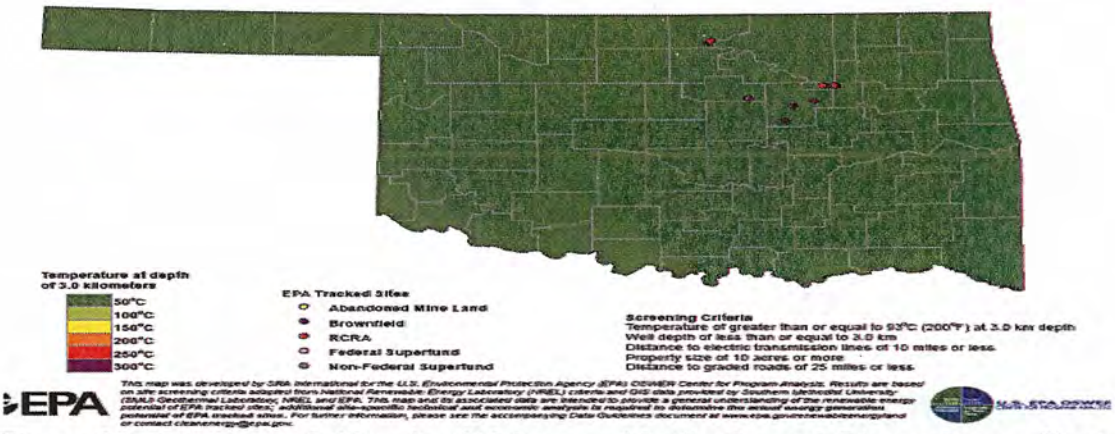


Figure 25 EPA Tracked Sites in Oklahoma with Geothermal Binary Power Plant Facility Siting Potential
Source: EPA, Oklahoma renewable energy map

3.5.2.2 Design Analysis

A ground-source heat pump was evaluated for economic feasibility for some Kaw Nation facilities. A cost of ground heat pump installation is generally expensive for existing buildings with efficient cooling and heating systems. As the air conditioning system is old in the Day Care Center in Newkirk, installation of a ground heat pump was evaluated by the RETScreen method. Data inputs are shown in Table 17. Results are given in Table 18.

Assumptions [50]

- Coefficient of performance (COP) is greater than 2.8 (4.0)
- Energy Efficiency Ratio (EER) is greater than 13.
- Systems are operated by electricity.
- Delivery efficiency is 100%.
- Weather conditions are the same as Ponca City.
- Vertical Closed Loop used as Heat Pump exchanger.

Table 17 Ground-Source Heat Pump Design

Geothermal Heat Pump Design	Unit	Value
Base load cooling system		
Capacity	kW	12
Manufacture		Maritime Geothermal
Model		DX-45-HACW
Cooling delivered	MWh	62
Coefficient of performance		4.0
Base load heating system		
Heating delivered	kW	6.9
Manufacturer		Amana
Model		PHD24C02F1
Seasonal efficiency	%	44
Fuel Type		Electricity
Fuel Cost	$/MWh	94

3.5.2.3 Cost Estimation

Assumptions [50]

- 2 percent inflation rate
- 25 years project life
- 3 percent fuel cost escalation rate

Table 18 Ground Heat Pump Cost Estimation

Annual costs (credits)	Unit	Quantity	Cost($)
Heating system			
Base load - Heat pump			
Energy efficiency measures			
Furnace & Air-conditioner	Credit	1	7,500
Ground-Source Heat Pumps - credit	Cost	1	3,020
Sub-total:			4480
Cooling system			
Base load - Heat pump	kW	12.0	3960
Fan & duct material – cost	Cost	1	7,500
Base case system	Cost	1	6,750
Sub-total:			18210
Total initial costs			22191
O&M			
Parts & labor	Project	275	550
O&M - Base case	Credit	275	(550)
Electricity	MWh	8	94.000
Sub-total:			764
Total	$		22955

As a result of the estimation, the total cost of a ground heat pump was $22,955, and the payback is more than 25 years. Therefore, the ground heat pump installation for the Day Care Center is not recommended based solely on economics. If other factors make heat pumps attractive, grants or other funding should be sought to defray part of the installation cost.

3.6 Overall Renewable Energy Summary

Potential renewable resources such as solar, wind, hydro, and geothermal were analyzed for economic feasibility. Renewable energy resource development offers many opportunities for the Kaw Nation, even though adoptable technology is limited if evaluated solely on the basis of economics. Table 19 summarizes renewable resource opportunities for Kaw Nation facilities.

Table 19 Summary of Renewable Energy Resource Development

Renewable Energy Source	Technology	Payback	Economic Feasibility	Facilities Evaluated
Solar	PV	16 years	Moderate	KEDA-6 (New Office Bldg.)
	Solar Hot water	13.5 years	Moderate	Wellness Center
Wind	Wind Turbine	More than 30 years	Poor	SouthWind Parking Lot Kanza Health Center Day Care Center JRM Community Bldg. Wellness Center
Hydropower	Micro hydropower	6.8 years	Favorable	Kaw City Facilities
Geothermal	Ground Heat pump	More than 25 years	Poor	Day Care Center

Chapter 4. Energy Audits and Retrofits

4.1 Overview

Buildings in the United States account for 69% of the electricity and 39% of the total energy used in the country[92]. These statistics indicate that overall energy consumption can be significantly reduced simply by reducing use of electricity and natural gas in buildings. Energy audits are able to assist in energy reduction by inspection, surveys and analysis of energy flows in buildings or systems. Types of Energy audits include walk-through audit, utility cost analysis, standard energy audit, and detailed energy audit.

- The walk-through audit is a short on-site visit of the facility to identify energy use and cost savings that can be achieved through simple and inexpensive actions
- The utility cost analysis requires a detailed analysis of the operating cost of the facilities. This analysis require several years of the utility data to evaluate the patterns of energy use, peak demand, weather effects, and potential energy savings.
- The standard energy audit consists of both of the walk-through audit and the utility cost analysis. The development of a baseline energy usage and the evaluation of potential energy savings are also included.
- The detailed energy audit is the most comprehensive but very time-consuming energy audit type. This audit includes evaluation of every energy measure in the whole building.

This report uses both standard energy audits and detailed energy audits for Kaw Nation buildings to result in better energy savings. Figures 26, 27 and 28 show the general patterns of energy consumption in commercial and residential buildings in the United States.

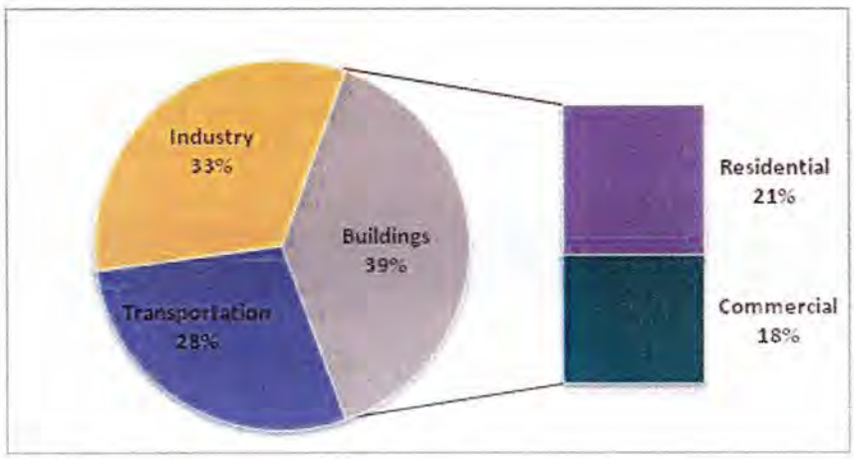


Figure 26 US Energy Consumption
Source: U.S. Department of Energy (DOE), *2008 Buildings Energy Data Book*, Section 1.1.1, 2008

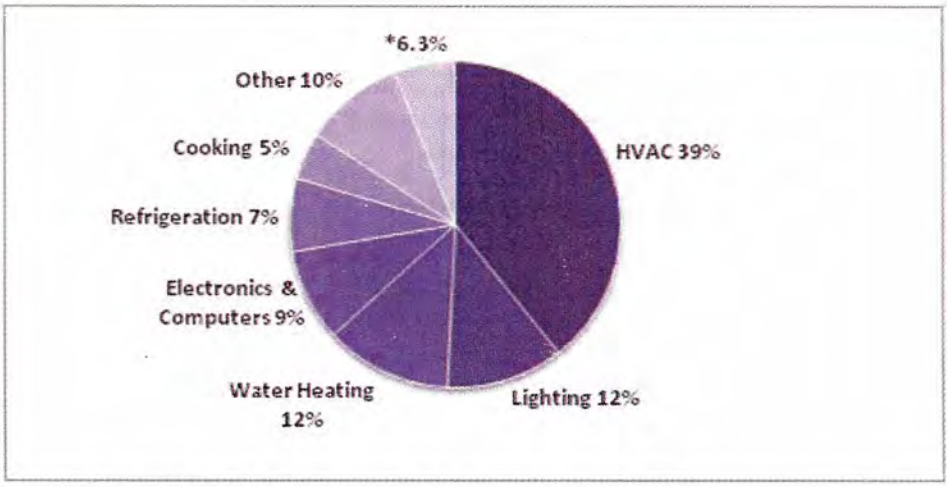


Figure 27 Residential Buildings Total Energy Use in 2006
Source: DOE, *2008 Buildings Energy Data Book*, Section 2.1.5, 2008

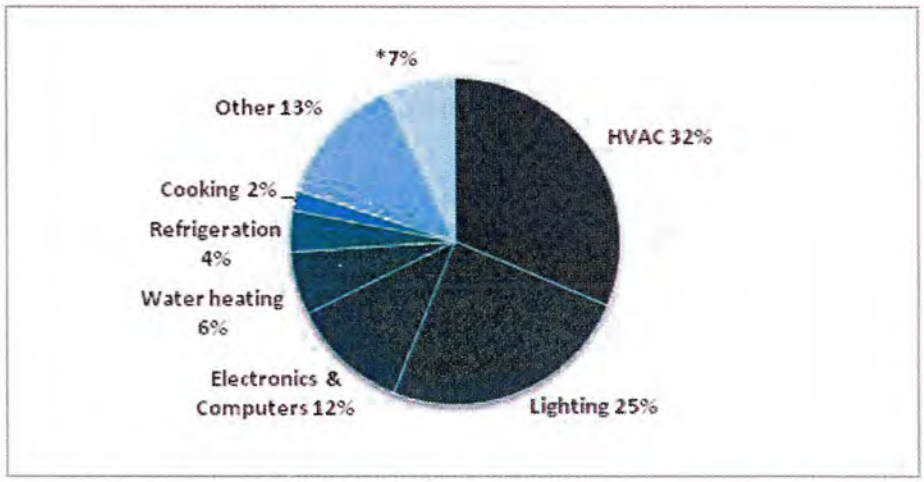


Figure 28 Commercial Buildings Energy Use

Source: DOE, *2008 Buildings Energy Data Book*, Section 3.1.4, 2008

4.2 Energy Auditing Strategy

4.2.1 Commercial Audit

Due to high electricity consumption and opportunities for installation of clean technology, energy audit activities on commercial buildings have become very important. Commercial building auditing can help reduce energy usage and provides opportunities to earn loans or grants for future energy savings. Table 20 shows the general procedure of commercial building auditing.

Table 20 Procedures of Commercial Building Auditing

Phase	Thermal Systems	Electric Systems
Utility analysis	Thermal energy use profile in the building	Electrical energy use profile
	Thermal energy use per unit area	Electrical energy use per unit area
	Thermal energy use distribution	Electrical energy use distribution (electrical equipment)
	Fuel types used	Weather effect on electrical energy use
	Weather effect on thermal energy use	Utility Rates structure (energy charges, power factor penalty)
	Utility rate structure	
On-Site Survey	Construction Materials	HVAC system type
	HVAC system type	All equipment type and density
	DHW system	Energy use for heating, cooling and water distribution
	Hot water/steam use for heating and cooling	
Energy Use Baseline	Review architectural, mechanical, and control drawings	
	Develop a base-case model	
	Calibrate the base-case model	
Energy Conservation Measures	Heat recovery system	Energy efficient equipment
	efficient heating system	HVAC retrofit
	Temperature Setback	Efficient cooling system
	EMCS	EMCS
	HVAC retrofit	Reduction of harmonics
	DHW use reduction	Power factor improvement
	Cogeneration	Cogeneration

Source: Moncef Krarti, A Book of Energy Audit of Building Systems, 2000

4.2.2 Residential Audit

A residential energy audit is a very effective tool for saving energy and improving energy efficiency. The largest portion of energy usage in residential houses in the United State is due to heating and cooling systems. This indicates that an audit of heating and cooling systems can have a direct effect on home energy bills. There are several ways to improve energy efficiency in residential heating and cooling. Achieving energy efficiency in the building envelope is the easiest way to improve heating and cooling efficiency. Several envelope measures will be discussed below. Another substantial saving can be achieved by evaluation of the lighting system. Many houses in the United State still use incandescent bulbs, which consume relatively large amounts of electricity while producing a heat load that must be removed in the summer. The simple improvement of lights is able to save a large amount of energy for residential buildings. Lighting system improvement is also discussed below.

Finally, home appliances affect residential energy usage. Improved energy efficiency in appliances can provide substantial benefits. The accuracy of energy estimates are greatly improved when the homeowner's billing history is available, showing the quantities of electricity, natural gas, fuel oil, or other energy sources consumed over a one or two-year period.

4.2.3 Kaw Nation Facilities

Kaw Nation facilities were audited during this project. The portions of electricity usage in are categorized into building envelope, lighting, appliances, and HVAC (heating, ventilation and cooling). It was found that heating, ventilation, and cooling improvements would provide the largest energy savings. For example, old HVAC equipment could be replaced with Energy Star equipment, reducing energy consumption by 10-20% or more. Efficient appliance usage would also save amounts of energy for Kaw Nation's facilities. Building envelope and lightings are also important factors to be inspected, especially for old buildings. A detailed audit of each building is found later in this report, in Chapter 5.

4.3 Energy Efficiency Improvements

4.3.1 Envelope Measures

Evaluation of the building envelope is the first step of the energy audit. Adequate insulation in buildings can avoid loss or gain of heat from the outdoors. Common residential air leakage sources are shown in Figure 29.

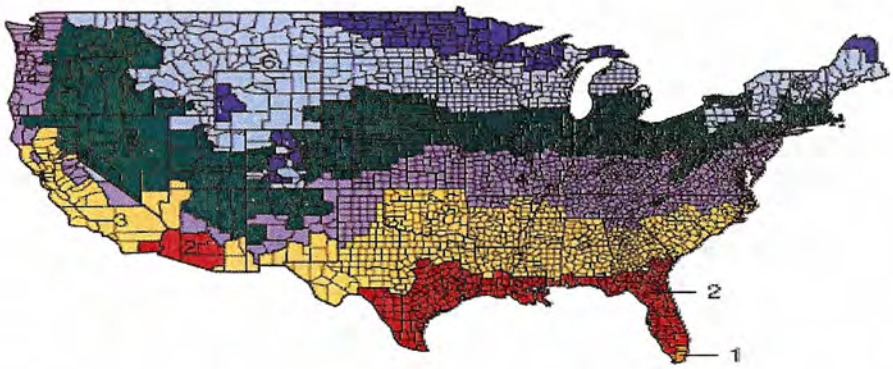
Figure 29 Conventional Air Leakage in the Residence
Source: Tom Wilson, Residential Energy Auditing Techniques, November, 2006

1Staircase Ceiling, 2 Recessed Light, 3 Chimney Chase, 4 Electric Wires and Box, 5 Balloon Wall, 6 Attic Entrances, 7 Partition Wall Top Plate, 8 Plumbing Vent Chase, 9 Exhaust Fan, 10 Dryer Vent, 11 Plumbing/Utility Penetrations, 12 Sill Plate, 13 Rim Joist, 14 Bathtub Opening, 15 Basement Windows & Doors, 16 Block Wall Cavities, 17 Water Heater/Furnace Flue Connections, 18 Ductwork, 19 Plumbing Chase, 20 Leakage Between Basement & Crawlspace, 21 Floor Boards, 22 Windows, 23 Laundry Chutes, 24 Stairwell, 25 Kneewall/Framing Intersection
26 Built-in Dresser, 27 Chimney Penetration, 28 Built-in Cabinet, 29 Holes in Plaster walls, 30 Furnace Registers, 31 Doors, 32 Baseboards, Coves, & Interior Trim, 33 Plumbing Access Panel, 34 Sink Plumbing Penetrations, 35 Dropped Soffit, 36 Electrical Outlets, 37 Electrical Fixtures, 38 Porch Framing Intersection, 39 Missing Siding & Trim, 40 Additions Dormers and Overhangs, 41 Unused Chimney, 42 Floor Joist

Proper insulation of a house can decrease heating and cooling costs. Energy usage is influenced by several factors: sunlight penetration, heat transfer, and air infiltration. Insulation is commonly evaluated based on the R-value. The R-value is the thermal resistance factor which represents resistance to heat flow. The unit of R-value is 1 $h \cdot ft^2 \cdot °F/Btu$, called R-1, which is the same as a metric value of 0.176110 $K \cdot m^2/W$. The higher the R-value is, the better the insulation of the building. However, installation of too high R-value insulation is usually cost-ineffective, because the insulation can cost more than the energy that it saves.

Optimized R-values are needed to save the maximum amount on energy bills. Optimum R-values for areas in the United States are shown in Figure 30. Oklahoma is in area 3 of this figure.

U.S. Department of Energy Recommended* Total R-Values for New Wood-Framed Houses



Zone	Attic	Wall Cavity	Wall Sheathing	Cathedral Ceiling	Wall				Floor
					Attic	Cathedral Ceiling	Cavity	Insulation Sheathing	
1	✓	✓	✓	✓	R30 to R49	R22 to R38	R13 to R15	None	R13
2	✓	✓	✓		R30 to R60	R22 to R38	R13 to R15	None	R25
2				✓	R30 to R60	R22 to R38	R13 to R15	None	R19 - R25
3	✓	✓	✓		R30 to R60	R22 to R38	R13 to R15	None	R25
3				✓	R30 to R60	R22 to R38	R13 to R15	R2.5 to R5	R25
4	✓	✓	✓		R38 to R60	R30 to R38	R13 to R15	R2.5 to R6	R25 - R30
4				✓	R38 to R60	R30 to R38	R13 to R15	R5 to R6	R25 - R30
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	✓	✓	✓	✓	R49 to R60	R30 to R60	R13 to R21	R5 to R6	R25 - R30
7	✓	✓	✓	✓	R49 to R60	R30 to R60	R13 to R21	R5 to R6	R25 - R30
8	✓	✓	✓	✓	R49 to R60	R30 to R60	R13 to R21	R5 to R6	R25 - R30

Figure 30 Recommended R-Values in the United States
Source: U.S Department of Energy http://www1.eere.energy.gov/consumer/tips/insulation.html

Based on the R-values in Figure 30, this study optimized the R-values for the facilities of the Kaw Nation. Facilities where new insulation might prove cost effective were narrowed to five, consisting of buildings which were built more than 20 years ago. These buildings are listed in Table 21.

Table 21 Feasible Kaw Nation Buildings for Installation of Insulation

Place	Year	Sq. Ft.	2008 Electric Usage (kWh/yr)	Yearly Electric Bills, $	Yearly Water Bills, $	Type of usage
Administration Building	1985	7,600	67,240	7837.84	272.9	Offices
Garrett/EPA Building	1979	3,500	59,132	7549.31	530.53	Offices
Historic Council House	1974	1,612	6,160	1100.96	530.25	Historic
Woodridge Market	1989	3,738	280,287	25471.35	1200.82	Store
KEDA (Brown House)	1883	2,600	9,127	924.72	128.09	Office

4.3.2 Roof and Wall Insulation

In the United States, asphalt shingles and cedar shakes are commonly used materials for roofing. R-values of these materials are 0.44 and 0.97 $K \cdot m^2/W$, which are low enough to justify the addition of insulation if the roof is not insulated. Roof types are generally sloping or flat. Sloping roofs can be insulated easily. Flat roofs can be insulated from inside in the same manner as wall insulation. Wall insulation can be of three types: cavity wall insulation, external, and internal wall insulation. Among these, cavity wall insulation is the most popular and cost effective. Insulation cost varies state to state, but generally averages $500-$1000 dollars for residential houses.

4.3.3 Window Insulation

Windows insulation can result in 10% to 20% reduction of heating and cooling costs. In the United States, most houses possess single-pane windows, which should be replaced with double-pane windows or sealed properly with caulking and weather stripping materials. There are four types of window insulation: replacement with double-pane windows, replacement with highly reflective glass, attaching window insulation films, and caulking window frames. Generally, installing double-pane windows and highly reflective glass are expensive retrofits for existing buildings. Payback periods are usually more than 10 years. Consequently, window insulation films and caulking of window frames are the best choices for this project. Several window insulation films are commercially available and are inexpensive and easy to install. Wind insulation is outlined in Table 22.

Table 22 Effective Methods of Window Insulation

Method	Pros	Cons
Rubber weather sealing	Inexpensive, effective, minimal alterations to appearance of windows	Damaging paint, leaving a sticky residue
Window insulation film	Inexpensive and effective	Windows are left with a cloudy, shrink-wrapped look
Cellular shades	Let in light and can be custom-fitted for doors and windows	Expensive and provide less insulation than heavier curtains
Layered curtains	Looks good, can be matched to home decor	Expensive and block out light
Draft Snakes	Inexpensive, easy to make at home	Only insulate the window sill, not the glass or frame

Source: Apartment Therapy, Five Ways to Insulate Your Windows for Winter

4.3.4 Air Leakage

Air leakage is one of the significant factors in the inefficiency of heating and cooling. Proper insulation of inside air can save 30% to 40% of heating and cooling loads.

Air envelope techniques include (Source: Energy audit of building systems by Moncef Krarti) [55]

- Caulking: This is the easiest way to seal leaks such as window and door leaks, wall and ceiling leaks, and water leaks. Types of caulking products are urethane, latex, and polyvinyl.
- Weather Stripping: This technique is used for window and door sealing by applying foam rubber.
- Landscaping: This is a long term project and takes more money by planting trees or shrubs to reduce wind and sun effects.
- Air Retarders: These products are to reduce air infiltration from outside by using the building exterior shells such as liquid-applied bituminous, liquid-applied rubber, sheet bituminous, and sheet plastic. Installation of these systems is typically expensive for existing buildings.

4.3.5 Insulation of Kaw Nation Facilities

Five old Kaw Nation facilities built before 1990 were evaluated for the addition of insulation, under the assumption that they were not initially insulated to current standards. Roof insulation, wall insulation, window insulation, and air sealing were evaluated fpr each building. Recommendations are based on the handbook of energy audit of building system by Moncef Kararti and the HVAC System Design Handbook by Roger W. Haines and C. Lewis Wilson.

Table 23 Types of Insulation Recommended for Kaw Nation Facilities

Insulation Type	Electric Usage	Reduced Electric Usage	Reduced Electric Bills	Cost of Insulation	Payback Period
Administration Building					
Roof	43104	32029	$1,291	$10,800	8
Walls	43150	37279	$684	$5,852	9
Windows	43123	24227	$2,203	$21,600	10
Air leakage	43133	21307	$2,544	$1,500	1
Garrett/EPA Building					
Roof	19856	14754	$651	$4,975	8
Walls	19872	17168	$345	$2,695	8
Windows	19932	11198	$1,115	$16,583	15
Air leakage	20787	10394	$1,327	$1,000	1
Historic Council House					
Roof	9145	6795	$420	$2,291	5
Walls	9152	7907	$223	$1,241	6
Windows	9199	5168	$720	$7,638	11
Air leakage	9354	4677	$836	$700	1
Woodridge Market					
Roof	39144	29086	$914	$5,313	6
Walls	39176	33846	$540	$2,878	5
Windows	39629	22264	$1,578	$17,709	11
Air leakage	39335	19668	$1,787	$1,100	1
KEDA (Brown House)					
Roof	7942	5902	$207	$3,696	18
Walls	7949	6867	$110	$2,002	18
Windows	8050	4522	$357	$12,319	34
Air leakage	7835	3918	$397	$900	2

As a result of this evaluation, elimination of air leakage method was determined to be the most reasonable and efficient for the facilities of the Kaw Nation. Due to high expense, roof insulation, wall insulation, and addition of double-paned windows are not recommended. However, window films, curtains, and cellular shades can be economically adopted for insulation methods.

4.4 Lighting

Upgrade of lighting systems can reduce energy usage in commercial and residential buildings. It is reported that 20 to 40% of total electricity consumption is used for lights in residential and office buildings. Much of the energy used by conventional lighting goes to produce heat which must be removed from the building during the summer. A new energy-efficient lighting system should be considered to reduce energy bills for the buildings of the Kaw Nation. The lighting system recommended for any particular area is affected by a number of factors: usable natural light, the purpose of the building or area, lamp operating hours, heat gains, and losses through glazed areas. Two options will be evaluated for Kaw buildings: the improvement of lighting bulbs and the control of the operation of lighting systems.

4.4.1 Lighting Bulb Improvements

Recommended lighting levels for many applications are shown in Table 24 below.

Table 24 Recommended lighting levels

Application	Lux (lm/m^2)	Application	Lux (lm/m^2)	Application	Lux (lm/m^2)
Offices		Common areas in buildings		Places of public assembly	
General	200-500	Entrance hall, lobby, waiting room	200	Cinema and theatre foyer	200
Reading Tasks	200-500	Enquiry desk	500	Booking office	300
Drafting	1000-2000	Corridor, passageway, stairs	100	Auditoria	100-150
Retail Stores		Atria	50-200	Library	150-300
General	200-500	Changing room, cloakroom, lavatory	100	Museum art gallery	50-300
Tasks/till Areas	200-500	Rest room	150	Lecture theatre	300
Fashion	500-750	Canteen, cafeteria, dining room	200	Church	100-300
Supermarket	750	Kitchen	300	Hotels	
Restaurant	200	Banks and building societies		Entrance hall	100
Bookshop, chemist, jeweler	500	Counter and office area	500	Reception desk	300

Superstore	1000	Public area	300	Bar, restaurant, dining room, lounge	50-200
Electrical and furniture store	750	Hospitals		Bedroom	50-100
Showroom	500-750	Common Areas	--	Kitchen	150-300
Arcades and malls	50-300	Patient Rooms	100-200	Classrooms	
Manufacturing				General	200-500
Fine Knitting	1000-2000			Chalkboards	500-1000
Electronics	1000-2000				

Source: US/Canada IESNA (93) & CIBSE Code for Interior Lighting, 1994

There are four commonly used technologies for new light systems: high-efficiency fluorescent lamps, compact fluorescent lamps, compact halogen lamps, and electronic ballasts.

High-efficiency fluorescent lamps are the most commonly used energy-efficient lighting in the United States. Around 60-70% of commercial buildings in the U.S. use fluorescent lamps due to their high efficiency diffuse light distribution, and long operation life. The typical efficacy output of fluorescent lamps is 70 lumens/watt to 90 lumens/watt. Compact fluorescent lamps are less efficient than full size fluorescent lamps, with 35 to 55 lumens/watt. However, they provide 75% more efficient energy savings and 10 times longer lifespans than incandescent light bulbs. Compact halogen lamps can be directly adapted for a replacement of incandescent lamps without any changes of lighting systems. These lamps can also save 30 per cent of the electricity required by incandescent light bulbs. Electronic ballasts can produce high-frequency current about 20 to 60 MHz which provides less flicker problems and high efficacy of 95 lumens/watt.

4.4.2 Lighting Controls

Energy saving from lighting systems is not only achieved by improving lighting lamps, but it can also be achieved by controlling on-off switching. The on-off switching control can be provided by automatic sensors, such as photo-sensors, infrared sensors, and ultrasound sensors. Photo-sensors are especially useful for outdoor lighting by preventing day time operation of lights. Infrared sensors are also often used for outdoor lighting, due to their abilities to sense thermal changes in the environment. The combination of photo-sensors and infrared sensors is often used for outdoor security and utility lighting. Ultrasound sensors are operated at a frequency of 25-40 KHz. They are often used for inside spaces. Energy savings using automatic lighting sensors are shown in Table 25.

Table 25 Energy Savings with Occupancy Sensor Retrofits

Place	Energy Savings
Offices (Private)	25-50%
Offices (Open Space)	20-25%
Rest Rooms	30-75%
Conference Rooms	45-65%
Corridors	30-40%
Storage Areas	45-65%
Warehouses	50-75%

Source: Book of Energy Audit of Building Systems, Monecef Krarti

4.5 Appliances and Electrical Power Systems

In the United State, household energy consumption by appliances is about 17% of total energy usage, [48] and the rates of electricity usage by appliances have increased over the past several years. Some recommendations for saving energy from appliances include more careful use of the appliance, installation of Energy Star label appliances, and replacing appliances that have exceeded their life expectancy.

General instructions on appliance use to conserve energy include:

- Recognition of appliance electricity consumption.
- Estimation of electricity consumption of appliances.
- Planning for only essential use of appliances.
- Switching off appliances to avoid phantom loads when not in use.

Table 26 shows electricity consumption by various appliances.

Table 26 Appliance Electricity Consumption

Appliance	watts/hour	Appliance	watts/hour
Desktop Computer & 17" LCD Monitor	150-300	Hair Dryer	1000
Toaster	800	Freezer	500
32" LCD TV	98-156	Printer	100
Dishwasher	1200-1500	Iron	1000
Air Conditioner	1000	Laptop	30-50
Microwave	600-1500	Coffee Maker	800

Washing Machine	500	**Fans**	
Clothes Dryer	1800-5000	Ceiling	65–175
Heaters		Window	55–250
Engine block	150-1000	Furnace	750
Portable	1500	Whole House	240–750
waterbed	400	Vacuum Cleaner	200-700

Source: Appliances, U.S Department of Energy, How Much Electricity Do You Use in a Week? 2009

4.5.1 Energy Star Label Appliances

The Energy Star label program was launched by the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Energy (DOE) due to the rapid increase in electricity usage by appliances. These agencies found that Energy Star labeled products were able to save more than 70% of the total electricity used by appliances. The Energy Star Program began with office equipment and now includes most electric appliances for the home. Table 27 compares the operating costs of old electric appliances and new Energy Star labeled products.

Table 27 Comparing Energy Star Product Operating Costs

Appliance	Average kWh used each year	Average kWh used each month	Monthly cost at $0.07/kWh
Refrigerator and freezer			
• Old refrigerator (10 cu. ft.) with manual defrost	479	40	2.8
• ENERGY STAR labeled manual defrost refrigerator (10 cu. ft.)	295	28	1.96
• Old frost-free refrigerator-freezer (16–18 cu. ft.)	1044	87	6.09
• ENERGY STAR auto-defrost refrigerator-freezer(16-18 cu. ft.)	450	38	2.66
• Old chest-type freezer manual defrost (12–15 cu. ft.)	658	55	3.85
• ENERGY STAR chest-type freezer (12–15 cu. ft.)	326	27	1.89
• Old upright freezer manual defrost (12–15 cu. ft.)	992	83	5.81
• ENERGY STAR upright freezer manual defrost (12-15 cu. ft.)	524	44	3.08
Cooking			
• Electric range: (usage varies widely)			
— manually cleaned oven	784	65	4.55
— self-cleaning oven (1 cleaning/month)	754	63	4.41
• Microwave oven (30 min./day at full power)	218	18	1.26

• Electric frying pan (12 times per month)	140	12	0.84
• Coffee maker (40 times/month).	117	10	0.7
• Toaster oven (12 hours/month)	250	21	1.47
• Dishwasher (energy to heat water)			
— using dry cycle (1 time/day)	270	22	1.54
— without dry cycle (1 time/day)	120	10	0.7
Laundry			
• Dryer (1 load/day)	910	76	5.32
• Top-loading washer (33 loads/month, including electrically heated hot water)	881	73	5.11
• Front-loading washer (33 loads/month, including electrically heated hot water)	264	22	1.54
• Iron (2 hours per week)	104	9	0.63
Entertainment			
• Color TV, solid state (5 hours/day)	364	30	2.1
• Stereo (3 hours/day)	109	9	0.63
• Clock radio (3 hours/day)	4	0.3	0.02
Computer			
• Computer & monitor (8 hours every weekday)	189	16	1.12
• Laser printer standard (8 hours every weekday)	282	24	1.68
Personal care and comfort			
• Waterbed (any size)	1,200	100	7
• Portable space heater (1,000 watts)	600	50	3.5
• Electric blanket (double size)	120	10	0.7
Other			
• Furnace fan	1,200	100	7
• Vacuum cleaner (4 times/month for 1 hour)	36	3	0.21
• Lawnmower (4 to 5 times/month for 1 hour)	52	4	0.28

Source: BChydro power Smart, Use Energy –Efficient Appliances in your home

Some states in the United States encourage residents to change older, inefficient appliances with new Energy Star labeled products through a rebate program. Oklahoma launched a rebate program for replacement of older appliances with Energy Star products, including refrigerators, clothes washers, room air conditioners, electric heat pump water heaters, solar water heaters (electric backup), gas furnaces, central air conditioners, and geothermal heat pumps. However, the program ended in May 2010 because total funding ($3,495,000) was depleted [64].

4.5.2 Life Expectancy of Appliances

The lifetime operation costs of appliances typically exceed their initial purchase price, and old appliances often impose higher costs for operation than would be required to purchase new appliances. Appliance life expectancy should be known, and old appliances should be

replaced before they consume excessive amounts of electricity. Table 28 shows life expectancies of several appliances.

Table 28 Lifespan of Appliances

Appliance	Average Lifespan In Year
Oven (gas & electric)	8~12
Refrigerator (top-mount or side-by-side)	8~14
Clothes washer	7~12
Clothes dryer	8~14
Dishwasher	7~12
Microwave	8~10

Source: American Home Shield, Average Lifespan of Major Appliances

4.6 HVAC (Heating, Ventilation, Air-Conditioning)

HVAC systems are typically worthwhile for energy auditing due to their high energy consumption, about 40-50% of total energy use [66]. Inefficient HVAC systems can have not only high energy consumption, but also high water consumption. Most HVAC systems in the Kaw Nation facilities are less than 6 years old and operate very efficiently. However, the air conditioning system of the Day Care Center in Newkirk is old and should be replaced in 5 to 7 years.

4.6.1 Replacement of Air-Conditioner in Day Care Center, Newkirk

The Day Care Center in Newkirk was selected for replacement of the air conditioning system due to the age and likely low energy efficiency of the current air conditioning system. The new cooling system was estimated using the RETScreen method. Results are shown in Tables 29 and 30 and Figure 31.

4.6.1.1 Design Assumptions [68]

- Compressor technology was applied for a small building.
- Ponca City weather data was assumed and used for the analysis
- Electricity was assumed to be the only energy supply
- 2% of inflation rate in electricity usage per year.
- Cooling capacity of 14.4 kW was determined based on cooling usage.

Table 29 Air Conditioning System Design for Day Care Center in Newkirk

Air Conditioning System Design		**Base case**	**Proposed case**
Cooled floor area for building	m^2	360	
Energy efficiency measures			0%
Cooling load for building	W/m^2	40	40
Non-weather dependent cooling	%	0%	0%
Total cooling	MWh	35	35
Base load cooling system			
Technology		Reciprocating	Compressor
Capacity	kW	14.4	100.0
Cooling delivered	MWh	35.4	35.4
Fuel type		Electricity	Electricity
Coefficient of performance - seasonal		3.50	5.00
Fuel consumption - annual	MWh	10	7
Fuel rate	$/kWh	0.094	0.094
Fuel cost	$	950	665
Peak load cooling system			
Technology			
Suggested capacity	kW		0.0
Capacity	kW		
Fuel type			Electricity
Coefficient of performance - seasonal			
Fuel consumption - annual	MWh		0
Cooling delivered	MWh		0.0
Fuel rate	$/kWh		
Fuel cost	$		0
Emission Analysis			
Base case electricity system (Baseline)		**GHG emission factor (excl. T&D)**	**T&D losses**
	Fuel type	**tCO2/MWh**	**%**
GHG emission			
Base case	tCO2	2.1	
Proposed case	tCO2	1.5	
Gross annual GHG emission reduction	tCO2	0.6	
GHG credits transaction fee	%	0.0%	
Net annual GHG emission reduction	tCO2	0.6	
GHG reduction income			
GHG reduction credit rate	$/tCO2	0.00	

4.6.1.2 Cost Estimation

Input and Assumptions:

- Only the air conditioning unit was replaced
- $300 O&M cost savings
- 20 year project life

Table 30 Cost estimation of Cooling System in Day Care Center, Newkirk

Financial parameters		
Inflation rate	%	2.0%
Project life	yr	20
Debt ratio	%	0
Debt interest rate	%	0
Debt term	yr	0
Initial costs		
Cooling system	$	7,000
Other	$	
Total initial costs	$	7,000
Annual costs and debt payments		
O&M (savings) costs	$	-300
Fuel cost - proposed case	$	665
Capacity charge - credit	$	-100
Total annual costs	$	265
Annual savings and income		
Fuel cost - base case	$	950
Other	$	
Total annual savings and income	$	950
Financial viability		
Pre-tax IRR - asset	%	9.6%
Simple payback	yr	10.2
Equity payback	yr	9.2

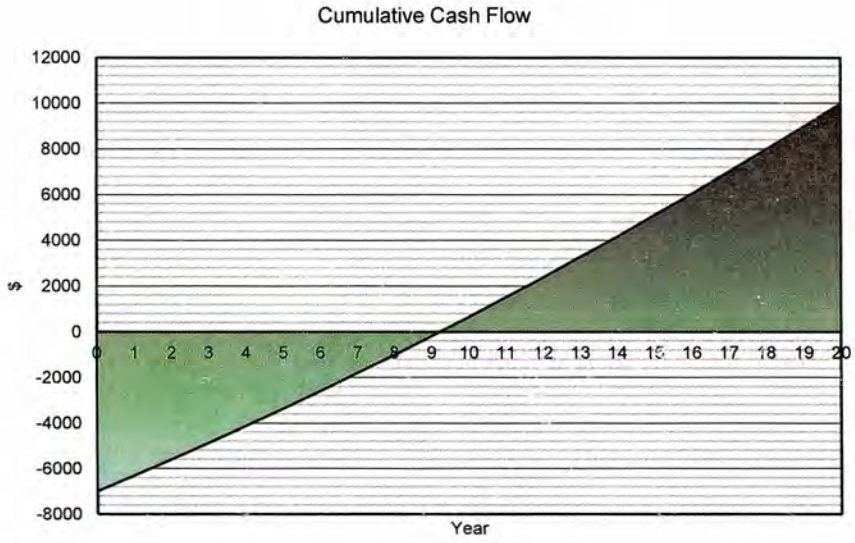


Figure 31 Cumulative Cash Flow Chart for Day Care Center

The payback period for the air conditioning system replacement in the Day Care Center is 9.2 years with a compressor based system. The total cost of replacement of the air conditioning system was evaluated $7000 dollars. This indicates that it is economically a reasonable project.

4.7 Energy Code

The Kaw Nation does not have its own building energy code for new building design. There are two widely used energy codes: the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE), and the International Energy Conservation Code (IECC). The ASHRAE handbook provides fundamentals for HVAC applications, HVAC systems and equipment, and refrigeration. It is updated every year by consulting the field of experts. The latest version of the ASHRAE handbook is available online at this address http://www.ashrae.org/publications/page/158. However, most states in the US adopted the IECC. Oklahoma also uses 2003 and 2006 IECC for residential and commercial code. State energy code reviews or updates every three year. The latest 2009 IECC is available online at http://www.internationalcodes.net/2009-international-energy-conservation-codes.shtml.
The recommended building energy code for the Kaw Nation is the latest 2009 IECC since the State of Oklahoma adopted the 2006 IECC and Oklahoma will implement the 2009 IECC.

Chapter 5. Electric Energy Audit and Recommendations

5.1 Data Collection

Electricity usage for the Kaw Nation facilities was provided from January to December 2008 by Kaw Nation representatives. To gather more specific information, the Kaw Nation facilities were inspected. The researcher inspected energy consumption of appliances, heating, cooling, and envelope measures for ten major facilities. Some assumptions were made to establish reasonable electricity usage patterns.

Assumptions:

- All buildings except the Day Care Center were assumed to use energy efficient cooling and heating systems. (Most cooling and heating systems are new or fewer than 10 years old).
- Average working hours were assumed to be 40 hours a week.
- Appliance working hours were developed for different items of electrical equipment.
- Electricity usage rates were included for personal electrical equipment.
- Energy savings were assumed based on general efficient use of electricity.
- The Southwind Casino was excluded from the auditing process due to its goal of higher usage as opposed to better energy efficiency.

5.2 Electricity Usage and Recommendation for Existing Buildings

The objective of this chapter is to evaluate electricity consumption data from Kaw Nation facilities and to determine whether more energy conservation is feasible. Ten existing facilities of the Kaw Nation were inspected to account for electricity consumption.

5.2.1 EPA Building and Garrett Dental Clinic

The first building evaluated was the EPA building. Data inputs are shown below, and audit results are presented in Table 31.

Annual electricity consumption	39533	kW/year
Windows		
Type	Double side metal frame	
Sealing	Good	No use of window insulation film
Area	30	m^2
Roof		
Type	flat	
Material	Metal frame	
Total Area	3500	ft^2

Energy efficient heating and cooling system.

Table 31 Energy Audit for the EPA building

Appliance	Unit	W/hour	kW/year	Saving (kW/year)	Options
Desktop computer & 17" LCD Monitor	15	200W/hours	4800	1800	Use one monitor for each computer in the EPA office. Turn off computers when not in use.
TV	2	110W/hour	0.48	-	-
Microwave	1	800w/hour	96	-	-
Freezer	3	500W/hour	1800	600	EPA offices do not need to use two freezers
Printer & Copier	2	150W/hour	72	-	-
Coffee maker	1	800W/hour	192	-	-
Fans					
Ceiling	20	80W/hour	3840	-	-
Other Office equipment	6		86.4	10	-
Dental equipment	5		72	-	-
Others			3400	-	-
Lighting				-	-
CFL	152	20W/hour	8755.2	700	More lights are installed than needed.
Sub Total			22114.08	2410	-
Air conditioner	Central		7116	142.32	Save heating and cooling costs by installing solar window films on windows and doors.
Heater	Central		8697	173.94	Install programmable thermostats to control the temperature
Total			37927.08	2583.94	**$323 savings per year**
Total (after savings)				35343.13	

According to Table 31, most of the energy consumption in the EPA and Dental Clinic Building is from lighting, computers, and freezers. The EPA offices use more compact fluorescent lamps (CFLs) than the number required to provide the 200 to 500 Lux needed for office tasks. Also, proper light turn on and off is recommended to save more energy. Computers in the EPA building use large amounts of energy. Each computer uses two monitors, and Energy Star Saving Mode is not used. Reducing monitors and providing efficient Energy Star Saving mode would save 10% of energy consumption on computers. Two freezers in the EPA building are excessive and old. Changing to an Energy Star Rated refrigerator, maintaining proper temperatures of 37-40°F for the fresh food section and 5°F for the freezer, and frequent cleaning of the coils behind the unit would provide for efficient energy use.

As seen in Figure 32, the trend of electricity usage for EPA building fits into the common electricity consumption pattern of commercial buildings. Using a programmable thermostat to adjust the temperature (68°F or lower in winter, 78°F or higher in summer, if the occupants could adapt to these temperatures) would conserve more energy. The Kaw Nation should establish a plan for specific energy usage throughout the year.

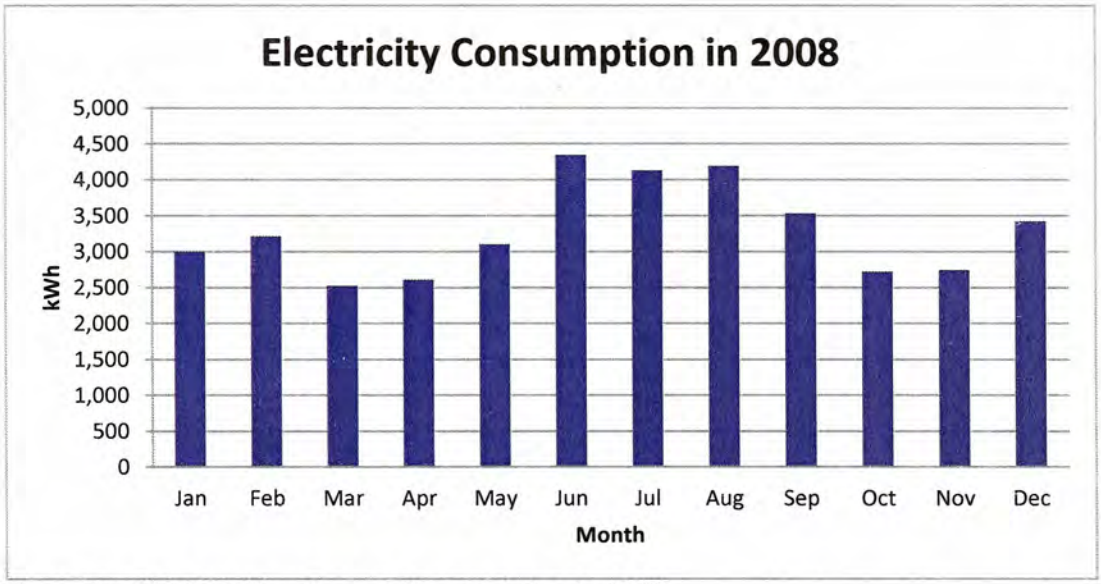


Figure 32 EPA Building Energy Consumption in 2008

5.2.2 Administrative Building

Annual electricity consumption		67240	kW/year
Windows			
Type	Double side metal frame		
Sealing	Good	No use of window insulation film	
Area		28	m^2
Roof			
Type	Flat		
Material	Metal frame		
Total Area		7600	ft^2

Energy efficient heating and cooling system

Table 32 Energy Audit for the Administrative Building

Appliance	Unit	W/hour	kW/yr	Saving (kW/year)	Options
Desktop computer & 17" LCD Monitor	14	200W/hours	6720	336	Proper turn on and off computers
TV	1	110W/hour	132	-	-
Microwave	1	800w/hour	96	-	-
Freezer	1	500W/hour	600	-	-
Printer & copier	3	150W/hour	108	-	-
Coffee maker	2	800w/hour	384	-	-
Fans				-	-
Ceiling	32	80W/hour	6144	5184	Too many operational fans for the building areas
Other Office equipment	20		288	50	Using less individual electronic equipment
Subtotal			13008	-	-
Lighting				-	-
CFL	200	20W/hour	11520	1152	Proper turn on and off
Air conditioner	Central		12709	254.18	Save heating and cooling values by installation
Heater	Central		15532	310.64	of solar window films on windows and doors
Total			67241	7286.82	**$889 savings per year**
Total(after savings)				59954.18	-

Table 32 presents energy consumption and saving options for the Administrative Building in Kaw City. For better energy savings and efficient use, lights should be reduced and turned on and off properly. Computers should be on energy saving mode. These practices would save at least 10% of energy expenditures.

According to Figure 33, the peak energy consumption occurs in the three summer months. This result indicates that air conditioning loads during summer in the Administrative Building should be examined for energy savings. It is recommended that programmable thermostats be used, and temperatures set as high in summer and as low in the winter as is comfortable to the occupants. Heating and cooling should be reduced when the building is unoccupied.

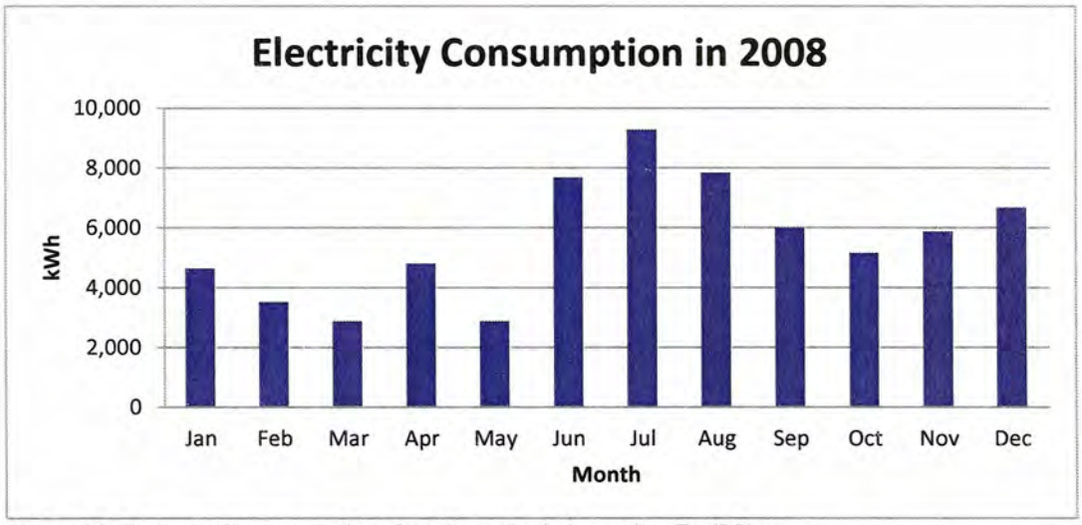


Figure 33 Energy Consumption for the Administrative Building

5.2.3 Kanza Museum

Annual electricity consumption		34120	kW/year
Windows			
Type	Double side metal frame		
Sealing	Good	No use of window insulation film	
Area	160	m^2	
Doors are based on glass			
Roof			
Type	Dome		
Material	Metal frame		
Total Area		7460	ft^2

Energy efficient heating and cooling system

Table 33 Energy Audit for the Kanza Museum

Appliance	Unit	W/hour	kW/year	Saving (kW/year)	Options
Desktop computer & 17" LCD Monitor	5	200W/hours	2400	120	Proper turn on and off computers
Fans					
Ceiling	20	80W/hour	3840	960	Too many operational fans for the building areas
Other Office equipment	2		28.8	-	-
Lighting					
CFL	150	20W/hour	8640	172.8	Proper turn on and off
Air conditioner	Central		10449	322.45	Save heating and cooling costs by installation of solar window films on windows and doors
Heater	Central		7882	394.1	
Others			881	-	-
Total			34120.8	1969.35	$240 savings per year
Total(after savings)				32151.45	

The Kanza Museum Building used 34120 kWh of electricity in 2008. Table 33 and Figure 34 indicate that electricity consumption on air conditioning in the building is excessive compared to other facilities of the Kaw Nation. The reasons are the following:

- Too much window area compared to other buildings.
- Windows are not properly covered with any window films.
- Automatic thermostats are not in use.

The Kaw Nation could save roughly half of energy consumption on air conditioning loads by installing window films and an automatic thermostat to control the temperature during the summer. These installations are highly recommended as cost-effective techniques to lower energy usage for the Kaw Nation.

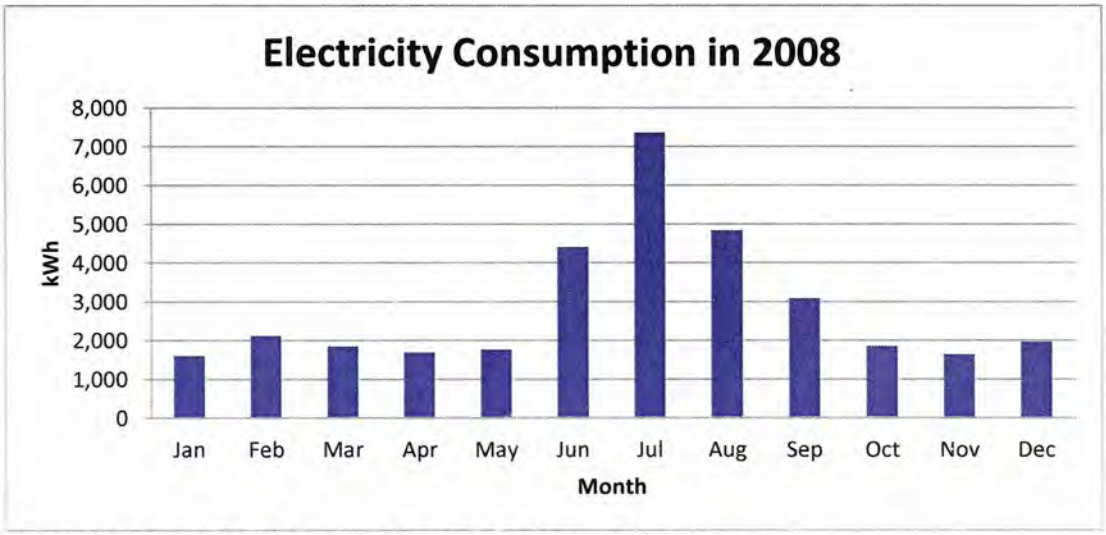


Figure 34 Electricity Consumption in the Kanza Museum

5.2.4 Mehojah Resource Center

Annual electricity consumption	67114	kW/year
Windows		
Type	Double side metal frame	
Sealing	Good	No use of window insulation film
Area	50	m^2
Roof		
Type	flat	
Material	Metal frame	
Total Area	6016	ft^2

Energy efficient heating and cooling system

Table 34 Energy Audit for the Mehojah Resource Center in Kaw City

Appliance	Unit	W/hour	kW/year	Saving (kW/year)	Options
Desktop computer & 17" LCD Monitor	11	200W/hours	5280	264	Proper turn on and off the computers
TV	1	110W/hour	132	-	-
Microwave	1	800w/hour	96	-	-
Freezer	2	500W/hour	1200	240	Energy Efficient Freezer
Printer & copier	1	150W/hour	36	-	-
Coffee maker	2	800w/hour	384	-	-
Fans					
Ceiling	36	80W/hour	6912	-	-
Other Office equipment	10		144	-	-
light					
CFL	180	20W/hour	10368	1152	Proper turn on and off
Others			10374	500	Reducing individual electronic equipment
Air conditioner	Central		16685	253.7	Save heating and cooling values by installation of solar window films on windows and doors
Heater	Central		15503	310.06	
Total			67114	2719.76	$334 savings per year
Total(after savings)				64394.24	

In the Mehojah Resource Center, the electricity consumption during 2008 was 67114 kW, which is excessive compared to other office buildings. Most energy consumption is from heating and cooling, appliances, and lighting. Heating and cooling loads could be reduced by addition of window insulation films, automatic thermostats, and other window sealing equipment. Appliance usage should be reduced by a proper turn on and off and replacing with

Energy Star products. Electricity consumption by lighting can be also reduced by automatic lighting sensors or proper turn on and off, and by reducing the number of lights. Overall savings would result from an air conditioning plan to reduce high electricity consumption in the summer. Programmable thermostats should be considered.

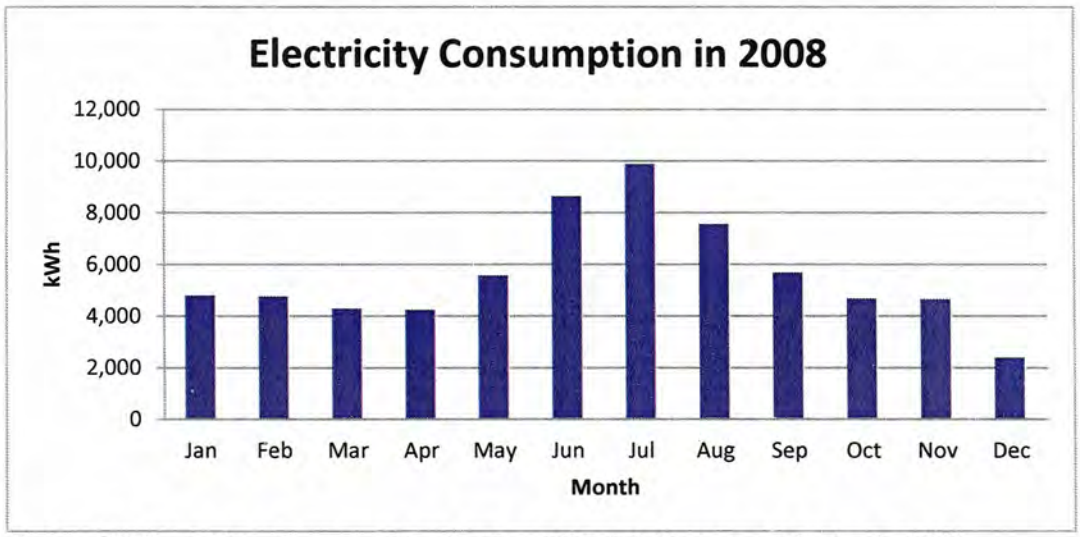


Figure 35 Electricity Consumption for the Mehojah Resource Center in 2008

5.2.5 Social Services Center

Annual electricity consumption		41560	kW/year
Windows			
Type	Double side metal frame		
Sealing	Good		
Area		70	m^2
Roof			
Type	slope		
Material	Metal frame		
Total Area		6080	ft^2

Energy efficient heating and cooling system

Table 35 Energy Audit for the Social Services Center in Kaw City

Appliance	Unit	W/hour	kW/year	Saving (kW/year)	Options
Desktop computer & 17" LCD Monitor	9	200W/hours	4320	216	Proper turn on and off of the computers
TV	1	110W/hour	132	-	-
Dishwasher	1	1400W/hours	336	48	Energy Efficient Dishwasher
Microwave	1	800w/hour	96	-	-
Printer & copier	1	150W/hour	36	-	-
Coffee maker	1	800w/hour	192	-	-
Fans					
Ceiling	30	80W/hour	5760	960	Reducing operation of ceiling fans
Other Office equipment	2		28.8	-	-
Others			6000		
Lighting					
CFL	160	20W/hour	9216	460.8	Proper turn on and off
Parking light				-	-
HID	6	400W/hour	4608	921.6	Automatic lighting sensors
Air conditioner	Central		10668	383.4	Save heating and cooling values by installation of solar window films on windows and doors
Heater	Central		9372	468.6	
Total			41579	3242.4	**$405 savings per year**
Total(after savings)				38316	

Electricity consumption in the Social Service Center during 2008 was 41560 kW. High energy usage results from three categories: heating and cooling, lighting, and appliances. Heating and cooling loads are the highest energy consumers. The pattern of twice the energy consumption during the summer compared to winter indicates too much energy is being used by air conditioners. The Kaw Nation should reduce cooling loads during the summer for energy efficient usage and conservation. Programmable thermostats should be considered.

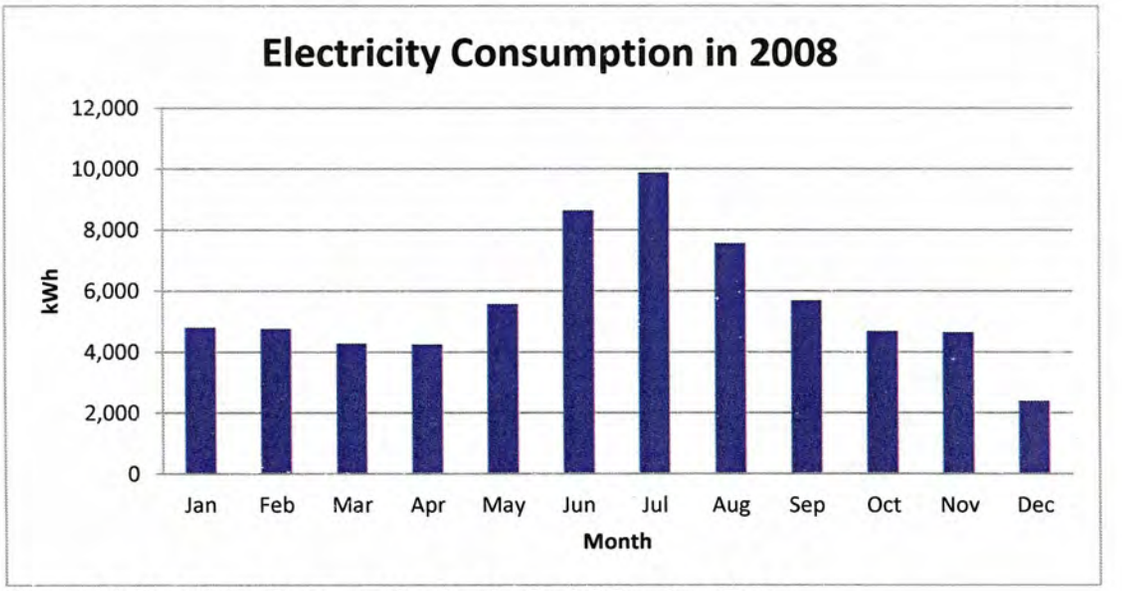


Figure 36 Electricity Consumption by the Social Services Center

5.2.6 Health Center

Annual electricity consumption	114680	kW/year
Windows		
Type	Double side metal frame	
Sealing	Good	
Area	56	m^2
Roof		
Type	slope	
Material	Metal frame	
Total Area	12690	ft^2

Energy efficient heating and cooling system

Table 36 Energy Audit for the Health Center in Newkirk

Appliance	Unit	W/hour	kW/year	Saving	Options
Desktop computer & 17" LCD Monitor	16	200W/hours	7680	384	Proper turn on and off the computers
TV	2	110W/hour	264	-	-
Dishwasher	1	1400W/hours	336	48	Energy Efficient Dishwasher
Microwave	2	800w/hour	192	-	-
Printer & copier	1	150W/hour	36	-	-
Coffee maker	1	800w/hour	192	-	-
Fans				-	-
Ceiling	32	80W/hour	6144	4800	Reducing operation of ceiling fans
Other Office equipment	10		144	-	-
Other medical equipment	10		40000	-	-
Others			11697	1000	Reducing use of individual electronic equipment
light					-
CFL	180	20W/hour	9216	460.8	Proper turn on and off
Other bulbs	60	40W/hour	2304	115.2	Proper turn on and off
Parking light					
HID (250W)	5	400W/hour	3840	768	Automatic lighting sensors
Air conditioner	Central		28675	1083.75	Save heating and cooling values by installation of solar window films on windows and doors
Heater	Central		26491	1324.55	
Total			114680	9552.3	**$979 saving per year**
Total(after savings)				104150	

Total electricity consumption of the Health Center in Newkirk in 2008 was 114680 kW. According to Table 36, heating and cooling, lighting, and appliances used most of this energy. Methods to reduce heating and cooling loads, lighting, and appliances have been mentioned previously and should be used at the Health Center. However, an unidentified electricity consumption of 11697 kWh was found, which is higher than should result solely from the use of personal electric equipment. The cause of this phantom electrical load should be identified and reduced, if possible.

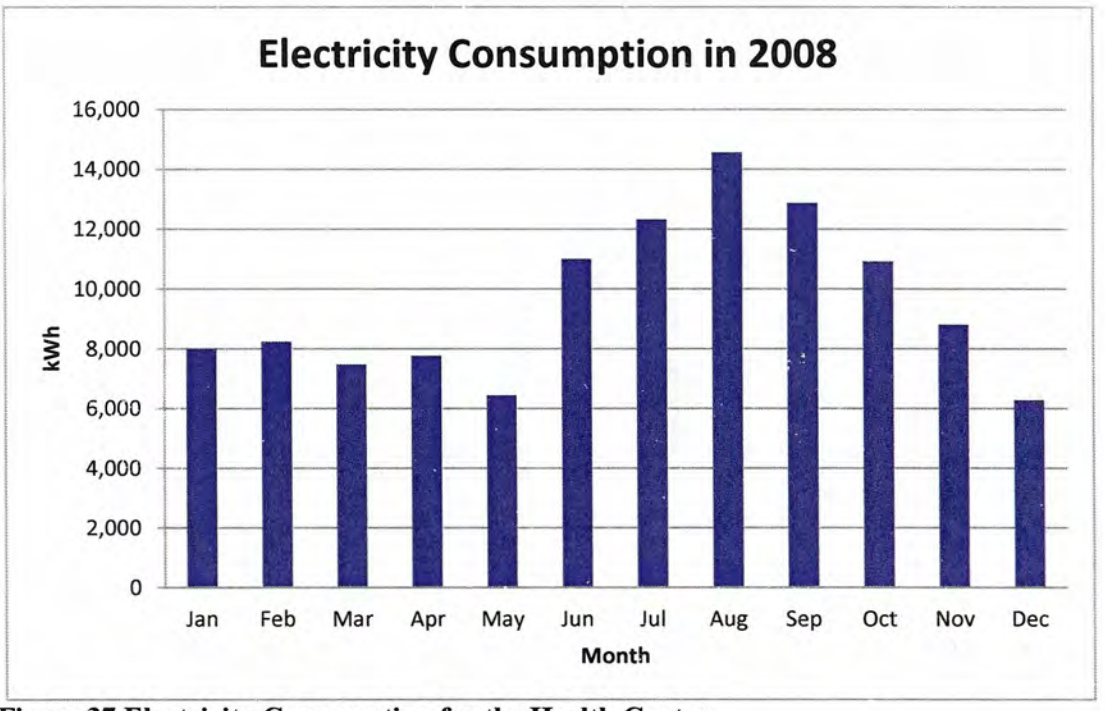


Figure 37 Electricity Consumption for the Health Center

5.2.7 Wellness Center

Annual electricity consumption	255600	kW/year
Windows		
Type	Double side metal frame	
Sealing	Good	
Area	70	m^2
Roof		
Type	slope	
Material	Metal frame	
Total Area	11450	ft^2

Energy efficient heating and cooling system

Table 37 Energy Audit for the Wellness Center in Newkirk

Appliance	Unit	W/hour	kW/year	Saving	Options
Desktop computer & 17" LCD Monitor	3	200W/hours	1440	72	Proper turn on and off the computers
TV	4	110W/hour	528	-	-
Dishwasher	1	1400W/hours	336	48	Energy Efficient Dishwasher
Microwave	1	800w/hour	96	-	-
Printer & copier	1	150W/hour	36	-	-
Coffee maker	1	800w/hour	192	-	-
Fans				-	-
Ceiling	26	80W/hour	4992	-	-
Other Office equipment	5		374.4	-	-
Other wellness equipment	10		1000	-	-
Water heater			80000	-	Installing a solar water heater
Others			22725	8272	Reducing individual electronic equipment
Lighting					
CFL	50	20W/hour	2880	144	Proper turn on and off
Other bulbs	5	40W/hour	576	28.8	Proper turn on and off
Parking light					
HID (250W)	4	400W/hour	3072	614.4	Automatic lighting sensors
Air conditioner	Central		68308	2415.4	Save heating and cooling values by installation of solar window films on windows and doors
Heater	Central		69044	2952.2	
Total			255600	14154.8	**$1183 savings per year**
Total(after savings)				241172	

As shown in Table 37, annual electricity consumption for the Wellness Center was 255600 kWh in 2008. Most electricity consumption was from the heater and air conditioner, lights, and water heater. Peak electricity consumption indicates that cooling loads during the summer were significantly higher than other facilities. Also, phantom electricity consumption was very high. The cause of these loads needs to be found and the loads reduced. The existing water heater, which has high electricity consumption, should be replaced by a solar hot water heater as mentioned earlier in the solar energy chapter.

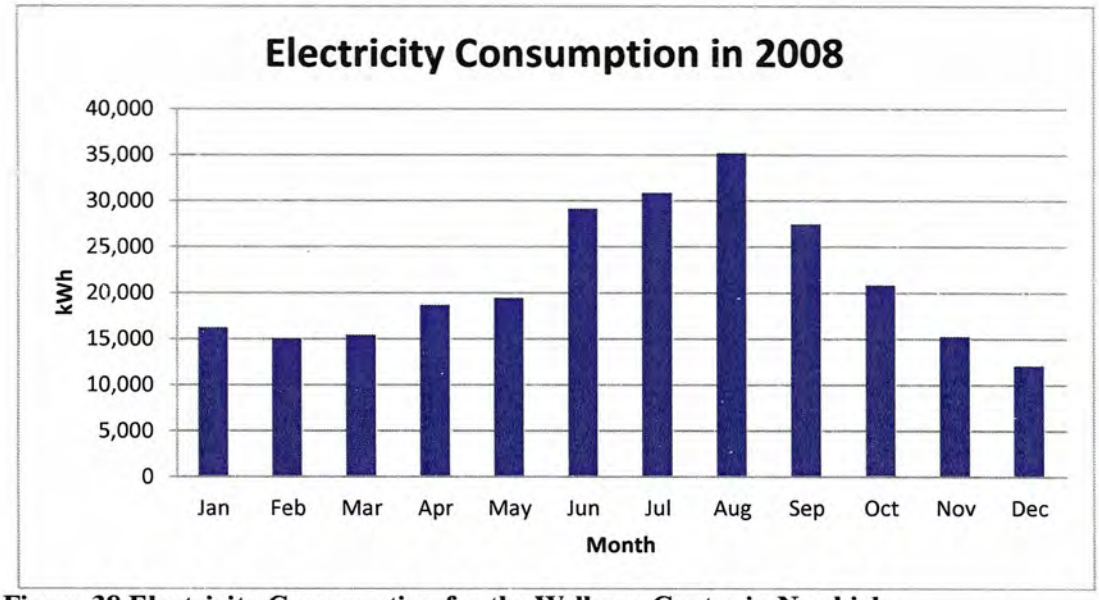


Figure 38 Electricity Consumption for the Wellness Center in Newkirk

5.2.8 Community Center and Gymnasium

Annual electricity consumption		131640	kW/year
Windows			
Type	Double side metal frame		
Sealing	Good		
Area		60	m^2
Roof			
Type	slope		
Material	Metal frame		
Total Area		13486	ft^2

Energy efficient heating and cooling system

Table 38 Energy Audit for the Community Center and Gymnasium in Newkirk

Appliance	Unit	W/hour	kW/year	Saving	Options
Desktop computer & 17" LCD Monitor	12	200W/hours	5760	288	Proper turn on and off the computers
TV	1	110W/hour	132	-	-
Dishwasher	1	1400W/hours	336	48	Energy Efficient Dishwasher
Microwave	2	800w/hour	192	-	-
Oven	3	1000W/hour	360	-	-
Printer & copier	1	150W/hour	72	-	-
Coffee maker	1	800w/hour	576	-	-
Fans				-	-
Ceiling	40	80W/hour	192	-	-
Other Office equipment	8		14.4	1.44	Reducing individual electronic equipment
Other wellness equipment	2		500		
Others			57080	5708	Reducing individual electronic equipment
light					
CFL	80	20W/hour	4608	230.4	Proper turn on and off
other bulbs	30	40W/hour	3456	172.8	Proper turn on and off
Parking light					
HID	4	400W/hour	3072	614.4	Automatic lighting sensors
Air conditioner	Central		24880	1244	Save heating and cooling values by installation of solar window films on windows and doors
Heater	Central		30409	1520.45	
Total			131640	9447.49	**$844 savings per year**
Total(after savings)				122148	

Table 38 indicates energy consumption in the Community Center and Gymnasium in Newkirk. Total energy consumption in 2008 was 131640 kW. Heating and cooling loads were high and other electricity consumption was also very high. Methods recommended previously to reduce heating and cooling loads should be applied to this facility. The source of the phantom loads should also be identified and remedied, if possible.

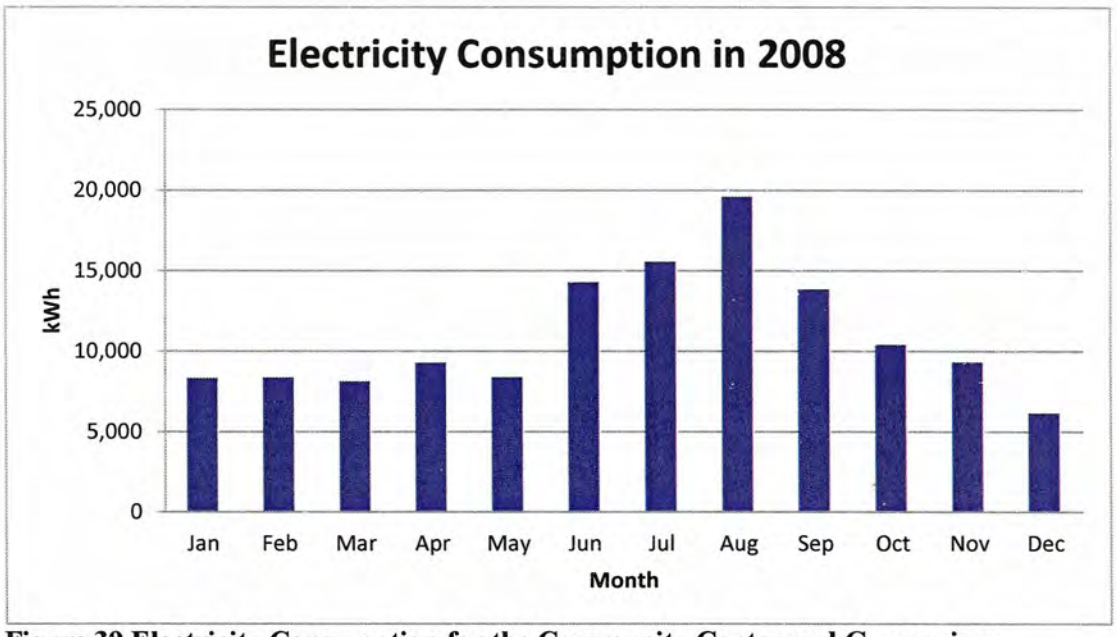


Figure 39 Electricity Consumption for the Community Center and Gymnasium

5.2.9 Day Care Center

Annual electricity consumption		89000	kW/year
Windows			
Type	Double side metal frame		
Sealing	Good		
Area		15	m^2
Roof			
Type	slope		
Material	Metal frame		
Total Area		3660	ft^2

Table 39 Energy Audit for the Day Care Center in Newkirk

Appliance	Unit	W/hour	kW/year	Saving	Options
Desktop computer & 17" LCD Monitor	9	200W/hours	4320	216	Proper turn on and off the computers
TV	3	220W/hour	792	-	-
Dishwasher	1	1400W/hours	336	48	Energy Efficient Dishwasher
Microwave	2	800w/hour	384	-	-
Printer & copier	1	150W/hour	18	-	-
Coffee maker	1	800w/hour	192	-	-
Fans				-	-
Ceiling	30	80W/hour	5760	-	-
Other Office equipment	2		28.8	-	-
Other equipment	2		500	-	-
Others			7254	2825.4	Reducing individual electronic equipment
Lighting					
CFL	60	20W/hour	4608	230.4	Proper turn on and off
other bulbs	2	40W/hour	307.2	15.36	Proper turn on and off
Air conditioner	Window 4		24475	3671.25	Change central air conditioning system and solar window film
Heater	Central		40025	1520.45	**$796 savings per year**
Total			89000	8310.86	
Total(after savings)				80789	

The Day Care Center in Newkirk consumed 89000 kW of electricity in 2008. Energy was used primarily by appliances and heating and cooling. Figure 40 shows high energy consumption during the summer, which might be acceptable since the purpose of a Day Care Center is to care for children who are more vulnerable to high temperatures. However, energy consumption during the period January to March is unusually high compared to usage in November and December. It is recommended that a technician inspects the heaters in the Day Care Center to see if they are operating properly. Programmable thermostats are recommended.

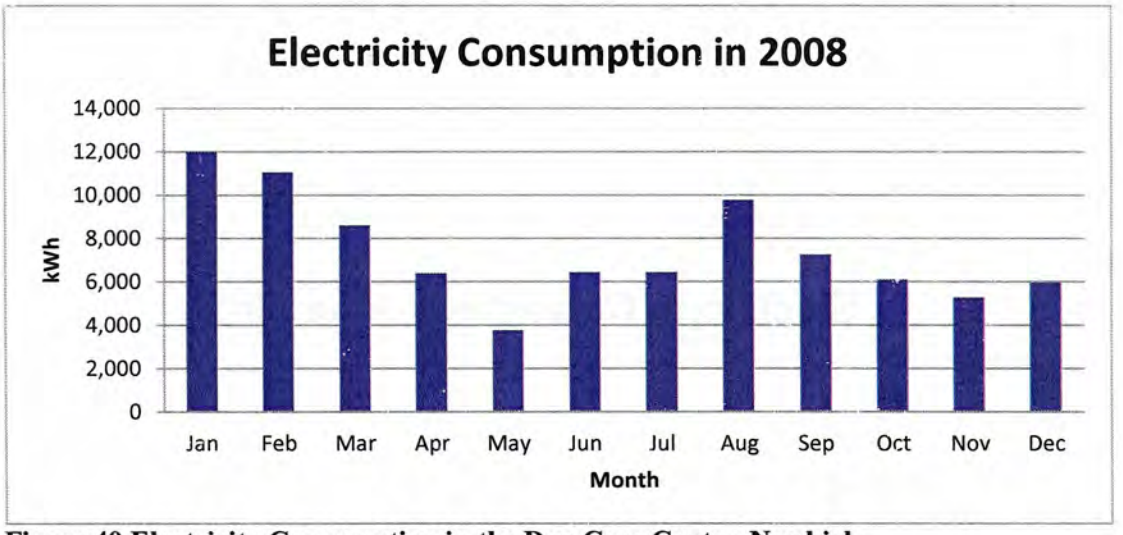


Figure 40 Electricity Consumption in the Day Care Center, Newkirk

5.2.10 SouthWind Parking Lot

Table 40 Energy Audit in the SouthWind Parking Lot

Annual electricity consumption 120360 kW/year

Appliance	W/hour	Unit	kW/year
HID	400W/hour	60	96768
Other lights	500W/hour	6	12096
Total			108864

The electricity consumption should be proportional to hours of darkness if the system is properly operated.

Date	Total kWh	Night Hours	Expected Monthly consumption	Savings	Automatic outdoor light sensor	Savings
Jan-08	8,200	14	10584	-2,384	8996.4	-796
Feb-08	11,800	13.5	10206	1,594	8675.1	3,125
Mar-08	13,520	12.5	9450	4,070	8032.5	5,488
Apr-08	7,120	11.8	8920.8	-1,801	7582.68	-463
May-08	10,840	10.7	8089.2	2,751	6875.82	3,964
Jun-08	8,160	9.5	7182	978	6104.7	2,055
Jul-08	9,800	9.5	7182	2,618	6104.7	3,695
Aug-08	8,440	10	7560	880	6426	2,014
Sep-08	8,600	11	8316	284	7068.6	1,531
Oct-08	11,080	12	9072	2,008	7711.2	3,369
Nov-08	12,560	12.8	9676.8	2,883	8225.28	4,335
Dec-08	10,240	13.2	9979.2	261	8482.32	1,758

Total	120,360	Total	106218	14,142	90285.3	30,075
Total ($)	$7823		$6904	$919		$1954

Source: Mesonet

- Negative numbers in Savings represent less electricity used than expected. This indicates that the lighting system was not properly operated.

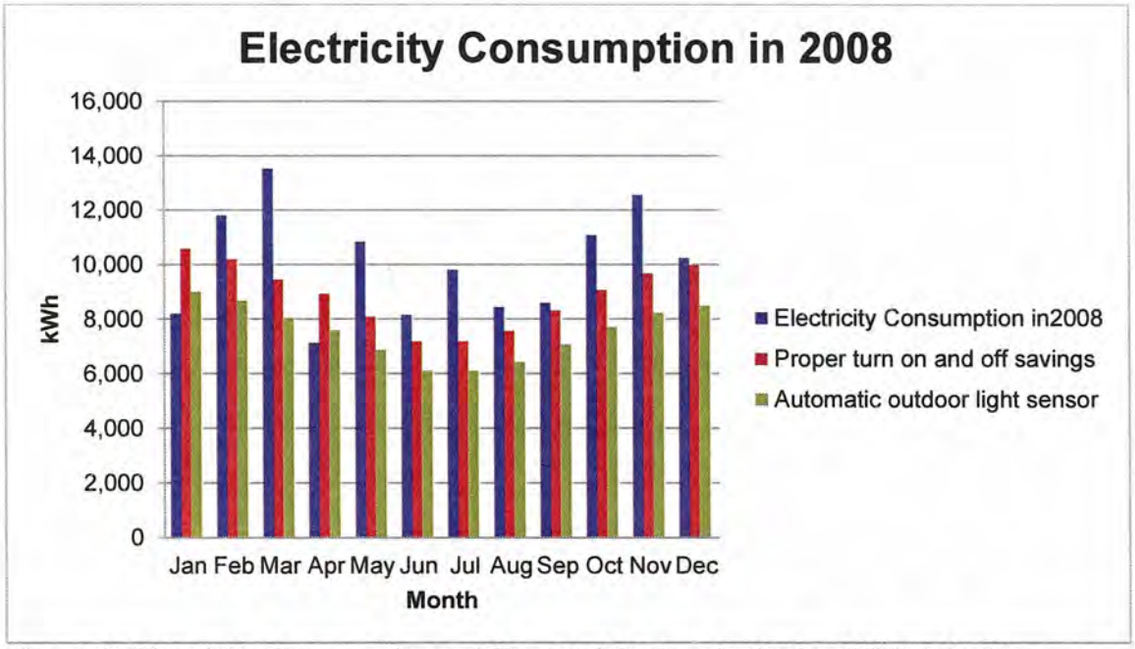


Figure 41 Electricity Consumption and Expected Savings in the SouthWind Parking lights

Electricity consumption in the SouthWind Parking lot was only from parking lot lighting. All parking lights were counted and inspected. As a result of the inspection and comparison with electricity usage during 2008, the researcher found that SouthWind Parking lights were not operated properly during 2008. If they were properly operated, the energy consumption values would have matched with the proper turn on and off values shown in Table 40 and Figure 41. These values were calculated based on hours of darkness in Newkirk.

5.3 New Construction

5.3.1 Education and Learning Center

Windows

Type	Double side metal frame
Sealing	Good
Area	18 m^2
Roof	
Type	Slope
Material	Metal frame
Total Area	4374 ft^2

Energy efficient heating and cooling system

This building was not completely equipped at the time this project was performed.

Table 41 Energy Audit for the Education and Learning Center

Appliance	Unit	W/hour	kW/year	Saving (kW/year)	Options
Desktop computer & 17" LCD Monitor	1	200W/hours	480	9.6	Proper turn on and off the computers
TV	1	110W/hour	0	-	-
Printer & copier	1	150W/hour	36	-	-
Coffee maker	-	800w/hour		-	-
Fans				-	-
Ceiling	16	80W/hour	3072	-	-
Other Office equipment	2		28.8	-	-
light					-
4m CFL	20	40W/hour	2304	-	-
CFL	40	20W/hour	2304	-	-
Parking light				-	-
HID (250W)	5	400W/hour	3840	768	Automatic lighting sensors
Others			8000	-	-
Air conditioner	Central		7650	382.5	Save heating and cooling values by installation of solar window films on windows and doors
Heater	Central		9350	467.5	
Total			37064	1627.6	**$203 saving per year**
Total(after savings)				35437	

The Education and Learning Center was not opened to the public during the summer of 2010. Therefore, no information on electrical usage is provided. However, the expected electricity consumption was estimated based on equipment that would be installed in the building. Total electricity usage was estimated about 37000 kW, though this number might increase up to 45000 kW.

5.4 Overall Analysis

Table 42 Summary of Electricity Consumption and Savings

Facilities	Electricity Usage Trend	Saving Options	Expected Savings
EPA Building & Garrett Dental clinic	Appliances, Heating & Cooling	Energy Star appliances, Reduction of monitors and lights, Installation of programmable thermostats.	$323 savings per year
Administrative Building	Appliances, High cooling loads	Proper turn on and off lights and appliances, persist with optimal temperature during summer	$889 savings per year
Kanza Museum	High cooling loads	Windows should be equipped with Solar Window films or other window covers.	$240 savings per year
Mehojah Resource Center	Appliances, Heating & Cooling	Proper turn on and off lights and appliances, persist with optimal temperature during summer	$334 savings per year
Social Service Center	Appliances, Heating & Cooling	Proper turn on and off lights and appliances, persist with optimal temperature during summer	$405 savings per year
Health Center	Appliances, Heating & Cooling, Other medical equipment	Proper turn on and off of all appliances, including medical equipment	$979 savings per year
Wellness Center	Heating & High cooling, Water Heater	Install a solar water heater	$1183 savings per year
Community Center and Gymnasium	High cooling loads	Install a programmable thermostat	$844 savings per year
Day Care Center	High heating loads	Inspect Heating and cooling system	$796 savings per year
SouthWind Parking Lots	More electricity consumption on lights than night time	Proper operation of lights with night time	$919 savings per year
Education & Learning Center	Not in operation yet	-	$203 savings per year

Chapter 6. Education and Outreach

6.1 Overview

Encouraging public participation is essential if the Kaw Nation wishes to achieve optimal energy efficiency and sustainability. Each resident who participates in energy savings procedures will benefit the entire Kaw Nation. A specific plan is needed to motivate an active participation. The plan should address these issues: raising public awareness, establishing a local environmental program and a school program, using the local network and media to advertise the program, and establishing energy saving activities for public participation.

6.2 Raising Public Awareness

Public participation is dependent on raising environmental awareness in daily life. Higher public awareness of energy savings will result in higher participation. The following strategies should be considered.

- Providing free energy auditing service for each residence.
- Energy saving programs for adults and kids.
- Awards for outstanding energy savings.
- Energy saving posters and stickers.
- Providing brochures or booklets with instruction on energy savings.
- Discussing energy saving issues in the mass media, on the Kaw Nation's home page, and in radio and television programs.
- Providing precise information on money that can be saved with energy conservation.
- Showing energy saving effects on the environment.

6.3 Local Environmental Programs and School Programs

For maximum public participation, local environmental programs and school programs are essential. A very effective method for educating residents is the energy saving class. This is discussed below.

6.3.1 Energy Saving Class

For more active energy efficient use and conservation, an energy saving class would be helpful to educate local residents. The class can be taught by an outside expert or the Kaw Nation's EPA officer. The class should include following topics:

- How much money do you spend on energy?
- Where are your greatest energy losses?
- How long will it take for an investment in energy efficiency to pay for itself in energy cost savings?
- Do the energy-saving measures provide additional benefits that are important to you (for example, increased comfort from installing double-paned, efficient windows)?
- How long do you plan to own your current home?
- Can you do the job yourself or will you need to hire a contractor?
- What is your budget and how much time do you have to spend on maintenance and

repair?

6.3.2 School Education

School-aged children are eager to learn about energy efficiency and sustainable, environmentally-friendly practices. They in turn take their new knowledge home and educate their parents. Age-appropriate lessons on energy efficiency and sustainability should be offered by local or area experts. Slogan or poster contests are great ways to motivate children to learn about a topic. Other options for school-level educational programs can be found on the excellent website "Kids for Saving the Earth", at http://kidsforsavingearth.org/index.html.

6.3.3 Energy Policy

Establishing a Tribal Energy Policy will contribute to the Kaw Nation's energy savings, because a written policy can have a great impact on a small community. The energy policy should encourage local residents to participate in energy efficient use and conservation. The following options will be helpful to establish an energy policy.

- Energy saving awards
- Discounts on replacing energy-inefficient equipment with new, efficient items.

6.3.4 Energy Communications

Communication programs such as booklets, brochures, stickers, mass media and internet homepage presentations are helpful in establishing a culture of energy efficiency. Booklets or brochures should include self-auditing methods and energy saving instructions for homeowner use. Stickers or leaflets can be used for the Kaw Nation's employees or residents to reminder them of energy saving techniques. Mass media and internet homepage can be used to provide easy access to energy saving instructions for residents.

6.4. Energy Saving Activity Participation

For active participation of local residents, the Kaw Nation needs to prepare as many details as possible such as campaigns of what we shall do for energy savings, home energy saving strategy, check lists of energy saving practices used in each house each month, and providing specific tasks for energy savings. The public should be invited to participate in establishing the Kaw Nation Energy Policy, so they are motivated to participate once the policy is established.

To summarize, all stakeholders should be involved in the energy program so that it will have maximum probability of success.

Chapter 7. Conclusions and Recommendations

This chapter includes a summary of overall findings, recommendations, and the future of energy efficient usage and conservation for the Kaw Nation.

7.1 Conclusions

Most non-polluted energy resources and energy auditing were analyzed to meet the goal of energy efficient usage and conservation for the Kaw nation. All analyses were based on the major Kaw Nation facilities and houses for residents.

7.1.1 Renewable Resources

Feasible renewable resources for the Kaw Nation were found solar, wind, hydro, geothermal energy. Among them, a solar photovoltaic system, a solar hot water system, and a micro-hydropower system are feasible options for the Kaw Nation. A payback period of each system is a solar PV system for 16 year payback period, a solar hot water system for 13.5 year payback period, and a micro-hydropower system for 7 year payback period. The payback period of 16years for installation of a solar PV system itself is not a recommended option. However, it could be a good option if it includes other benefits such as a present view and environmental friendly for visitors. The 13.5 year payback period for solar hot water system installation is a recommended option for the Kaw Nation. Plus, the solar hot water system provides a present view and a clean image of the Kaw Nation for visitors. The micro-hydropower system was estimated at least a payback period and the most efficient. However, the installation of this system requires rights of using the Arkansas River.

Overall, to install these systems requires a specific design to estimate the exact amount of costs. Other systems such as wind turbine, and geothermal heat pump could be considered feasible options for the Kaw Nation if sufficient grants or funding were available. In addition, the Kaw Nation has no state financial incentives which limit some energy opportunities.

7.1.2 Auditing

An energy audit is the most favorable option for the Kaw Nation to improve energy efficient usage and conservation. All major Kaw Nation buildings were inspected and audited to develop energy efficient strategies. The auditing strategies include envelope measures, lighting, appliances, heating and cooling, and policy. The researcher found that only window and air leakage insulations were necessary for the Kaw Nation facilities in envelope measurement. Replacing and controlling lights are required in some places such as the SouthWind Parking Lot, and Community and Gymnasium Buildings. Improvement of appliances was found in most inspected buildings. A cooling system in the Day Care Center was inspected poor and a heating system also spent too much electricity. The cooling system was evaluated for a new installation and the heating system should be watched. In addition, automatic thermostats should be placed all over facilities to maintain an optimal temperature. More detail plans in energy use would save 10% or more of total energy use for the Kaw Nation facilities.

7.1.3 Education and Outreach

For efficient energy improvement, the Kaw Nation should encourage public to participate the energy plan. For better participation of public, the Kaw Nation would provide several programs and policy. The programs were categorized into local programs for adults and school programs for students. Plus, the surveys for free energy auditing and easy access to energy audit information were offered to the public. These plans would urge the public to participate the energy efficient use and conservation campaigns.

7.2 Recommendations

7.2.1 Kaw City Facilities

This report presented the results of auditing of buildings in Kaw City, which should provide for significant reduction in energy usage. More detailed audits would be helpful to find the source of the phantom energy loads found at several facilities, as outlined in Chapter 5. Implementing the recommendations should result in at least a 10% reduction in energy usage.

The project found an economically-viable option to install alternative energy systems for Kaw City. The alternative is a micro-hydro turbine, which is recommended for the following reasons:

- Great accessibility of high flow rate water (Arkansas River)
- Close enough for low expense on piping and cabling
- Proximity of buildings to be supplied with power
- High demand of electricity
- Approximately seven year payback with a 350 kW micro-hydro system

However, the Kaw Nation must negotiate rights to use Arkansas River water, which may not be feasible.

7.2.2 Newkirk Facilities

All the Newkirk facilities also need to be audited by professional auditors. This study found that most of facilities in Newkirk used more electricity on cooling and heating than should be required. More detailed information of the Kaw Nation facility is provided in Chapter 5.

For sustainable energy installation, the report evaluated solar photo-voltaic (PV) power, solar hot water, wind turbines, and ground-source heat pumps in facilities in Newkirk. Solar hot water and the PV systems were determined to be the only economical options for the Kaw Nation. Installation of solar hot water system in Wellness Center, Newkirk is strongly recommended for the following reasons:

- High demand for hot water
- High electricity usage by the existing water heater
- More customers expected in the future
- Reasonable payback period of 13.5 years

A PV system in the office building next to the casino might be considered because of the favorable public opinion it should generate in casino customers. However, it cannot be recommended solely on economics because the payback period is 16 years, and PV panels are expensive. The Kaw Nation is evaluating installation of wind turbines in the area. This project found that wind power would have a very long payback and is not favorable based solely on economics.

7.3 Kaw Nation Residents

Overall energy efficient usage and conservation for the Kaw Nation needs support from local people. More energy savings can be achieved with active public participation than through governmental action alone. The report includes recommendations on planning the energy saving programs and achieving public support.

Appendix A: Biomass

Overview

Biomass is one of the best renewable energy resources because of its accessibility and reasonable price range. Biomass (plant material and animal waste) supplies almost 15 times as much energy as wind and solar combined in the United States and has the potential to supply much more. There is a wide variety of biomass materials, including tree and grass crops and forestry, agricultural, and urban wastes. Converting these resources to electricity uses several technology such as gasification, combustion, co-firing, hydrolysis, fermentation, co-firing, and hydro-thermal liquefaction. Each technology will be explained in this appendix. Evaluation of biomass energy systems needs to consider not only technology but also biomass characteristics. Important properties of biomass are moisture content, ash content, heating values, and elemental composition.

Woody biomass

Woody biomass includes waste woods (e.g., untreated construction and demolition wood), logs, tree residues (by-product of forest management such as leaves, needles, and limbs), and residues from wood-using firms (sawmills and paper mills).

Agricultural Resources

Agricultural biomass is a relatively broad category of biomass that includes the food-based portion of crops (such as corn, sugarcane, and beets), the nonfood-based portion of crops (such as corn stove, orchard trimmings, and rice husks), perennial grasses, and animal waste. Traditionally, there have been high costs associated with recovering most agricultural residues, and therefore, they have not yet been widely used for energy purposes. However, they can offer a sizeable biomass resource if technology and infrastructure are developed to economically recover and deliver this type of biomass to processing facilities

Biomass Properties [28]

Moisture content

The moisture content of biomass is the quantity of water in the material, expressed as a percentage of the material's weight. This weight can be referred to on a wet basis, on a dry basis, and on a dry-and-ash-free basis. Reduction in combustion temperature below the optimum may result in incomplete combustion of the fuel giving rise to the emission of tars and creosote which may condense in the flue, especially if it is long or includes changes of direction, and particulates. Many biomass gasifiers are designed to operate on very low moisture content feedstock, perhaps 10-20%. Other technologies, such as anaerobic digestion, fermentation, hydrothermal upgrading and supercritical gasification all make use of feedstock in an aqueous medium, and are particularly suitable for very high moisture content biomass, and for which drying is unnecessary.

Ash content

The percentage of material in biomass that remains after the carbon is combusted. It consists of a wide range of elements and usually averages less than 0.5 percent in wood, 5 to 10 percent in diverse agricultural crop materials, and up to 30 to 40 percent in rice husks and milfoil. Ash can melt onto surfaces in biomass incinerators, causing problems that vary from clogging to severe operating difficulties.

Heating value

Heating values are dependent on various factors such as moisture content, biomass properties, density of biomass and combustion technology. Moisture content has a direct impact on heating value, as shown below in Figure 42.

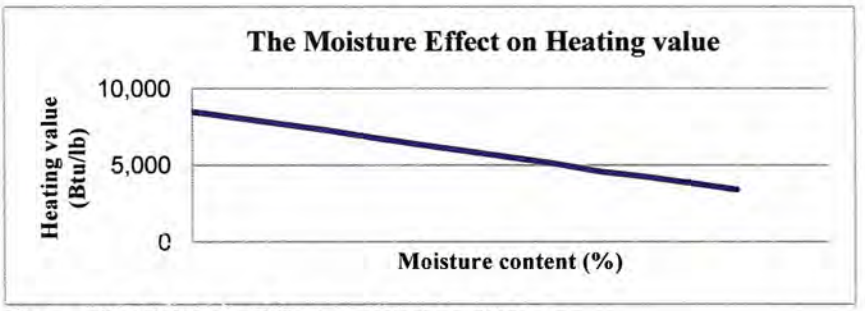


Figure 42 Moisture Effect on Heating Value

Elemental composition

Elemental composition includes mainly carbon, oxygen, and hydrogen in biomass materials. Most biomass also contains a small proportion of nitrogen. Typical solid biomass properties are shown in Table 43, with coal shown in the first column for reference.

Table 43 Typical Solid Fuel Properties

Property	Coal	Peat	Wood without bark	Bark	Forest Residue	Willow	Straw	Reed Canary grass
Ash Content (d)	8.5-10.9	4.0-7	0.4-0.5	2.0-3.0	1.0-3.0	1.1-4.0	5	6.2-7.5
Moisture Content W(%)	6.0-10	5-60	5-60	45-65	50-60	50-60	17-25	15-20
Net calorific Value (MJ/kg)	26-28.3	20.9-21.3	18.5-20	18.5-23	18.5-20	18.4-19.2	17	17.1-17.5
C,% (d)	76-87	52-56	48-52	48-52	48-52	47-51	45-47	45.5-46.1
H,% (d)	3.5-5	5-6.5	6.2-6.4	5.7-6.8	6-6.2	5.8-6.7	5.8-6.0	5.7-5.8
N,% (d)	0.8-1.5	1.0-3	0.1-0.5	0.3-0.8	0.3-0.5	0.2-0.8	0.4-0.6	0.65-1.04
O,% (d)	2.8-11.3	30-40	38-42	24.3-40.2	40-44	40-46	40-46	44
S,% (d)	0.5-3.1	<0.05-0.3	<0.05	<0.05	<0.05	0.02-0.10	0.05-0.2	0.08-0.13

Cl,% (d)	<0.1	0.02-0.06	0.01-0.03	0.01-0.03	0.01-0.04	0.01-0.05	0.14-0.97	0.09
K,% (d)	0.003	0.8-5.8	0.02-0.05	0.1-0.4	0.1-0.4	0.2-0.5	0.69-1.3	0.3-0.5
Ca,% (d)	4.0-12	0.05-0.1	0.1-1.5	0.02-0.08	0.2-0.9	0.2-0.7	0.1-0.6	9

d=dry basis

Source: A. Maciejewska, H. Veringa, J. Sanders, S.D. Peteves, DG JRC, CO-FIRING OF BIOMASS WITH COAL, 2006

Process

The most commonly used biomass power generation technologies are direct combustion, gasification, slow and fast pyrolysis, and anaerobic digestion, as shown in Table 44. Each technology used in different situations and fashions has advantages and disadvantages.

Table 44 Biomass Power Technology in Commercial/Demonstration Phase during 2000-2006

Technology Category	Biomass Conversion Technology	Primary Energy Form Produced	Primary Energy Conversion and Recovery Technology	Final Energy Products
Direct combustion	Stove/Furnace	Heat	Heat exchanger	Hot air, hot water
Direct combustion	Pile burners	Heat, steam	Steam turbine	Electricity
Direct combustion	Stoker grate boilers	Heat, steam	Steam turbine	Electricity
Direct combustion	Suspension boilers: Air spreader stoker or cyclonic	Heat, steam	Steam turbine	Electricity
Direct combustion	Fluidized-bed combustor: FB – bubbling CFB circulating	Heat, steam	Steam turbine	Electricity
Direct combustion	Co-firing in coal-fired boilers: (several types)	Heat, steam	Steam turbine	Electricity
Gasification (atmospheric)	updraft, counter current fixed bed	Low Btu producer gas	Combustion boiler + steam generator and turbine	Process heat or heat plus electricity
Gasification (atmospheric)	Downdraft, moving bed	Low Btu producer gas	Spark engine (internal combustion)	Power, electricity
Gasification (atmospheric)	Circulating Fluidized Bed (CFB) dual vessel	medium Btu producer gas	Burn gas in boiler w/ Steam Turbine	Electricity
Gasification (atmospheric)	Co-fueling in CFB gasifiers	Low or medium Btu producer gas	Combustion turbine or boiler and steam turbine	Electricity
Slow pyrolysis	Kilns or retorts	Charcoal	Stoves and furnaces	Heat
Fast (flash) pyrolysis	Reactors	Pyrolysis oil (bio-oil), charcoal	Combustion turbines, boilers, diesel engines, furnaces, catalytic reactors	Heat, electricity, synthetic liquid, fuels, (BTL)
Anaerobic digestion	Digesters, landfills	Biogas (medium Btu gas)	Spark ignition engines, combustion turbines,	Heat, electricity

Source: Compiled by Lynn Wright, Oak Ridge, TN, Biomass Energy Data Book Edition 2

Gasification

The gasification process combusts biomass into gases consisting of carbon monoxide (CO), hydrogen (H_2) and methane (CH_4). These gases then run internal-combustion engines to generate electricity. The simple process is shown in Figure 30. In this process, moisture content must be limited to 5-30%; dryer biomass has the better efficiency.

The process is aimed at converting the energy potential of a solid fuel into a gaseous product, whose energy content has the form of chemical energy with the capacity to generate work. Consequently this gas product shares the usual advantages of gas fuels over solid fuels:

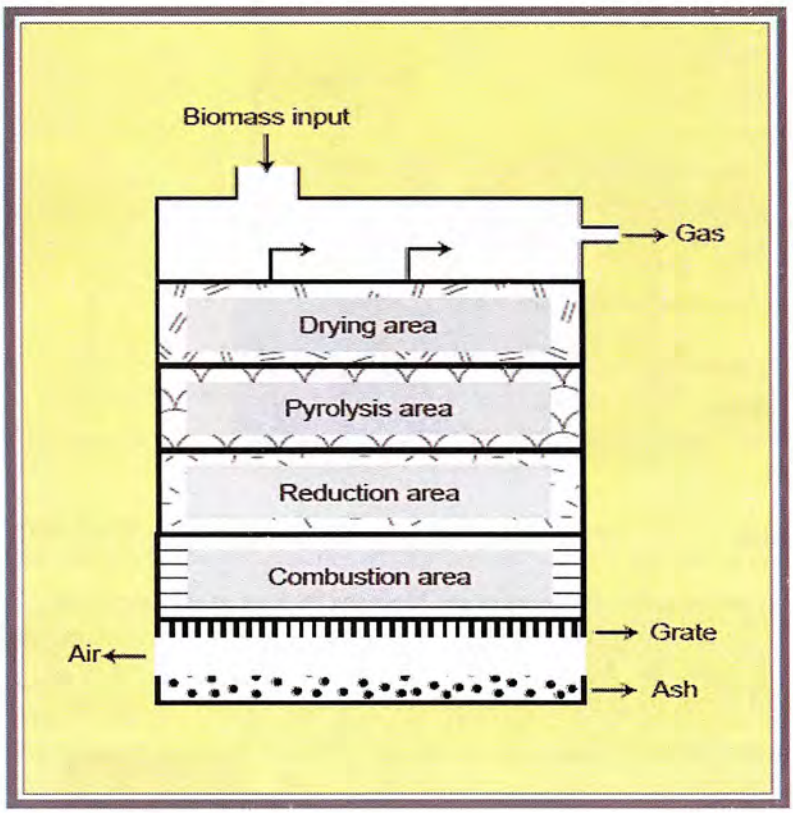


Figure 43 Gasification Process
Source: Peter Quaak, Harrie Knoef, Hubert E Stassen, Energy from Biomass: A Review of Combustion and Gasification Technologies, 1998.

- Easier handling
- More efficient combustion, due to lower excess air
- Less fouling of heat exchanging surfaces
- Optional applications in either internal – combustion engines, gas turbines or CHP units.

Combustion

Combustion is a process in which the total or partial oxidation of carbon and hydrogen converts the chemical energy of biomass into heat. This system is less expensive to build and

simpler than gasification, but it is generally less efficient. A direct-combustion diagram is shown in Figure 44.

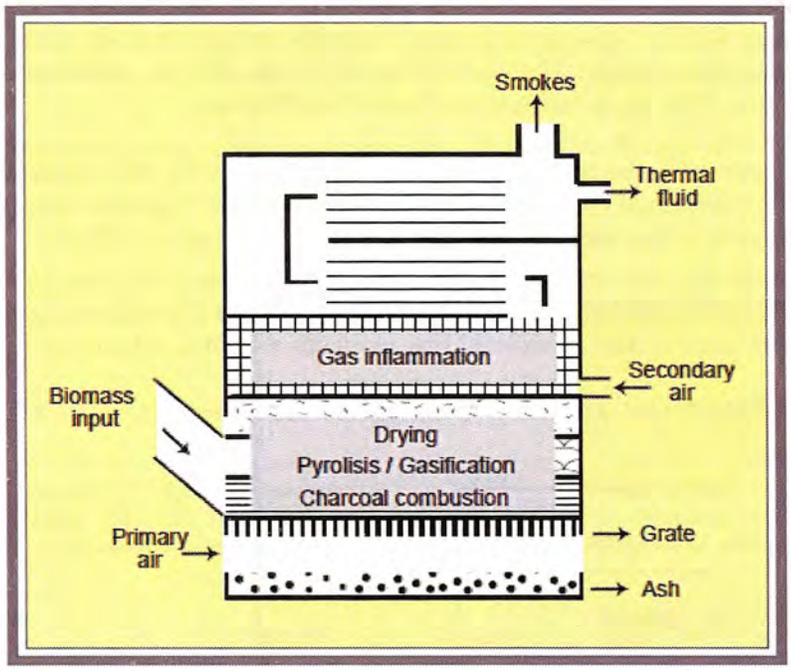


Figure 44 Combustion Process
Source: Peter Quaak, Harrie Knoef, Hubert E Stassen, Energy from Biomass: A Review of Combustion and Gasification Technologies, 1998.

Pyrolysis and Fermentation

Pyrolysis is an incineration process which decomposes biomass by heat at temperatures greater than 800 F in the absence of oxygen. Biomass used for pyrolysis includes plants such as sugar cane, corns, switch grass, etc. Among these plants, Oklahoma possesses a large quantity of switch grass and sweet sorghum. The process is explained below in Figure 45.

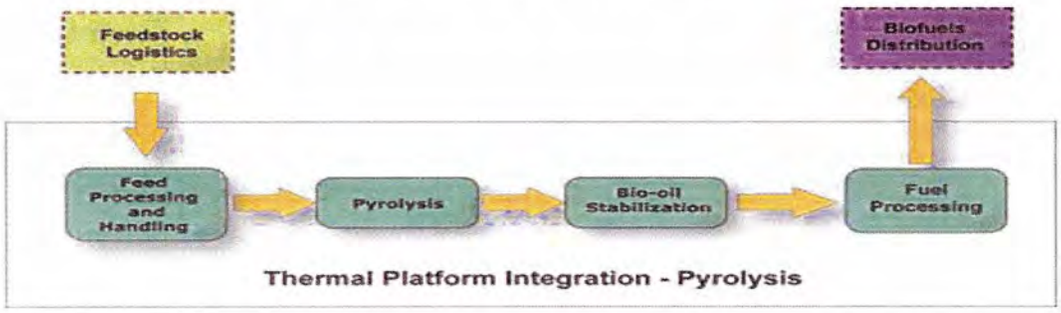


Figure 45 Pyrolysis Process
Source: Energy Efficiency & Renewable Energy, DOE

In the process, biomass comes to the pyrolysis process which generates vapor bio-oil and then, it continues to the condensation process to transform liquid bio-oil. Finally, a fuel processing stage mixes or transforms by biofuel usage.

Fermentation

Fermentation is a hydrolysis process that converts biomass into ethanol using bio-organism ssuch as bacteria and yeast. The process is illustrated below in Figure 46.

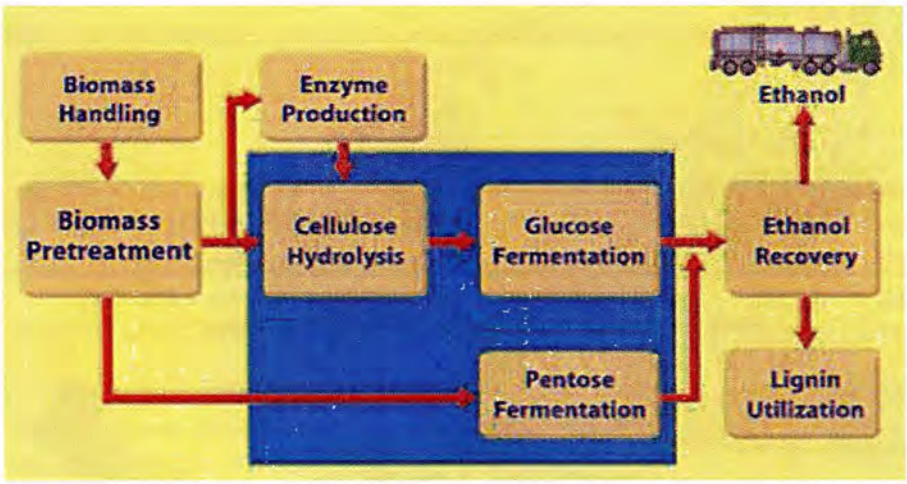


Figure 46 Biofuel Extraction Process from Biomass
Source: Renewable Fuels Association and the Department of Energy, Energy Efficiency and Renewable Energy,

In the fermentation process, biomass size is reduced and uniformed to provide better efficiency. In the biomass pretreatment process, biomass is broken down into simple sugars by hydrolysis reaction. In the enzyme production process, enzymes help hydrolyze complex biomass carbohydrates into glucose. The glucose is converted to ethanol by fermentation using yeast or bacteria. Finally, ethanol is separated from the other components and distilled to obtain pure ethanol. The other components from the process can be burned to produce electricity.

Co-Firing

Co-Firing burns two different resources at the same time. This system can be easily adopted for an existing coal firing system without any changes. Co-firing with biomass helps reduce costs and can reduce air pollution. The process of co-firing is shown in Figure 47.

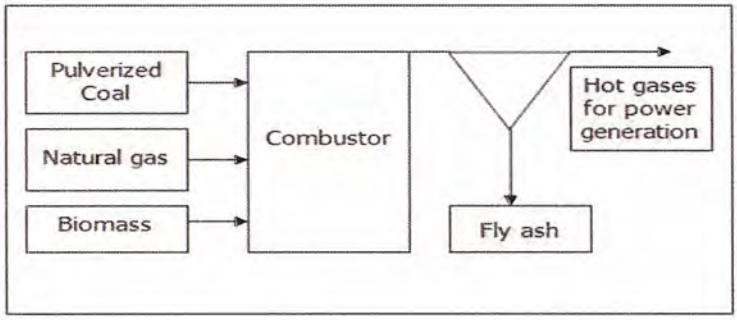


Figure 47 Co-Firing Process
Source: Dalhousie University Mechanical Engineering Department, Circulating Fluidized Bed Laboratory, Biomass co-firing

Data Sources

The biomass resources in the United State were gained from the U.S. Department of Energy. The amount of available biomass in Kay County is about 100-150 thousand tons/year, as shown in Figure 48.

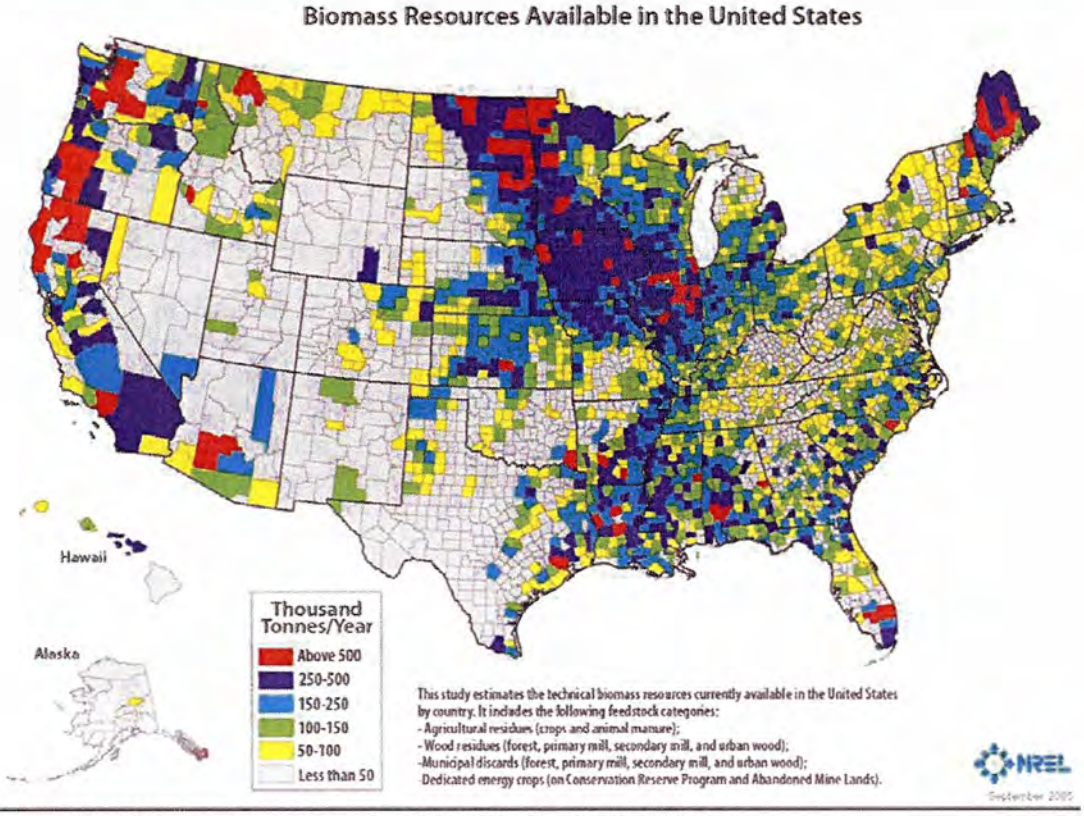


Figure 48 Biomass Resources Available in the United States
Source: National Renewable Energy Laboratory

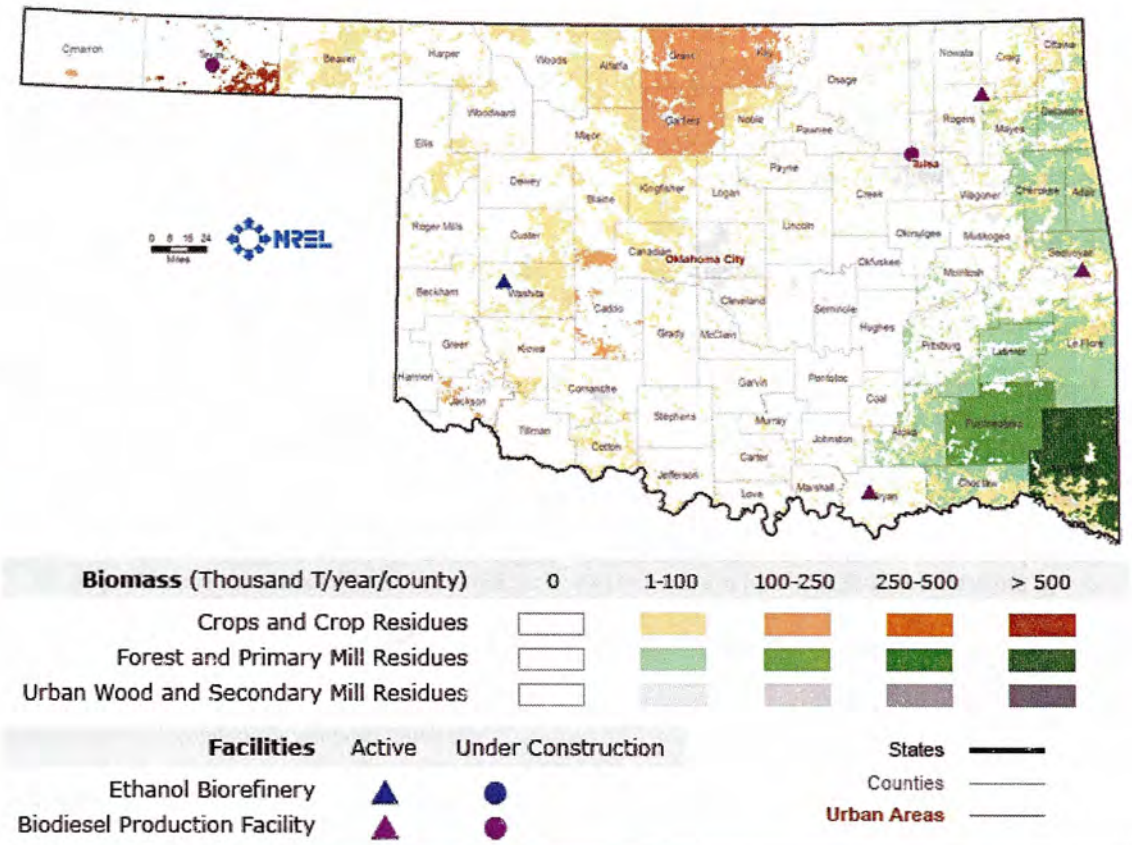


Figure 49 Oklahoma Biomass Resources
Source: National Renewable Energy Laboratory

The Oklahoma biomass map shown in Figure 49 indicate that Kay County has better biomass resources than other counties in Oklahoma. It indicates a positive prospect of biomass usage in the Kaw Nation area.

Appendix B: Funding Opportunities for Renewable Energy Resource

The purpose of this appendix is to provide past and potential funding opportunities of renewable resource development for the Kaw Nation. Many funding opportunities have been placed in the area of renewable resource development and some of opportunities are still available. Most of recent funding opportunities can be found at http://www.grants.gov.

Funding Opportunities

Source [51]

Department of Energy

Department of Energy (DOE) promotes Tribal energy sufficiency, economic development, and employment on Tribal lands through the use of renewable energy and energy efficiency technologies. DOE also provides tribal energy program opportunities which offer several grants for tribal lands. Previously, **Renewable Energy and Energy Efficiency Deployment in Indian Country** (FOA number DE-PS36-09GO99014), **Assessing the Feasibility of Renewable Energy Development and Energy Efficiency Deployment on Tribal Lands** (FOA number DE-PS36-09GO99024), **First Steps toward Tribal Weatherization — Human Capacity Development** (FOA number DE-PS36-09GO99022) were processed. As a result, DOE has funded 45 tribal energy projects totaling $8.4 million over the last two years. However, no solicitations are currently open. To check out tribal funding opportunities is to visit at
http://apps1.eere.energy.gov/tribalenergy/government_grants.cfm#Tribal.
Contact information
Lizana Pierce, Project Manager
U.S. Department of Energy: Golden Field Office
1617 Cole Boulevard, MS 1501
Golden, CO 80401
Telephone: (303) 275-4727, (303) 275-4727
Fax: (303) 275-4753
E-mail: lizana.pierce@go.doe.gov

For financial assistance opportunities through DOE's Office of Energy Efficiency and Renewable Energy (EERE), see EERE Financial Opportunities. The site includes information on the funding and award process, types of financial assistance, and how to apply for these opportunities. The funding opportunities are usually taken by the following process: Strategic planning, Energy options analysis, Capacity building, Organizational development, Feasibility studies, and Cost-shared development projects

http://www.energy.gov/recovery/renewablefunding.htm

Federal Government Funding Opportunities

For federal government grant opportunities, access Grants.gov

Additionally, the U.S. Environmental Protection Agency (EPA) has produced a 59-page guide to help find financial and technical assistance for renewable energy and energy efficiency projects. The publication provides an extensive list of grants available from EPA, other federal agencies, state governments, and private foundations. Grants are organized by topic, with detailed descriptions and contact information for each grant. The document also provides links to online resources with more information. Funds are available for such activities as installing energy-efficient equipment in buildings, purchasing fuel-efficient vehicles for fleets, and promoting renewable energy installations or purchases. Funding is also available to develop related education and outreach materials. See the EPA guide, **Funding Opportunities: A Directory of Energy Efficiency, Renewable Energy, and Environmental Protection Assistance Programs (2006)** (PDF 899 KB).

American Recovery and Reinvestment Act Opportunities

The American Recovery and Reinvestment Act of 2009 provides various funding opportunities for local and tribal governments, as well as tax incentives and bond programs relevant to clean energy efforts. Local and tribal governments should refer to guidelines published by the federal agency administering each funding stream for more detail about allowable activities. **American Recovery and Reinvestment Act of 2009: A Guide to Renewable Energy and Energy Efficiency Opportunities for Local and Tribal Governments** (PDF 148 KB), published by EPA in February 2009, provides information on those opportunities.

U.S. Department of Interior Grant Opportunities

For energy and mineral development grant opportunities or for technical assistance provided through DOI's Division of Energy and Mineral Development (DEMD), contact the Division at (303) 969-5270, (303) 969-5270 or write to 12136 West Bayaud Avenue suite 300, Lakewood, CO 80228.

U.S. Department of Agriculture Grant Opportunities

The U.S. Department of Agriculture (USDA) provides Rural Business Enterprise Grants to public bodies, private nonprofit corporations, and Federally-recognized Indian Tribal groups to finance and facilitate development of small and emerging private business enterprises located in 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.

USDA provides Rural Business Opportunity Grants to public body, nonprofit corporation, Indian tribe, or cooperative with members that are primarily rural residents to promote sustainable economic development in rural communities with exceptional needs. This is accomplished by making grants to pay costs of providing economic planning for rural communities, technical assistance for rural businesses, or training for rural entrepreneurs or economic development officials.

U.S. Department of Commerce Grant Opportunities

The U.S. Department of Commerce's Economic Development Administration (EDA) offers grants for Comprehensive Economic Development Strategy (CEDS) development grants (PDF 212 KB). Technical assistance and funding is also available for economic development.

U.S. Environmental Protection Agency Grant Opportunities

For funding opportunities available through EPA, see the American Indian Environmental Office's Tribal Grants Web page.

U.S. Housing and Urban Development Grant Opportunities

For U.S. Department of Housing and Urban Development (HUD) grants for Indian housing and community development, see Public and Indian Housing Grants.

Low-Income Energy Assistance

The U.S. Department of Health and Human Services (HHS) offers assistance to low-income households to meet their home heating and cooling needs through the Low-Income Home Energy Assistance Program (LIHEAP). If your Tribe is not a LIHEAP tribal grantee, you may need to contact state grantees for assistance.

The DOE Weatherization Assistance Program reduces energy costs for low-income households by increasing the energy efficiency of their homes while ensuring their health and safety. The program is implemented on a state and local level through a network of more than 900 local weatherization service providers.

Appendix C: Energy Auditing Tips

Home window insulation tips

Cold-Climate Windows Keep Heat In
Double-pane windows with low-e coating on the glass reflect heat back into the room during the winter months.

- You can use a heavy-duty, clear plastic sheet on a frame or tape clear plastic film to the inside of your window frames during the cold winter months. Remember, the plastic must be sealed tightly to the frame to help reduce infiltration.
- Install tight-fitting, insulating window shades on windows that feel drafty after weatherizing.
- Close your curtains and shades at night; open them during the day.
- Keep windows on the south side of your house clean to let in the winter sun.
- Install exterior or interior storm windows; storm windows can reduce heat loss through the windows by 25% to 50%. Storm windows should have weather stripping at all movable joints; be made of strong, durable materials; and have interlocking or overlapping joints. Low-e storm windows save even more energy.
- Repair and weatherize your current storm windows, if necessary.

Warm-Climate Windows Keep Heat Out
In the summertime, the sun shining through your windows heats up the room. Windows with low-e coatings on the glass reflect some of the sunlight, keeping your rooms cooler.

Warm-Climate Window Tips

- Install white window shades, drapes, or blinds to reflect heat away from the house.
- Close curtains on south- and west-facing windows during the day.
- Install awnings on south- and west-facing windows.
- Apply sun-control or other reflective films on south-facing windows to reduce solar gain.

Source: U.S Department of Energy [57]

Heating and Cooling Tips

Source [67]

- Set your thermostat as low as is comfortable in the winter and as high as is comfortable in the summer.
- Clean or replace filters on furnaces once a month or as needed.
- Clean warm-air registers, baseboard heaters, and radiators as needed; make sure they're not blocked by furniture, carpeting, or drapes.
- Bleed trapped air from hot-water radiators once or twice a season; if in doubt about how to perform this task, call a professional.
- Place heat-resistant radiator reflectors between exterior walls and the radiators.
- Turn off kitchen, bath, and other exhaust fans within 20 minutes after you are done cooking or bathing; when replacing exhaust fans, consider installing high-efficiency, low-noise models.
- During the heating season, keep the draperies and shades on your south-facing windows open during the day to allow the sunlight to enter your home and closed at night to reduce the chill you may feel from cold windows.
- During the cooling season, keep the window coverings closed during the day to prevent solar gain.

A survey form for home energy audits and checklist for efficient home energy use follow.

Survey for Home Energy Audit

						Greenhouse Gases generation(tons/MWH)		
						CO_2	CH_4	N_2O
Category	Item	Number	Watts	Hours of use/year	Total consumption (KWH)	0.861	0.011	0.0223
Lighting								
	Interior Light Fixture (Compact Florescent Lights)		20					
	Floor Lamp		50					
	LED Light		25					
	Incandescent lights		100					
	Lighting Total							
Appliances								
	Refrigerator		400					
	Freezer		500					
	Dehumidifiers		545					
	Efficient Ventilation Fan		80					
	Dishwasher (electric hot water heater)		1200					
	Clothes Washer (electric hot water heater)		500					
	Desktop computer & 17" LCD Monitor		200					
	TV		200					
	Microwave		110					
	Printer & Copier		800					
	Coffee maker		800					
	Stereo		110					
	VCR		40					
	Iron		1000					
	Vacuum Cleaner		650					
	Room air conditioning		1000					
	Central air conditioning		3000					
	Central heater		1200					
	Portable heater		1500					
	Water heater		800					
	Fans		80					
	Other home equipment		100					
	Appliances Total							
Total electricity Consumption								
Water			Number	Water savings/day (gal)	Yearly water savings (gal)			

	Low flow showerheads		11	
	Faucet Aerators		11	
	Pipe Wrap		9	
	Total			
Proper home Insulation		Number of home	Electricity savings	Yearly savings
	Ceiling Insulation		8%	
	Duct Insulation		8%	
	Wall Insulation		5%	
	Floor Insulation		5%	
	Door		3%	
	Windows		6%	
	Shading or Planting Trees		2%	
	Complete Home Weatherization		10%	
	DIY Weatherstripping		5%	

Source: GHG values were taken from general electricity generation factors [76]

Check Lists for Efficient Home Energy Use

Category	Problems	Instruction	Savings
Insulation			
Walls	Cracks or cavity	Cracks or cavities are able to seal by caulking or other ways. Generally old walls should be insulated with more than R13 value	Proper wall insulation saves up to 8% of total energy consumption
Attic	Uninsulated	Attic should be insulated in order to prevent warm air leakage by fiberglass blankets with caulking.	Up to 10% energy savings of HAVC energy
Floors	Cold, uninsulated	Cold floors should be insulated by fiberglass	Saving up to 5% of total energy consumption
Basement	Unheated basement	Exterior walls with R-10 value, Interior walls with R-21 using fiberglass or other products	Saving up to 4% of total energy consumption
Water heater	Losing heat	Insulate water heater with blanket or fiberglass or any types of clothes.	Preventing heat loss up to 45%
Windows	Air leaks, sunlight	Replace double pane windows, seal with caulks, weatherstrip, window insulation film, etc.	Saving up to 20% of heating and cooling energy
Doors	Air leaks	Replace storm doors, weather-strip around doors	Saving up to 10% of heating and cooling energy
Outdoors	Too much wind and sunlight	Plant trees or shrubs to protect from wind and sunlight	Preventing strong wind and sunlight can save 8% of heating and cooling costs.
Appliances			
Refrigerator	More than 10 year olds	Changing energy star rated refrigerator, maintain proper temperature (37-40°F for the fresh food section, 5°F for freezer), clean coils behind	Saving up to 2% of total energy consumption
Computers	Not turning off	Power down when not in use, set the sleep mode after 20 minute inactivity	Saving up to 5% of energy costs on appliances
Laundry	Hot water usage, drier	Use cold water to wash clothes, Use a clothes line or drying rack	Saving up to $63 yearly energy savings from water, 2% of energy savings from drier
Dish	Frequent use of dishwasher and much use of hot water	Use dishwasher when fully loaded, do not use hot water in dishwater, wash dishes by hands instead of dishwasher	Saving up to 3% of electricity bills.

Other electric equipment	Old, not in use	Plug out when not in use, replace with energy star rated product	Saving up to 10% of appliance use
Lighting			
Bulbs	Incandescent bulbs, improper turn off	Replace most of incandescent bulbs with Energy Star CFLs, Turn off when not in the room	Saving $30 or more of each bulb in electricity costs, proper turn-off can save up to 10% of electricity.
HAVC			
Thermostat	No possession	Use a programmable thermostat to adjust the temperature in the house, Set the thermostat 68°F or lower in winter, 80°F or higher in summer	Saving 40% of heating and cooling cost
Air-conditioning	Old, Filters	Air conditioner with out of life span should be replaced an Energy star rated air conditioner(More than 13SHEER), filters must be clean by timely replacement, Use fans with air conditioner	Saving up to 40% of cooling costs
Heating	Cold or hot	Adjust the temperature 68°F or lower in winter, open blinds or drapes to allow sunlight in winter, use extra blankets instead of heating	Saving up to 30% of heating costs
Ventilation	Old fans	Replace with energy star ceiling fans	Saving up to 50% of ventilating costs
Water			
Shower heads, Faucets	Old, inefficient equipment, leaks	Replace with aerator faucets and low-flow showerheads	Saving up to 22 gals per day

Source: Utah Clean Energy, Home Energy Checklist; Seattle City Light and the Seattle, Department of Planning & Development's City Green Building Program, Do-it-yourself home energy audit

Appendix D: Transportation

Overview

Transportation in the United State uses 65 percent of the nation's oil, mostly in the form of gasoline [93]. This oil usage results in one-third of total Green House Gas (GHG) emissions in the United State [94]. Figures 50 and 51 show GHG emissions in the United State. Transportation generates 28% of total greenhouse gas (GHG) generation. Reducing oil usage in transportation will provide not only energy savings but also reduction of GHG emissions. In the Kaw Nation, most transportation uses residential cars.

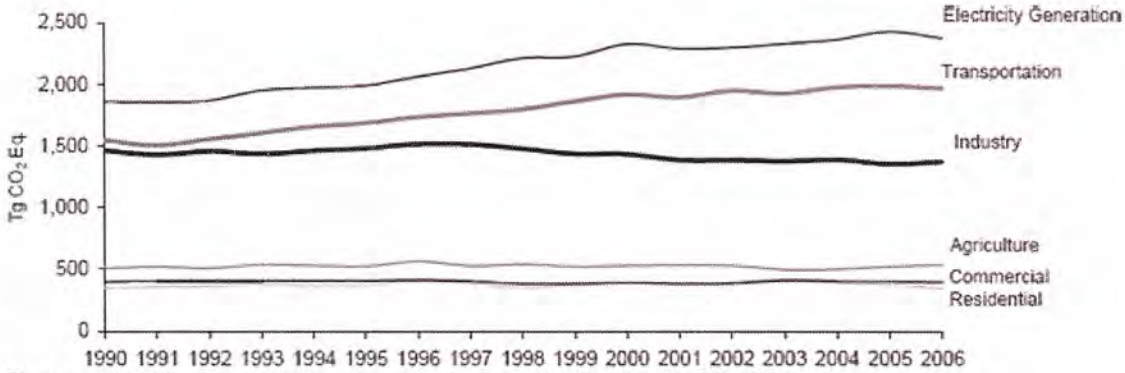


Figure 50 U.S. Greenhouse Gas Emissions by Sector, 1990-2006
Source: EPA, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006

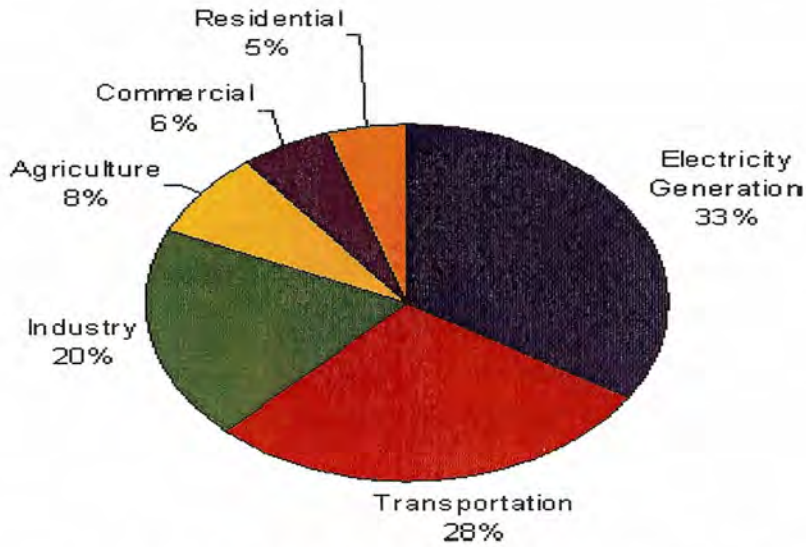


Figure 51 Percentage of U.S. Greenhouse Gas Emissions, 2006 (all gases, in Teragram [Tg] CO2 equivalent)
Source: EPA, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006

Reducing Transport Activity

Reduction of transport activity directly contributes to energy savings for the Kaw Nation. In this appendix, three options for reduction of transport activity are included.

Carpooling

Carpooling or ride sharing will reduce car usage for residents. Carpooling is simple and easy, though many people do not do it due to inconvenience and unawareness of its importance. The Kaw Nation needs to support a carpooling system by providing a carpool mapping system and easy access to each neighbor. Carpool mapping systems and providing contact information for each neighbor will encourage more carpooling for the Kaw Nation people.

Use of Alternative Vehicles

Many people in the United State communicate between work and home using their cars, even when distances are short. For a short distance, bikes or scooters are better because this helps not only to save energy but also provides healthful exercise. The Kaw Nation needs to encourage people to ride more bikes by providing free bikes and safe biking roads.

Working at Home

There is increasing use of "telecommuting", since much work is electrictronically-based and people can work using home computers. The Kaw Nation employees work mostly in their offices, even though much work could be performed through telecommuting. The Kaw Nation should test one or more days of "work from home" for employees to see if it is efficient. This will help energy savings for employees and employers.

Driving and Car Maintenance

Careful driving and proper car maintenance also helps reduction in gas usage. However, many people do not optimally drive and maintain their cars. There are several tips for driving and maintaining cars.

Driving Tips [70]

- Idling gets you 0 miles per gallon. The best way to warm up a vehicle is to drive it. No more than 30 seconds of idling on winter days is needed. Anything more simply wastes fuel and increases emissions.
- Aggressive driving (speeding, rapid acceleration, and hard braking) wastes gas. It can lower your highway gas mileage 33% and city mileage 5%.
- Avoid high speeds. Above 60 mph, gas mileage drops rapidly.
- Clear out your car; extra weight decreases gas mileage by 1% to 2% for every 100 pounds.
- Reduce drag by placing items inside the car or trunk rather than on roof racks. A roof rack or carrier provides additional cargo space and may allow you to buy a smaller car. However, a loaded roof rack can decrease your fuel economy by 5% or more.
- Check into telecommuting, carpooling and public transit to cut mileage and car maintenance costs.

Car Maintenance Tips

- Use the grade of motor oil recommended by your car's manufacturer. Using a different motor oil can lower your gasoline mileage by 1% to 2%.
- Keep tires properly inflated and aligned to improve your gasoline mileage by around 3.3%.
- Get regular engine tune-ups and car maintenance checks to avoid fuel economy problems due to worn spark plugs, dragging brakes, low transmission fluid, or transmission problems.
- Replace clogged air filters to improve gas mileage by as much as 10% and protect your engine.
- Combine errands into one trip. Several short trips, each one taken from a cold start, can use twice as much fuel as one trip covering the same distance when the engine is warm.

Source: U.S. Department of Energy, Driving and Car Maintenance

Energy-Efficient Vehicles and Alternative fuels

Source [71]

Diesel is the most efficient combustion system used in transportation. Diesel can deliver 20 to 40 percent more miles per gallon than gasoline and also emits 10 to 20 percent less GHG. For these reasons, diesel cars are becoming more popular and offer consumers a new choice in fuel-efficient and low-emission technology. Ultra-low sulfur diesel and biodiesel are being sold in the U.S. now, which results in lower sulfur dioxide emissions. According to EPA estimates, with the implementation of the new fuel standards for diesel, nitrogen oxide emissions will be reduced by 2.6 million tons each year and soot or particulate matter will be reduced by 110,000 tons a year.

Most states in the U.S. provide incentives for purchase of these cars. EPA also provides information on diesel cars at www.fueleconomy.gov.

Biodiesel: biodiesel is an environmentally friendly fuel used for diesel vehicles. There are currently no stations providing biodiesel near the Kaw Nation area.

Hybrids: a hybrid vehicle uses batteries such as nickel metal hydride or lithium ion along with a conventional engineusing gasoline or diesel fuel. Hybrids offer greater fuel economy and lower emissions than conventional vehicles.

Ethanol: ethanol mixed gasoline is sold in most of stations in Oklahoma. Ethanol reduces GHG emissions and also gets a tax credit of $0.016 for each gallon of ethanol-blended fuel sold in Oklahoma.

Natural gas: natural gas vehicles in Oklahoma are recommended for the following reasons: lower GHG emissions, low natural gas price, more stations under construction in the State, and more tax credits.

Hydrogen: a hydrogen vehicle produces no GHG emission. However, it is not recommended due to inaccessibility of stations and high vehicle cost.

Policy

The State of Oklahoma encourages renewable energy usage in transportation by offering several incentives. However, many of these incentives are not applicable to the Kaw Nation.

Some of the incentives are listed below:

Natural gas using vehicles [72]

Compressed Natural Gas (CNG) Fueling Infrastructure Development
The Oklahoma state legislature intends to increase the CNG fueling infrastructure in the state, with the overall goal of having one public fueling station located every 100 miles along the interstate highway system by 2015, and one public fueling station every 50 miles by 2025

Natural Gas Vehicle (NGV) Promotion
The Oklahoma state legislature urges the U.S. Environmental Protection Agency to take regulatory steps that will encourage the use of NGVs. Recommended steps include revising and streamlining aftermarket conversion certification requirements for small volume manufacturers; waiving requirements for re-certifying natural gas engine conversion kits if the kit has been previously certified for a vehicle model and neither the kit nor the specific vehicle model have substantially changed; providing additional guidance to small volume manufacturers regarding conversion of older vehicle models; and continuing NGV research, development, and demonstration.

In lieu of the motor fuel excise tax, owners are subject to an annual flat fee on motor vehicles including passenger automobiles, pickup trucks, vans and heavy-duty vehicles using liquefied petroleum gas (propane), compressed natural gas (CNG), liquefied natural gas (LNG), methanol, or blends of 85% methanol and 15% gasoline (M85). Propane vehicles with a payload capacity of less than 2,000 pounds (lbs) are taxed at a rate of $50 per vehicle per year. CNG, LNG, methanol, and M85 vehicles with a payload capacity of less than 2,000 lbs are taxed at a rate of $100 per vehicle per year. Propane, CNG, LNG, methanol, and M85 vehicles with a payload capacity greater than 2,000 lbs are taxed at a rate of $150 per vehicle per year. If the owner acquires the vehicle or converts it to run on the alternative fuel after July 1 of the tax year, the flat fee is half of the above mentioned amount. Vehicles must display a decal issued, on an annual basis, by the Oklahoma Tax

Alternative Fuel Vehicle

Alternative Fuel Vehicle (AFV) Tax Credit
For tax years beginning before January 1, 2015, Oklahoma provides a one-time income tax credit for 50% of the cost of converting a vehicle to operate on an alternative fuel, or for 50% of the incremental cost of purchasing a new original equipment manufacturer AFV. The state also provides a tax credit for 10% of the total vehicle cost, up to $1,500, if the incremental cost of a new AFV cannot be determined or when an AFV is resold, as long as a tax credit has not been previously taken on the vehicle. Equipment used for conversions must be new and must not have been previously used to modify or retrofit any vehicle. The alternative fuels eligible for the credit are compressed natural gas, liquefied natural gas, liquefied petroleum gas, hydrogen fuel cell, and electricity. Only qualified electric vehicles placed into service before July 1, 2010, are eligible. For vehicles propelled by electricity only, the credit is based on the full purchase price of the vehicle. For vehicles equipped with an internal combustion engine, such as a hybrid electric vehicle, the credit is based on the portion of the motor vehicle which is attributable to the propulsion of the vehicle by electricity. Tax credits may be carried forward for up to five years. (Reference House Bill 3024, 2010, and Oklahoma Statutes 68-2357.22)

Alternative Fueling Infrastructure Tax Credit
For tax years beginning before January 1, 2015, the state provides a tax credit for up to 75% of the cost of installing alternative fueling infrastructure. Alternative fuels eligible for the credit include compressed natural gas (CNG), liquefied natural gas, liquefied petroleum gas, and electricity; infrastructure related to the delivery of hydrogen into the tank of a motor vehicle is eligible for the 2010 tax year only. The infrastructure must be new and must not have been previously installed or used to fuel alternative fuel vehicles. A tax credit is also available for up to 50% of the cost of installing a residential CNG fueling system, up to $2,500. The tax credit may be carried forward for up to five years. (Reference House Bill 3024, 2010, and Oklahoma Statutes 68-2357.22)

Alternative Fuel Vehicle (AFV) and Fueling Infrastructure Loans
The Oklahoma Department of Central Services has an Alternative Fuels Conversion Loan program to help convert government-owned fleets to operate on alternative fuels. This program provides 0% interest loans for vehicle conversions, for the construction of AFV fueling infrastructure, and for the incremental cost associated with the purchase of an Original Equipment Manufacturer AFV. The program provides up to $10,000 per converted or newly purchased vehicle and up to $150,000 for the development or installation of fueling infrastructure. Repayment of the loan has a maximum seven-year period and repayment is collected through a surcharge in the amount equivalent to the per gallon fuel cost savings from using an alternative fuel. If the price of the alternative fuel does not remain below the price of the conventional fuel that was replaced, repayment is suspended. Eligible applicants include state and county agencies and divisions, municipalities, school districts, mass transit authorities, and public trust authorities. (Reference Oklahoma Statutes 74-130.4 and 74-130.5)

Alternative Fuel Vehicle (AFV) Loans
Oklahoma has a private loan program with a 3% interest rate for the cost of converting private fleets to operate on alternative fuels, for the incremental cost of purchasing an Original Equipment Manufacturer AFV, and for the installation of AFV fueling infrastructure. The repayment of the loan has a maximum six-year period.
http://www.afdc.energy.gov/afdc/laws/laws/OK/tech/3253

Appendix D: Waste Management

Overview

People in the U.S. generated about 250 million tons of municipal solid waste in 2008, with 54% of the waste being discarded in landfills [73]. This equates to between 3.8 and 4.5 pounds per person, every day. Waste management can be described in four steps (source reduction, recycling, waste transformation, landfilling). In this appendix, source reduction and recycling will be addressed because these have the most positive impact. Source reduction and recycling are the most efficient methods to reduce waste from each home and commercial building. Figure 52 shows total MSW Generation in 2008 and Figure 53 shows the EPA solid waste management hierarchy.

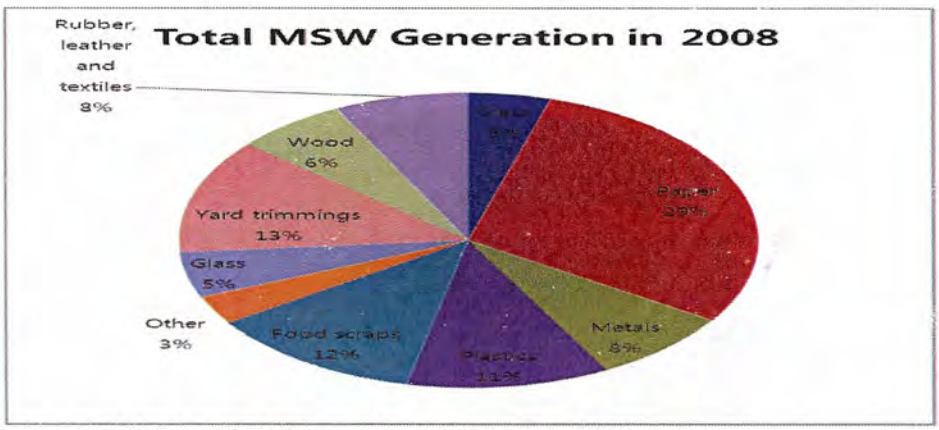


Figure 52 Total MSW Generation in the U.S., 2008
Source: EPA, Municipal Solid Waste Generation, Recycling, and Disposal in the United States: Facts and Figures for 2008

Figure 53 The Solid Waste Management Hierarchy
Source: Fairfax County, Fairfax County Solid Waste Management

Waste Prevention and Source Reduction

Source Reduction

The highest level and most effective method of waste management is source reduction. Source reduction prevents waste from being generated. Most waste in the Kaw Nation comes from residential houses. The best way to reduce waste for the Kaw Nation is to minimize house waste and yard waste. The home waste management requires public education, government action.

Public Education

Public education of waste reduction is the first step to begin a waste management program. The Kaw Nation should provide residents with promotional material and other assistance such as booklets, newsletters, brochures, free waste audits, awards programs, and workshops to recognize the importance of waste reduction.

Waste reduction can be achieved by following these simple steps:

-Minimize waste by using reusable products at home and office. Using reusable products such as dishes, cups, napkins can reduce waste up to 20%.

-Practice environmentally friendly shopping. Use your own bag for grocery shopping and buy products with less packing. Do not buy unnecessary products.

-Reduce paper as much as possible. Reuse back pages of paper as a workbook, a memo, or for routine printing. Require junk mail terminator kits.

-Use different trash bins for waste and recycling products. Separating waste and recycling products can reduce waste by 40%.

- Use nontoxic products such as water based paints, water instead of cleaners, and natural solvents. Using nontoxic products can save both environment and health.

-Compost food and yard waste. Composting is a simple method to reduce food and yard waste. There are also commercially available composting bins.

Government Action

Waste management cannot succeed without supervision from the local government. In Oklahoma, there are no rules requiring recycling or waste reduction. The Kaw Nation can encourage responsible waste management by reducing garbage fees for recycled items, charging additional garbage fees for un-recycled items, providing recycling bins for residents, and giving the awards for best waste reduction.

Recycling

Recycling waste is one of most effective ways to reduce waste going to disposal. It saves energy usage and prevents pollution such as water pollution, and GHG emissions. The most common recycled materials include papers, glass, plastics, metal, and wood. In the U.S., the recycling rate has recently increased more than 20 percent compared to the late 1990s. In 2008, office-type paper recovery rose to about 71 percent (4.3 million tons), and about 65 percent of yard trimmings were recovered. Metals were recycled at a rate of almost 35 percent. More detail information is shown in Figure 54 and Table 45.

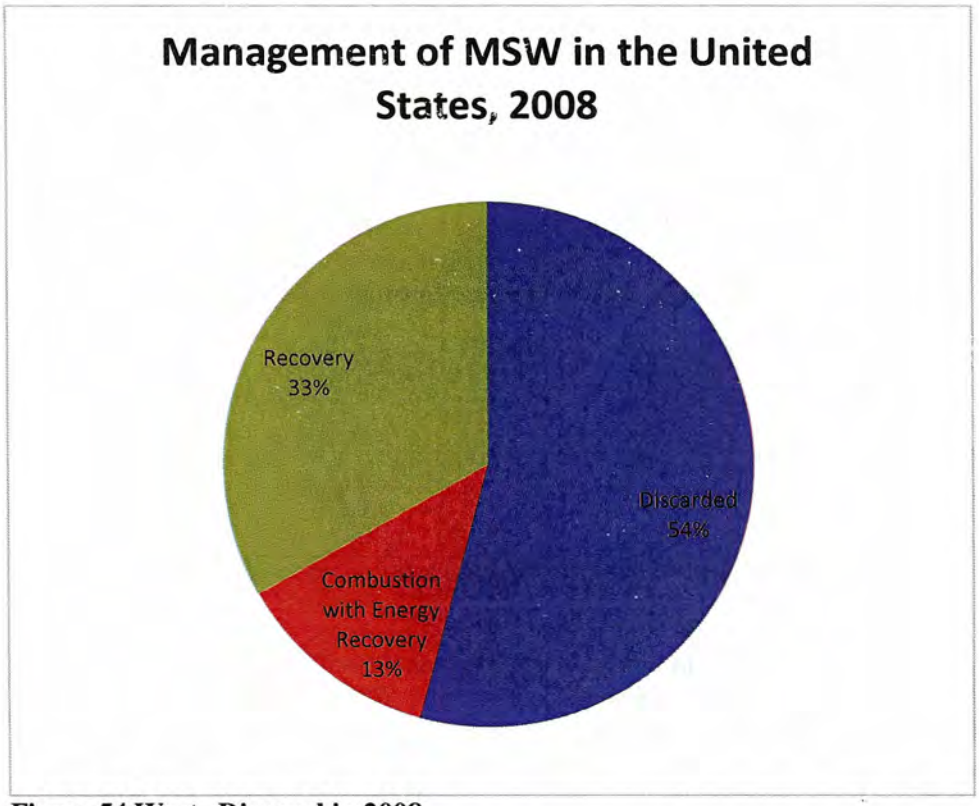


Figure 54 Waste Disposal in 2008
Source: EPA, Municipal Solid Waste Generation, Recycling, and Disposal in the United States: Facts and Figures for 2008

Table 45 Generation and Recovery of Products in MSW, 2008* (in millions of tons and percent of generation of each product)

Products	Weight Generated	Weight Recovered	Recovery as Percent of Generation
Paper and paperboard	77.42	42.94	28.00%
Glass	12.15	2.81	23.10%
Metals			
Steel	15.68	5.29	33.70%
Aluminum	3.41	0.72	21.10%
Other nonferrous metals†	1.76	1.21	68.80%
Total metals	20.85	7.22	34.60%
Plastics	30.05	2.12	7.10%
Rubber and leather	7.41	1.06	14.30%
Textiles	12.37	1.89	15.30%
Wood	16.39	1.58	9.60%
Other materials	4.5	1.15	25.60%
Total materials in products	181.14	60.77	33.50%
Other wastes			
Food, other‡	31.79	0.8	2.50%
Yard trimmings	32.9	21.3	64.70%
Miscellaneous inorganic wastes	3.78	Negligible	Negligible
Total other wastes	68.47	22.1	32.30%
Total municipal solid waste	249.61	82.87	33.20%

Source: Municipal Solid Waste Generation, Recycling, and Disposal in the United States: Facts and Figures for 2008, EPA

Greenhouse gas (GHG) emission can be reduced more than 30 million metric tons of carbon dioxide equivalent by recycling 8 million tons of metals. (This is equivalent to removing more than 4.5 million cars from the road for one year.) For better recycling rates, the Kaw Nation should develop a specific plan of recycling. Plans should consider following factors.

- Actual recycling rate in the Kaw Nation.
- Composition of wastes generated from households in the Kaw Nation.
- Education on recycling for residents.
- Development of a new recycling plan.
- Encouragement of residents to participate in he program.
- Periodical updates of the program and participation rates.
- Monthly checking of recycling rates.
-

The Kaw Nation does not possess a recycling center. The nearest recycling center is located in Ponca City. The Kaw Nation should consider building a small recycling center which only offers collection and transfers collected materials to the recycling center in Ponca City (1001 West Prospect, phone: 580-767-0456[75]).

Summary

For overall reduction of solid waste in Kaw Nation, source reduction and recycling are recommended.

Source reduction can be achieved by:

- Public education
- Government action

Effective source reduction programs with the above four factors will contribute higher waste reduction rates to the Kaw Nation.

Recycling could be improved by:

- Checking actual recycling rates
- Developing a detailed recycling plan based on types of waste generation
- Holding recycling education programs
- Building a recycling collection center

Appendix E: Budgeting

Overview

Total electricity consumption by the Kaw Nation facilities was 7,504,229 kW at a cost of $516,865.40 in 2008. Most of facilities were provided electricity by the Kay Electric Cooperation. There might be other providers who would offer lower prices. This chapter will discuss alternate electricity providers in the Kaw Nation area.

Electricity Provider Determination for the Kaw Nation

Most of the large Kaw Nation facilities are located in Newkirk and use the Kay Electric as an electricity provider.

Electricity providers near the Kaw Nation are the following:

- Verdigris Valley Electric Cooperation (8901 E 146th Street North, Collinsville, OK - (918) 371-2584, (918) 371-2584)
- Kay Electric (300 West Doolin Avenue, Blackwell, OK - (580) 363-1260, (580) 363-1260)
- Caney Valley Electric Co-Op (401 Lawrence Street, Cedar Vale, KS - (620) 758-2262(620) 758-2262)
- Ponca City Utility Services (516 East Grand Avenue, Ponca City, OK - (580) 767-0311, (580) 767-0311)
- Indian Electric Cooperative Inc (601 South Main Street, Fairfax, OK - (918) 642-3314, (918) 642-3314
- City of Blackwell (221 W. Blackwell, Blackwell, OK 74631 Office: (580) 363-7200, (580) 363-7200, Fax: 580 363-3091)
- Newkirk-city (106 S Maple Ave, Newkirk, OK 74647, (508)362-2117)

Figure 55 Electricity Providers near Kaw Nation
Source: Google Map

Table 46 Electricity Rates from Feasible Providers

Utility	Rate type	Customer Charge	Minimum Charge	Season	$/kW	Options
Verdigris Valley Electric Cooperation	General	$25.00	$25.00	Winter and Summer	$0.0713	
	Large	$50.00	$50.00	Winter and Summer	$0.0698	1st 150 kWh/kW of billing demand
					$0.0448	Over 150 kWh/kW of billing demand
Kay Electric	Commercial general	$35.00			$0.0950	30 kW demand
		$80.00			$0.0600	Over 30kW demand
	Commercial large	$400.00			$0.0050	First 1,000,000 kWh
					$0.0030	Over 1,000,000 kWh
Caney Valley Electric Co-Op	Residential	$7.00		Winter	$0.1066	
				Summer	$0.1006	
	Small commercial	$8 for one phase			$0.1012	
		$11 for three phase			$0.9520	
City of Blackwell	Residential	$10.00			$0.1040	FIRST 600 kWh
					$0.0900	Over 600 kWh
	Commercial	$18.00			$0.1100	
	Commercial large	$8.00			$0.0550	
City of Newkirk		$13.00	$13.00		$0.0725	Less than 490kWh
					$0.0650	2,500 kWh
					$0.0600	Over 3,000 kWh
City of Ponca	-	-	-	-	-	
Indian Electric	General	$29.00	$19.00		$0.0737	

Source: Verdigris Valley Electric Cooperation, Kay Electric Cooperative, Caney Valley Electric Co-Op, City of Blackwell, City of Newkirk, Indian Electric

Cost Comparison with Feasible providers

Kay Electric, which is the largest provider for the Kaw Nation, has the lowest per kWhr charge of all providers for the class of service used by the Kaw Nation. However, it may be possible for the Nation to negotiate lower rates with Kay Electric or other providers in the future, especially if the Nation builds a substantial amount of generation capacity on its own.

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