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Energy Consumption and Renewable Energy Development Potential on Indian Lands

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Contacts

This report was prepared by the staff of the Renewable Information Team, Coal, Nuclear, and Renewables Division, Office of Coal, Nuclear, Electric and Alternate Fuels; and the Energy Consumption Division, Office of Energy Markets and End Use. General information regarding this publication may be obtained from Fred Mayes, Team Leader. (202/426-1166, e-mail fred.mayes@eia.doe. gov).

Questions regarding specific information in the report should be directed as follows:

1. Energy Consumption, Dwight French, 202/586-1126, dwight.french@eia.doe.gov

2. Renewable Energy, Louise Guey-Lee, 202/426-1143, louise.guey-lee@eia.doe.gov

Preface

In June 1999, the Secretary of the Department of Energy, Bill Richardson, launched the Department's broad based Indian Initiative. As part of this initiative, he asked the Energy Information Administration (EIA) to prepare a study of energy on Indian lands to include:

- "the electricity use and needs of Indian households and tribes,"
- "the comparative electricity rates that Indian households are paying, and"
- "the potential for renewable resources development of Indian lands."

The EIA prepared this report in response to the Secretary's request. The report is organized into the four chapters and four appendices that follow.

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Executive Summary

Renewable energy projects are considered particularly appropriate on Indian lands because they are generally environmentally benign and harmonize well with nature, consistent with Indian culture. Accordingly, the Department of Energy (DOE) has provided financial support each year since 1992 for developing renewable energy projects on these lands.[1] In February 1999, Secretary of Energy Bill Richardson revised and extended DOE's original 1992 Indian lands policy[2] through a $1.8 million solicitation for renewable projects.

A major focus of the current policy is to improve the quality of life on Native American lands through increased access to energy. To this end, the Secretary of Energy directed the Energy Information Administration (EIA) to undertake a study of the cost and availability of electricity to Indian households on Indian lands, as well as the feasibility of using renewable energy there. Because most tribal lands are remote and sparsely populated, they are also considered to be good sites for testing the market potential of dispersed energy sources like renewables.

This report examines electricity use, prices, and renewable energy potential for both Federally Recognized Indian Reservations, and Tribal Jurisdictional Statistical Areas (TJSAs) in Oklahoma.[3] The principal results are:

- Indian households on reservations are disproportionately without electricity. The analysis determined that 14.2 percent of Indian households on reservations had no access to electricity, as compared to only 1.4 percent of all U.S. households.[4]
- According to EIA's Residential Energy Consumption Survey (RECS), electricity prices paid by Indian households in 1997 (8.7 cents per kWh) were not statistically different from prices paid by U.S. households as a whole (8.1 cents per kilowatthour (kWh)). However, Indians living on Indian lands generally pay a greater portion of their income for electricity (Figure ES1). Regional data on electricity prices for Indian households in 1998 were also estimated from an EIA survey of U.S. electric utilities (Table ES1). Ninety-two percent of the 175,000 Indian households on Indian lands are located in just four of the North American Electric Reliability Council subregions. Electric utilities servicing counties containing Indian lands in three of those four subregions have higher rates than all utilities with residential customers in the subregion. From these data, it is impossible to determine whether the higher costs are due to the cost of service for sparsely populated rural areas, including Indian lands or other factors.
- Some Indian lands appear to have potential for renewable energy development. Sixty-one reservations/TJSAs, having 50 percent of the Indian population on Indian lands, appear to have renewable resources that might be developed for central station generation for a levelized cost of less than 2 cents per kilowatthour (kWh) above regional wholesale prices (Table ES2). These premiums exclude any transmission costs required to connect the plant to the regional transmission grid.[5] Biomass energy on the Eastern Cherokee

[1] See website http://www.doe.gov/news/releases99/febpr/pr99022.htm for a discussion of the revised Indian energy policy and Appendix A.

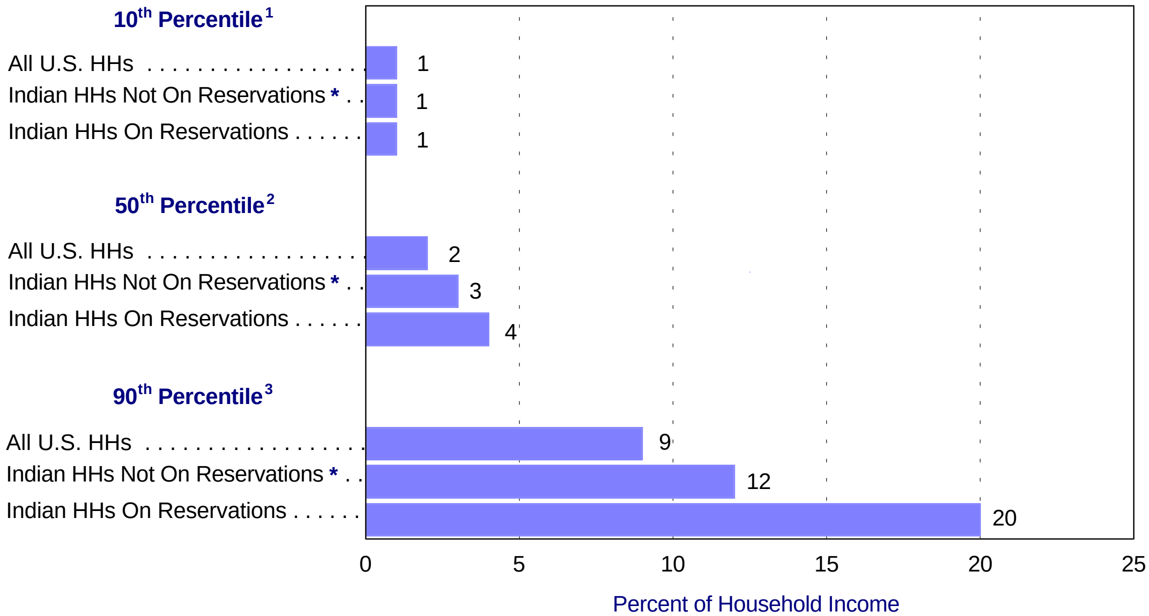
[2] The Department of Energy (DOE) first developed a policy governing its work with American Indians in 1992. Among other things, the policy stated that, "The Department will identify and seek to remove impediments to working directly and effectively with tribal governments on DOE programs." Further, the policy committed DOE to consider Indian cultural issues in all of its programs.

[3] The term "Indian lands" is used to denote Federally Recognized Indian Reservations and TJSAs together.

[4] Although the 1990 Decennial Census source data allows for the possibility that households incurred no electricity cost simply because electricity was provided by some other payer, subsequent contacts with Indian affairs experts demonstrated this is not the case.

[5] The cost premiums also assume there is an existing transmission and distribution system infrastructure for these reservations to use the power themselves. Otherwise marketing power to off-reservation customers is likely to be the only feasible option, as costs for new distribution systems to sparsely arrayed reservation households would be quite high.

Figure ES1. Percentiles of Electricity Costs Relative to Total Household Income, for Households that Pay for Electricity, 1990



HHs = Households.

[1] 10th percentile indicates that the least-burdened 10 percent of households pay no more than this percentage of income for electricity.

[2] 50th percentile indicates the median electricity expenditures as a percent of income.

[3] 90th percentile indicates that the most-burdened 10 percent of households pay at least this percentage of income for electricity.

* Includes households in TJSAs.

Source: U.S. Bureau of the Census, 1990 Decennial Census of Housing.

reservation in western North Carolina has the lowest incremental cost of all fuels on Indian lands examined, at just 0.1 cents per kWh more than the wholesale price of electricity. On the same reservation, wind power is projected to cost only 0.4 cents per kWh more. In general, biomass provides the greatest potential for relatively inexpensive renewable-based central station power on 52 of the 61 reservations distributed widely across the United States. By contrast, all of the Indian lands where wind has the lowest renewable cost premium are located in New Mexico. The premium for wind electricity on New Mexico reservations is 1.8 cents per kWh.

- The Indian lands with the greatest need for electrification are generally in Arizona. On the Navajo Reservation,[6] almost 37 percent of all households do not have access to electricity (Table ES3). This occurs despite the fact that there is an indigenous supply of coal and a large power generation station with major transmission lines on this reservation. Moreover, the Navajo Reservation accounts for 75 percent of all Indian households on tribal lands not having electricity. Other Arizona reservations with high rates of non-electric households include: Hopi Reservation (29 percent), Salt River Reservation (12 percent), and Fort Apache Reservation (9 percent). In the Dakotas, the Standing Rock Reservation also has a very high rate of households without electricity, 18 percent.

- Photovoltaic (PV) rooftop modules may be a feasible way to provide limited electric service (without backup power) to large numbers of households on the Navajo Reservation, and possibly others. The levelized cost for distributed PV generation ranges from 28.0 to 51.6 cents per kWh. While substantially higher than the average

[6] That is, the Navajo Reservation and Trust Lands, located primarily in Arizona but also in New Mexico and Utah.

Table ES1. 1998 Residential Average Revenue per Kilowatthour
(1998 cents/kWh)

NERC Region	Average for All U.S. Households			
	NERC Subregion	All Households Average	Average for Indians on Indian Lands [a]	Percent of Indian Households
ECAR	ECAR	7.7	8.5	0.2
ERCOT	ERCOT	7.8	–	–
MAAC	MAAC	10.1	–	–
MAIN	EM	7.2	–	–
MAIN	NI	10.6	–	–
MAIN	SCI	8.8	–	–
MAIN	WUM	7.2	7.8	1.6
MAPP	MAPP	7.4	7.8	11.1
NCPP	NEPX	11.6	13.2	0.3
NCPP	NYPP	13.6	12.8	1.2
SERC	FL	8.0	8.4	0.3
SERC	SOC	7.4	6.9	0.5
SERC	TVA	6.4		
SERC	VACAR	7.9	8.4	1.1
SPP	N	7.3	9.2	0.2
SPP	SE	7.3	6.8	0.1
SPP	WC	6.4	7.1	38.0
WSCC	AZN	8.9	8.2	31.2
WSCC	CNV	10.3	10.6	2.1
WSCC	NWP	5.6	6.3	11.7
WSCC	RMPA	7.4	8.1	0.4

[a]Note that 92 percent of the Indian population living on Indian land is in 4 regions: MAPP, SPP/WC, WSCC/AZN, and WSCC/NWP.

NERC = North American Electric Reliability Council. See Appendix D for map of NERC regions.

Source: Energy Information Administration, 1998 Form EIA-861, "Annual Electric Utility Report," and EIA estimates as documented in this report.

residential price of electricity, the Navajo Reservation has many households extremely remote from transmission / distribution lines. This raises distribution costs to a level far higher than average. DOE's National Center for Photovoltaics indicates that a distance from the nearest utility line of only a quarter mile raises distribution costs sufficiently to make PVs cost-effective at 25 to 50 cents per kWh. In addition, if the cost of the PV system can be paid for through a 30-year home mortgage, its levelized cost can be reduced to 15 to 20 cents per kWh. These estimates exclude the cost of back-up power or energy storage, which could raise the cost of full-service PV rooftop-based electricity by a factor of 3 or 4.

- Biomass central station projects on the Navajo Reservation in Arizona and wind projects on the Mescalero Apache Reservation in New Mexico might also offer potential renewable resources to electrify Indian households. Those reservations have the highest and fourth-highest rates of households without electricity, 37 and 15 percent, respectively. Relatively high rates of non-electrification, however, call into question whether the necessary distribution systems are in place to provide grid-connected power to these households.

TJSAs in Oklahoma are generally characterized by high rates of electrification—the same as the Oklahoma population at large—modest renewable energy resources, and moderate electricity rates. Indians living on TJSAs in Oklahoma pay electricity rates comparable to those paid by other citizens. However, central station biomass may have a potential market there. It has a premium of only 1.8 cents per kWh over the wholesale price of electricity on the Cherokee, Choctaw, and Kiowa tribal lands.

Table ES2. Indian Lands With Highest Potential for Central Station Development[a]

Indian Land	State Abbreviation	1990 Indian Occupied Housing Units	Wholesale Price (98c/kWh)	Minimum Renewable Premium (98c/kWh)	Renewable Fuel
Eastern Cherokee Reservation	NC	1,786	4.3	0.1	Biomass
Eastern Cherokee Reservation	NC	1,786	4.3	0.4	Wind
Alabama and Coushatta Reservation	TX	143	4.1	0.7	Biomass
Coushatta Reservation	LA	12	4.1	0.7	Biomass
Mississippi Choctaw Reservation	MS	830	3.7	0.7	Biomass
Poarch Creek Reservation	AL	66	3.7	0.7	Biomass
Iowa Reservation	KS--NE	33	3.1	1.6	Biomass
Kickapoo Reservation	KS	100	3.1	1.6	Biomass
Sac and Fox (KS-NE) Reservation	KS--NE	16	3.1	1.6	Biomass
Hannahville Community	MI	37	2.9	1.7	Biomass
Lac du Flambeau Reservation	WI	428	2.9	1.7	Biomass
L'Anse Reservation	MI	257	2.9	1.7	Biomass
Menominee Reservation	WI	824	2.9	1.7	Biomass
Oneida (West) Reservation	WI	707	2.9	1.7	Biomass
Potawatomi (Wisconsin) Reservation	WI	71	2.9	1.7	Biomass
Sokaogon Chippewa Community	WI	62	2.9	1.7	Biomass
Stockbridge Reservation	WI	156	2.9	1.7	Biomass
Wisconsin Winnebago Reservation	WI	118	2.9	1.7	Biomass
Lac Vieux Desert Reservation	MI	37	2.9	1.7	Biomass
Cherokee TJSA	OK	20,308	3.0	1.8	Biomass
Choctaw TJSA	OK	9,080	3.0	1.8	Biomass
Kiowa-Comanche-Apache-Fort Sill Apache TJSA	OK	3,511	3.0	1.8	Biomass
Fort Apache Reservation	AZ	2,232	3.4	1.8	Biomass
Navajo Reservation	AZ--NM--U	29,375	3.4	1.8	Biomass
Isleta Pueblo	NM	831	3.4	1.8	Wind
Jemez Pueblo	NM	402	3.4	1.8	Wind
Jicarilla Apache Reservation	NM	607	3.4	1.8	Wind
Mescalero Apache Reservation	NM	595	3.4	1.8	Wind
Nambe Pueblo	NM	118	3.4	1.8	Wind
Picuris Pueblo	NM	48	3.4	1.8	Wind
Taos Pueblo	NM	422	3.4	1.8	Wind
Tesuque Pueblo	NM	60	3.4	1.8	Wind
ZIA Pueblo	NM	143	3.4	1.8	Wind
Bay Mills Reservation	MI	104	2.9	1.8	Biomass
Isabella Reservation	MI	209	2.9	1.8	Biomass
Sault Ste. Marie Reservation	MI	77	2.9	1.8	Biomass
Bois Forte (Nett Lake) Reservation	MN	106	2.7	1.9	Biomass
Deer Creek Reservation	MN	1	2.7	1.9	Biomass
Fond du Lac Reservation	MN	342	2.7	1.9	Biomass
Grand Portage Reservation	MN	87	2.7	1.9	Biomass
Leech Lake Reservation	MN	999	2.7	1.9	Biomass
Mille Lacs Reservation	MN	119	2.7	1.9	Biomass
Prairie Island Community	MN	20	2.7	1.9	Biomass

See notes at end of table.

Table ES2. Indian Lands With Highest Potential for Central Station Development [a] (Continued)

Indian Land	State Abbreviation	1990 Indian Occupied Housing Units	Wholesale Price (98c/kWh)	Minimum Renewable Premium (98c/kWh)	Renewable Fuel
Red Lake Reservation	MN	928	2.7	1.9	Biomass
Vermillion Lake Reservation	MN	27	2.7	1.9	Biomass
White Earth Reservation	MN	816	2.7	1.9	Biomass
Omaha Reservation	IA--NE	429	2.7	1.9	Biomass
Sac and Fox (Iowa) Reservation	IA	135	2.7	1.9	Biomass
Bad River Reservation	WI	285	2.7	1.9	Biomass
Crow Creek Reservation	SD	352	2.7	1.9	Biomass
Devils Lake Sioux Reservation	ND	627	2.7	1.9	Biomass
Flandreau Reservation	SD	78	2.7	1.9	Biomass
Fort Berthold Reservation	ND	848	2.7	1.9	Biomass
Lac Courte Oreilles Reservation	WI	523	2.7	1.9	Biomass
Lake Traverse (Sisseton) Reservation	ND--SD	739	2.7	1.9	Biomass
Lower Brule Reservation	SD	237	2.7	1.9	Biomass
Biomass Red Cliff Reservation	WI	216	2.7	1.9	Biomass
St. Croix Reservation	WI	138	2.7	1.9	Biomass
Santee Reservation	NE	140	2.7	1.9	Biomass
Turtle Mountain Reservation	ND--SD	1,452	2.7	1.9	Biomass
Winnebago Reservation	NE	311	2.7	1.9	Biomass
Yankton Reservation	SD	490	2.7	1.9	Biomass

[a]Excludes Trust Lands.

Notes: The wholesale price is the 1998 average revenue for sales for resale (including firm and non-firm) and the transmission cost to the intertie.

Source: EIA estimates as documented in this report.

Some of the least costly renewable applications described in this report might generate a positive cash flow for Indian lands if the power were sold into the wholesale electricity market. Several State and Federal incentives exist or have been proposed for renewable power, such as a payment of 1.2 cents per kWh from the Energy Policy Act's (EPACT) Renewable Energy Production Incentive (REPI) program.[7] These incentives could further increase the feasibility of renewable energy projects on Indian lands. In addition, if the Administration's proposed electricity restructuring legislation were enacted,[8] renewable energy projects on Indian tribal lands would be awarded double credits in the Renewable Portfolio Standard credit trading program.

In evaluating the above information, it is critical to note that renewable energy project feasibility tends to be highly site- and project-specific. Therefore, the feasibility of projects at any location, such as those mentioned above, are highly dependent upon numerous local factors (e.g., land use, terrain, electricity infrastructure, actual electric rates paid).

[7] This is a levelized cost. The actual REPI incentive is 1.5 cents per kWh.

[8] The Administration's "Comprehensive Electricity Competition Plan" proposal, submitted September 17, 1999, is available on the internet at: http://home.doe.gov/policy/ceca.htm.

Table ES3. Renewable Options for Indian Lands with High Incidences of Indian Households Without Electricity [a]

Indian Land	1990 Indian Occupied Housing Units	Percent Without Electricity	State Policies
Navajo Reservation	29,375	36.8	Y
Hopi Reservation	1,724	28.6	Y
Standing Rock Reservation	1,133	18.2	N
Mescalero Apache Reservation	595	15.2	Y
Salt River Reservation	855	11.9	Y
Fort Apache Reservation	2,232	9.3	Y
Papago Reservation	2,086	7.8	Y
Lake Traverse (Sisseton) Reservation	739	7.8	N
Gila River Reservation	2,295	7.6	Y
Turtle Mountain Reservation	1,452	5.9	N
Pine Ridge Reservation	2,215	5.8	N
San Carlos Reservation	1,634	5.7	Y
Fort Belknap Reservation	656	5.5	Y
Rosebud Reservation	1,656	5.1	N
Iowa TJSA	64	4.9	N
Jicarilla Apache Reservation	607	4.7	Y
Fort Berthold Reservation	848	4.6	N
Wind River Reservation	1,474	3.9	N
Leech Lake Reservation	999	3.5	Y
Pascua Yaqui Reservation	525	3.0	Y
Cheyenne River Reservation	1,293	3.0	N
Otoe-Missouria TJSA	130	2.9	N
Lac Courte Oreilles Reservation	523	2.8	N
Zuni Pueblo	1,465	2.7	Y
Flathead Reservation	1,732	2.1	Y
Colorado River Reservation	652	2.0	Y
Fort Hall Reservation	832	1.9	N
White Earth Reservation	816	1.9	Y
Acoma Pueblo	586	1.9	Y
Northern Cheyenne Reservation	880	1.7	Y
Nez Perce Reservation	581	1.7	N
Fort Peck Reservation	1,591	1.7	Y
Mississippi Choctaw Reservation	830	1.6	N
Devils Lake Sioux Reservation	627	1.6	N

[a]Excludes Trust Lands.
Source: EIA estimates as documented in this report.

1. Introduction

Household energy availability and use on Indian lands[1] is significantly below that of non-Indian households. In fact, sizable Indian populations have no access to electricity at all. This perpetuates a low standard of living, as energy supply and economic well-being are closely linked. Consequently, the Secretary of Energy requested this report to quantify the electricity and renewable energy situations on Indian lands and discuss the potential for using renewable energy there. One goal of the study is to provide a sound basis for Congress to decide how best to appropriate funds to provide Indian households with electricity in an environmentally benign and economically efficient fashion, so that they can advance and enjoy the same prosperity that other Americans do.

The biggest challenge in conducting this study was obtaining the necessary data. While EIA collects extensive data on U.S. energy supply and consumption patterns, only a small amount of information is related to ethnic groups. Since current EIA data have proven inadequate, EIA has turned to older studies (e.g., energy consumption), or has approximated the necessary information (e.g., energy prices).

Chapter 2 discusses Indian household electrification, prices Indians paid for energy compared to the U.S. population as a whole, and other related issues. Here, EIA used the 1990 Decennial Census of Population and Housing and EIA's 1997 Residential Energy Consumption Survey. While these data are slightly dated and based on only representative samples of the population, they recognize ethnicity and thus provide insight unavailable elsewhere. EIA was able to approximate current information on electricity rates for Indian land households from its electric power data surveys.

Renewable resources are an excellent source of clean, sustainable energy. Chapter 3 analyzes the potential for developing these resources to solve the Indians' problems of electrification and self sufficiency (in energy supply), as well as addresses the possible marketing of power on and off Indian lands. Renewable resources for this study include solar, wind, biomass, geothermal, and hydropower.

In order to assess which Indian lands have what renewable resources, a series of composite maps is presented in Chapter 3—one for each energy source except hydroelectric power and an additional one for the electric power transmission grid. Some forms of renewable energy, such as solar / photovoltaic, small wind, geothermal heat pumps, and wood seem to be candidates for use in dispersed applications. Large-scale wind and solar, high-heat geothermal, and biomass are more likely for central station applications. An economic assessment of renewable-based electricity is presented for selected tribal lands having a high incidence of households without electricity and, alternatively, for selected lands with comparatively favorable opportunities for developing central station power to be marketed on and off Indian lands.

To conduct this assessment, certain estimates or data were required for each Indian land:

- The average residential price for electricity in the area, including and surrounding each Indian land. For households off the grid and without electricity, this gives an indication of the price they would pay if connected, in addition to the potential cost of extending the transmission and distribution system.

- The wholesale price of electricity for the area surrounding each Indian land.[2] This is used to approximate the revenue the Indians might receive for electricity produced by them and marketed off Indian lands.

- The cost of developing renewable electricity based on historical costs used in the EIA's

[1] The terms "Indian lands" and "Indian tribal lands" in this report refer to Federally Recognized Indian Reservations in the 48 contiguous States and Tribal Jurisdictional Statistical Areas in Oklahoma. Thus, Federal reservations in Alaska and Hawaii, as well as State Indian lands, are excluded.

[2] The historical wholesale price includes the cost of transmission to the intertie.

Energy Modeling System. The lower the costs compared to wholesale prices, the better the prospects are for renewable resource development. Unfortunately, this combination rarely occurs in practice. In the West, where most Indian lands with good renewable resources are located, the wholesale price of electricity is lower than in the rest of the United States,[3] thus leading to poor comparative economics for renewable energy.

Chapter 3 also presents an analysis of factors (e.g. project criteria) that influence the economic and technical feasibility of renewable projects. Areas to be assessed include revenue flows, demand planning, indirect costs/benefits, infrastructure, financial condition, and project assessment. The chapter concludes with a discussion of limitations on renewable energy development.

Finally, Chapter 4 presents the results of the study. Appendix A lists DOE-funded Indian Energy Projects from FY1994 through FY1999. The tables in Appendix B detail energy consumption. Appendix C contains information about accessing dynamic maps of renewable resource potential on Indian lands. Appendix D presents a map of North American Electric Reliability Council (NERC) regions. A Glossary is also included.

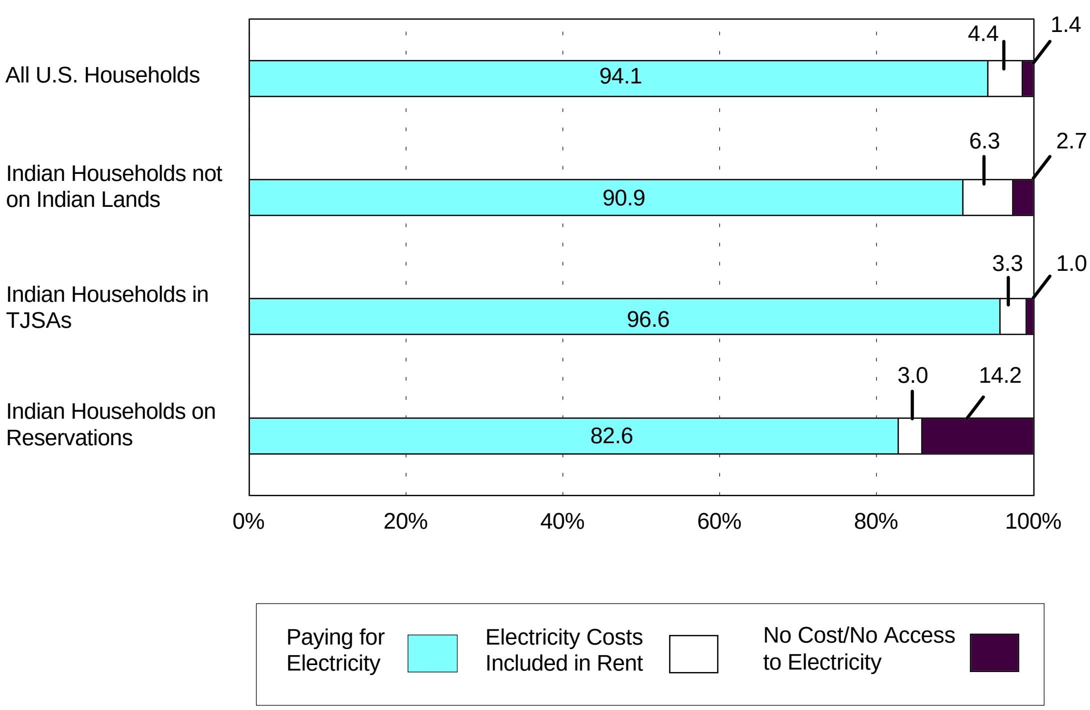
[3] A considerable amount of the electricity sold into Indian lands comes from hydroelectric power sold by the Western Area Power Administration and the Bonneville Power Administration.

2. Energy Consumption on Indian Lands

According to the U.S. Bureau of the Census, American Indians comprise slightly under 1 percent of the U.S. population (an estimated 2.3 million persons in 1997) and, correspondingly, slightly less than 1 percent of U.S. households nationwide. Many Indian households are found in and around reservations/tribal lands, but Indian households are also distributed throughout the country. In considering initiatives to support the Indian population, one must consider Indian access to and costs for energy, especially electricity. This chapter summarizes available information on these issues from the 1990 Census of Housing (the so-called "long form" of the Decennial Census) and the Energy Information Administration's (EIA) 1997 Residential Energy Consumption Survey (RECS), a national sample survey of household energy use that enables energy data to be evaluated according to household characteristics. Both the Census of Housing data and the RECS data for U.S. households as a whole are quite precise, but RECS data for Indian households are subject to larger uncertainty because Indian households are a small proportion of households in the country, and thus, in the RECS sample.

Of the approximately 600,000 Indian households in the United States in 1990, almost 20 percent were on Indian reservations with over 500 households. Another 10 percent were located in so-called Tribal Jurisdictional Statistical Areas (TJSAs) in Oklahoma, and the remaining 70+ percent were spread across the country. The Indians in households not on Indian lands, as well as those in the TJSAs, had access status for electricity similar to U.S. households as a whole (Figure 1). Only a small percentage of households were recorded by the 1990 Housing Census as having no cost for electricity/no access. However, Indians on reservations were another story. Fully one in 7 households, about

Figure 1. Percent Distribution of U.S. and Indian Households by Electricity Access/Payment Status, 1990



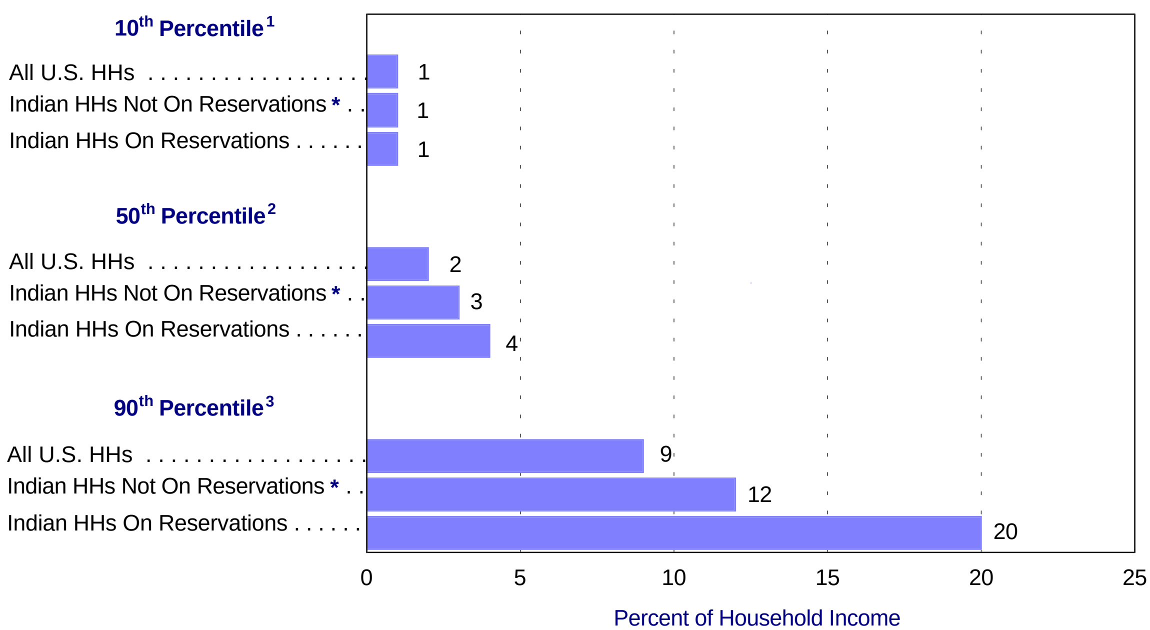
Source: U.S. Bureau of the Census, 1990 Decennial Census of Housing.

16,000 total, were in the no cost / no access category, and authoritative sources state that the reason is the lack of access to electricity, not central purchasing organizations or other arrangements that might provide Indian households with access at no cost.[4] Over three-quarters of these 16,000 households were located on the Navajo reservation of Arizona / New Mexico, where over one-third of the 34,000 households did not have access, even though generation and transmission facilities are located within the boundaries of the reservation. Detailed information from the 1990 Census of Housing, which include data for individual TJSAs and reservations of over 500 Indian households, is given in Appendix B.

Indian households that did pay for electricity in 1990 had costs that were similar to U.S. households as a whole, whether or not they were on reservations. However, because of their generally lower household incomes, electricity costs were a greater burden for Indian households, especially those on reservations (Figure 2). While the distribution of electricity costs relative to household income was only slightly more burdensome for Indian households outside of reservations than for the general population, fully 10 percent of Indian households on reservations spent 20 percent or more of their income on electricity.

The access issue is much less clear for natural gas and other fuels (e.g., coal, wood, and propane). These are not considered as crucial for the modern lifestyle as electricity and are not used by virtually all U.S. households, as electricity is. However, for Indian households on reservations that do pay for these fuels, the burden remains. The most-burdened 10 percent of these households paid a much higher proportion of their income for these fuels in 1990 than did U.S. households as a whole or non-reservation Indian households (Figure 3). It should also be noted that 37 percent of Indian households on reservations used and paid for one or more fuels besides natural gas and electricity in 1990, a

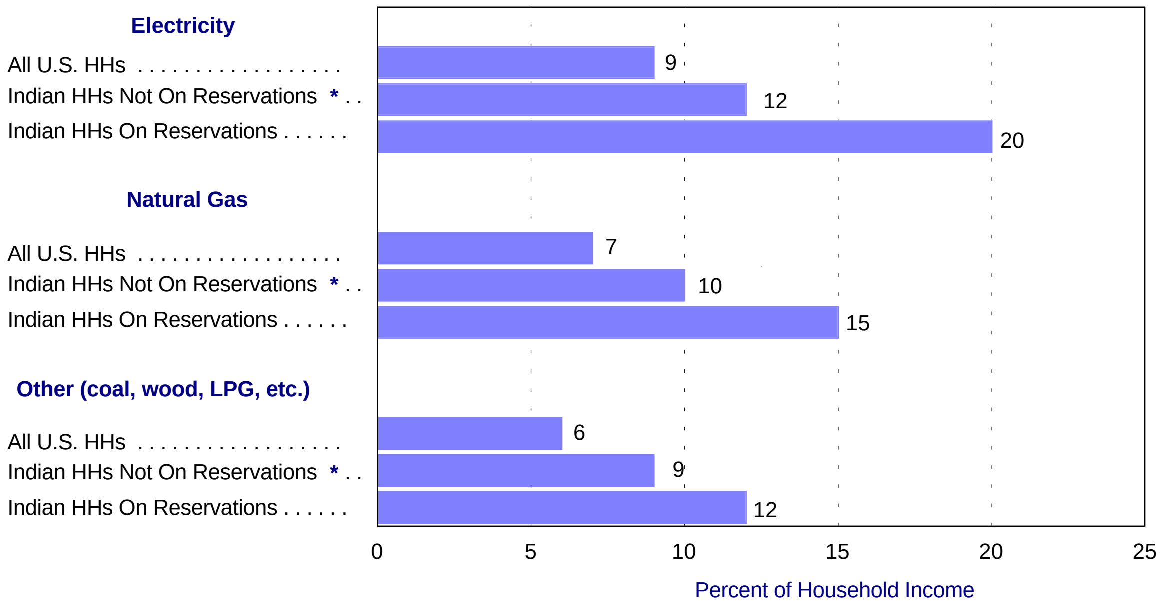
Figure 2. Percentiles of Electricity Costs Relative to Total Household Income, for Households That Pay for Electricity, 1990



HHs = Households.
[1] 10th percentile indicates that the least-burdened 10 percent of households pay no more than this percentage of income for electricity.
[2] 50th percentile indicates the median electricity expenditures as a percent of income.
[3] 90th percentile indicates that the most-burdened 10 percent of households pay at least this percentage of income for electricity.
* Includes households in TJSAs.
Source: U.S. Bureau of the Census, 1990 Decennial Census of Housing.

[4] Based on conversations with Richard Wilson of the Bureau of Indian Affairs on February 17, 2000 and David Lester of the Council of Energy Resource Tribes on February 25, 2000.

Figure 3. 90th Percentile[1] of Energy Costs Relative to Total Household Income for Households Paying for the Energy, 1990



HHs = Households; LPG = Liquefied Petroleum Gases.
[1] 90th percentile indicates that the most-burdened 10 percent of households paying for an energy source paid at least this proportion of their household income for it.
* Includes households in TJSAs.
Source: U.S. Bureau of the Census, 1990 Decennial Census of Housing.

percentage that is twice as high as for U.S. households in general (18.4 percent) or for Indian households not on reservations (17.5 percent).

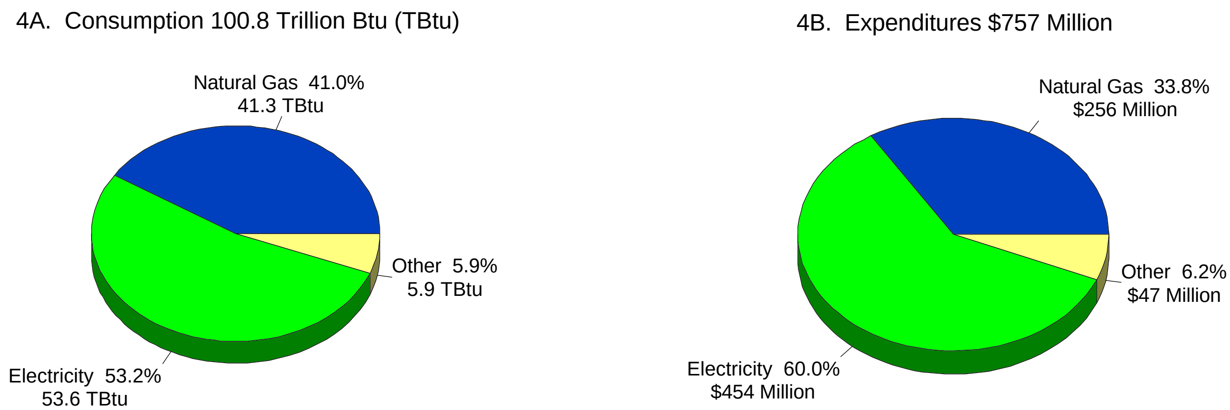
The next portion of this chapter focuses on more recent data from the EIA's 1997 Residential Energy Consumption Survey (RECS), which includes energy consumption as well as expenditures data, but is much less precise due to its relatively small sample size, especially for Indian households.[5] The 1997 RECS estimates that Indian households consumed about 101 trillion Btu (TBtu) of major energy sources (electricity, natural gas, LPG, fuel oil, and kerosene) in 1997, roughly the same amount as households in the Kansas City metropolitan area. Over half this energy, about 54 trillion Btu, is electricity (including power station use and transmission losses), and another 41 trillion Btu is natural gas. Together, these two sources account for 94 percent of major energy use (Figure 4), about the same fraction that they repre-sent for all U.S. households. The electricity quantity is equivalent to 5.2 billion kWh, about the amount that could be generated by a 600-MW power plant operating at full capacity 24 hours per day throughout the year. The total 1997 energy bill for Indian households was about $750 million. Electricity accounted for three-fifths of Indian household energy expenditures, and natural gas about one-third.

The average Indian household consumed about 143 million Btu of primary energy (including electricity losses), 28 million less than the average across all U.S. households, geographically adjusted.[6] This difference across

[5] RECS data cover all Native American households, whether on tribal lands or not.

[6] The remainder of this section compares average household energy use and expenditures and average energy prices for Indian households and U.S. households as a whole. One major problem with such comparisons is that Indian households are distributed much different geographically across the U.S. than households of other groups. Energy use and energy costs vary widely by geographic area, due to availability of energy sources, utility cost structures, etc. Thus, unadjusted comparisons between Indian households and U.S. households as a whole might reflect geographic differences rather than any difference attributable to Indian experience. To address this concern, all data for U.S. households are adjusted so that they are based on a distribution in the geographic areas measured by the RECS that is the same as the distribution of Indian population in those areas as of July 1, 1997, according to the U.S. Census Bureau's population data set PE-65, "Estimates of the Population of States by Age, Sex, Race, and Hispanic Origin: 1990 to 1997."

Figure 4. Energy Consumption and Expenditures for Major Energy Sources in All Indian Households, 1997



Source: Energy Information Administration, 1997 Residential Energy Consumption Survey.

major energy sources is of marginal statistical significance. However, the average Indian household supplied with electricity clearly uses less than the average U.S. household. On average, Indian households use only about 75 percent of the electricity used by U.S. households in general, a statistically significant difference (Figure 5).

Primarily because of this substantial difference in electricity use, the average 1997 energy bill for Indian households was almost $1,100, nearly $200 less than the average bill for all U.S. households—a significant difference. Natural gas, however, does not show a significant difference (Figure 6). Indian households paid prices for electricity (8.7 cents per kWh) and natural gas ($6.36 per thousand cubic feet) that were not significantly different from the prices paid by U.S. households as a whole (Figure 7). In other words, while Indian households use less energy, and specifically, less electricity than U.S. households as a whole, RECS shows no evidence of differential price experience for Indian households.

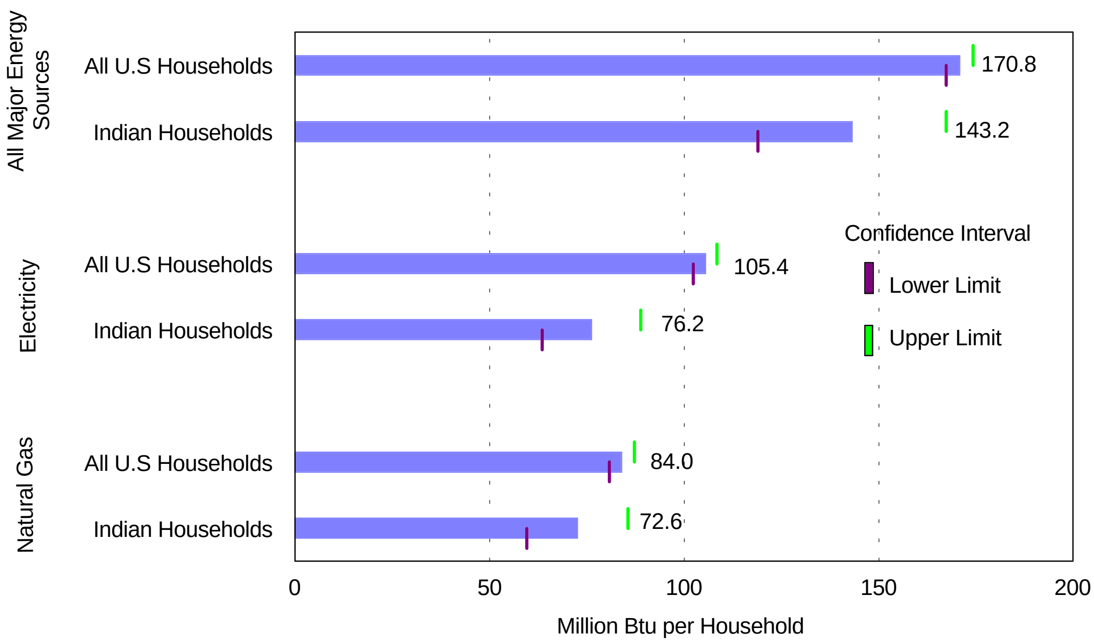
Retail Electricity Rates Paid by Indians Living on Indian Reservations and TJSAs

For comparison with the RECs survey statistics gathered from the Indian households, additional information on electricity prices on Indian Reservations and TJSAs in 1998 was estimated from the electric utilities serving those areas. EIA's "Annual Electric Utility Report" (Form EIA-861) collects data from all electric utilities on their residential sales and revenues in each State. The survey does not specifically identify Indian lands, however, so average prices have been estimated using several sources to identify the utilities serving each Indian land. These prices should thus be viewed as approximate.

Roughly 40 percent of Indian households on reservations and TJSAs pay between 7.0 and 7.5 cents per kWh for electricity in their homes (Figure 8). Ninety-two percent of the 175,000 Indian households on Indian lands are located in just four of the North American Electric Reliability Council subregions (Table 1). Electric utilities servicing counties containing Indian lands in three of those four subregions have higher rates than all utilities with residential customers in the subregion. From these data, it is impossible to determine whether the higher costs are due to the cost of service for sparsely populated rural areas, including Indian lands, or other factors.

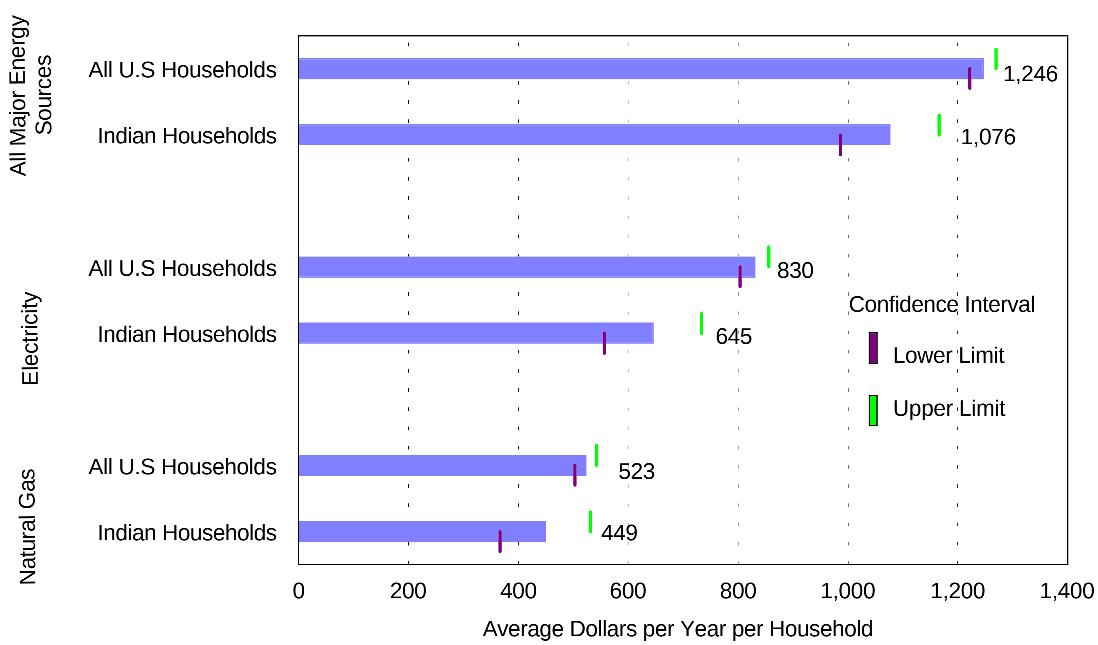
Not surprisingly, the reservations with the lowest prices are those in the Pacific Northwest where extensive hydropower is available, while the highest prices are in Maine, New York, and California (Table 2). Reservations in New Mexico are also estimated to have relatively high rates.

Figure 5. Consumption in 1997 Per Household Using Energy Source: All U.S. Households and All Indian Households



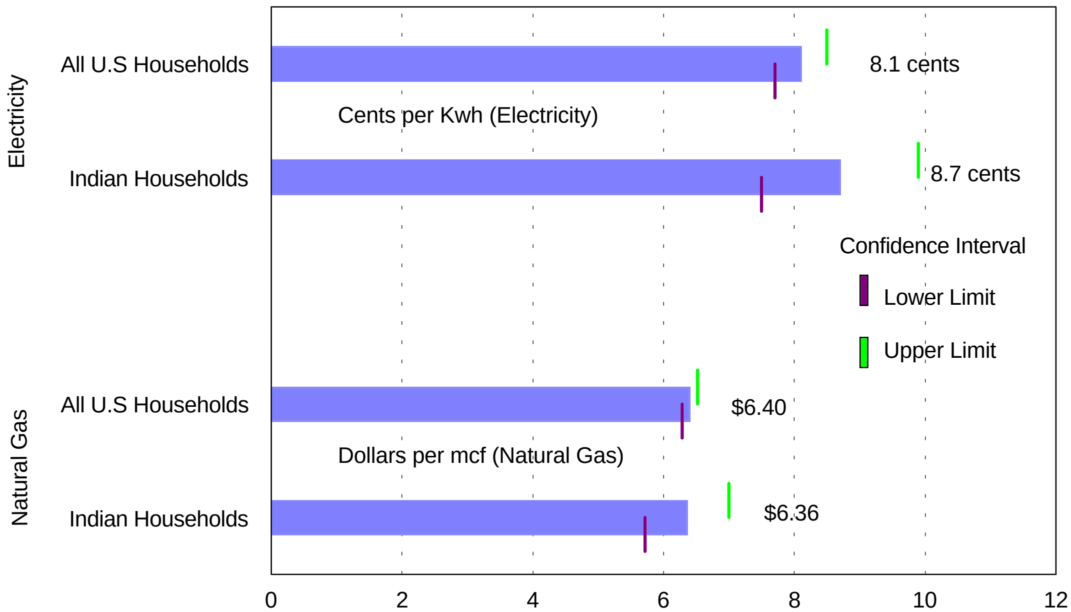
Source: Energy Information Administration, 1997 Residential Energy Consumption Survey.

Figure 6. Expenditures in 1997 Per Household Using Energy Source: All U.S. Households and Indian Households



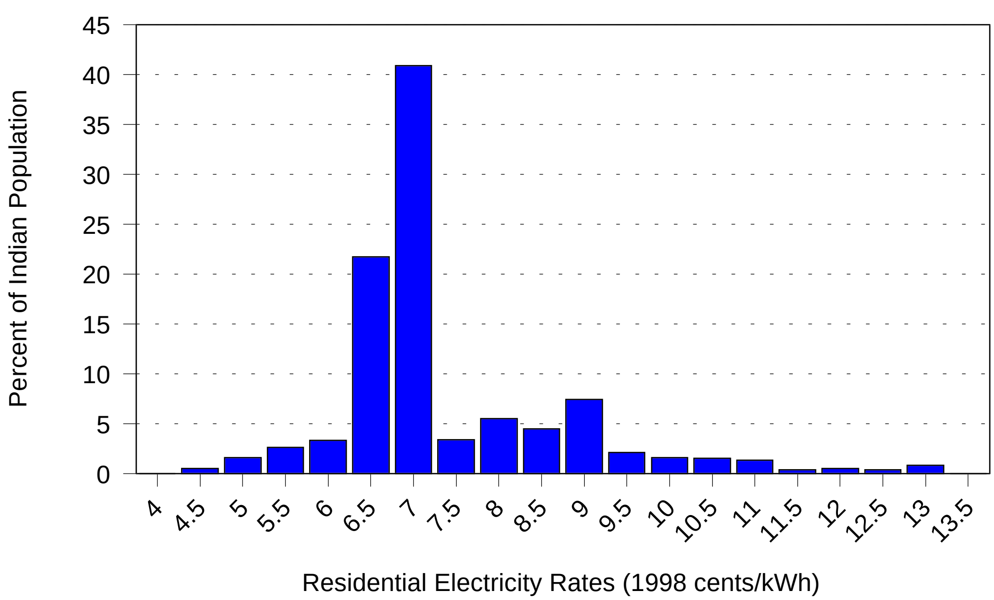
Source: Energy Information Administration, 1997 Residential Energy Consumption Survey

Figure 7. Electricity and Natural Gas Prices: All U.S. Households and All Indian Households



mcf = Thousand Cubic Feet.
Source: Energy Information Administration, 1997 Residential Energy Consumption Survey.

Figure 8. Distribution of Residential Electricity Rates on Indian Lands



Note: Costs shown are for ranges between consecutive figures.
Source: Energy Information Administration estimates as documented in this report from Energy Information Administration, 1998 Form EIA-861, "Annual Electric Utility Report," and Bureau of Census, 1990 Decennial Census.

Table 1. 1998 Residential Average Revenue per Kilowatthour (1998 Cents/kWh)

NERC Region	Average for All U.S. Households							
	NERC Sub-region	Coop-eratives	Investor-Owned Utilities	Municipal Utilities	All Other	All Households Average	Average for Indians on Indian Lands[a]	Percent of Indian Households
ECAR	ECAR	6.8	7.9	6.4	6.2	7.7	8.5	0.2
ERCOT	ERCOT	7.5	8.0	7.0	–	7.8	–	--
MAAC	MAAC	9.2	10.2	8.6	–	10.1	–	--
MAIN	EM	6.8	7.2	7.0	–	7.2	–	--
MAIN	NI		10.7	7.4	–	10.6	–	--
MAIN	SCI	10.1	8.7	6.6	–	8.8	–	--
MAIN	WUM	8.1	7.3	5.9	--	7.2	7.8	1.6
MAPP	MAPP	7.4	8.0	6.1	6.7	7.4	7.8	11.1
NCPP	NEPX	15.5	11.7	9.4	--	11.6	13.2	0.3
NCPP	NYPP	8.5	14.1	4.0	13.5	13.6	12.8	1.2
SERC	FL	7.9	8.1	7.6	--	8.0	8.4	0.3
SERC	SOC	7.7	7.3	7.1	5.8	7.4	6.9	0.5
SERC	TVA	6.6		6.3	--	6.4		
SERC	VACAR	8.2	7.7	8.5	6.6	7.9	8.4	1.1
SPP	N	7.6	7.4	6.8	--	7.3	9.2	0.2
SPP	SE	7.1	7.4	6.9	6.3	7.3	6.8	0.1
SPP	WC	7.0	6.3	6.4	--	6.4	7.1	38.0
WSCC	AZN	10.2	9.4	8.3	7.9	8.9	8.2	31.2
WSCC	CNV	6.7	10.6	10.0	8.3	10.3	10.6	2.1
WSCC	NWP	5.9	6.1	4.7	4.5	5.6	6.3	11.7
WSCC	RMPA	7.7	7.6	6.4	8.3	7.4	8.1	0.4

[a] Note that 92 percent of the Indian population living on Indian land, are in 4 regions: MAPP, SPP/WC, WSCC/AZN, and WSCC/NWP.

– = Not applicable.

NERC = North American Electric Reliability Council. See Appendix D for map of NERC regions.

Source: Energy Information Administration, 1998 Form EIA-861, "Annual Electric Utility Report," and EIA estimates as documented in this report.

Methodology for Estimating Electricity Rates Paid by Indian Land Households

The EIA-861 data were used as the source of all utility average residential electricity prices. To assign one or more utilities to each Indian land as the most likely provider, EIA used the following sources:

- A list from the Rural Utilities Service (RUS) of Cooperative Utilities that serve Native Americans
- Information from various web sites about utilities that sold electricity to Indian lands
- Specific information on the utilities serving the Navajo Tribal Utility Authority and the Tohono O'Odham Tribal Authority
- General information and assumptions about electricity providers to Indian lands.

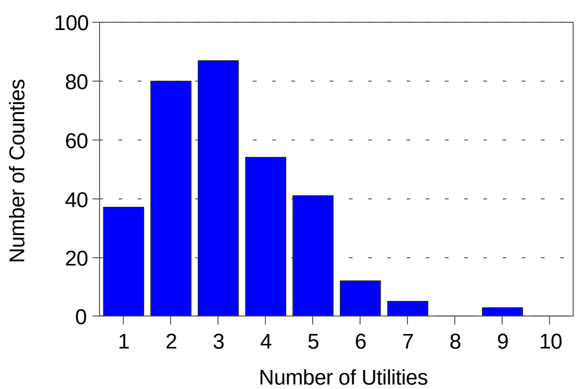
For the majority of Indian lands, counties in the Indian land were matched with utilities having residential sales in those counties. However, in most counties, there are multiple utility providers, including investor-owned utilities (IOUs), cooperatives, and other providers, such as public utility districts, State agencies, or Federal agencies. Municipals were excluded because they serve single towns or cities and would overstate the number of potential providers to the reservations. Of the 319 counties which contain populated portions of reservations or TJSAs, almost 40 were served by only one utility, but 61 had 5 or more utilities (Figure 9).

Table 2. Reservations with the Highest Residential Electricity Prices

Reservation Name	State	Indian Population	Average Residential Price (1998 cent/kWh)
Penobscot Reservation and Trust Lands	ME	417	13.4
Indian Township Reservation	ME	541	13.3
Pleasant Point Reservation	ME	523	13.3
Onondaga Reservation	NY	2	13.2
St. Regis Mohawk Reservation	NY	1,923	13.2
Tuscarora Reservation	NY	310	13.2
Agua Caliente Reservation	CA	117	13.1
Cabazon Reservation	CA	20	13.1
Cahuilla Reservation	CA	82	13.1
Morongo Reservation	CA	527	13.1
Pechanga Reservation	CA	289	13.1
Santa Rosa Reservation	CA	37	13.1
Soboba Reservation	CA	308	13.1
Cattaraugus Reservation	NY	2,051	13.0
Torres-Martinez Reservation	CA	143	12.9
Oil Springs Reservation	NY	0	12.6
Mescalero Apache Reservation	NM	2,516	12.4
Tonawanda Reservation	NY	453	12.1

Note: Several reservations are in the same county and therefore have the same estimated electricity prices.
Source: EIA estimates as documented in this report.

Figure 9. Number of Non-Municipal Utilities Serving Counties with Indian Lands



Source: Energy Information Administration, 1998 Form EIA-861, "Annual Electric Utility Report," and Bureau of Census, 1990 Decennial Census.

If there was no information to determine which utility was the provider, it was assumed that if a cooperative were in a county in which there was an Indian land, then it was the likely provider. In cases where more than one of these cooperatives was listed for a county, their rates were averaged. The methodology further assumed that if the Bureau of Indian Affairs (BIA) sold power in the county, it was a likely provider. For the remaining counties, where no RUS borrower or BIA was designated, the residential rates of all the IOUs and cooperatives serving the county were averaged. If there were no IOUs or cooperatives in a county, which occurred in a few cases in the Northwest, then the Public Utility District average rate was used.

Average residential electric rates by county were combined into an average for each Indian land by weighting each county according to the number of households in the county.

3. Potential for Renewable Energy

Introduction

This chapter provides information needed to determine good renewable energy prospects on Indian tribal lands. It begins with a series of maps showing U.S. renewable energy resources and the Nation's electricity grid with an overlay of Indian tribal land boundaries. Following the maps is an assessment by individual tribal land of the premium for each renewable electricity resource over the cost of purchased electricity. The results include two lists of sites for further investigation. One shows Indian lands where the marginal cost of renewable energy over current wholesale electricity cost was least; the other shows the highest percentage of tribal members without electricity.

Because renewable energy availability tends to be highly site-specific and because there are often restrictions and other considerations on land use for renewable energy projects, it is essential to conduct individual project and site analyses before beginning any project. This chapter provides an outline for this process following the data on renewable electricity costs and concludes with a discussion of limitations in developing renewable resources.

Renewable Resources on Indian Lands

Federal and Oklahoma Indian tribal lands are located primarily in the western United States (Figure 10). This also tends to be where renewable resources are located. Maps of solar/photovoltaic, concentrated solar power, wind, biomass, and geothermal resources are shown overlaying tribal land boundaries (Figures 11-15). For hydropower, no map-friendly source of resource potentials was readily available. Therefore, EIA developed a generic assessment of new hydroelectric plant costs, based on studies conducted by the Department of Energy's Idaho National Engineering and Environmental Laboratory (INEEL). Finally, the potential for renewable resources—particularly for selling renewable power into the grid—is strongly influenced by access to transmission lines, transmission line capability, and transmission line load (Figure 16). Figure 16 shows transmission and location information. Unfortunately, no comprehensive source of data on transmission line load exists.

A major caveat exists in applying resource estimates to small land area reservations. Resources are estimated either at the county level or some other small grid level (e.g., 25 by 25 miles for solar). However, some reservations are much smaller than this grid size. In those cases, it is quite possible that either the resources listed are not actually on the reservation (e.g., biomass) or there are small-area considerations that make the resource not viable on the reservation.

Federal and Oklahoma Indian Lands

The map showing the boundaries of Federally Recognized American Indian Reservations and Tribal Jurisdictional Statistical Areas (in Oklahoma) indicates the areas that are the subject of this report. It is derived from a similar one available from the U.S. Department of the Interior, Bureau of Indian Affairs, Geographic Data Service Center (GDSC). A series of Indian maps are available on the GDSC website: http://www.gdsc.bia.gov/maps.htm#epa1. Underlying data is based on the U.S. Department of Commerce, Bureau of Census, 1992 Tiger Line Files.

Solar Resources for Flat Plate Collectors

Figure 11 provides monthly average daily total solar resource information on grid cells of approximately 40 km by 40 km in size. The insolation values represent the resource available to a flat plate collector, such as a photovoltaic panel, oriented due south at an angle from horizontal equal to the latitude of the collector location. This is common practice for PV system installation, although other orientations are also used.

Figure 10. Federal and Oklahoma Indian Lands

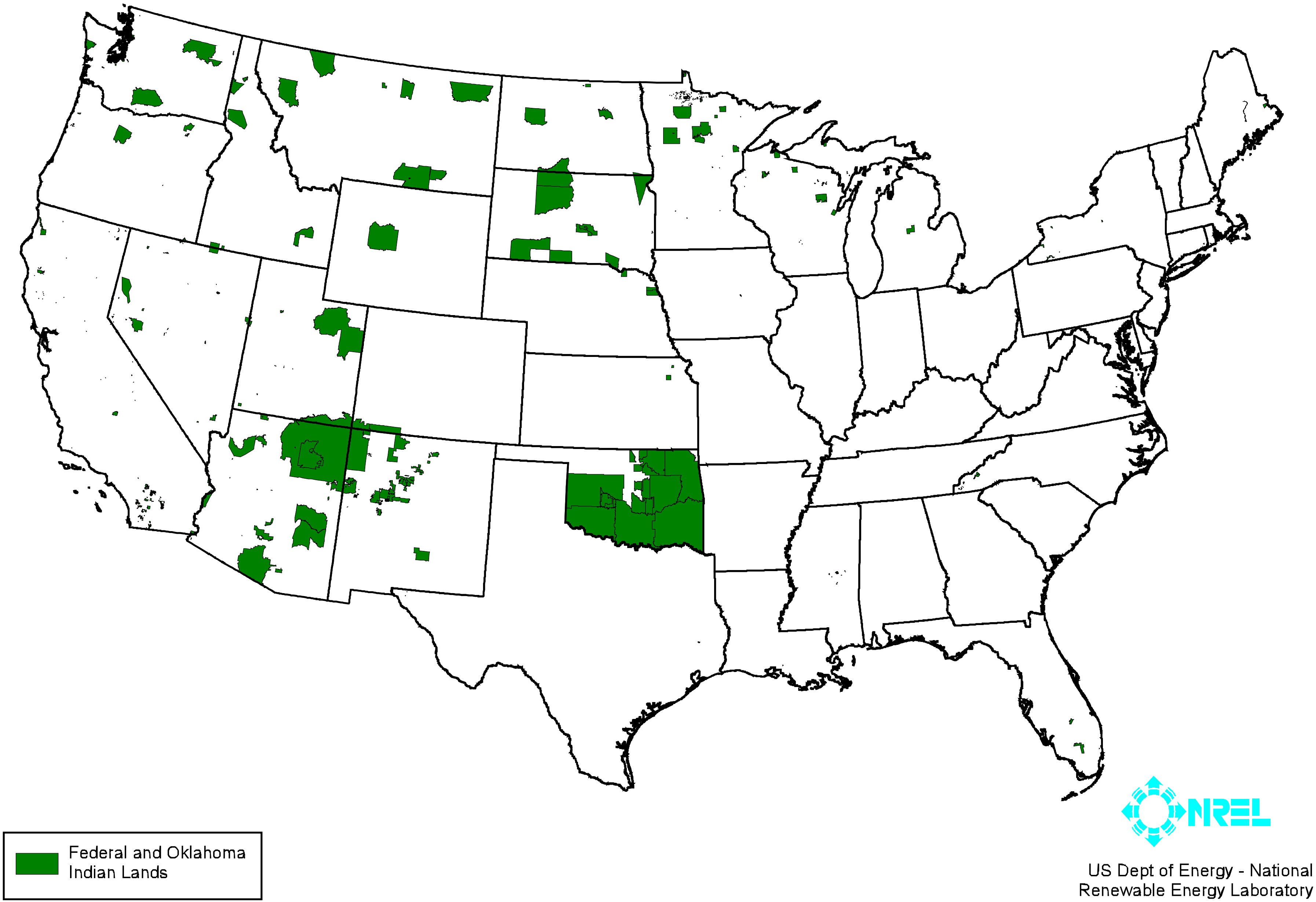


Figure 11. Solar Photovoltaic (PV) Resource Potential

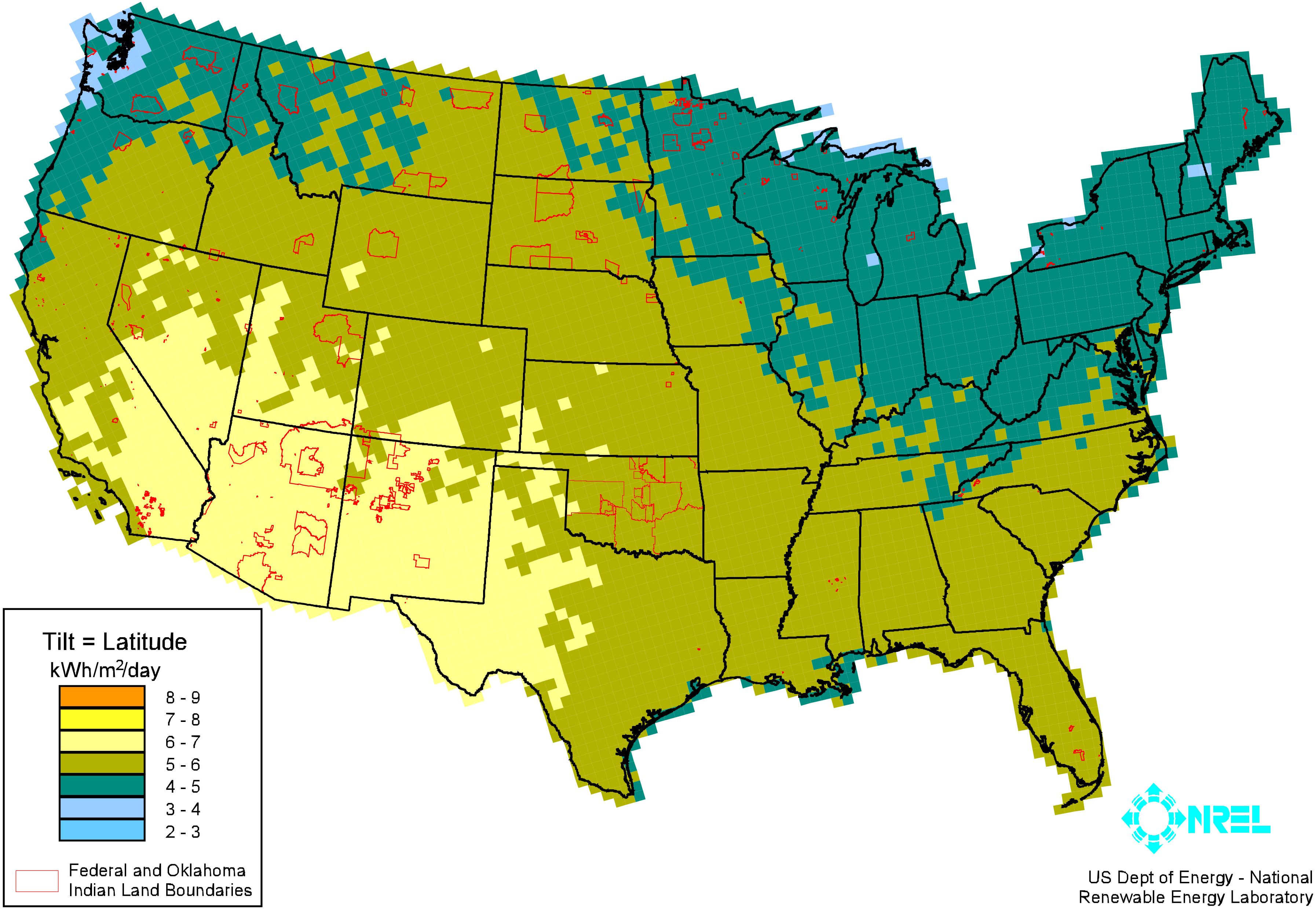


Figure 12. Concentrated Solar Power (CSP) Resource Potential

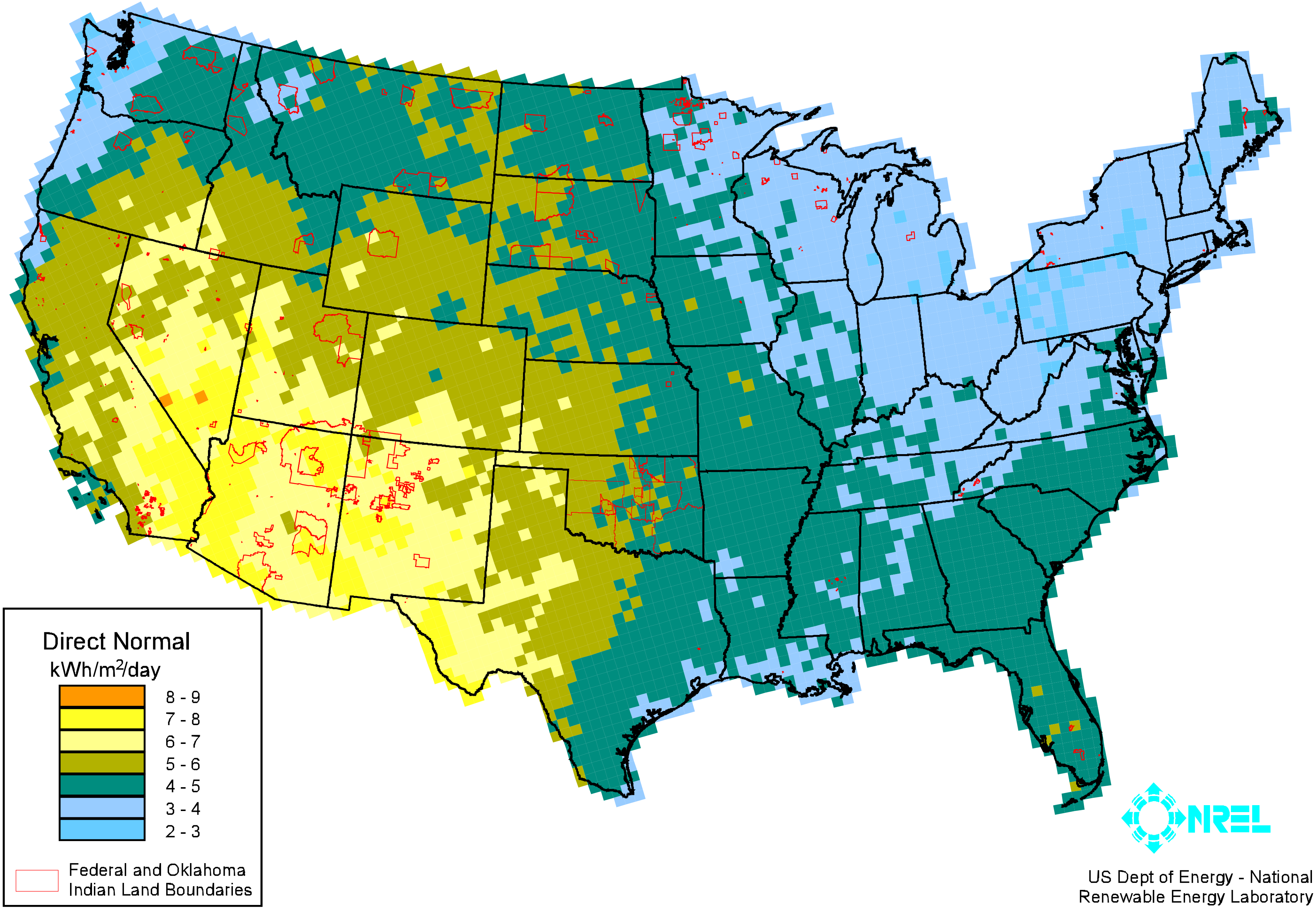


Figure 13. Wind Resource Potential

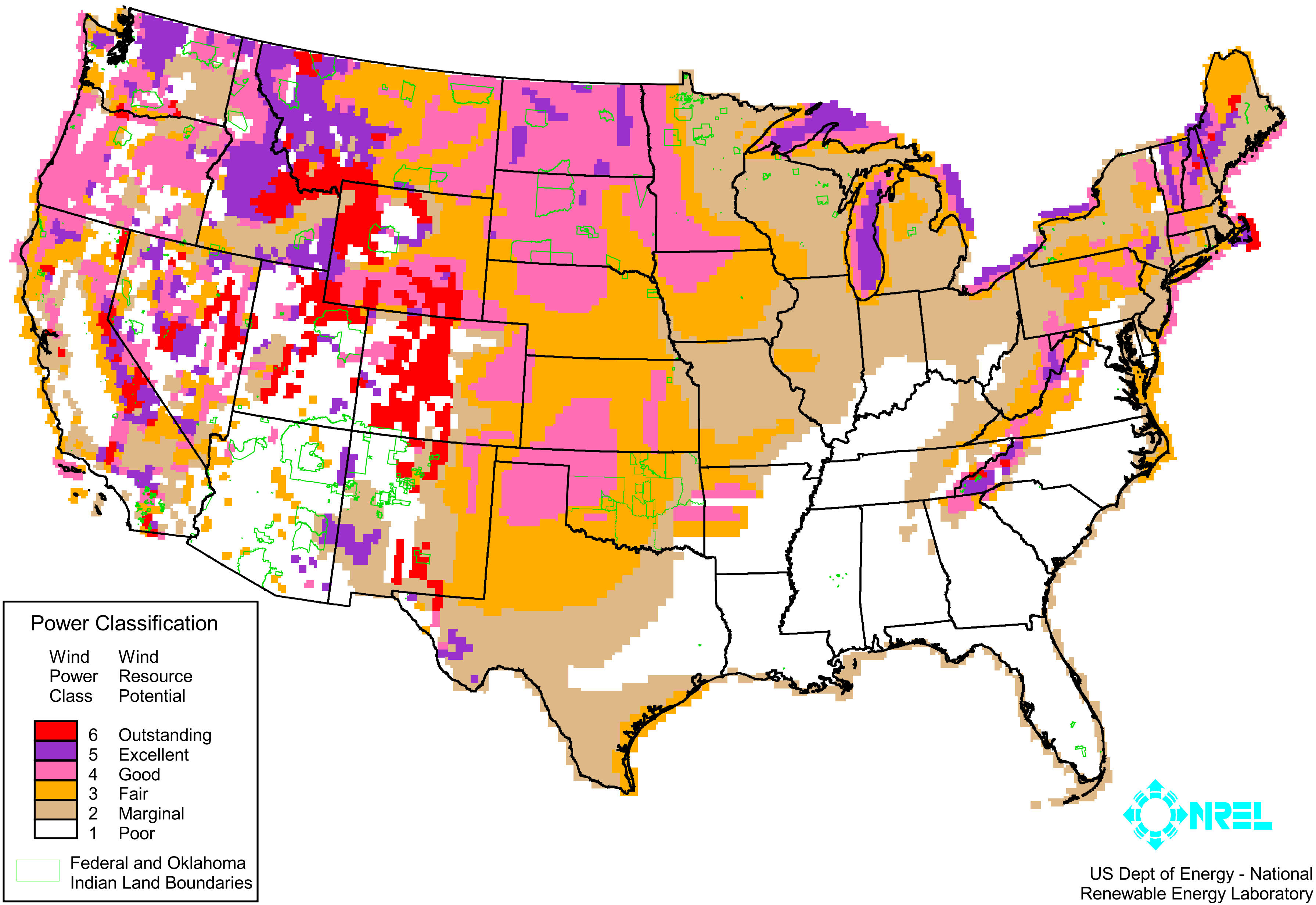


Figure 14. Biomass and Biofuels Resource Potential

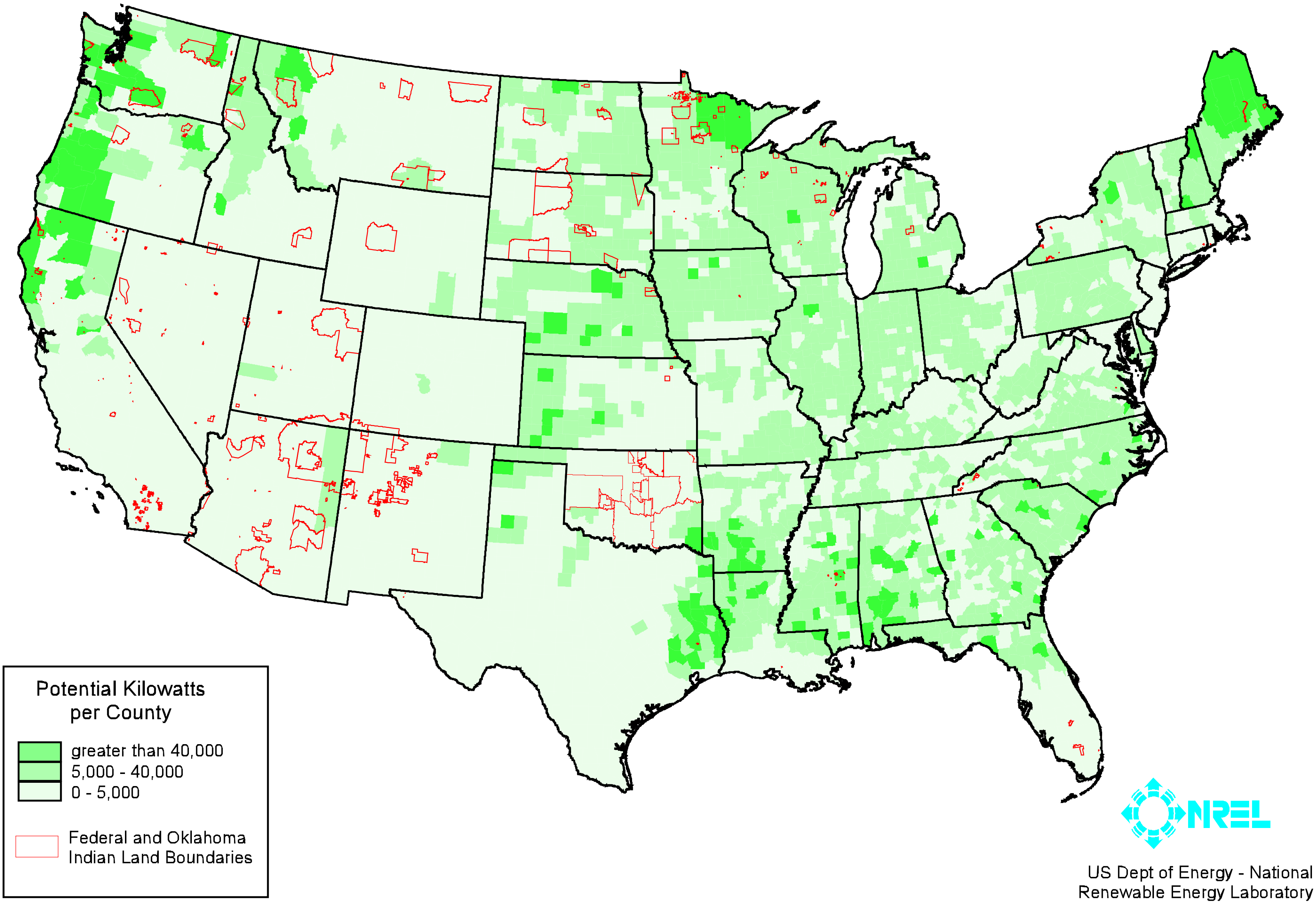


Figure 15. Geothermal Resource Potential

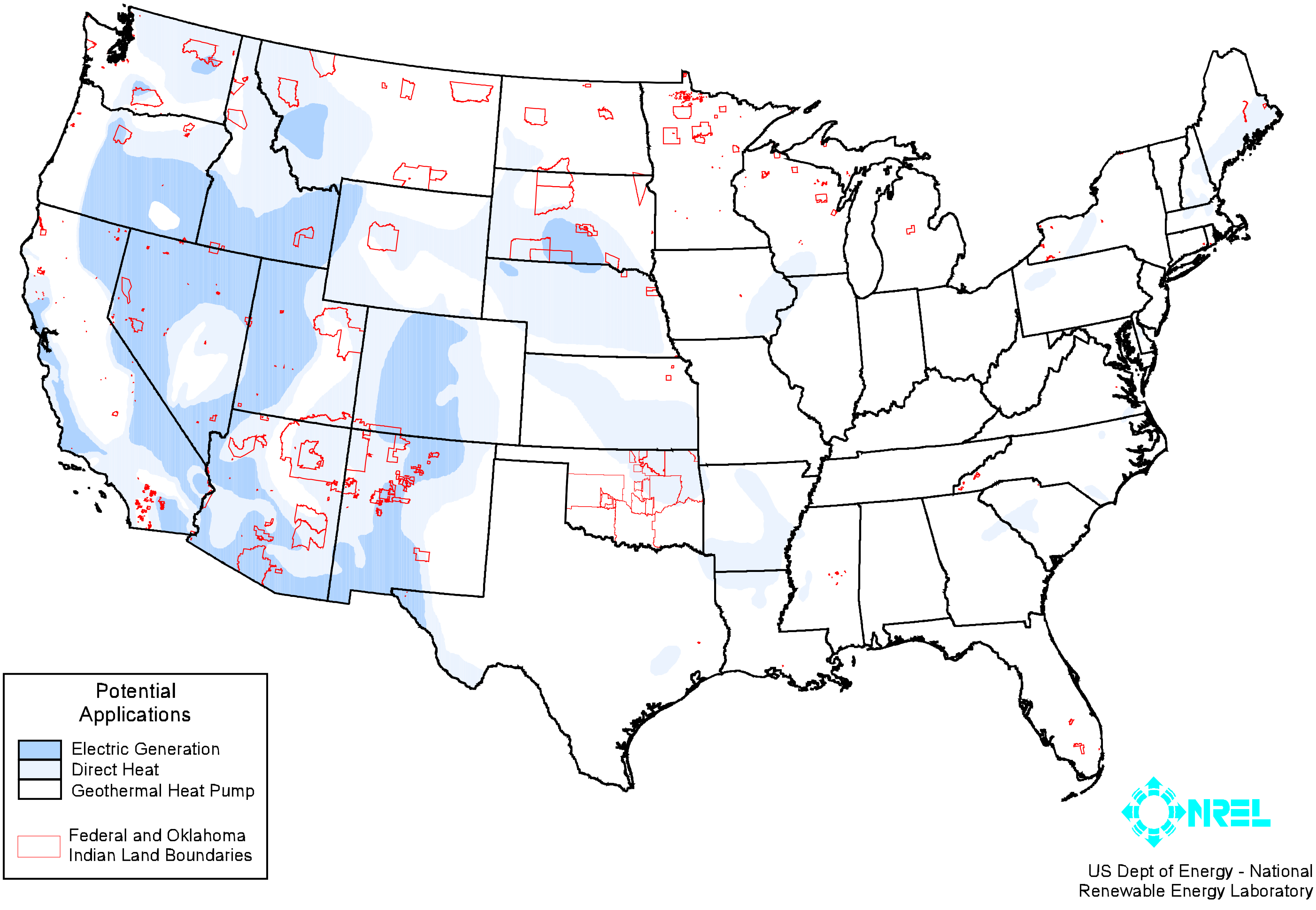
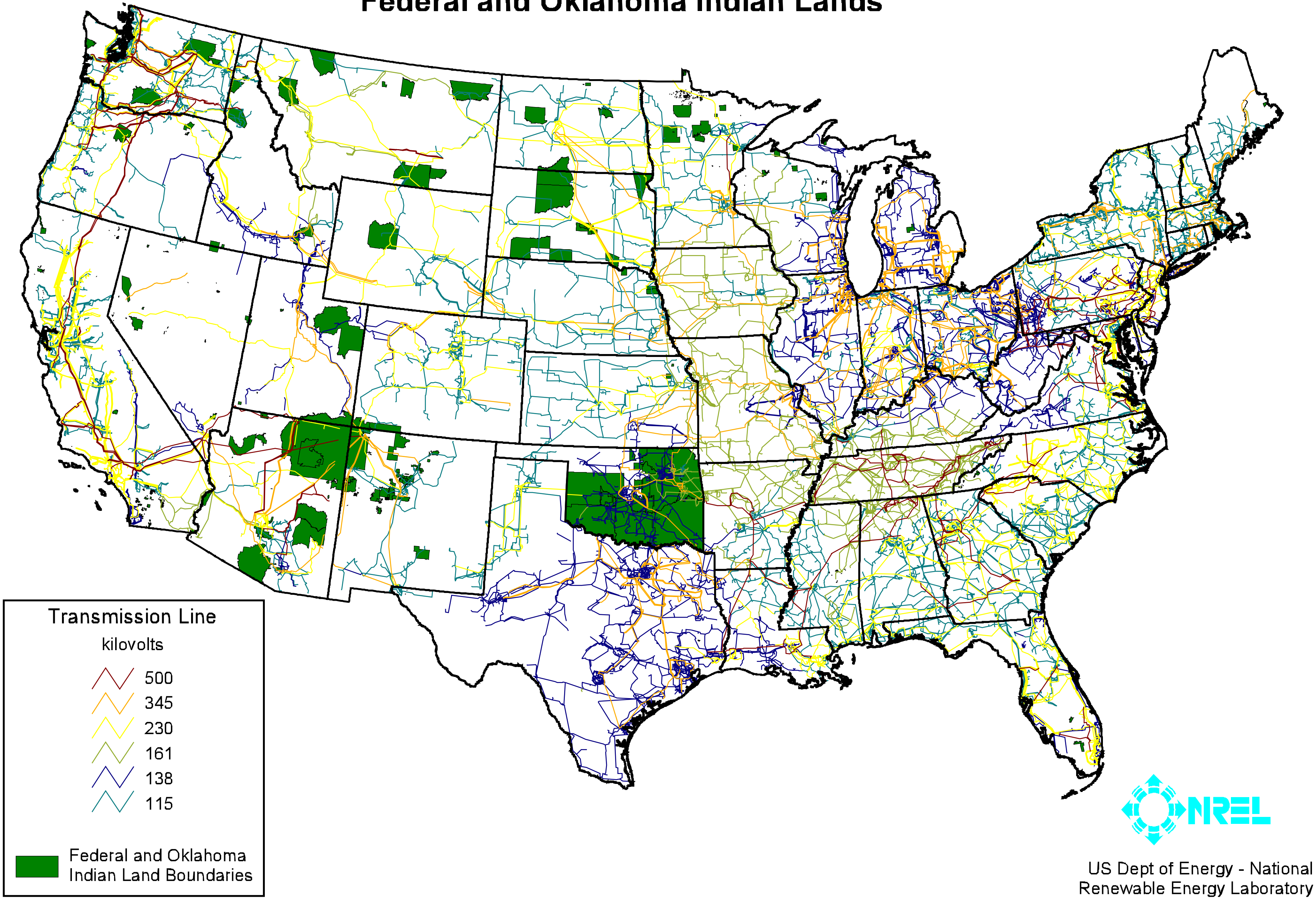


Figure 16. Transmission Lines with Federal and Oklahoma Indian Lands



The map was developed from the Climatological Solar Radiation (CSR) Model. The CSR model was developed by the National Renewable Energy Laboratory for the U.S. Department of Energy.[7, 8] This model uses information on cloud cover, atmospheric water vapor and trace gases, and the amount of aerosols in the atmosphere, to calculate the monthly average daily total insolation (sun and sky) in units of kilowatthours per meter squared per day (kWh / m^2 / day falling on a horizontal surface. The cloud cover data used as input to the CSR model are an 8-year histogram (1985–1992) of monthly average daily cloud fraction provided for grid cells of approximately 40 km x 40 km in size. Thus, the spatial resolution of the CSR model output is defined by this database. The data are obtained from the National Climatic Data Center in Asheville, North Carolina, and were developed from the U.S. Air Force Real Time Nephanalysis (RTNEPH) program. Atmospheric water vapor, trace gases, and aerosols are derived from a variety of sources, as summarized in the references. The procedures for converting the modeled global horizontal insolation into the insolation received by a flat plate collector at latitude tilt are described in Marion and Wilcox (1994).[9]

Because the resource data are for a non-tracking system, the available resource tends to be lower than for concentrating systems in sunny areas, but higher in cloudy areas. This is because under cloudy conditions PV systems can still convert the sky radiation to useable electricity, whereas concentrators shut down completely when the sun is obscured by clouds.

Where possible, existing ground measurement stations are used to validate the model. Nevertheless, there is uncertainty associated with the meteorological input to the model, since some of the input parameters are not available at a 40-km resolution. As a result, it is believed that the modeled values are accurate to approximately 10 percent of a true measured value within the grid cell. Due to terrain effects and other microclimate influences, the local cloud cover can vary significantly even within a single grid cell. Furthermore, the uncertainty of the modeled estimates increases with distance from reliable measurement sources and with the complexity of the terrain.

Areas with ratings of at least 5 to 6 kWh / m^2 / day are required to be considered suitable for development.

Solar Resources for Concentrating Systems

Figure 12 provides monthly average daily total solar resource information on grid cells of approximately 40 km by 40 km in size. The insolation values represent the resource available to concentrating systems that track the sun throughout the day. Such systems include concentrating solar power systems such as trough collectors or dishes. The values are also useful for assessing the resource available to solar hot water systems.

The map was developed from the Climatological Solar Radiation (CSR) Model. The CSR model was developed by the National Renewable Energy Laboratory for the U.S. Department of Energy.[10, 11] This model uses information on cloud cover, atmospheric water vapor and trace gases, and the amount of aerosols in the atmosphere, to calculate the monthly average daily total insolation) in units of kWh / m^2 / day falling on a device that tracks the sun throughout the day. The cloud cover data used as input to the CSR model are an 8-year histogram (1985–1992) of monthly average daily cloud fraction provided for grid cells of approximately 40 km x 40 km in size. Thus, the spatial resolution of the CSR model output is defined by this database. The data are obtained from the National Climatic Data Center in Asheville, North Carolina, and were developed from the U.S. Air Force Real Time Nephanalysis (RTNEPH) program. Atmospheric water vapor, trace gases, and aerosols are derived from a variety of sources, as summarized in the references.

[7] Maxwell, E, R. George and S. Wilcox, "A Climatological Solar Radiation Model," in *Proceedings of the 1998 Annual Conference, American Solar Energy Society* (Albuquerque NM).

[8] George, R, and E. Maxwell, 1999: "High-Resolution Maps of Solar Collector Performance Using A Climatological Solar Radiation Model," in *Proceedings of the 1999 Annual Conference, American Solar Energy Society* (Portland, ME).

[9] Marion, W. and S. Wilcox, 1994: "Solar Radiation Data Manual for Flat-plate and Concentrating Collectors," NREL / TP-463-5607, National Renewable Energy Laboratory (1617 Cole Boulevard, Golden, CO, 80401).

[10] Maxwell, E, R. George and S. Wilcox, "A Climatological Solar Radiation Model," in *Proceedings of the 1998 Annual Conference, American Solar Energy Society* (Albuquerque NM).

[11] George, R, and E. Maxwell, 1999: "High-Resolution Maps of Solar Collector Performance Using A Climatological Solar Radiation Model," in *Proceedings of the 1999 Annual Conference, American Solar Energy Society* (Portland, ME).

Because the resource data are for a tracking system, the available resource tends to be higher than for non-tracking systems in sunny areas, but lower in cloudy areas. This is because under cloudy conditions tracking systems are unable to use any of the solar resource, which is obscured, while flat plate collectors can still make use of the sky radiation that is still available.

Where possible, existing ground measurement stations are used to validate the model. Nevertheless, there is uncertainty associated with the meteorological input to the model, since some of the input parameters are not available at a 40-km resolution. As a result, it is believed that the modeled values are accurate to approximately 10 percent of a true measured value within the grid cell. Due to terrain effects and other microclimate influences, the local cloud cover can vary significantly even within a single grid cell. Furthermore, the uncertainty of the modeled estimates increases with distance from reliable measurement sources and with the complexity of the terrain. Concentrating solar collectors are much more sensitive to solar resource characteristics than flat plate collectors, so that these sources of uncertainty are more important to concentrator applications.

Areas with ratings of at least 5 to 6 kWh/m^2/day are required to be considered suitable for development.

Wind Resources

The national wind resource assessment of the United States was created for the U.S. Department of Energy in 1986 by the Pacific Northwest Laboratory and is documented in the *Wind Energy Resource Atlas of the United States*, October 1986. The atlas can be viewed on the Internet at http://rredc.nrel.gov/wind/pubs/atlas.

The wind resource assessment was based on surface wind data, coastal marine area data and upper-air data, where applicable. In data-sparse areas, three qualitative indicators of wind speed or power were used when applicable: topographic/meteorological indicators (e.g. gorges, mountain summits, sheltered valleys); wind deformed vegetation; and eolian landforms (e.g. playas, sand dunes). The data were evaluated at a regional level to produce 12 regional wind resource assessments, the regional assessments were then incorporated into the national wind resource assessment.

The conterminous United States was divided into grid cells 1/4 degree of latitude by 1/3 degree of longitude (or approximately 18 by 24 miles). Each grid cell was assigned a wind power class ranging from 1 to 7, with 7 being the windiest. The wind power density limits for each wind power class is shown in Table 3. Each grid cell contains sites of varying power class. The assigned wind power class is representative of the range of wind power densities likely to occur at exposed sites within the grid cell. Hilltops, ridge crests, mountain summits, large clearings, and other locations free of local obstruction to the wind are expected to be well exposed to the wind. In contrast, locations in narrow valleys and canyons, downwind of hills or obstructions, or in forested or urban areas are likely to have poor wind exposure.

Table 3. Classes of Wind Power Density at Heights of 10 m and 50 m[(a)]

Wind Power Class*	10 m (33 ft)		50 m (164 ft)	
	Wind Power Density (W/m^2)	Speed[(b)] m/s (mph)	Wind Power Density (W/m^2)	Speed[(b)] m/s (mph)
1	0	0	0	
	100	4.4 (9.8)	200	5.6 (12.5)
2	150	5.1 (11.5)	300	6.4 (14.3)
3	200	5.6 (12.5)	400	7.0 (15.7)
4	250	6.0 (13.4)	500	7.5 (16.8)
5	300	6.4 (14.3)	600	8.0 (17.9)
6	400	7.0 (15.7)	800	8.8 (19.7)
7	1,000	9.4 (21.1)	2,000	11.9 (26.6)

[a] Vertical extrapolation of wind speed based on the 1/7 power law.
[b] Mean wind speed is based on Rayleigh speed distribution of equivalent mean wind power density. Wind speed is for standard sea-level conditions. To maintain the same power density, speed increases 3%/1000 m (5%/5000 ft) elevation.
* Note: Each wind power class should span two power densities. For example, Wind Power Class = 3 represents the Wind Power Density range between 150 W/m^2 and 200 W/m^2. The offset cells in the first column attempt to illustrate this concept.

Areas designated class 4 or greater are suitable for most utility-scale wind turbine applications, whereas class 2 and 3 areas are marginal for utility-scale applications but may be suitable for rural applications. Class 1 areas are generally not suitable, although a few locations (e.g., exposed hilltops not shown on the maps) with adequate wind resource for wind turbine applications may exist in some class 1 areas. The degree of certainty with which the wind power class can be specified depends on three factors: the abundance and quality of wind data; the complexity of the terrain; and the geographical variability of the resource. A certainty rating was assigned to each grid cell based on these three factors, and is included in the *Wind Energy Resource Atlas of the United States.*

Biomass Resources

Figure 14 provides county-level estimates of biomass resources available for biofuels production or biomass power stations. The map includes only those resources available from crop and forest residues. It does not include managed crop or forest resources, urban residues, municipal solid waste (MSW) or landfill gas (LFG).

The biomass resource data were derived from several sources. One of the sources was an NREL contracted study of crop residue for 36 eastern States. The data are based on a 3-year average of corn and wheat residue available for energy, taking into account tillage practices and rainfall erosion deterrence. The units for the original data were in dry tons per county. These were converted to total kilowatts per county by assuming that one dry ton is equivalent to 1,100 kW-hr / yr at a 65-percent plant capacity factor and a 35-percent plant conversion efficiency. This study only included the eastern 36 States where data were available. For a few of these 36 States, county level data were missing for a few counties. The report is in draft form, titled "Corn Stover and Wheat Straw Removal Analysis" by Richard G. Nelson.

The forest residue data were derived from the forest inventory and analysis unit of the USDA Forest Service Timber Product Output database retrieval system (see http://srsfia.usfs.msstate.edu/rpa) web site. The data used from this site were county level data for the conterminous United States. The 1996 data included were logging and mill residues, and other removals (precommercial thinnings, land clearing, timber stand improvements, etc.). The logging residue and other removals data were converted into potential kilowatts per county from thousand cubic feet. This was done by assuming that one thousand cubic feet of residue is equivalent to 14 dry tons, and a dry ton is equivalent to 1,100 kW-hr / yr at a 65-percent plant capacity factor and a 35-percent plant conversion efficiency. The mill residue was converted directly from thousand dry tons into potential kilowatts per county.

A resource potential greater than 5,000 kilowatts per county would be required to be a candidate for development.

Geothermal Resources

The map for geothermal resource potential was derived from data obtained from the Southern Methodist University Geothermal Laboratory, Dallas, TX.[12] The resource estimates are based on heat flow rates, which are determined by multiplying the thermal gradient in degrees Kelvin per kilometer (^{0}K/km) and the thermal conductivity in watts per meter degrees Kelvin (W/m-^{0}K).[13]

Geo-referenced data of heat flow in units of mW/m^2 (milliwatts per meter squared), provided by the SMU Geothermal Laboratory at a 5-km resolution, were imported into the Geographic Information System (GIS). Contours were then interpolated for intervals of 10 milliwatts/m^2. Designations for electric generation, direct use, and ground-source heat pump applications were determined to approximate the maps shown on the State Energy Alternatives web site (http://www.eren.doe.gov/state_energy/index.cfm) as follows: (1) Areas designated as having electric generation potential show heat flow rates ranging from 80 to 151 mW/m^2; (2) Areas designated with having direct use potential show heat flow rates ranging from 60 to 80 mW/m^2; and (3) Areas with heat flow rates less than 60 mW/m^2 are considered appropriate only for ground-source heat pump applications.

[12] Geothermal Lab, Department of Geological Sciences, Southern Methodist University. Website at http://www.smu.edu/~geothermal.

[13] Blackwell, D.D., K.W. Wisian, and J.L. Steele, *Geothermal Resource/Reservoir Investigations Based On Heat Flow And Thermal Gradient Data For The United States.* Website at http://id.inel.gov/geothermal/fy97/explore/exp-16.html.

Transmission Lines with Federal and Oklahoma Indian Lands

Figure 16 data were received from the Federal Energy Management Administration (FEMA) around 1993 and represent a schematic of transmission line connectivity. As such, it can be used appropriately to show whether there is or is not a transmission line of a stated voltage in some given area. But it cannot be used for analysis that would require actual knowledge of easement locations.

Hydropower

While hydropower currently contributes the greatest share of renewable electricity generation in the United States, there are several limitations to its expansion. Rivers provide multiple functions that must be balanced, including electricity production, recreation, fisheries and ecological environments. The characteristics of each location are unique and must be thoroughly evaluated in a public manner before licensing can be achieved. This is particularly true when considering new hydroelectric facilities on Indian lands.

The Department of Energy, through its Idaho National Engineering and Environmental Laboratory (INEEL), in conjunction with the ORNL, developed a computer model to perform a State-by-State assessment of undeveloped hydropower potential, based upon the Federal Energy Regulatory Commission's (FERC) Hydroelectric Power Resources Assessment database and other sources.[14] The model takes into consideration various, cultural, fishery, geologic, historic, recreational, scenic and other environmental attributes. Based on the attributes of each site, a suitablility factor for development is assessed. For the purposes of this study, it is critical to note that the model was developed to create regional totals and is not intended to provide definitive estimates for specific sites.

The DOE hydropower program has estimated the following generic information on hydroelectric developments costs, based on 21 projects completed in 1993:

Average unit size: 31 MW
Capital cost: $1,700 to $2,300 per kW
Operation and maintenance costs: 0.7 cents/kWh
Operating life: 50 or more years
Capacity factor: 40 to 50 percent
Total cost: 2.4 cents per kWh

If these characteristics are used to create a levelized cost using the cost of capital and a 20-year life consistent with the other technologies considered in this report, the total cost ranges from 5.2 to 8.4 cents per kWh. In contrast, DOE estimated that levelized total costs were 2.4 cents per kWh. Part of the reason for their lower levelized cost compared to estimate is likely due to the consideration of an economic recovery period of 50 years rather than 20 years. This alone cannot account for the entire difference, however, so a much lower cost of capital, such as 3 percent real annualized cost, must have been used to achieve its levelized total cost estimate of 2.4 cents per kWh.

As another point of comparison, FERC assumes a 30-year life in its hydropower licensing process. Making this assumption along with EIA assumptions on the real cost of capital, the total levelized cost ranges from 4.8 to 7.7 cents per kWh.

Renewable Resources and Development Costs for Indian Lands

General

This section of the report provides an economic assessment of the potential for renewable electricity projects on Indian tribal lands. Results are categorized separately for central station and dispersed applications. These results will be provided after a general description of the methods and data used to arrive at these conclusions. Following the major results is a section providing supporting details, followed by a discussion of Federal and State renewable support programs which could influence the bottom-line economic feasibility of Indian tribal land renewable energy projects. Since the benchmark for central station renewable electricity prices is wholesale electricity prices, the final part of the section contains a discussion of those prices.

General Approach

The renewable resource information provided by the previously shown maps along with cost information is

[14] For more information, see the INEL web site: http://www.inel.gov/national/hydropower/state/stateres.htm. The study began in 1989 to assess the amount of undeveloped conventional hydropower potential in each State. The undeveloped hydropower potential considered includes development three types of sites: new sites with no current development, addition of power generation to a currently developed site without generation, and an increase of capacity at existing generation sites.

used to determine the best resource by reservation. However, as discussed in the section on Project Criteria that follows, a much more thorough and local evaluation of a resource would need to be conducted before any development decisions could be made.

An estimate of the levelized cost for electricity production from each resource was developed based on renewable technology characteristics assumed by EIA in the *Annual Energy Outlook 2000*.[15] For each technology type, a capital cost, fixed O&M cost, and variable O&M cost were extracted for the year 2000. The capital costs are assumed to vary regionally based on labor and material cost differentials, while O&M costs are assumed to be the same for all plants of the same type. Additional sources, such as the DOE Office of Energy Efficiency and Renewable Energy/Electric Power Research Institute (EE/EPRI) *Renewable Technology Characteristics Characterizations*,[16] were consulted as well. In particular, data for geothermal was augmented, as will be described below, because of the site-specific treatment in the AEO2000 modeling framework.

A simple real levelized cost[17] in 1998 cents per kWh was computed for each region and resource class based on a 10- percent real discount rate and a 20-year economic life of equipment, except for hydropower, where equipment life was assumed to be 30 years. No adjustment was made for tax deductions associated with debt interest payments, because these would not be available if the tribes make the investments. Further, since region-specific transmission costs were not known, they were not included. As discussed in the Project Criteria Section, alternative cost of capital and financing assumptions might apply. Any specific project evaluation would also involve a much more sophisticated financial analysis taking into consideration the matching of generation output, demand levels, alternative prices, and the necessary transmission, intertie, and distribution costs.

Highest Potential Renewable Energy Projects

Central Station Generation

Some of the reservations have multiple renewable resource options, whereas others are not well situated for any renewable resource development. Table 4 lists the Indian lands with the greatest potential based on the following:

- Reservation/renewable resource combinations having the lowest renewable development cost premium (excluding transmission costs), excluding hydropower. These are generally based on either wind or biomass; and
- The regional wholesale electricity price (which includes transmission costs)

Sixty-one reservations or TJSAs, which have 50 percent of the Indian population on Indian lands, appear to have resources that could be developed for less than 2 cents per kWh above their regional wholesale prices. With renewable incentives at the State or Federal level (discussed below), these projects might be cost-effective depending on the cost of transmission required to connect the new capacity to the grid.

Four reservations could generate central station renewable-based electricity cheaper than the wholesale cost of power sold to those reservations, assuming EPACT production incentive payments were available. These reservations are: the Eastern Cherokee Reservation (NC), the Alabama and Coushatta Reservation (TX), the Coushatta Reservation (LA), and the Mississippi Choctaw Reservation and Trust (MS). Biomass is the renewable resource of choice on all these lands. The renewable electricity cost premium ranges from 0.1 cents per kWh to 0.7 cents per kWh.

For the 13 areas that have both wind and biomass resources, the biomass development cost is projected to be lower than the wind development cost. However, if a Production Tax Credit (PTC) or Renewable Energy Production Incentive (REPI) credit were available, the wind costs would be lower in a few cases. This is because biomass resources on Indian lands are not expected to be "closed loop," and therefore not eligible for these tax credits. In addition, some type of State renewable portfolio standard or public benefits funds are available for 24 of the reservations.

A major assumption regarding the above cost premiums is that transmission and distribution systems (T&D) are

[15] Energy Information Administration, *Annual Energy Outlook 2000*, DOE/EIA-0383(2000) (Washington, DC, December 1999). These projections are produced using the National Energy Modeling System (NEMS).

[16] U.S. Department of Energy and the Electric Power Research Institute, *Renewable Technology Characteristics Characterizations*, TR-109496 (Palo Alto, California, December 1997).

[17] The levelized cost equals (capital cost * discount rate / (1-(1 / (1+discount rate)^years))) + annual fixed operating costs) / (8760 * capacity factor) + variable operating cost.

Table 4. Indian Lands with Highest Potential for Central Station Development[a]

Indian Land	State Abbreviation	Land Area (thous m2)	1990 Indian Population	1990 Indian Occupied Housing Units	Regional Wholesale Price (98c/kWh)	Regional Residential Price (98c/kWh)	Wind Cost (98c/kWh)	Biomass Cost (98c/kWh)	Geo-thermal Type	Distributed PV Cost (98c/kWh)	Solar Concentrat or Cost (98c/kWh)	Wind or Biomass Cost Minus Wholesale (98c/kWh)	PV Cost Minus Residential Price (98c/kWh)	State Policies
Eastern Cherokee Reservation .	NC	210,092	5,388	1,786	4.3	8.4	4.7	4.4	P	32.8	na	0.1	24.5	N
Alabama and Coushatta Reservation	TX	18,085	477	143	4.1	6.9	na	4.7	P	32.8	na	0.7	26.0	Y
Coushatta Reservation	LA	967	33	12	4.1	7.3	na	4.7	P	32.8	na	0.7	25.6	N
Mississippi Choctaw Reservation	MS	75,283	3,655	830	3.7	6.9	na	4.4	P	32.8	na	0.7	25.9	N
Poarch Creek Reservation	AL	1,021	149	66	3.7	6.5	na	4.4	P	32.8	na	0.7	26.3	N
Iowa Reservation	KS--NE	50,546	83	33	3.1	8.8	na	4.7	P	32.8	na	1.6	24.0	N
Kickapoo Reservation	KS	77,240	370	100	3.1	8.9	na	4.7	P	32.8	na	1.6	23.9	N
Sac and Fox (KS-NE) Reservation	KS--NE	59,762	48	16	3.1	7.8	na	4.7	P	32.8	na	1.6	25.0	N
Hannahville Community	MI	14,424	144	37	2.9	8.6	na	4.6	P	40.1	na	1.7	31.6	N
Lac du Flambeau Reservation . .	WI	279,279	1,432	428	2.9	9.0	na	4.6	P	40.1	na	1.7	31.1	N
L'Anse Reservation	MI	238,211	717	257	2.9	9.7	na	4.6	P	40.1	na	1.7	30.5	N
Menominee Reservation	WI	921,697	3,182	824	2.9	7.4	na	4.6	P	40.1	na	1.7	32.7	N
Oneida (West) Reservation	WI	264,947	2,447	707	2.9	7.0	na	4.6	P	40.1	na	1.7	33.1	N
Potawatomi (Wisconsin) Reservation	WI	48,175	266	71	2.9	7.0	na	4.6	P	40.1	na	1.7	33.1	N
Sokaogon Chippewa Community	WI	6,304	230	62	2.9	7.0	na	4.6	P	40.1	na	1.7	33.1	N
Stockbridge Reservation	WI	90,141	447	156	2.9	7.4	na	4.6	P	40.1	na	1.7	32.7	N
Wisconsin Winnebago Reservation	WI	3,306	468	118	2.9	7.4	na	4.6	P	40.1	na	1.7	32.7	N
Lac Vieux Desert Reservation . .	MI	22	119	37	2.9	8.0	na	4.6	P	40.1	na	1.7	32.1	N
Cherokee TJSA	OK	17,354,150	66,356	20,308	3.0	7.0	na	4.7	D	32.8	17.7	1.8	25.9	N
Choctaw TJSA	OK	27,485,841	28,411	9,080	3.0	6.8	6.3	4.7	P	32.8	17.7	1.8	26.0	N
Kiowa-Comanche-Apache-Fort Sill Apache TJSA	OK	16,944,113	13,108	3,511	3.0	7.1	6.3	4.7	P	32.8	17.7	1.8	25.8	N
Fort Apache Reservation	AZ	6,805,650	9,825	2,232	3.4	9.0	5.7	5.2	D	27.8	14.7	1.8	18.8	Y
Navajo Reservation	AZ--NM--U	56,663,414	123,944	29,375	3.4	7.3	5.7	5.2	D	27.8	11.3	1.8	20.5	Y
Isleta Pueblo	NM	849,602	2,699	831	3.4	9.6	5.2	na	P	27.8	14.7	1.8	18.2	Y
Jemez Pueblo	NM	361,753	1,738	402	3.4	9.9	5.2	na	P	27.8	14.7	1.8	17.9	Y
Jicarilla Apache Reservation ...	NM	3,331,837	2,375	607	3.4	11.1	5.2	na	P	27.8	14.7	1.8	16.6	Y
Mescalero Apache Reservation .	NM	1,862,526	2,516	595	3.4	12.4	5.2	na	P	27.8	14.7	1.8	15.4	Y
Nambe Pueblo	NM	82,983	329	118	3.4	10.5	5.2	na	P	27.8	14.7	1.8	17.3	Y
Picuris Pueblo	NM	70,879	147	48	3.4	11.1	5.2	na	P	27.8	14.7	1.8	16.7	Y
Taos Pueblo	NM	401,140	1,211	422	3.4	11.1	5.2	na	P	27.8	14.7	1.8	16.7	Y
Tesuque Pueblo	NM	68,682	232	60	3.4	10.5	5.2	na	P	27.8	14.7	1.8	17.3	Y

See notes at end of table.

Table 4. Indian Lands with Highest Potential for Central Station Development[a] (Continued)

Indian Land	State Abbre-viation	Land Area (thous m2)	1990 Indian Population	1990 Indian Occupied Housing Units	Regional		Wind Cost (98c/kWh)	Biomass Cost (98c/kWh)	Geo-thermal Type	Distributed PV Cost (98c/kWh)	Solar Concentrator Cost (98c/kWh)	Wind or Biomass Cost Minus Wholesale (98c/kWh)	PV Cost Minus Residential Price (98c/kWh)	State Policies
					Wholesale Price (98c/kWh)	Residential Price (98c/kWh)								
Zia Pueblo	NM	483,222	637	143	3.4	9.9	5.2	na	P	27.8	14.7	1.8	17.9	Y
Bay Mills Reservation	MI	9,020	403	104	2.9	7.7	na	4.8	P	40.1	na	1.8	32.4	N
Isabella Reservation	MI	561,552	740	209	2.9	9.1	na	4.8	P	40.1	na	1.8	31.0	N
Sault Ste. Marie Reservation	MI	2,357	315	77	2.9	7.7	na	4.8	P	40.1	na	1.8	32.4	N
Bois Forte (Nett Lake) Reservation	MN	422,114	346	106	2.7	7.3	na	4.6	P	40.1	na	1.9	32.8	Y
Deer Creek Reservation	MN	90,937	6	1	2.7	10.5	na	4.6	P	40.1	na	1.9	29.7	Y
Fond du Lac Reservation	MN	427,274	1,106	342	2.7	7.4	na	4.6	P	40.1	na	1.9	32.8	Y
Grand Portage Reservation	MN	189,472	207	87	2.7	8.3	na	4.6	P	40.1	na	1.9	31.9	Y
Leech Lake Reservation	MN	2,518,421	3,390	999	2.7	8.0	na	4.6	P	40.1	na	1.9	32.2	Y
Mille Lacs Reservation	MN	13,801	428	119	2.7	7.6	na	4.6	P	40.1	na	1.9	32.5	Y
Prairie Island Community	MN	2,082	56	20	2.7	7.7	na	4.6	P	40.1	na	1.9	32.4	Y
Red Lake Reservation	MN	2,279,585	3,602	928	2.7	10.4	na	4.6	P	40.1	na	1.9	29.8	Y
Vermillion Lake Reservation	MN	4,206	87	27	2.7	7.0	na	4.6	P	40.1	na	1.9	33.1	Y
White Earth Reservation	MN	2,818,924	2,759	816	2.7	6.2	6.3	4.6	P	40.1	na	1.9	34.0	Y
Omaha Reservation	IA--NE	808,138	1,908	429	2.7	6.4	na	4.6	P	32.8	na	1.9	26.5	Y
Sac and Fox (Iowa) Reservation	IA	15,341	564	135	2.7	8.8	na	4.6	P	32.8	na	1.9	24.0	Y
Bad River Reservation	WI	497,356	868	285	2.7	9.0	na	4.6	P	40.1	na	1.9	31.1	N
Crow Creek Reservation	SD	1,092,181	1,531	352	2.7	8.0	6.3	4.6	D	32.8	na	1.9	24.8	N
Devils Lake Sioux Reservation	ND	1,015,293	2,676	627	2.7	7.0	6.3	4.6	P	40.1	na	1.9	33.2	N
Flandreau Reservation	SD	8,978	249	78	2.7	7.3	6.3	4.6	P	32.8	na	1.9	25.6	N
Fort Berthold Reservation	ND	3,415,995	2,999	848	2.7	7.6	6.3	4.6	P	32.8	17.6	1.9	25.2	N
Lac Courte Oreilles Reservation	WI	276,850	1,771	523	2.7	9.1	na	4.6	P	40.1	na	1.9	31.1	N
Lake Traverse (Sisseton) Reservation	ND--SD	3,754,809	2,821	739	2.7	6.8	6.3	4.6	P	32.8	na	1.9	26.0	N
Lower Brule Reservation	SD	877,281	994	237	2.7	6.9	6.3	4.6	E	32.8	na	1.9	26.0	N
Red Cliff Reservation	WI	56,688	727	216	2.7	9.0	na	4.6	P	40.1	na	1.9	31.1	N
St. Croix Reservation	WI	7,539	462	138	2.7	7.9	na	4.6	P	40.1	na	1.9	32.2	N
Santee Reservation	NE	447,874	425	140	2.7	6.8	na	4.6	D	32.8	na	1.9	26.0	N
Turtle Mountain Reservation	ND--SD	181,139	4,746	1,452	2.7	6.5	5.6	4.6	P	32.8	na	1.9	26.4	N
Winnebago Reservation	NE	449,152	1,156	311	2.7	6.4	na	4.6	D	32.8	na	1.9	26.4	N
Yankton Reservation	SD	1,724,337	1,994	490	2.7	8.6	na	4.6	D	32.8	17.6	1.9	24.2	N

[a]Excludes Trust Lands

Notes: For geothermal, E indicated potential for electricity generation, D for direct heat, and P for geothermal heat pumps. Central station development costs exclude transmission costs. The wholesale price is the 1998 average revenue for sales for resale (including firm and non-firm) and the transmission cost to the intertie.

Source: EIA estimates as documented in this report.

available to these reservations. If this is true, the reservations could either market power to the grid or use the power themselves. If only transmission lines are available, then marketing power to off-reservation customers is likely to be the only feasible option, as costs for new distribution systems to sparsely arrayed reservation households will be quite high. Marketing power from new plants also requires intertie costs, not included. Unfortunately, reservations with high electricity nonuse rates probably may have neither accessible transmission nor distribution (T&D) systems capable of reaching a large number of households without electricity. The need to put even just a distribution system in for such households would raise the cost of delivering any central station-generated electricity substantially. Renewables are unlikely to be differentially affected in this regard, except for possible power conditioning provisions for wind energy.

There appear to be 82 reservations and TJSAs, having 22 percent of the Indian population on Indian lands, which have central station renewable development costs for renewables more than 10 cents per kWh higher than the regional wholesale price. These are areas with only central PV and/or solar concentrator resources. For these areas, it is unlikely that any renewable subsidy could make these resources attractive.

Hydropower would be competitive at the low end of its estimated cost range (about 5 cents per kWh). However, because this study could not determine the existence of undeveloped water resource potential on Indian lands, hydropower was excluded from consideration. Further, the difficulty in licensing hydropower projects in recent years makes it questionable whether such projects could be approved on Indian lands without special dispensation for Indian land hydropower projects.

Distributed Generation

Renewable distributed generation generally is only cost-effective in areas that are remote and are unconnected to the electrical grid. Therefore, distributed generation is probably most appropriate for reservations with a relatively large fraction of households without electricity, such as the Navajo reservation.[18] The renewable generation options and prices for the reservations with greater than the national average of 1.4 percent of households without electricity is shown in Table 5. The results suggest that PV rooftop modules may be a feasible way to provide limited electric service (without backup power) to large numbers of households on the Navajo reservation, and possibly others. The levelized costs for distributed PV generation ranges from 28.0 to 40 cents per kWh. While higher than the average residential price of electricity by 15 to 34 cents per kWh,[19] the Navajo reservation has many households extremely remote from transmission / distribution lines. This raises distribution costs to a level far higher than average. DOE's National Center for Photovoltaics indicates that a distance from the nearest utility line of only a quarter mile raises distribution costs sufficiently to make PVs cost-effective at 25 to 50 cents per kWh. In addition, if the cost of the PV system can be paid for through a 30-year home mortgage, its levelized cost can be reduced to 15 to 20 cents per kWh.

A major point of emphasis regarding the above costs is that they are for PV rooftop only electricity. These estimates exclude the cost of back-up power or energy storage, which could raise the cost of full-service PV rooftop-based electricity by a factor of 3 or 4.

By comparison, for the same reservations, the cost of central station renewables above the wholesale generation price is roughly 0.7 to 15 cents per kWh. It is important to note that these costs are not reduced by any incentive payments, (e.g., the wind tax credit), and they do not reflect transmission costs (which might add another 0.7 to 2.0 cents per kWh) or distribution costs, which could be substantial for remote locations. However, as mentioned earlier, the cost of distribution systems to areas without electric service is likely to be the same for most generating technologies.

Resource Potential and Cost

Wind and biomass are generally the most cost-effective renewable resources, so they will be treated first. When the distribution of renewable resources is shown for the Indian lands, only those lands which are inhabited are included.

Wind

Wind resources vary significantly with topography and meteorological conditions and in some cases the best wind class can be surrounded by areas with no

[18] As discussed previously, information about electrical access on reservations and TJSAs is from Census data for reservations with more than 500 Indian households.

[19] These costs do not include any subsidy or incentive payments, which might reduce the cost of PVs.

Table 5. Renewable Options for Indian Lands with High Incidences of Indian Households Without Electricity[a]

Indian Land	State Abbre-viation	1990 Indian Population	1990 Indian Occupied Housing Units	Regional		Wind Cost (98c/kWh)	Biomass Cost (98c/kWh)	Geo-thermal type	Solar Concentrator Cost (98c/kWh)	Minimum Central Cost Minus Wholesale (98c/kWh)	Solar Thermal Minus Wholesale Price (98c/kWh)	Distributed PV Cost (98c/kWh)	PV Cost Minus Residenti al Rate (98c/kWh)	Percent Without Elect	State Policies
				Wholesale Price (98c/kWh)	Residential Price (98c/kWh)										
Navajo Reservation	AZ--NM--U	123,944	29,375	3.4	7.3	5.7	5.2	D	11.3	1.8	7.9	27.8	20.5	36.8	Y
Hopi Reservation	AZ	7,061	1,724	3.4	8.8	na	na	D	11.3	7.9	7.9	27.8	19.0	28.6	Y
Standing Rock Reservation	ND--SD	4,870	1,133	2.7	8.7	6.3	na	P	17.6	3.6	14.9	32.8	24.1	18.2	N
Mescalero Apache Reservation	NM	2,516	595	3.4	12.4	5.2	na	P	14.7	1.8	11.3	27.8	15.4	15.2	Y
Salt River Reservation	AZ	3,533	855	3.4	8.4	na	na	D	14.7	11.3	11.3	27.8	19.4	11.9	Y
Fort Apache Reservation	AZ	9,825	2,232	3.4	9.0	5.7	5.2	D	14.7	1.8	11.3	27.8	18.8	9.3	Y
Papago Reservation	AZ	8,480	2,086	3.4	8.4	na	na	E	11.3	2.6	7.9	27.8	19.4	7.8	Y
Lake Traverse (Sisseton) Reservation	ND--SD	2,821	739	2.7	6.8	6.3	4.6	P	na	1.9	na	32.8	26.0	7.8	N
Gila River Reservation	AZ	9,116	2,295	3.4	9.1	na	na	E	14.7	2.6	11.3	27.8	18.7	7.6	Y
Turtle Mountain Reservation	ND--SD	4,746	1,452	2.7	6.5	5.6	4.6	P	na	1.9	na	32.8	26.4	5.9	N
Pine Ridge Reservation	NE--SD	10,455	2,215	2.7	8.2	6.3	na	D	17.6	3.6	14.9	32.8	24.6	5.8	N
San Carlos Reservation	AZ	7,110	1,634	3.4	9.0	5.7	na	E	11.3	2.3	7.9	27.8	18.8	5.7	Y
Fort Belknap Reservation	MT	2,338	656	2.3	6.4	na	na	P	17.7	15.5	15.5	32.8	26.5	5.5	Y
Rosebud Reservation	SD	6,883	1,656	2.7	7.7	6.3	na	E	17.6	3.3	14.9	32.8	25.2	5.1	N
Iowa TJSA	OK	239	64	3.0	7.3	na	na	D	17.7	14.7	14.7	32.8	25.6	4.9	N
Jicarilla Apache Reservation	NM	2,375	607	3.4	11.1	5.2	na	P	14.7	1.8	11.3	27.8	16.6	4.7	Y
Fort Berthold Reservation	ND	2,999	848	2.7	7.6	6.3	4.6	P	17.6	1.9	14.9	32.8	25.2	4.6	N
Wind River Reservation	WY	5,676	1,474	2.3	6.6	5.1	na	D	14.4	2.9	12.1	32.8	26.3	3.9	N
Leech Lake Reservation	MN	3,390	999	2.7	8.0	na	4.6	P	na	1.9	na	40.1	32.2	3.5	Y
Pascua Yaqui Reservation	AZ	2,284	525	3.4	9.3	na	na	E	14.7	2.6	11.3	27.8	18.5	3.0	Y
Cheyenne River Reservation	SD	5,100	1,293	2.7	8.7	6.3	na	P	17.6	3.6	14.9	32.8	24.1	3.0	N
Otoe-Missouria TJSA	OK	478	130	3.0	7.6	na	na	D	17.7	14.7	14.7	32.8	25.3	2.9	N
Lac Courte Oreilles Reservation	WI	1,771	523	2.7	9.1	na	4.6	P	na	1.9	na	40.1	31.1	2.8	N
Zuni Pueblo	AZ--NM	7,073	1,465	3.4	9.1	na	na	D	14.7	11.3	11.3	27.8	18.7	2.7	Y
Flathead Reservation	MT	5,130	1,732	2.3	5.2	5.6	4.9	D	17.7	2.6	15.5	32.8	27.6	2.1	Y
Colorado River Reservation	AZ--CA	2,345	652	3.4	9.1	na	na	D	11.3	7.9	7.9	27.8	18.7	2.0	Y
Fort Hall Reservation	ID	3,035	832	2.3	5.7	6.3	na	E	17.7	3.7	15.5	32.8	27.1	1.9	N
White Earth Reservation	MN	2,759	816	2.7	6.2	6.3	4.6	P	na	1.9	na	40.1	34.0	1.9	Y
Acoma Pueblo	NM	2,551	586	3.4	10.1	na	na	P	14.7	11.3	11.3	27.8	17.7	1.9	Y
Northern Cheyenne Reservation	MT--SD	3,542	880	2.3	6.7	6.3	na	P	17.7	4.0	15.5	32.8	26.2	1.7	Y
Nez Perce Reservation	ID	1,863	581	2.3	7.1	na	4.9	D	na	2.6	na	40.1	33.0	1.7	N
Fort Peck Reservation	MT	5,782	1,591	2.7	7.2	6.3	na	P	17.6	3.6	14.9	40.1	33.0	1.7	Y
Mississippi Choctaw Reservation	MS	3,655	830	3.7	6.9	na	4.4	P	na	0.7	na	32.8	25.9	1.6	N
Devils Lake Sioux Reservation	ND	2,676	627	2.7	7.0	6.3	4.6	P	na	1.9	na	40.1	33.2	1.6	N

[a] Excludes Trust Lands

Notes: For geothermal, E indicated potential for electricity generation, D for direct heat, and P for geothermal heat pumps. Central station development costs exclude transmission costs. For the purpose of computing the minimum levelized cost for central station renewables, a cost of 6 cents/kWh was used for geothermal. The wholesale price is the 1998 average revenue for sales for resale (including firm and non-firm) and the transmission cost to the intertie.

Source: EIA estimates as documented in this report.

potential. As a result, the assignment of wind classes to reservations based on mapping of resources can only be approximate.

Roughly 45 reservations were identified that have areas with Class 5 or 6 winds, which are the best for wind development (Table 6). Another 48 reservations have Class 4 winds, while 205 reservations have only wind, classes of 3 or below and would not have areas suitable for wind development. In terms of the percent of Indian population on reservations and the TJSAs slightly more than half are in areas with good wind resources (Class 4 or above), while the rest are not. Most of the reservations with good wind resources are in the West and Upper Midwest, primarily California, New Mexico, Nevada, Utah, Wyoming, Arizona, Montana, and North Dakota. The one reservation in the East with good potential is the Eastern Cherokee Reservation in North Carolina. Of the 17 Oklahoma Tribal Jurisdictional Areas, only 3 of them, representing 24 percent of their Indian populations, contain areas with Class 4 winds. The remaining TJSAs have only Class 3 winds.

Table 6. Distribution of Indian Lands by Wind Class

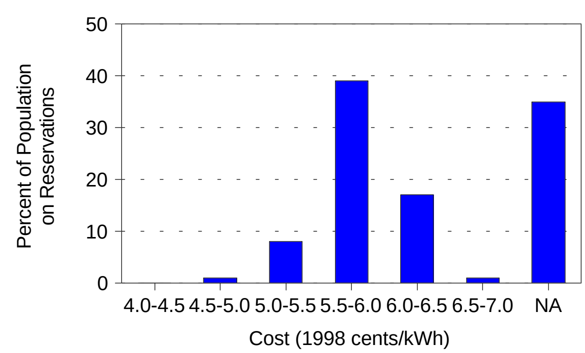
Wind Class	Number of Reservations and TJSAs	Percent of Indian Population
0	124	17
3	81	31
4	48	20
5	15	26
6	30	6
Total	**298**	**100**

Source: EIA estimated from 1990 Decennial Census and NREL wind resource map.

In evaluating the economic potential of wind, the technology characteristics from the *AEO2000* were used. In the year 2000, the national average capital cost is assumed to be $980 per kW, with operating costs of $26 per kW-year. This is for a 50-MW wind farm using 750-kW turbines. In the *AEO2000,* a cost of $167 to $440 per kW is added for transmission facilities for all technology types, depending on the region. For wind an additional cost of $8 to $80 per kW is included depending on how far the facility will be from existing transmission lines. The capacity factor assumed varies by wind class including: 32 percent for Class 6, 29 percent for Class 5, and 26 percent for Class 4.

For those reservations with the best (Class 5 and 6) resources, the average levelized cost of production before considering transmission costs or any renewable incentives is estimated to be 4.7 to 5.9 cents per kWh. For Class 4 winds the cost is 6.2 to 6.6 cents per kWh. The levelized costs are higher for Class 4 areas because the expected capacity factor is lower at lower wind speeds. Figure 17 shows the distribution of wind costs by Indian population on the reservations and the TJSAs. The actual development costs are highly dependent on transmission costs. These would add an additional 0.7 to 2 cents per kWh, depending on the distance and terrain in connecting to existing transmission lines. As a result, the total cost of a project to export power would range from roughly 5 to 9 cents per kWh before credits (Figure 18). Wind sites with better transmission access may have lower costs than those with better wind conditions, so both factors need to be considered for siting specific plants. As mentioned earlier, if Federal or State incentives of 1.5 cents is available, the cost could be reduced to as low as 2.7 cents per kWh in the most favorable circumstances. In most regions if this could be achieved, wind would compete favorably with the current wholesale price.

Figure 17. Distribution of Wind Development Costs Excluding Transmission Costs

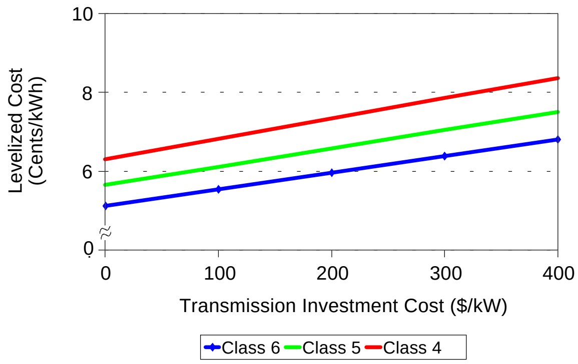


NA = Not applicable.
Source: EIA estimates as documented in this report.

An alternative wind turbine configuration would be small-scale turbines for use within a Native American community. In this case the turbine costs would likely be higher per kilowatt and costs for backup power capacity would be necessary, but the potential transmission costs would be significantly reduced. There would also be local distribution costs if the area was currently not connected to the grid.[20]

[20] An example of an installed remote wind and pv hybrid system in a remote Mexican village is described by DOE, Office of Energy Efficiency and Renewable Energy (www.eren.doe.gov/pv/hybridcase.html), although no cost information is provided.

Figure 18. Example of Wind Levelized Costs Including Transmission for Northwest Power Region



Source: EIA estimates as documented in this report.

Biomass

The NREL characterization of biomass provides three levels of resource: 0-5 MW, 5-40 MW, and greater than 40 MW per county. Because biomass fuel sources have relatively low energy content for their mass, they cannot be transported economically very far—generally 50 miles. For the purposes of this report, we have assumed that Indian lands in counties with the lowest level of biomass resource would not be candidates for biomass development. There are 180 reservations and / or TJSAs that fall into this category, as shown in Table 7.

Table 7. Distribution of Indian Lands by Biomass Category

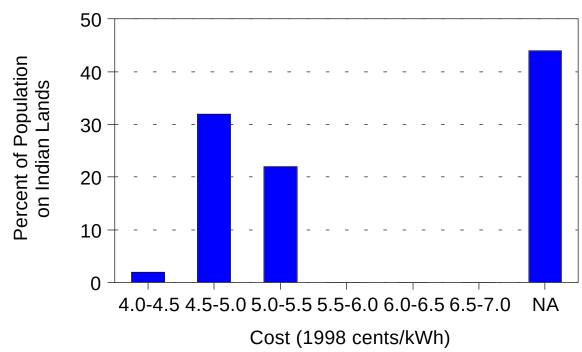
Biomass Category	Number of Reservations and TJSAs	Percent of Indian Population
0-5 MW	180	44
5-40 MW	69	46
> 40 MW	49	10
Total	**298**	**100**

Source: EIA estimated from 1990 Decennial Census and NREL biomass resource map.

The categories of biomass capacity potential are based on assumptions of an efficiency of 35 percent and an annual capacity factor of 65 percent. In the *AEO2000*, the characterization of biomass generation assumes a 5-percent higher efficiency and a 23-percent higher capacity factor, which together lead to roughly 14 percent less capacity for each dry ton of biomass. Given the otherwise conservative estimate of the biomass resources based on only two agricultural crops, the difference in assumptions would not likely lead to a significant difference in the categorization of Indian lands.

The biomass levelized costs for reservations with potential ranges from 4.4 to 6.7 cents per kWh based on *AEO2000* technology and regional fuel costs assumptions. These assumptions include a capital cost of $1,865 per kW, $44 per kW-year operating costs, and a variable cost of 0.53 cents per kWh. Figure 19 illustrates that roughly 32 percent of reservations (populated weighted) have a cost of 4.5 to 5.0 cents per kWh, while another 22 percent are in the 5.0 to 5.5 cents per kWh range. Because biomass fuels are transportable over some limited distance (usually 50 miles), power plants may be able to be situated closer to transmission lines than wind plants and therefore have lower transmission costs.

Figure 19. Distribution of Biomass Development Costs Excluding Transmission Costs



NA = Not available.
Source: EIA estimates as documented in this report.

Geothermal

As shown previously, geothermal resources can be characterized as sufficient for electricity production, for direct heating or simply for geothermal heat pumps. Based on the maps produced by NREL, 57 reservations may have some potential for electricity production, representing roughly 10 percent of the Indian population on reservations and TJSAs. Another 72 reservations and the TJSAs appear to have potential for geothermal direct heat applications, such as district heating. The remaining Indian lands have the potential for geothermal heat pump use. It is important to note that there are currently 51 sites where exploratory geothermal wells have been drilled to determine the feasibility of electricity production. None of these are on Indian tribal lands.

The cost to develop geothermal resources is very site-specific. The levelized costs calculated from the *AEO2000* for the 51 sites included in the model data base average from 3.7 cents per kWh to 5.6 cents per kWh for the three regions in which they are considered. Generic development costs for geothermal plants (EE/EPRI Technology Characteristics) report a range from 3.3 cents per kWh for flash-steam (high temperature) systems to 4.1 cents per kWh for binary systems (moderate temperature).[21] Other sources have indicated that most resources are in the 5.0 to 7.0 cents per kWh range. Once again the cost of transmission from a remote site to a market might add another 0.7 to 2.0 cents per kWh.

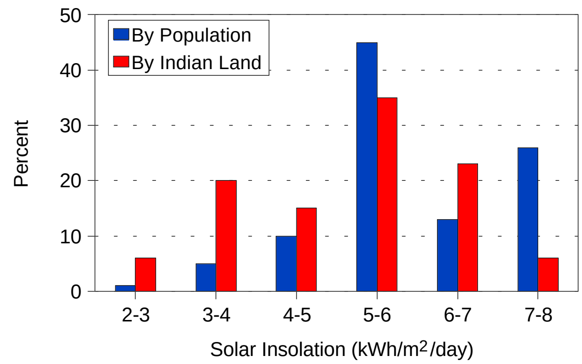
Geothermal heat pumps provide heating and cooling, as in an air heat pump, but use the ground rather than the air as the source of heat. They cost significantly more than standard heat pumps, but are several times more efficient.

Solar Thermal

Concentrated solar systems are significantly more expensive than most other renewable technologies. Areas with higher levels of solar insolation will be more economically favorable because higher capacity factors can be achieved. We have assumed that a minimum of 5-6 kWh/m^2/day insolation is required to even consider concentrated solar technologies, although the likeliest development is in regions with 7-8 or 6-7 kWh/m^2/day. There are 17 reservations with some areas having this highest level of insolation, and 66 with the 6-7 level. Figure 20 illustrates the distribution of solar resources for the reservations by Indian population and by number of reservations.

Based on solar technology characteristics used for the *AEO2000* projection, the levelized costs range from 11.0 cents per kWh (without transmission) to 15.0 cents per kWh for the 6-8 kWh/m^2/day areas. The average capital cost for a 100 MW solar-only power tower with 6-hour molten salt thermal storage is assumed to $3,040 per kW, and the capacity factors vary from 42 percent for the best areas to 26.5 percent for the 5-6 kWh/m2/day areas.[22] Annual operating costs are assumed to be $47 per kW. Because solar insolation is relatively uniform over large areas, concentrated solar plants could be located to minimize the interconnection costs to existing transmission lines. The cost, however, may still be substantial for some Indian lands.

Figure 20. Distribution of Resources for Concentrated Solar Applications

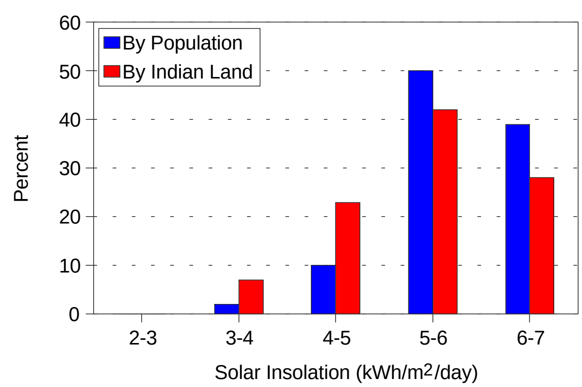


Source: EIA estimates as documented in this report.

Photovoltaics

The solar resources for photovoltaics (PV) are somewhat different than that for solar concentrator systems because PVs use diffuse as well as direct sunlight. The same areas generally are favorable for both. Figure 21 shows the distribution by both number of reservations and Indian population on reservations and TJSAs for the PV resource. The TJSAs in Oklahoma all receive the 5-6 kWh/m^2/day insolation.

Figure 21. Distribution of Resources for Photovoltaics



Source: EIA estimates as documented in this report.

The *AEO2000* estimated installed capital cost for 2 kW residential rooftop PV systems is $5,500 per kW installed, with an annual operating cost of $10 per kW. Some states offer income or other tax benefits which are

[21] U.S. Department of Energy and the Electric Power Research Institute, *Renewable Technology Characteristics Characterizations,* TR-109496 (Palo Alto, California, December 1997).

[22] The capacity factors are input by region in NEMS and were mapped to solar insolation areas based on the NREL maps.

not considered here. The resulting levelized costs for distributed generation range from 28.0 to 51.6 cents per kWh, which is significantly higher than the average residential price of electricity. However, for remote areas where distribution costs would be far higher than average, PVs can be the cost-effective choice. In fact, DOE's National Center for Photovoltaics suggests that a distance from the nearest utility line of only a quarter mile is sufficient to make PVs cost-effective at 25 to 50 cents per kWh. In addition, if the cost of the PV system can be paid for through a 30-year home mortgage, the levelized cost can be reduced to 15 to 20 cents per kWh.[23]

State and Federal Regulatory Policies Affecting Renewable Energy Feasibility on Indian Lands

Several States have enacted legislation to stimulate renewable energy development. In some States, renewable portfolio standards are being used to insure that a minimum level of renewable generation is used to meet future electricity requirements. There are 7 States having Indian lands which have enacted renewable portfolio standards (Table 8). If the portfolio standard allows for tradeable credits,[24] projects developed on Indian lands could have additional value.

Table 8. States with Indian Lands and State RPS or Public Benefits Funds

State	RPS	Public Benefits Fund
Arizona	Y	
California		Y
Connecticut	Y	Y
Iowa	Y	
Maine	Y	
Minnesota	Y	Y
Montana		Y
Nevada	Y	
New Mexico		Y
New York		Y
Oregon		Y
Rhode Island		Y
Texas	Y	

RPS = Renewable Portfolio Standard
Source: Union of Concerned Scientists, North Carolina Solar Center, and EIA.

Another method of encouraging renewable development has been to establish system benefits funds that are created through customer charges. The funds are often used to promote energy efficiency and provide subsidies to low-income customers in addition to funding renewable projects. As indicated in Table 8, there are 8 States where renewable development on Indian lands might benefit from such funds. Because many State legislatures and commissions are actively considering electricity restructuring, the States that offer renewable incentives may change over the next few years.[25] Roughly two-thirds of the Indian lands, representing half of the Indian reservation and TJSA population, are in States which have either a renewable portfolio standard or a system benefits fund.

In several States, utilities have been allowed or required to establish "green power" marketing options so consumers can voluntarily pay more for power generated from renewable or other clean sources. In States that have adopted retail competition, green power marketers are among those companies vying for customer market share. This allows the market to establish a premium for renewable power that the Indian tribes may be able to capture. However, the relative geographic isolation of some tribes may prohibit the cost-effective export of power into these markets.

There are also existing and proposed Federal policies to encourage renewables. The Energy Policy Act of 1992 created a 1.5 cents per kWh (adjusted for inflation) production tax credit (PTC) for wind and closed-loop biomass projects, where biomass crops are grown on a sustainable basis. This credit expired at the end of June 1999, but was retroactively extended until the end of December 2001. The tax credit increases with inflation and is available for the first 10 years of a project. On a levelized cost basis over a 20-year project life, the equivalent credit is 1.2 cents per kWh (1998 dollars). Because the credit is tax-based, Indian tribes would not benefit unless a private developer was the owner of the project. There is a corresponding renewable energy production incentive (REPI) for public utilities, which is paid through Congressional appropriations, and might be applicable.

The Clinton Administration's proposed Federal electricity restructuring legislation calls for a Federal

[23] Through the Native SUN Hopi Solar Electric Enterprise, Native Americans on the Hopi and Navajo Reservations can apply for low interest loans of 8 percent for a period of 4 years and up to $7000 (information from May 1997).

[24] The Administration's electricity restructuring legislation allows utilities who do not generate the required percentage from renewable sources to purchase tradeable credits from utilities generating an excess percentage from renewable sources to meet the minimum.

[25] See EIA website at http://www.eia.doe.gov/cneaf/electricity/chg_str/regmap.html.

renewable portfolio standard of 7.5 percent by 2010, with a marginal cost cap of 1.5 cents per kWh. There is also a provision to give projects on Indian lands double tradeable credits. If this type of legislation passes, it would make renewable project development on Indian lands much more attractive.

Wholesale Electricity Rates

Central station renewable generators will compete against wholesale purchased power whether the power is used on the reservation or for export. Until very recently, wholesale prices were dictated by cost-of-service contracts. In some parts of the country, wholesale prices are now being set by competitive markets and the trend will continue, as FERC's orders concerning wholesale competition continue to be implemented.[26] Over time, with competitive electricity markets, wholesale prices roughly equilibrate to the long-run marginal cost of generation or, in other words, the lowest cost of building new generation facilities. The competitive nature of the market may also lead to lower costs than occur under cost-of-service. During the transition period, wholesale prices may be lower or higher than the long-run marginal cost, depending on whether there is surplus supply or shortages, respectively. Table 9 shows the 1998 average wholesale electricity prices by NERC subregion.

Table 9. Wholesale Electricity Prices, 1998 (Cents/kWh)

NERC region	Sub-Region	1998 Average [a]
ECAR	ECAR	2.9
ERCOT	ERCOT	3.9
MAAC	MAAC	3.4
MAIN	EM	2.5
MAIN	NI	2.7
MAIN	SCI	3.4
MAIN	WUM	2.9
MAPP	MAPP	2.7
NCPP	NEPX	4.4
NCPP	NYPP	2.4
SERC	FL	4.5
SERC	SOC	3.7
SERC	TVA	4.5
SERC	VACAR	4.3
SPP	N	3.1
SPP	SE	4.1
SPP	WC	3.0
WSCC	AZN	3.4
WSCC	CNV	3.1
WSCC	NWP	2.3
WSCC	RMPA	3.0

[a]The wholesale price reported is a weighted average of all sales for resale (firm and non-firm).

Source: Energy Information Administration, 1998 Form EIA-861, "Annual Electric Utility Report."

Currently, the lowest cost wholesale power is, on average, in the western regions, partly due to the presence of large-scale Federal hydropower facilities that sell power for resale to utilities. These facilities will likely continue using cost-of-service pricing.[27] Regional variations in wholesale prices will remain in any case because the underlying marginal generation prices vary with regional fuel prices and other factors.

For example, the Western Area Power Authority (WAPA) sold power at an average rate of 1.6 cents per kWh in 1998 from all of its several facilities.[28] There are six reservations that receive power from two of the WAPA projects at rates of 0.6 to 1.8 cents per kWh.[29] In the past, WAPA and other Federal Power Marketing Administrations (PMAs) sold power only to utilities, which included Tribal Utility Authorities and the BIA, who then resold the power to preference customers. Recently, they have begun to allow sales to groups other than utilities and have been actively marketing to tribal groups. When the contracts from a project or program expire, some allocation is set aside for new customers and Native Americans. WAPA has completed contracts with 25 tribes in the Upper Midwest for the year 2001 and beyond. Other WAPA facility contracts expire in 2004 and 2008, so there will be additional opportunities for tribes to receive Federal power allocations.

The Bonneville Power Administration (BPA) is also marketing to tribes. The option to sign long-term relatively low cost contracts with Federal power may make

[26]See Energy Information Administration, *The Changing Structure of the Electric Power Industry: Selected Issues 1998*, DOE/EIA-0620 (Washington, DC, July 1998) and EIA's website: http://www.eia.doe.gov/cneaf/electricity/page/restructure.html for updated state information.

[27]The Administration's proposed legislation on restructuring, as well as most formal proposals, maintains Federal preference power at cost-of-service rates.

[28]Western Area Power Administration, *1998 Annual Report*.

[29]For example, the average price of power from the Pick-Sloan Missouri Basin Program in 1998 was 1.7 cents per kWh.

development of central station renewables less attractive for many reservations, but also could be used to back up intermittent power from renewables.

Project Criteria

This section presents an analysis of factors that influence the economic and technical feasibility of two types of projects: distributed generation and central station plants. While the scope and risks of central station power plants are fundamentally greater than that of distributed generation, the basic evaluation process should address the same factors. In the case of the central station plant, the studies and assessments should be of greater detail, employing more sophisticated forecasting techniques. Assessments of distributed generation (in this instance assumed to be associated with individual dwellings or clusters of dwellings), must necessarily consider the alternative of taking power from a central station power plant. In the evaluation of a project to bring or expand electricity use on Tribal lands, both distributed generation applications and central station power plants require careful consideration. Further, substantial overlap exists in the factors that need to be considered.

As will be discussed in greater detail below, a first step in any project evaluation is a clear statement of the objectives of the project. The assessment should avoid the narrow definition of the specific electricity needs on the reservation and recognize the broader considerations of Tribal cultures and infrastructure development needs.

Because of the scale of typical central station power facilities and the potential disruption to the reservation brought about by these types of large projects, a holistic approach may offer the only chance to completely succeed with a project's broader objectives. Most likely, employing this type of approach will enhance the acceptance and adoption of distributed generation.

Evaluating alternative approaches for electricity use on Indian lands should consider all the conventional alternatives. However, the use of renewable energy resources may be more consistent with historical Tribal cultures. The consideration of the use of a more environmentally benign renewable resource will require a fuller consideration of "externalities" than may otherwise enter the evaluation process. The project criteria discussed below are intended to provide a broad checklist to ensure the wider consideration of these "externalities."

A summary guide has been prepared to facilitate the evaluation of expanded electrification through the use of renewable technologies. "A Guide to Project Criteria for Renewable Project Planning Assessments," provides a list of major activities and products, major tasks involved in the various assessments, and the areas of investigation and information requirements. The Guide is subdivided into six basic areas for discussion and lists the typical information requirements and approach to assessing project feasibility.

A detailed and complete discussion of all the factors and areas of investigation identified in the Guide are beyond the limited scope of this paper. This paper will discuss each of the major activities and highlight some of the factors more directly tied to the application of renewable technologies. While the Guide lists each activity in a specific order, the activities are interrelated, interdependent, and would typically proceed in parallel.

Revenue Assessment

We list the revenue assessment first because it has the greatest number of considerations unique to the application of renewable technologies. Revenue assessment is defined here to include all sources of funding that can be identified to support the project. Once a project and its objectives have been defined, the revenue assessment should begin.

There are a wide variety of potential funding vehicles and sources that should be investigated. As identified in the column of areas of investigation, the spectrum of funding sources ranges from grants to customer revenues. The National and State interest in providing incentives for the development of renewable technologies, energy efficiency, and conservation offers project developers a number of places to seek funding at various stages of the project. For example, DOE grants may be available to fund specific feasibility studies. State level initiatives may provide revenue support for renewable projects. The Guide footnotes a good source for reviewing lending sources available for select renewable technologies. Finally, the Federal and State level initiatives for restructuring the electric power industry have fundamentally altered the available opportunities and make it necessary to carefully consider these initiatives when seeking revenue sources and assessing market opportunities. In particular, one should consider the potential impact of "green power" and "renewable portfolio standards" that may be included in these State level initiatives.

Demand Planning

Again, with an eye to the application of renewable technologies, understanding energy use and more specifically the opportunities for electricity use are critical. The intermittent nature of many renewable technologies suggests the need for storage or backup supplies. However, consumer awareness of these limitations may allow for changes in typical consumer behavior that may facilitate the use of these technologies. Further, if electricity is being introduced for the first time, then these behavioral patterns may yet to be formed allowing for an easier adoption of the technology.

The introduction or expansion of electricity use requires careful consideration of the spatial distribution of load. Scattered and low densities (consumers per mile) make the distribution of electricity relatively costly. Alternative applications of distributed generation technology such as solar thermal space and water heating or PV electrical applications, may be able to avoid much investment in the transmission, distribution and central station generation facilities.

Finally, the daily and seasonal cycle in electricity use tends to translate into low load factors.[30] A lower load factor requires a greater investment in capacity per unit of energy used. Since renewable technologies tend to have higher investment costs, low load factor applications tend to be less attractive. Marginal cost pricing of electricity should lead to shifting patterns of electricity use to increase load factors, thereby creating greater opportunities for economical application of renewable technologies.

Indirect Impacts

Expanding the availability of electricity on Tribal lands can have a dramatic impact on the lives of all the residents. Careful consideration of the economic development needs, cultural factors, and environmental impacts of alternative technologies will allow the application of the holistic approach mentioned above. Given the changing nature of the electricity industry and the increased volatility in market prices, these factors should be a key project criteria and play an important part in the overall project assessment.

Infrastructure Assessment

The introduction of expanded electricity use on Tribal lands requires a review of the associated infrastructure needs of the alternatives. A holistic approach would ask about the opportunities for employment, the associated educational and training needs associated therewith, and other factors. The project(s) can bring economic development to the reservations but careful planning and coordination are required to fulfill the potential of these projects.

Financial Condition Assessment

The costs and impact of electrification of Tribal lands will require the commitment of Tribal resources. The impact of the project on the economic vitality of the reservation and the drain or expansion of its financial resources should be an important project criterion. Structured appropriately, the financial exposure and risks to the reservation should be balanced with the anticipated returns.

Specific Project Assessment

Absent a holistic approach, this might be the only major activity contributing to the evaluation of alternative electricity production and use alternatives. However, as discussed above, there can and should be a much broader approach taken to the question of expanded use of electricity on Tribal lands. The major tasks identified in this section of the Guide represent the typical project assessment considerations of any project whether it employs renewable technologies or not. It is important that the alternatives are identified and the factors that make the selected project the best choice should be highlighted in the financial plan.

While there can be many formats or methods of documenting the evaluation and selection of projects for expanded electrification and central station power production on Tribal lands, we have chosen to recommend that all the considerations be brought together in a summary document we are calling the “Financial Plan.” This document could be used to present findings to potential financial sponsors, community groups, and key Tribal organizations to gain acceptance and approval. The effort to prepare a financial plan and present it to key players will be critical to successfully marketing the project to the various funding sources (identified in the revenue assessment activity) and to the Tribal community.

[30] Load factor is defined as the total energy consumption divided by the peak consumption multiplied by the number of hours in the period.

A Guide to Project Criteria for Renewable Project Planning Assessments

Activity/Product	Major Tasks	Areas of Investigation / Information Requirements
1. **Revenue Assessment** – Objective is to pull together all possible sources of revenues and funding for the project for input into the "Financial Plan"	A. Identify funding sources [a] B. Identify alternative revenue sources C. Identify energy expenditures	i. DOE grants ii. Other federal/state grants iii. Subsidized loans iv. Loan guarantees v. Tax exempt financing vi. Tax credits vii. Renewable portfolio standards credits viii. Access to Green Power Pricing and associated markets ix. State level renewable initiatives x. Gaming and other Tribal venture revenues xi. Tribal taxes i. Customer revenues (both on and off the reservations) ii. Avoided payments to other competitive suppliers iii. Net metering
2. Demand Planning -- Objective is to develop detailed estimates of the potential sales (demand) for the output of the project for input into the "Financial Plan"	A. Develop energy use profiles B. Identify electricity use opportunities	i. Current end use energy profiles ii. Demand in neighboring areas or sales to the grid iii. Current and potential future commercial and industrial sales (including use profiles) iv. Alternative end use profiles given access to electricity v. Estimates of current and future household expenditures for heating, cooling, lighting and electrical needs vi. Data and projections of population, number of households, income, employment vii. Data and projections for economic development and new/alternative energy use viii. Data and projections of household energy use and demand for electricity ix. Diurnal and seasonal energy and electricity use by household x. Allocate load to specific locations (sectionalize load into small areas for assessment of distribution and interconnection capacity needs). [b]

[a] See "The Borrower's Guide to Financing Solar Energy Systems: A Federal Overview," Prepared by the U.S. Department of Energy, (DOE/GO-10098-660), September 1998.

[b] See "Transmission and Distribution System Cost Data Development: Implementation Report," Prepared for the Energy Information Administration by OnLocation, Inc., November 1996.

Activity/Product	Major Tasks	Areas of Investigation / Information Requirements
3. **Indirect Impacts** — Objective is to identify and document the indirect impacts of the project(s) on the residents of the Tribal lands for input into the "Financial Plan"	A. Perform regional/reservation socioeconomic impact assessment B. Perform environmental impact assessment C. Determine types and level of benefits to non-users D. Assess value of combining renewable energy based micro-grid with conventional extension of service from neighboring utilities	i. Levels of service desired ii. New opportunities for alternative commercial and industrial businesses iii. Potential for local renewable technology manufacturing plant(s) e.g., PV manufacturing facility iv. Value of reduced dependence on non-renewable energy resources v. Reduction in risks due to volatility in electricity and fuel prices vi. Data and projections of population, no. of households, income, employment vii. Land use projections viii. Technical skills required to construct and maintain equipment
4. **Infrastructure Assessment** — Objective is to identify all the infrastructure needs of the project(s) to assure their availability to support the project and as input into the "Financial Plan"	A. Define infrastructure needs B. Define educational systems related to technical skills to construct and operate C. Accomodate way governing bodies of tribe function	i. Alternative land use ii. Roads and utilities iii. Avoided and required transmission interconnection requirements iv. Avoided and required distribution system requirements v. Avoided and required generation capacity requirements (including reserves/backup) vi. Legal aspects of development on sovereign lands
5. **Financial Condition Assessment** — Objective is assess the impact of the project(s) on the overall financial condition of the reservation for input into the "Financial Plan"	A. Assess reservation/region's economic vitality B. Assess reservation/region's debt management	i. Real estate, business activity, education systems, etc. ii. Debt per capita, debt service as percent of revenues, debt as percent of total assets, interest coverage ratios, etc. iii. Impact on project(s) on enhancing Tribal debt service capacity
6. **Specific Project Assessment** — Objective is to pull together all the factors and impacts of the project into a single comprehensive document that can be used to communicate with all the players outside the project team, i.e., the "Financial Plan"	A. Develop estimates of project costs B. Develop estimates of project revenues C. Develop alternatives D. Develop estimates of alternative's costs and revenues E. Financial plan preparation and presentation to project sponsors	i. Capacity requirements of selected project and alternatives ii. Cost of financing: costs-of-capital and capital structure iii. Installed capital cost of project iv. Expected economic life v. Intermittence of power production and need for storage or backup vi. Annual operations and maintenance costs vii. Annual or periodic capital expenditures costs viii. T&D costs – avoided or connect costs ix. Backup costs if connected to grid (level of reliability failure rates and outage duration) x. Federal and State Taxes xi. Project timing xii. Construction costs xiii. Contingencies necessary xiv. Alternative financing (see above) xv. Cash flow needs and schedule

Limitations on Use of Renewable Energy

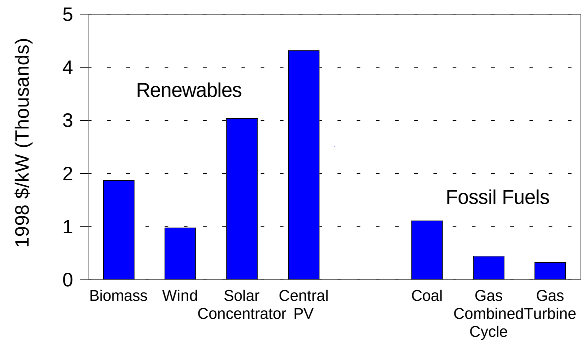
Renewable technologies have both distinct advantages and disadvantages in the production of electricity. Their most obvious and attractive attributes are their reliance on energy resources that are viewed as inexhaustible and environmentally benign. However, as with other technologies, renewable technologies have their limitations.

This section will highlight some of these in meeting the energy needs on Tribal lands. A complete delineation of all the attributes, costs and performance factors of renewable technologies is beyond the scope of this paper. The highlights that follow are intended to be illustrative of the barriers associated with the use of renewable technologies as electricity producing facilities. Central station power production and distributed generation (generation at or near the final end use location) are discussed separately. Most of the limitations that will be discussed apply to both applications of renewable technology. However, distributed applications can potentially avoid significant delivery costs (costs of transmission and distribution) and in certain specific situations, this will improve their overall economic competitiveness.

High up-front capital costs represent one of the most significant economic barriers to the adoption of renewable technology. For central station power plant applications, the capital costs for renewable technologies are from 3 to 15 times that of conventional technology (Figure 22). The overall savings in fuel and annual operations and maintenance costs of the renewable technology must overcome the high front-end capital costs for the technology to become competitive. For virtually all the renewable technologies in central station applications, it is difficult to overcome the front-end capital cost disadvantage under current and projected economic conditions absent special circumstances or subsidies.

The situation is not quite as bleak for distributed generation applications of renewable technology. The high up-front capital costs still persists in these applications, but the avoided transmission and distribution costs can, on occasion, overcome this disadvantage. To determine the potential economic opportunity for distributed generation applications requires site specific facts regarding the energy and capacity requirements and the alternative costs of generation, transmission, and distribution. Unfortunately, the potential range in these costs is very large. Further, these costs vary with terrain, the extent of existing facilities and their utilization levels. Thus, generic cost are calculations without site specific data are too uncertain to be of use. Therefore, any estimate of the full potential of distributed generation applications to meet the energy needs on Tribal lands lacks sufficient data to be credible.

Figure 22. Capital Costs of Electric Generating Technologies



Note: These are overnight capital costs for plants that would be purchased in 2000 and be online 2 to 4 years later.

Source: Energy Information Administration, *Annual Energy Outlook, 2000*.

Another major hurdle for the solar and wind renewable technologies is their intermittent output. This intermittence results in a relatively low annual capacity factor and in many situations, there is a need for some form of energy storage or a backup source of power. This additional requirement adds to the system costs and limits the economic applications of the technology. In the case of central station applications, it also limits the degree to which the technology can meet total demand (i.e., given a capacity credit for reserve planning purposes).

Central station power production using wind technology involves the construction of wind farms. Thus, wind farms are positioned to make the best use of the wind resource, which is frequently not in the immediate vicinity of the existing bulk power transmission grid. The cost of interconnecting the wind farm to the bulk power grid often involves the construction of additional transmission facilities further exasperating the economics of utilizing wind technology.

An added concern regarding wind farms is the potential resistance to such land use of Tribal property. Again, further specific investigation regarding the existence of a suitable site for a wind farm on Tribal lands is required before any assessment can be made. In addition, the Tribal community's acceptance of this use would be required before an assessment of the potential for wind technology to satisfy a significant portion of the energy needs on Tribal lands can be made.

Also, Tribal lands in many instances are remote and far away from load centers. Similarly, there is a great distance between the better wind resources and the centers of electricity demand. Much of the wind resource is found in the states of the Great Plains and the eastern slope of the Rocky Mountains while the major load centers tend to be on the east and west coast of the United States. To take full advantage of the wind resource on Tribal lands, significant investment in additional transmission capacity is likely required. Most of the cost associated with added transmission capacity is fixed in terms of a return on investment. Transmission facilities have relatively low annual operations and maintenance costs associated with them. However, the economic returns associated with the incremental transmission investment are hampered by the intermittent nature of the wind resource and resultant relatively low capacity factors.

4. Conclusions

Four reservations have been identified which might generate central station renewable-based electricity at a lower cost (excluding transmission cost) than the wholesale cost of power sold to those reservations, assuming favorable transmission costs. These reservations are the Eastern Cherokee Reservation (NC), the Alabama and Coushatta Reservation (TX), the Coushatta Reservation (LA), and the Mississippi Choctaw Reservation and Trust (MS). Biomass is the renewable resource of choice on all these lands. The renewable electricity cost premium, excluding transmission charges, ranges from 0.1 cents per kWh to 0.7 cents per kWh.

Biomass is the least costly renewable resource on 52 of the 61 reservations having the lowest renewable central station electricity cost premium. The remaining 9 reservations (all in New Mexico) have wind as the least costly renewable resource. Biomass has a major advantage over wind because it does not require back-up power. Furthermore, connecting wind power facilities to the electricity grid requires a number of special considerations. Wind power, however is eligible for EPACT production incentive payments, while biomass facilities are eligible only if they are closed loop.

Despite its high absolute cost, rooftop photovoltaic installations may be feasible to provide limited electric service to a high number of Indian households without access to electricity on tribal lands, because no distribution or transmission facilities are required. This, of course, means that electricity will be unavailable at night unless some form of back-up power (e.g., diesel generators) or storage batteries is used—both high-cost options.

Compared with the Nation as a whole, Indian households on tribal lands overall pay essentially comparable rates (on a per kilowatthour basis) to those paid by non-Indian households with similar demographics. However, Indian households spend a greater share of income on electricity than do non-Indian households.

Electrification is a sizable problem for only a small number of Indian reservations. However, the reservation with the highest percentage of households without electricity, the Navajo reservation in Arizona, is also by far the largest reservation in the U.S. That one reservation accounts for about 75 percent of all Indian reservation households without electricity, and the non-electrified Navajo households represent about 10 percent of all Indian reservation households.

Appendix A

DOE Funded Indian Energy Projects
Fiscal Years 1994 through 1999

Fiscal Year 1994

State	Grantee	Funding (Current Dollars)		Description
		DOE	Non DOE	
Alaska	Agdaagux Tribe	250,000	5,211,000	Hydroelectric Plant Construction
	Cape Fox Corporation	250,000	346,264	Hydroelectric Feasibility Study
	Chignik Lagoon Village	42,000	0	Small Hydro Feasibility Study
	Haida Corporation	249,918	60,805	Hydroelectric Feasibility Study
	Koniag Corporation	246,944	61,736	Analysis of Energy & renewable resources
Arizona	White Mtn. Apache	129,047	39,482	Feasibility of Wood/Waste Cogeneration Plant
California	Hoopa Valley Tribe	97,078	18,140	Solar and Efficiency
Colorado	Ute Mt. Ute Tribe	194,965	85,696	PV installation for water pumping
Montana	Blackfeet Tribe	126,607	25,142	Wind Feasibility Study
	Fort Peck Tribes	249,476	0	Wind Farm Feasibility Study
New Mexico	Laguna Pueblo	248,665	0	PV Manufacturing Feasibility Study
	Zuni Pueblo	91,781	23,003	PV Feasibility Study for water pumping
North Dakota	Turtle Mt. Band of Chippewas	248,133	20,000	Wind Feasibility Study
South Dakota	Lower Brule Sioux	247,300	86,800	Analysis of Energy and Renewable Options
Wisconsin	Oneida Tribe	154,855	42,525	Passive Solar and Energy Efficiency
Renewable		**2,826,769**	**6,020,593**	
Montana	Crow Tribe	299,115	299,115	Feasibility Study for Minemouth Cogeneration
Washington	Confederated Tribes of Colville	555,000	555,000	Gas-fired Cogeneration Plant
Non Renewable		**854,115**	**854,115**	
FY 94 Total		**3,680,884**	**6,874,708**	

Fiscal Year 1995

State	Grantee	Funding (Current Dollars)		Description
		DOE	Non DOE	
Alaska	Atka	44,000	0	Hydroelectric Feasibility Study
	Cape Fox	125,000	110,700	Hydroelectric FERC Application
	Haida Corporation	190,758	95,902	Hydroelectric Feasibility Study Phase II
Arizona	Hualapai	200,000	50,000	PV Water Pumping Stations
California	Manzanita Band	80,000	14,608	Wind Energy Tribal Office
Colorado	Ute Mt.Ute Tribe	196,780	85,696	PV Installation for Water Pumping
Connecticut	Mohegan	154,700	0	Efficiency and Renewable Options
Idaho	Nez Perce	166,702	78,521	Biodiesel Production Feasibilty Study
Michigan	Keewenaw	181,500	10,000	Wood Waste Feasibility Study
Montana	Blackfeet	152,865	86,053	Wind Turbine Construction and Operation
New Mexico	Jemez Pueblo	91,608	23,000	Wind Farm Feasibility & Resource Study
	Jicarilla Apache	162,136	20,698	Hydroelectric Feasibility Study
	Nambe Pueblo	152,294	0	PV Feasibility Study for 1 MW facility
	Picuris Pueblo	129,197	27,299	Purchase Renewable and Efficiency Equipment
North Dakota	Devil's Lake Sioux	190,965	63,000	Wind Resource Assessment, Installation & Operation
	Standing Rock Sioux	171,617	40,000	IRP Development Considering Renewable Energy
Renewable		**2,390,122**	**705,477**	
Alaska	Chignik Lagoon Village	100,717	50,000	Diesel Generators and Electrical Distribution Lines
Arizona	Navajo	6,600,000	0	Transmission Line
California	Hoopa Valley Tribe	64,500	13,759	Weatherization and Energy Efficiency Project
Montana	Crow Tribe	500,000	0	Minemouth Cogeneration Plant
Non Renewable		**7,265,217**	**63,759**	
FY 95 Total		**9,655,339**	**769,236**	

Fiscal Year 1996

State	Grantee	Funding (Current Dollars)		Description
		DOE	Non DOE	
Alaska	Haida Native Village Corp	2,000,000	4,475,000	Hydroelectric Project
Reneweable		**2,000,000**	**4,475,000**	
Arizona	Navajo	6,100,000	0	Transmission Line
Montana	Crow	500,000	0	Energy
Non Renewable		**6,600,000**	**0**	
FY 96 Total		**8,600,000**	**4,475,000**	

Fiscal Year 1997

State	Grantee	Funding (Current Dollars)		Description
		DOE	Non DOE	
Alaska	Eyak Native Corp.*	1,905,000	13,505,000	Hydroelectric Project
	Haida Native Village Corp.	1,000,000	**	Hydroelectric Project
New Mexico	Jicarilla Apache Tribe	200,000	123,915	Hydroelectric Project Feasibility Study
Renewable		**3,105,000**	**13,628,915**	
Alaska	Klawock-Thorne Bay Kassan*	952,000	1,753,000	Electrical Intertie
Non Renewable		**952,000**	**1,753,000**	
FY97 Total		**4,057,000**	**15,381,915**	

*The award was made to the State of Alaska who in turn gave the funds to the appropriate entity.

**The cost share in FY96 was reduced by the amount of the FY97 award.

Fiscal Year 1998

State	Grantee	Funding (Current Dollars) DOE	Non DOE	Description
Alaska	Eyak Native Corporation	1,757,000	***	Power Creek Hydroelectric Project
	Village of Old Harbor/ Village of Scammon Bay	502,000	1,941,900	Hydroelectric Project Feasibility Study
New Mexico	Jicarilla Apache Tribe	200,000	35,502	Hydroelectric Project Feasibility Study
Renewables		**2,459,000**	**1,977,402**	
Alaska	Skagway Bay	877,000	4,449,000	Upper Lyn Canal Regional Electric Project
Non Renewable		**877,000**	**4,449,000**	
FY98 Total		**3,336,000**	**6,426,402**	

***The cost share in FY97 was reduced by the amount of the FY98 award.

Fiscal Year 1999

State	Grantee	Funding (Current Dollars) DOE	Non DOE	Description
Arizona	Navajo	210,000	120,000	PV installations at remote residences
California	Ramona Band	182,000	213,070	Hybrid PV/Wind/Solar Hot Water System
	Manzanita Band	269,036	67,640	Hybrid Wind/PV installation in tribal buildings
New Mexico	Jicarila Apache Tribal Utility Authority	109,794	30,194	PV Installation
	Pueblo Laguna	198,518	39,703	PV/Wind/Solar hot water system
North Dakota	Three Affiliated Tribes	200,000	50,000	Wind 100 Kw turbine installation Ft. Berthold Resv.
South Dakota	Rosebud Sioux Tribe	508,750	508,750	Wind 750 Kw turbine installation
Wisconsin	Oneida Tribe	173,391	47,386	Solar Hot Water and PV Electric
Renewable		**1,851,489**	**1,076,743**	
FY 99		**1,851,489**	**1,076,743**	

Sources: Personal communication with Steve Sargent, U.S. Department of Energy, Denver Regional Support Office, January 2000, Peggy Brookshire, U.S. Department of Energy, Idaho Operations Office, February 2000, and Nick Chevance, Western Area Power Administration, March 2000.

Appendix B

Energy Consumption Detailed Tables

Table B1a. Number and Percent Distribution of Energy Costs of Households for Electricity

Geographic Area	Occupied Housing Units	Households Paying for Electricity			Households with Costs in Rent		Households with no Costs/no Access		Electricity Cost as a Percent of HH Income		
									Percentile		
		Number	Percent	Mean	Number	Percent	Number	Percent	10	50	90
All U.S. Households	91,947,410	86,524,761	94.1	$851	4,049,303	4.4	1,373,346	1.4	1	2	9
All Indian Households	599,159	538,931	89.9	$835	31,906	5.3	28,322	4.7	1	3	14
Not on Reservations	486,627	445,938	91.6	$838	28,456	5.8	12,233	2.5	1	3	12
On Reservations	112,532	92,993	82.6	$822	3,450	3.0	16,089	14.2	1	4	20
Acoma Pueblo and Trust Lands, NM	584	573	98.1	$614	0	0.0	11	1.8	1	3	22
Blackfeet Reservation, MT	1,863	1,832	98.3	$1,012	16	0.8	15	0.8	2	6	24
Cattaraugus Reservation, NY	657	599	91.1	$974	48	7.3	10	1.5	1	4	16
Cheyenne River Reservation, SD	1,282	1,178	91.8	$1,104	66	5.1	38	2.9	2	7	38
Colorado River Reservation, AZ-CA	635	607	95.5	$1,219	15	2.3	13	2.0	2	6	27
Colville Reservation, WA	1,200	1,180	98.3	$965	7	0.5	13	1.0	2	5	19
Crow Reservation and Trust Lands, MT	1,075	1,051	97.7	$989	20	1.8	4	0.3	2	6	25
Devils Lake Sioux Reservation, ND	631	577	91.4	$1,468	44	6.9	10	1.5	2	10	42
Eastern Cherokee Reservation, NC	1,760	1,725	98.0	$927	26	1.4	9	0.5	2	5	17
Flathead Reservation, MT	1,734	1,655	95.4	$766	43	2.4	36	2.0	1	5	15
Fort Apache Reservation, AZ	2,322	2,083	89.7	$586	22	0.9	217	9.3	1	4	12
Fort Belknap Reservation and Trust Lands, MT	637	557	87.4	$890	45	7.0	35	5.4	2	6	22
Fort Berthold Reservation, ND	829	734	88.5	$912	57	6.8	38	4.5	1	5	19
Fort Hall Reservation and Trust Lands, ID	830	800	96.3	$953	14	1.6	16	1.9	1	5	20
Fort Peck Reservation, MT	1,602	1,532	95.6	$971	43	2.6	27	1.6	2	6	23
Gila River Reservation, AZ	2,335	2,148	91.9	$737	9	0.3	178	7.6	2	6	24
Hoopa Valley Reservation, CA	536	527	98.3	$865	5	0.9	4	0.7	1	4	13
Hopi Reservation and Trust Lands, AZ	1,720	1,215	70.6	$566	13	0.7	492	28.6	1	3	12
Isleta Pueblo, NM	833	829	99.5	$651	0	0.0	4	0.4	1	3	16
Jicarilla Apache Reservation, NM	632	600	94.9	$751	2	0.3	30	4.7	1	3	11
Lac Courte Oreilles Reservation and Trust Lands, WI	527	450	85.3	$704	62	11.7	15	2.8	2	5	12
Laguna Pueblo and Trust Lands, NM	1,015	1,008	99.3	$698	0	0.0	7	0.6	1	3	17
Lake Traverse (Sisseton) Reservation, ND-SD	747	629	84.2	$1,289	60	8.0	58	7.7	3	10	42
Leech Lake Reservation, MN	1,015	934	92.0	$993	45	4.4	36	3.5	2	7	20
Menominee Reservation, WI	830	796	95.9	$600	24	2.8	10	1.2	1	3	11
Mescalero Apache Reservation, NM	613	424	69.1	$804	96	15.6	93	15.1	1	4	13
Mississippi Choctaw Reservation and Trust Lands, MS	922	907	98.3	$791	0	0.0	15	1.6	2	4	17
Navajo Reservation and Trust Lands, AZ-NM-UT	34,161	20,902	61.1	$579	693	2.0	12,566	36.7	1	3	16
Nez Perce Reservation, ID	590	558	94.5	$949	22	3.7	10	1.6	2	5	22
Northern Cheyenne Reservation and Trust Lands, MT-SD	871	800	91.8	$1,227	56	6.4	15	1.7	3	8	27
Oneida (West) Reservation, WI	711	681	95.7	$669	30	4.2	0	0.0	1	3	8
Osage Reservation, OK	1,944	1,925	99.0	$959	10	0.5	9	0.4	1	4	16
Papago Reservation, AZ	2,100	1,896	90.2	$590	40	1.9	164	7.8	1	6	21
Pascua Yaqui Reservation, AZ	526	501	95.2	$646	9	1.7	16	3.0	2	5	24
Pine Ridge Reservation and Trust Lands, NE-SD	2,302	2,149	93.3	$1,060	20	0.8	133	5.7	2	8	30
Red Lake Reservation, MN	917	910	99.2	$1,241	3	0.3	4	0.4	3	8	27
Rosebud Reservation and Trust Lands, SD	1,924	1,753	91.1	$1,122	72	3.7	99	5.1	2	9	39

See notes at end of table.

Table B1a. Number and Percent Distribution of Energy Costs of Households for Electricity (Continued)

Geographic Area	Occupied Housing Units	Households Paying for Electricity			Households with Costs in Rent		Households with no Costs/no Access		Electricity Cost as a Percent of HH Income		
									Percentile		
		Number	Percent	Mean	Number	Percent	Number	Percent	10	50	90
St. Regis Mohawk Reservation, NY	628	615	97.9	$989	5	0.7	8	1.2	1	5	19
Salt River Reservation, AZ	857	732	85.4	$1,073	23	2.6	102	11.9	2	7	37
San Carlos Reservation, AZ	1,636	1,542	94.2	$792	0	0.0	94	5.7	1	5	32
Standing Rock Reservation, ND-SD	1,135	552	48.6	$758	377	33.2	206	18.1	1	4	17
Turtle Mountain Reservation and Trust Lands, ND-SD	1,982	1,700	85.7	$1,210	165	8.3	117	5.9	2	8	27
Uintah and Ouray Reservation, UT	656	648	98.7	$1,079	2	0.3	6	0.9	2	6	50
Warm Springs Reservation and Trust Lands, OR	665	665	100.0	$1,162	0	0.0	0	0.0	2	5	20
White Earth Reservation, MN	833	774	92.9	$909	43	5.1	16	1.9	2	7	19
Wind River Reservation, WY	1,530	1,403	91.6	$790	67	4.3	60	3.9	1	5	17
Yakima Reservation and Trust Lands, WA	1,544	1,430	92.6	$1,110	114	7.3	0	0.0	2	6	23
Zuni Pueblo, AZ-NM	1,462	1,423	97.3	$907	0	0.0	39	2.6	1	4	21

Note: HH = Households.
Source: U.S. Bureau of the Census, 1990 Decennial Census of Housing.

Table B1b. Number and Percent Distribution of Energy Costs of Oklahoma TJSA Households for Electricity

Geographic Area	Occupied Housing Units	Households Paying for Electricity			Households with Costs in Rent		Households with no Costs/no Access		Electricity Cost as a Percent of HH Income		
									Percentile		
		Number	Percent	Mean	Number	Percent	Number	Percent	10	50	90
Oklahoma Households	1,206,135	1,157,569	95.9	$882	35,415	2.9	13,151	1.0	1	3	11
All Indian Households	78,870	76,013	96.3	$851	2,040	2.5	817	1.0	1	4	14
Not on Tribal Jurisdictions	16,880	16,127	95.5	$895	573	3.3	180	1.0	1	4	13
On Tribal Jurisdictions	61,990	59,886	96.6	$840	1,467	2.3	637	1.0	1	4	14
Absentee Shawnee-Citizens Band of Potawatomi	1,702	1,674	98.3	$1,089	6	0.3	22	1.2	2	4	14
Caddo-Wichita-Delaware	190	187	98.4	$925	3	1.5	0	0.0	2	4	43
Cherokee	20,268	19,682	97.1	$815	356	1.7	230	1.1	1	4	13
Cheyenne-Arapaho	1,905	1,862	97.7	$919	32	1.6	11	0.5	2	4	24
Chickasaw	6,691	6,560	98.0	$899	74	1.1	57	0.8	2	4	15
Choctaw	9,252	9,031	97.6	$801	111	1.1	110	1.1	2	5	14
Creek	14,717	13,810	93.8	$823	762	5.1	145	0.9	1	3	11
Iowa	81	74	91.3	$924	3	3.7	4	4.9	2	4	12
Kaw	211	211	100.0	$931	0	0.0	0	0.0	1	3	17
Kiowa-Camanche-Apache-Fort Sill Apache	3,479	3,355	96.4	$863	82	2.3	42	1.2	2	4	18
Otoe-Missouria	138	134	97.1	$952	0	0.0	4	2.8	3	10	26
Pawnee	515	509	98.8	$915	0	0.0	6	1.1	2	5	13
Sac and Fox	1,368	1,359	99.3	$824	9	0.6	0	0.0	1	4	15
Seminole	1,063	1,048	98.5	$817	9	0.8	6	0.5	2	4	12
Tonkawa	238	228	95.7	$805	10	4.2	0	0.0	2	5	13
Creek-Seminole Joint Area	167	157	94.0	$750	10	5.9	0	0.0	2	4	13
Iowa-Sac and Fox Joint Area	5	5	100.0	$1,016	0	0.0	0	0.0	0	0	7

Note: HH = Households.
Source: U.S. Bureau of the Census, 1990 Decennial Census of Housing.

Table B2a. Number and Percent Distribution of Energy Costs of Households for Natural Gas

Geographic Area	Occupied Housing Units	Households Paying for Gas			Households with Costs in Rent		Households with no Costs/no Access		Gas Cost as a Percent of HH Income		
									Percentile		
		Number	Percent	Mean	Number	Percent	Number	Percent	10	50	90
All U.S. Households	91,947,410	55,495,001	60.3	$631	6,037,357	6.5	30,415,052	33.0	0	2	7
All Indian Households	599,159	358,949	59.9	$586	39,399	6.5	200,811	33.5	1	2	10
Not on Reservations	486,627	298,340	61.3	$580	35,811	7.3	152,476	31.3	1	2	10
On Reservations	112,532	60,609	53.8	$613	3,588	3.1	48,335	42.9	1	3	15
Acoma Pueblo and Trust Lands, NM	584	455	77.9	$726	0	0.0	129	22.0	1	3	30
Blackfeet Reservation, MT	1,863	1,046	56.1	$727	24	1.2	793	42.5	2	5	17
Cattaraugus Reservation, NY	657	351	53.4	$952	9	1.3	297	45.2	1	5	23
Cheyenne River Reservation, SD	1,282	893	69.6	$704	76	5.9	313	24.4	1	5	20
Colorado River Reservation, AZ-CA	635	336	52.9	$449	6	0.9	293	46.1	0	2	12
Colville Reservation, WA	1,200	11	0.9	$260	4	0.3	1,185	98.7	0	1	4
Crow Reservation and Trust Lands, MT	1,075	687	63.9	$962	18	1.6	370	34.4	1	5	20
Devils Lake Sioux Reservation, ND	631	219	34.7	$714	9	1.4	403	63.8	1	4	15
Eastern Cherokee Reservation, NC	1,760	207	11.7	$299	23	1.3	1,530	86.9	0	2	6
Flathead Reservation, MT	1,734	221	12.7	$669	17	0.9	1,496	86.2	1	4	13
Fort Apache Reservation, AZ	2,322	1,741	74.9	$602	84	3.6	497	21.4	1	3	11
Fort Belknap Reservation and Trust Lands, MT	637	384	60.2	$714	40	6.2	213	33.4	1	4	16
Fort Berthold Reservation, ND	829	507	61.1	$789	13	1.5	309	37.2	1	5	19
Fort Hall Reservation and Trust Lands, ID	830	240	28.9	$677	0	0.0	590	71.0	1	5	16
Fort Peck Reservation, MT	1,602	1,240	77.4	$949	35	2.1	327	20.4	2	5	21
Gila River Reservation, AZ	2,335	1,430	61.2	$468	0	0.0	905	38.7	1	4	17
Hoopa Valley Reservation, CA	536	324	60.4	$551	0	0.0	212	39.5	1	3	10
Hopi Reservation and Trust Lands, AZ	1,720	1,378	80.1	$537	7	0.4	335	19.4	0	3	11
Isleta Pueblo, NM	833	680	81.6	$765	0	0.0	153	18.3	1	3	15
Jicarilla Apache Reservation, NM	632	587	92.8	$795	6	0.9	39	6.1	1	4	11
Lac Courte Oreilles Reservation and Trust Lands, WI	527	438	83.1	$787	62	11.7	27	5.1	2	5	16
Laguna Pueblo and Trust Lands, NM	1,015	806	79.4	$842	0	0.0	209	20.5	1	3	18
Lake Traverse (Sisseton) Reservation, ND-SD	747	256	34.2	$704	34	4.5	457	61.1	1	6	32
Leech Lake Reservation, MN	1,015	463	45.6	$572	29	2.8	523	51.5	1	3	17
Menominee Reservation, WI	830	697	83.9	$847	37	4.4	96	11.5	1	4	23
Mescalero Apache Reservation, NM	613	416	67.8	$846	98	15.9	99	16.1	1	4	14
Mississippi Choctaw Reservation and Trust Lands, MS	922	578	62.6	$457	0	0.0	344	37.3	1	2	12
Navajo Reservation and Trust Lands, AZ-NM-UT	34,161	17,924	52.4	$466	1,303	3.8	14,934	43.7	0	2	12
Nez Perce Reservation, ID	590	16	2.7	$523	0	0.0	574	97.2	0	4	*
Northern Cheyenne Reservation and Trust Lands, MT-SD	871	239	27.4	$814	5	0.5	627	71.9	1	5	18
Oneida (West) Reservation, WI	711	526	73.9	$816	27	3.7	158	22.2	1	4	13
Osage Reservation, OK	1,944	1,683	86.5	$575	35	1.8	226	11.6	1	3	11
Papago Reservation, AZ	2,100	674	32.0	$478	46	2.1	1,380	65.7	1	4	23
Pascua Yaqui Reservation, AZ	526	484	92.0	$454	14	2.6	28	5.3	1	4	18
Pine Ridge Reservation and Trust Lands, NE-SD	2,302	1,744	75.7	$805	53	2.3	505	21.9	1	6	24
Red Lake Reservation, MN	917	56	6.1	$424	0	0.0	861	93.8	0	2	31
Rosebud Reservation and Trust Lands, SD	1,924	1,124	58.4	$717	49	2.5	751	39.0	1	5	21
St. Regis Mohawk Reservation, NY	628	329	52.3	$371	19	3.0	280	44.5	0	1	10
Salt River Reservation, AZ	857	291	33.9	$427	0	0.0	566	66.0	1	2	9
San Carlos Reservation, AZ	1,636	1,083	66.1	$598	0	0.0	553	33.8	0	4	21
Standing Rock Reservation, ND-SD	1,135	437	38.5	$814	296	26.0	402	35.4	1	3	14
Turtle Mountain Reservation and Trust Lands, ND-SD	1,982	932	47.0	$751	146	7.3	904	45.6	1	4	18
Uintah and Ouray Reservation, UT	656	409	62.3	$780	4	0.6	243	37.0	1	5	25
Warm Springs Reservation and Trust Lands, OR	665	23	3.4	$623	0	0.0	642	96.5	1	2	6
White Earth Reservation, MN	833	330	39.6	$590	8	0.9	495	59.4	1	3	13
Wind River Reservation, WY	1,530	1,017	66.4	$735	76	4.9	437	28.5	1	4	15
Yakima Reservation and Trust Lands, WA	1,544	71	4.5	$375	48	3.1	1,425	92.2	0	1	2
Zuni Pueblo, AZ-NM	1,462	1,070	73.1	$647	15	1.0	377	25.7	1	3	9

* = Value withheld due to data quality concerns.
Note: HH = Households.
Source: U.S. Bureau of the Census, 1990 Decennial Census of Housing.

Table B2b. Number and Percent Distribution of Energy Costs of Oklahoma TJSA Households for Natural Gas

Geographic Area	Occupied Housing Units	Households Paying for Electricity			Households with Costs in Rent		Households with no Costs/no Access		Electricity Cost as a Percent of HH Income		
									Percentile		
		Number	Percent	Mean	Number	Percent	Number	Percent	10	50	90
Oklahoma Households	1,206,135	925,194	76.7	$554	47,389	3.9	233,552	19.3	1	2	8
All Indian Households	78,870	61,706	78.2	$541	2,675	3.3	14,489	18.3	1	3	10
Not on Tribal Jurisdictions	16,880	12,761	75.5	$588	805	4.7	3,314	19.6	1	2	10
On Tribal Jurisdictions	61,990	48,945	78.9	$529	1,870	3.0	11,175	18.0	1	3	11
Absentee Shawnee-Citizens Band of Potawatomi	1,702	1,188	69.8	$526	3	0.1	511	30.0	1	3	11
Caddo-Wichita-Delaware	190	178	93.6	$679	3	1.5	9	4.7	1	4	33
Cherokee	20,268	16,247	80.1	$492	329	1.6	3,692	18.2	1	3	10
Cheyenne-Arapaho	1,905	1,467	77.0	$597	21	1.1	417	21.8	1	3	20
Chickasaw	6,691	5,069	75.7	$532	163	2.4	1,459	21.8	1	3	11
Choctaw	9,252	7,438	80.3	$467	168	1.8	1,646	17.7	1	3	11
Creek	14,717	11,277	76.6	$565	996	6.7	2,444	16.6	1	2	9
Iowa	81	49	60.4	$392	0	0.0	32	39.5	1	1	5
Kaw	211	172	81.5	$697	9	4.2	30	14.2	1	2	10
Kiowa-Camanche-Apache-Fort Sill Apache	3,479	2,902	83.4	$615	95	2.7	482	13.8	1	3	13
Otoe-Missouria	138	79	57.2	$688	0	0.0	59	42.7	1	5	22
Pawnee	515	434	84.2	$619	1	0.1	80	15.5	1	3	10
Sac and Fox	1,368	1,211	88.5	$592	25	1.8	132	9.6	1	3	13
Seminole	1,063	879	82.6	$629	34	3.1	150	14.1	1	4	15
Tonkawa	238	221	92.8	$687	13	5.4	4	1.6	1	4	19
Creek-Seminole Joint Area	167	129	77.2	$488	10	5.9	28	16.7	1	4	12
Iowa-Sac and Fox Joint Area	5	5	100.0	$780	0	0.0	0	0.0	0	0	5

Note: HH = Households.
Source: U.S. Bureau of the Census, 1990 Decennial Census of Housing.

Table B3a. Number and Percent Distribution of Energy Costs of Households for Other Fuels

Geographic Area	Occupied Housing Units	Households Paying for Other Fuels			Households with Costs in Rent		Households with no Costs/no Access		Other Fuel Cost as a Percent of HH Income		
									Percentile		
		Number	Percent	Mean	Number	Percent	Number	Percent	10	50	90
All U.S. Households	91,947,410	16,931,961	18.4	$594	3,574,582	3.8	71,440,867	77.6	0	1	6
All Indian Households	599,159	127,081	21.2	$430	17,175	2.8	454,903	75.9	0	1	9
Not on Reservations	486,627	85,421	17.5	$446	16,123	3.3	385,083	79.1	0	1	7
On Reservations	112,532	41,660	37.0	$399	1,052	0.9	69,820	62.0	0	2	12
Acoma Pueblo and Trust Lands, NM	584	275	47.0	$528	0	0.0	309	52.9	0	2	15
Blackfeet Reservation, MT	1,863	547	29.3	$423	10	0.5	1,306	70.1	0	2	9
Cattaraugus Reservation, NY	657	233	35.4	$682	8	1.2	416	63.3	1	3	12
Cheyenne River Reservation, SD	1,282	190	14.8	$511	15	1.1	1,077	84.0	1	2	10
Colorado River Reservation, AZ-CA	635	10	1.5	$167	0	0.0	625	98.4	0	1	1
Colville Reservation, WA	1,200	296	24.6	$302	11	0.9	893	74.4	0	1	8
Crow Reservation and Trust Lands, MT	1,075	175	16.2	$479	8	0.7	892	82.9	0	2	9
Devils Lake Sioux Reservation, ND	631	159	25.1	$833	3	0.4	469	74.3	2	4	12
Eastern Cherokee Reservation, NC	1,760	1,148	65.2	$329	8	0.4	604	34.3	1	2	6
Flathead Reservation, MT	1,734	796	45.9	$485	9	0.5	929	53.5	0	3	11
Fort Apache Reservation, AZ	2,322	748	32.2	$265	0	0.0	1,574	67.7	0	2	6
Fort Belknap Reservation and Trust Lands, MT	637	116	18.2	$320	7	1.0	514	80.6	1	2	9
Fort Berthold Reservation, ND	829	95	11.4	$488	6	0.7	728	87.8	1	2	11
Fort Hall Reservation and Trust Lands, ID	830	311	37.4	$358	0	0.0	519	62.5	0	1	9
Fort Peck Reservation, MT	1,602	36	2.2	$248	2	0.1	1,564	97.6	0	1	63
Gila River Reservation, AZ	2,335	188	8.0	$175	6	0.2	2,141	91.6	0	1	8

See notes at end of table.

Table B3a. Number and Percent Distribution of Energy Costs of Households for Other Fuels (Continued)

Geographic Area	Occupied Housing Units	Households Paying for Other Fuels			Households with Costs in Rent		Households with no Costs/no Access		Other Fuel Cost as a Percent of HH Income		
									Percentile		
		Number	Percent	Mean	Number	Percent	Number	Percent	10	50	90
Hoopa Valley Reservation, CA	536	344	64.1	$406	0	0.0	192	35.8	0	2	7
Hopi Reservation and Trust Lands, AZ . .	1,720	1,294	75.2	$322	0	0.0	426	24.7	0	2	10
Isleta Pueblo, NM	833	225	27.0	$370	0	0.0	608	72.9	0	1	10
Jicarilla Apache Reservation, NM	632	127	20.0	$281	6	0.9	499	78.9	0	1	7
Lac Courte Oreilles Reservation and Trust Lands, WI	527	307	58.2	$415	6	1.1	214	40.6	1	3	9
Laguna Pueblo and Trust Lands, NM	1,015	379	37.3	$398	0	0.0	636	62.6	0	2	14
Lake Traverse (Sisseton) Reservation, ND-SD	747	84	11.2	$546	14	1.8	649	86.8	1	4	9
Leech Lake Reservation, MN	1,015	532	52.4	$611	18	1.7	465	45.8	1	5	15
Menominee Reservation, WI	830	322	38.7	$684	16	1.9	492	59.2	1	3	13
Mescalero Apache Reservation, NM	613	173	28.2	$270	0	0.0	440	71.7	0	1	5
Mississippi Choctaw Reservation and Trust Lands, MS	922	170	18.4	$168	0	0.0	752	81.5	0	1	3
Navajo Reservation and Trust Lands, AZ-NM-UT	34,161	17,058	49.9	$347	370	1.0	16,733	48.9	0	2	15
Nez Perce Reservation, ID	590	246	41.6	$280	0	0.0	344	58.3	0	2	6
Northern Cheyenne Reservation and Trust Lands, MT-SD	871	119	13.6	$283	0	0.0	752	86.3	0	1	5
Oneida (West) Reservation, WI	711	215	30.2	$605	6	0.8	490	68.9	1	2	7
Osage Reservation, OK	1,944	247	12.7	$253	0	0.0	1,697	87.2	0	0	4
Papago Reservation, AZ	2,100	386	18.3	$157	28	1.3	1,686	80.2	0	2	15
Pascua Yaqui Reservation, AZ	526	37	7.0	$64	17	3.2	472	89.7	0	1	1
Pine Ridge Reservation and Trust Lands, NE-SD	2,302	521	22.6	$637	11	0.4	1,770	76.8	1	4	21
Red Lake Reservation, MN	917	503	54.8	$494	0	0.0	414	45.1	0	3	13
Rosebud Reservation and Trust Lands, SD	1,924	531	27.5	$390	39	2.0	1,354	70.3	1	3	13
St. Regis Mohawk Reservation, NY	628	475	75.6	$713	15	2.3	138	21.9	0	3	19
Salt River Reservation, AZ	857	55	6.4	$199	0	0.0	802	93.5	0	0	22
San Carlos Reservation, AZ	1,636	247	15.0	$207	0	0.0	1,389	84.9	0	1	11
Standing Rock Reservation, ND-SD	1,135	164	14.4	$845	77	6.7	894	78.7	2	11	33
Turtle Mountain Reservation and Trust Lands, ND-SD	1,982	461	23.2	$647	5	0.2	1,516	76.4	1	3	13
Uintah and Ouray Reservation, UT	656	156	23.7	$252	0	0.0	500	76.2	0	1	9
Warm Springs Reservation and Trust Lands, OR	665	139	20.9	$365	0	0.0	526	79.0	0	1	7
White Earth Reservation, MN	833	519	62.3	$604	51	6.1	263	31.5	1	4	13
Wind River Reservation, WY	1,530	284	18.5	$302	13	0.8	1,233	80.5	0	1	6
Yakima Reservation and Trust Lands, WA	1,544	446	28.8	$440	23	1.4	1,075	69.6	0	2	10
Zuni Pueblo, AZ-NM	1,462	806	55.1	$284	0	0.0	656	44.8	0	1	9

Note: HH = Households.
Source: U.S. Bureau of the Census, 1990 Decennial Census of Housing.

Table B3b. Number and Percent Distribution of Energy Costs of Oklahoma TJSA Households for Other Fuels

Geographic Area	Occupied Housing Units	Households Paying for Other Fuels			Households with Costs in Rent		Households with no Costs/no Access		Other Fuel Cost as a Percent of HH Income		
									Percentile		
		Number	Percent	Mean	Number	Percent	Number	Percent	10	50	90
Oklahoma Households	1,206,135	145,505	12.0	$173	12,637	1.0	1,047,993	86.8	0	0	3
All Indian Households	78,870	13,029	16.5	$204	641	0.8	65,200	82.6	0	1	4
Not on Tribal Jurisdictions	16,880	1,621	9.6	$195	162	0.9	15,097	89.4	0	0	3
On Tribal Jurisdictions	61,990	11,408	18.4	$205	479	0.7	50,103	80.8	0	1	4
Absentee Shawnee-Citizens Band of Potawatomi	1,702	385	22.6	$262	0	0.0	1,317	77.3	0	1	5
Caddo-Wichita-Delaware	190	10	5.2	$151	0	0.0	180	94.7	0	0	0
Cherokee	20,268	5,388	26.5	$215	89	0.4	14,791	72.9	0	1	4
Cheyenne-Arapaho	1,905	134	7.0	$171	6	0.3	1,765	92.6	0	0	7
Chickasaw	6,691	1,017	15.1	$179	37	0.5	5,637	84.2	0	1	4
Choctaw	9,252	2,071	22.3	$193	19	0.2	7,162	77.4	0	1	4
Creek	14,717	1,652	11.2	$175	282	1.9	12,783	86.8	0	1	3
Iowa	81	14	17.2	$196	0	0.0	67	82.7	0	3	18
Kaw	211	27	12.7	$152	0	0.0	184	87.2	0	0	100
Kiowa-Camanche-Apache-Fort Sill Apache	3,479	290	8.3	$270	33	0.9	3,156	90.7	0	1	4
Otoe-Missouria	138	11	7.9	$282	0	0.0	127	92.0	1	2	6
Pawnee	515	72	13.9	$310	4	0.7	439	85.2	0	1	6
Sac and Fox	1,368	145	10.5	$224	0	0.0	1,223	89.4	0	1	6
Seminole	1,063	153	14.3	$237	6	0.5	904	85.0	0	1	5
Tonkawa	238	4	1.6	$130	3	1.2	231	97.0	0	1	1
Creek-Seminole Joint Area	167	32	19.1	$193	0	0.0	135	80.8	0	1	4
Iowa-Sac and Fox Joint Area	5	3	60.0	$100	0	0.0	2	40.0	0	0	0

Note: HH = Households.
Source: U.S. Bureau of the Census, 1990 Decennial Census of Housing.

Appendix C

Dynamic Maps of Renewable Resource Potential on Indian Lands

In addition to the hard-copy maps shown in Chapter 3, maps of renewable resources on Indian lands and the U.S. transmission grid are available electronically at the following National Renewable Energy Laboratory (NREL) website:

http://maps.nrel.gov/gis.html .

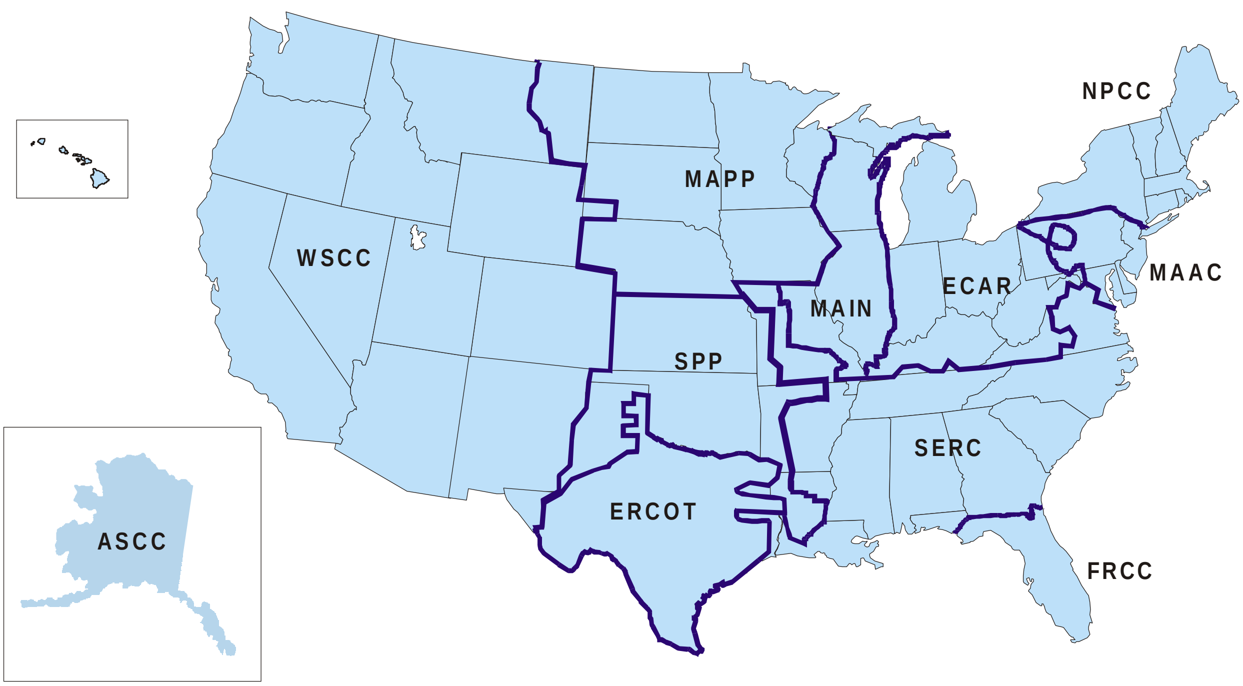
These maps are dynamic in the sense that one can examine the maps in greater or lesser detail. One can also include or exclude major geographic features from the maps, such as Interstate highways and metropolitan areas. Obtain information on how to use the map server by clicking the button "Map Server Info" in the lower left-hand corner of the screen.

The maps shown are the result of overlaying the Indian lands map with resource and transmission grid maps. As a result, it is not possible to manipulate any data used to build the maps (e.g., create a list of all Indian lands with wind resource class greater than or equal to 4). It is possible to develop such a capability, however, because NREL created the maps using the Arc View geographic information system (GIS). Further capability exists to develop map-based links to non-map data (e.g., electricity generator data by longitude-latitude, county Census data) and use Arc View GIS techniques to develop downloadable spreadsheets with both map- and nonmap-based data. This would permit one to develop a user-friendly tool that both policymakers and project proposers could use, based upon a common set of data.

Appendix D

Map of North American Electric Reliability Council Regions

Figure D1. North American Electric Reliability Council Regions for the Contiguous United States, Alaska and Hawaii



ECAR - East Central Area Reliability Coordination Agreement
ERCOT - Electric Reliability Council of Texas
FRCC - Florida Reliability Coordinating Council
MAAC - Mid-Atlantic Area Council
MAIN - Mid-America Interconnected Network
MAPP - Mid-Continent Area Power Pool
NPCC - Northeast Power Coordinating Council
SERC - Southeastern Electric Reliability Council
SPP - Southwest Power Pool
WSCC - Western Systems Coordinating Council

Note: The Alaska Systems Coordinating Council (ASCC) is an affiliate NERC member.
Source: North American Electric Reliability Council.

Glossary

Alternating Current: An electric current that reverses its direction at regularly recurring intervals, usually 50 or 60 times per second.

Amorphous Silicon: An alloy of silica and hydrogen, with a disordered, noncrystalline internal atomic arrangement, that can be deposited in thin-layers (a few micrometers in thickness) by a number of deposition methods to produce thin-film photovoltaic cells on glass, metal, or plastic substrates.

Annualized Growth Rates: Calculated as follows:

$$(x_n / x_1)^{1/n} \quad ,$$

where x is the value under consideration and n is the number of periods.

Aquifer: A subsurface rock unit from which water can be produced.

ARI: Air-Conditioning and Refrigeration Institute

Availability Factor: A percentage representing the number of hours a generating unit is available to produce power (regardless of the amount of power) in a given period, compared to the number of hours in the period.

Biodiesel: A renewable fuel synthesized from soy beans, other oil crops, or animal tallow which can substitute for petroleum diesel fuel.

Biomass: Organic nonfossil material of biological origin constituting a renewable energy source.

Black Liquor: A byproduct of the paper production process that can be used as a source of energy.

British Thermal Unit (Btu): The quantity of heat needed to raise the temperature of 1 pound of water by 1°F at or near 39.2°F.

Capacity Factor: The ratio of the electrical energy produced by a generating unit for the period of time considered to the electrical energy that could have been produced at continuous full-power operation during the same period.

Capacity, Gross: The full-load continuous rating of a generator, prime mover, or other electric equipment under specified conditions as designated by the manufacturer. It is usually indicated on a nameplate attached to the equipment.

Capital Cost: The cost of field development and plant construction and the equipment required for the generation of electricity.

Cast Silicon: Crystalline silicon obtained by pouring pure molten silicon into a vertical mold and adjusting the temperature gradient along the mold volume during cooling to obtain slow, vertically-advancing crystallization of the silicon. The polycrystalline ingot thus formed is composed of large, relatively parallel, interlocking crystals. The cast ingots are sawed into wafers for further fabrication into photovoltaic cells. Cast-silicon wafers and ribbon-silicon sheets fabricated into cells are usually referred to as polycrystalline photovoltaic cells.

Climate Change (Greenhouse Effect): The increasing mean global surface temperature of the Earth caused by gases in the atmosphere (including carbon dioxide, methane, nitrous oxide, ozone, and chlorofluorocarbons). The greenhouse effect allows solar radiation to penetrate the Earth's atmosphere but absorbs the infrared radiation returning to space.

Cogeneration: The production of electrical energy and another form of useful energy (such as heat or steam) through the sequential use of energy.

Combined Cycle: An electric generating technology in which electricity is produced from otherwise lost waste heat exiting from one or more gas (combustion) turbines. The exiting heat is routed to a conventional boiler or to a heat recovery steam generator for utilization by a steam turbine in the production of electricity. Such designs increase the efficiency of the electric generating unit.

Concentrator: A reflective or refractive device that focuses incident insolation onto an area smaller than the reflective or refractive surface, resulting in increased insolation at the point of focus.

Cull Wood: Wood logs, chips, or wood products that are burned.

Direct Current: An electric current that flows in a constant direction. The magnitude of the current does not vary or has a slight variation.

Electric Utility Restructuring: With some notable exceptions, the electric power industry historically has been composed primarily of investor-owned utilities. These utilities have been predominantly vertically integrated monopolies (combining electricity generation, transmission, and distribution), whose prices have been regulated by State and Federal government agencies. Restructuring the industry entails the introduction of competition into at least the generation phase of electricity production, with a corresponding decrease in regulatory control. Restructuring may also modify or eliminate other traditional aspects of investor-owned utilities, including their exclusive franchise to serve a given geographical area, assured rates of return, and vertical integration of the production process.

Emission: The release or discharge of a substance into the environment; generally refers to the release of gases or particulates into the air.

Evacuated Tube: In a solar thermal collector, an absorber tube, which is contained in an evacuated glass cylinder, through which collector fluids flows.

Exempt Wholesale Generator (EWG): A nonutility electricity generator that is not a qualifying facility under the Public Utility Regulatory Policies Act of 1978.

Externalities: Benefits or costs, generated as a by-product of an economic activity, that do not accrue to the parties involved in the activity. Environmental externalities are benefits or costs that manifest themselves through changes in the physical or biological environment.

Flat Plate Pumped: A medium-temperature solar thermal collector that typically consists of a metal frame, glazing, absorbers (usually metal), and insulation and that uses a pump liquid as the heat-transfer medium: predominant use is in water heating applications.

Flow Control: The laws, regulations, and economic incentives or disincentives used by waste managers to direct waste generated in a specific geographic area to a designated landfill, recycling, or waste-to-energy facility.

Fuel Cells: One or more cells capable of generating an electrical current by converting the chemical energy of a fuel directly into electrical energy. Fuel cells differ from conventional electrical cells in that the active materials such as fuel and oxygen are not contained within the cell but are supplied from outside.

Fuelwood: Wood and wood products, possibly including coppices, scrubs, branches, etc., bought or gathered, and used by direct combustion.

Fumarole: A vent from which steam or gases issue; a geyser or spring that emits gases.

Generation (Electricity): The process of producing electric energy from other forms of energy; also, the amount of electric energy produced, expressed in watthours (Wh).

Geopressured: A type of geothermal resource occurring in deep basins in which the fluid is under very high pressure.

Geothermal Energy: As used at electric utilities, hot water or steam extracted from geothermal reservoirs in the Earth's crust that is supplied to steam turbines at electric utilities that drive generators to produce electricity.

Geothermal Plant: A plant in which a turbine is driven either from hot water or by natural steam that derives its energy from heat found in rocks or fluids at various depths beneath the surface of the earth. The fluids are extracted by drilling and/or pumping.

Geyser: A special type of thermal spring that periodically ejects water with great force.

Giga: One billion.

Green Pricing: In the case of renewable electricity, green pricing represents a market solution to the various problems associated with regulatory valuation of the nonmarket benefits of renewables. Green pricing programs allow electricity customers to express their willingness to pay for renewable energy development through direct payments on their monthly utility bills.

Grid: The layout of an electrical distribution system.

Groundwater: Water occurring in the subsurface zone where all spaces are filled with water under pressure greater than that of the atmosphere.

Heat Pump: A year-round heating and air-conditioning system employing a refrigeration cycle. In a refrigeration cycle, a refrigerant is compressed (as aliquid) and expanded (as a vapor) to absorb and reject heat. The heat pump transfers heat to a space to be heated during the winter period and by reversing the operation extracts (absorbs) heat from the same space to be cooled during the summer period. The refrigerant within the heat pump in the heating mode absorbs the heat to be supplied to the space to be heated from an outside medium (air, ground or ground water) and in the cooling mode absorbs heat from the space to be cooled to be rejected to the outside medium.

Heat Pump (Air Source): An air-source heat pump is the most common type of heat pump. The heat pump absorbs heat from the outside air and transfers the heat to the space to be heated in the heating mode. In the cooling mode the heat pump absorbs heat from the space to be cooled and rejects the heat to the outside air. In the heating mode when the outside air approaches 32° F or less, air-source heat pumps loose efficiency and generally require a back-up (resistance) heating system.

Heat Pump (Geothermal): A heat pump in which the refrigerant exchanges heat (in a heat exchanger) with a fluid circulating through an earth connection medium (ground or ground water). The fluid is contained in a variety of loop (pipe) configurations depending on the temperature of the ground and the ground area available. Loops may be installed horizontally or vertically in the ground or submersed in a body of water.

Heat Pump (efficiency): The efficiency of a heat pump, that is, the electrical energy to operate it, is directly related to temperatures between which it operates. Geothermal heat pumps are more efficient than conventional heat pumps or air conditioners that use the outdoor air since the ground or ground water a few feet below the earth's surface remains relatively constant throughout the year. It is more efficient in the winter to draw heat from the relatively warm ground than from the atmosphere where the air temperature is much colder, and in summer transfer waste heat to the relatively cool ground than to hotter air. Geothermal heat pumps are generally more expensive ($2,000-$5,000) to install than outside air heat pumps. However, depending on the location geothermal heat pumps can reduce energy consumption (operating cost) and correspondingly, emissions by more than 20 percent compared to high-efficiency outside air heat pumps. Geothermal heat pumps also use the waste heat from air-conditioning to provide free hot water heating in the summer.

High-Temperature Collector: A solar thermal collector designed to operate at a temperature of 180 degrees Fahrenheit or higher.

Hot Dry Rock: Heat energy residing in impermeable, crystalline rock. Hydraulic fracturing may be used to create permeability to enable circulation of water and removal of the heat.

Hub Height: In a horizontal-axis wind turbine, the distance from the turbine platform to the rotor shaft.

Hydraulic Fracturing: Fracturing of rock at depth with fluid pressure. Hydraulic fracturing at depth may be accomplished by pumping water into a well at very high pressures. Under natural conditions, vapor pressure may rise high enough to cause fracturing in a process known as hydrothermal brecciation.

Independent Power Producer (IPP): A wholesale electricity producer (other than a qualifying facility under the Public Utility Regulatory Policies Act of 1978), that is unaffiliated with franchised utilities in the area in which the IPP is selling power and that lacks significant marketing power. Unlike traditional utilities, IPPs do not possess transmission facilities that are essential to their customers and do not sell power in any retail service territory where they have a franchise.

Internal Collector Storage (ICS): A solar thermal collector in which incident solar radiation is absorbed by the storage medium.

Kilowatt (kW): One thousand watts of electricity (See Watt).

Kilowatthour (kWh): One thousand watthours.

Levelized Cost: The present value of the total cost of building and operating a generating plant over its economic life, converted to equal annual payments. Costs are levelized in real dollars (i.e., adjusted to remove the impact of inflation).

Liquid Collector: A medium-temperature solar thermal collector, employed predominantly in water heating, which uses pumped liquid as the heat-transfer medium.

Low-Temperature Collectors: Metallic or nonmetallic solar thermal collectors that generally operate at temperatures below 110 degrees Fahrenheit and use pumped liquid or air as the heat transfer medium. They usually contain no glazing and no insulation, and they are often made of plastic or rubber, although some are made of metal.

Magma: Naturally occurring molten rock, generated within the earth and capable of intrusion and extrusion, from which igneous rocks are thought to have been derived through solidification and related processes. It may or may not contain suspended solids (such as crystals and rock fragments) and / or gas phases.

Marginal Cost: The change in cost associated with a unit change in quantity supplied or produced.

Medium-Temperature Collectors: Solar thermal collectors designed to operate in the temperature range of 140 degrees to 180 degrees Fahrenheit, but that can also operate at a temperature as low as 110 degrees Fahrenheit. The collector typically consists of a metal frame, metal absorption panels with integral flow channels (attached tubing for liquid collectors or integral ducting for air collectors), and glazing and insulation on the sides and back.

Megawatt (MW): One million watts of electricity (See Watt).

Merchant Facilities: High-risk, high-profit facilities that operate, at least partially, at the whims of the market, as opposed to those facilities that are constructed with close cooperation of municipalities and have significant amounts of waste supply guaranteed.

Net Photovoltaic Cell Shipment: The difference between photovoltaic cell shipments and photovoltaic cell purchases.

Net Photovoltaic Module Shipment: The difference between photovoltaic module shipments and photovoltaic module purchases.

Nonutility Generation: Electric generation by nonutility power producers to supply electric power for industrial, commercial, and military operations, or sales to electric utilities. See **Nonutility Power Producer**.

Nonutility Power Producer: A corporation, person, agency, authority, or other legal entity or instrumentality that owns electric generating capacity and is not an electric utility. Nonutility power producers include qualifying cogenerators, qualifying small power producers, and other nonutility generators (including independent power producers) without a designated, franchised service area that do not file forms listed in the *Code of Federal Regulations,* Title 18, Part 141.

Operation and Maintenance (O&M) Cost: Operating expenses are associated with operating a facility (i.e., supervising and engineering expenses). Maintenance expenses are that portion of expenses consisting of labor, materials, and other direct and indirect expenses incurred for preserving the operating efficiency or physical condition of utility plants that are used for power production, transmission, and distribution of energy.

Parabolic Dish: A high-temperature (above 180 degrees Fahrenheit) solar thermal concentrator, generally bowl-shaped, with two-axis tracking.

Parabolic Trough: A high-temperature (above 180 degrees Fahrenheit) solar thermal concentrator with the capacity for tracking the sun using one axis of rotation.

Passive Solar: A system in which solar energy alone is used for the transfer of thermal energy. Pumps, blowers, or other heat transfer devices that use energy other than solar are not used.

Peak Watt: A manufacturer's unit indicating the amount of power a photovoltaic cell or module will produce at standard test conditions (normally 1,000 watts per square meter and 25 degrees Celsius).

Photovoltaic Cell: An electronic device consisting of layers of semiconductor materials fabricated to form a junction (adjacent layers of materials with different electronic characteristics) and electrical contacts and being capable of converting incident light directly into electricity (direct current).

Photovoltaic Module: An integrated assembly of interconnected photovoltaic cells designed to deliver a selected level of working voltage and current at its output terminals, packaged for protection against environment degradation, and suited for incorporation in photovoltaic power systems.

Public Utility Regulatory Policies Act of 1978 (PURPA): One part of the National Energy Act, PURPA contains measures designed to encourage the conservation of energy, more efficient use of resources, and equitable rates. Principal among these were suggested retail rate reforms and new incentives for production of electricity by cogenerators and users of renewable resources.

Pulpwood: Roundwood, whole-tree chips, or wood residues.

Quadrillion Btu: Equivalent to 10 to the 15th power Btu.

Qualifying Facility (QF): A cogeneration or small power production facility that meets certain ownership, operating, and efficiency criteria established by the Federal Energy Regulatory Commission (FERC) pursuant to the Public Utility Regulatory Policies Act of 1978 (PURPA). (See the Code of Federal Regulations, Title 18, Part 292.)

Refuse-Derived Fuel (RDF): Fuel processed from municipal solid waste that can be in shredded, fluff, or densified pellet forms.

Renewable Energy Source: An energy source that is regenerative or virtually inexhaustible. Typical examples are wind, geothermal, and water power.

Ribbon Silicon: Single-crystal silicon derived by means of fabricating processes that produce sheets or ribbons of single-crystal silicon. These processes include edge-defined film-fed growth, dendritic web growth, and ribbon-to-ribbon growth.

Roundwood: Logs, bolts, and other round timber generated from the harvesting of trees.

Silicon: A semiconductor material made from silica, purified for photovoltaic applications.

Single Crystal Silicon (Czochralski): An extremely pure form of crystalline silicon produced by the Czochralski method of dipping a single crystal seed into a pool of molten silicon under high vacuum conditions and slowly withdrawing a solidifying single crystal boule rod of silicon. The boule is sawed into thin wafers and fabricated into single-crystal photovoltaic cells.

Solar Energy: The radiant energy of the sun, which can be converted into other forms of energy, such as heat or electricity.

Solar Thermal Collector: A device designed to receive solar radiation and convert it into thermal energy. Normally, a solar thermal collector includes a frame, glazing, and an absorber, together with the appropriate insulation. The heat collected by the solar thermal collector may be used immediately or stored for later use.

Solar Thermal Collector, Special: An evacuated tube collector or a concentrating (focusing) collector. Special collectors operate in the temperature (low concentration for pool heating) to several hundred degrees Fahrenheit (high concentration for air conditioning and specialized industrial processes).

Thermosiphon System: A solar collector system for water heating in which circulation of the collection fluid through the storage loop is provided solely by the temperature and density difference between the hot and cold fluids.

Tipping Fee: Price charged to deliver municipal solid waste to a landfill, waste-to-energy facility, or recycling facility.

Transmission System (Electric): An interconnected group of electric transmission lines and associated equipment for moving or transferring electric energy in bulk between points of supply and points at which it is transformed for delivery over the distribution system lines to consumers, or is delivered to other electric systems.

Turbine: A machine for generating rotary mechanical power from the energy of a stream of fluid (such as water, steam, or hot gas). Turbines convert the kinetic energy of fluids to mechanical energy through the principles of impulse and reaction, or a mixture of the two.

Vapor-Dominated Geothermal System: A conceptual model of a hydrothermal system where steam pervades the rock and is the pressure-controlling fluid phase.

Watt (Electric): The electrical unit of power. The rate of energy transfer equivalent to 1 ampere of electric current flowing under a pressure of 1 volt at unity power factor.

Watt (Thermal): A unit of power in the metric system, expressed in terms of energy per second, equal to the work done at a rate of 1 joule per second.

Watthour (Wh): The electrical energy unit of measure equal to 1 watt of power supplied to, or taken from, an electric circuit steadily for 1 hour.

Wheeling: The use of the transmission facilities of one system to transmit power and energy by agreement of and for, another system with a corresponding wheeling charge (e.g., the transmission of electricity for compensation over a system that is received from one system and delivered to another system).

Wood Pellets: Fuel manufactured from finely ground wood fiber and used in pellet stoves.