U.S. DEPARTMENT OF ENERGY | Office of Indian Energy



Developing Clean Energy Projects on Tribal Lands

Data and Resources for Tribes

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Renewable Energy Technical Potential on Tribal Lands

The U.S. Department of Energy (DOE) Office of Indian Energy Policy and Programs commissioned an updated estimate of renewable energy potential on Indian lands to reflect and incorporate fast-moving renewable technology efficiency innovations. Updated data was analyzed by the DOE Office of Indian Energy and by DOE's National Renewable Energy Laboratory (NREL), which used geospatial methodology to update and substantiate the estimated renewable energy technical potential on tribal lands. The purpose is to provide tribal governments with data to make informed decisions about renewable development options for their communities.

Key Findings

- American Indian land comprises approximately 2% of U.S. land but contains an estimated **5% of all renewable energy resources.**
- The total technical potential on tribal lands for electricity generation from utility-scale rural **solar** resources is about **14 billion MWh, or 5.1%** of total U.S. generation potential.
- The total technical potential on tribal lands for electricity generation from **wind** resources is about **1,100 million MWh, or about 3.4%** of the total U.S. technical potential.
- The total technical potential on tribal lands for electricity generation from **hydropower** resources is about **7 million MWh, or about 2.9%** of the total U.S. technical potential.

About the DOE Office of Indian Energy

Empowering Indian Country to Energize Future Generations

The DOE Office of Indian Energy was established by Congress to provide federally recognized Tribes and Alaska Native entities with technical and financial assistance to encourage, facilitate, and assist in energy and energy infrastructure development in Indian Country.

In direct response to the requests of Tribes and Alaska Native Tribes, DOE Office of Indian Energy has designed key programs to provide tribal leaders and staff with the knowledge needed to make informed energy decisions—decisions with the power to help:

- Stabilize energy costs
- Enhance energy security
- Strengthen tribal energy infrastructure
- Promote tribal self-determination.

By providing reliable, accurate information and expert technical assistance, the DOE Office of Indian Energy seeks to empower Tribes by providing analytical tools and technical support to bolster tribal leadership decision making, and the next generation of energy development in Indian Country.

To learn more about the history of the Office and its program mission, please visit *www.energy.gov/IndianEnergy*.

At the Indian Pueblo Cultural Center in Albuquerque, New Mexico, this photovoltaic carport delivers about 23 megawatt-hours of clean electricity to the local utility grid. *Photo from Sandia National Laboratories, NREL 08978*

A Shared Path Toward a Sustainable Energy Future

The DOE Office of Indian Energy's approach is, first and foremost, a collaborative one as it works with tribal nations, federal agencies, state governments, non-governmental organizations, and the private sector to support tribally led development of the considerable energy resources that exist.

To guide the strategic planning and implementation of the Department's tribal energy programs and policies, Energy Secretary Steven Chu established an Indian Country Energy and Infrastructure Working Group (ICEIWG). In addition, the DOE Office of Indian Energy has launched three near-term strategic initiatives to support the tribal energy development and capacity-building priorities established in the Congressional statute defining the DOE Office of Indian Energy's mission:

- Strategic Technical Assistance Response Team (START) Programs
- Tribal Energy Education Programs
- Tribal Leader and Best Practices Forums.

Through the Indian Country Energy and Infrastructure Working Group, DOE Office of Indian Energy collaborates and identifies real-time tribal experiences representing obstacles and opportunities in energy and related infrastructure development and capacity building in Indian Country. *Photo from Brooke Oleen, National Conference of State Legislatures*

The DOE Office of Indian Energy coordinates and manages the government-to-government and intertribal collaboration involved in carrying out all DOE tribal energy-related activities and initiatives prescribed through the Energy Policy Act of 2005.

DOE Indian Energy START Programs

To better position tribal energy and infrastructure projects for financing and construction, the DOE Office of Indian Energy Strategic Technical Assistance Response Team (START) Programs provide community-based assistance to federally recognized Native American and Alaska Native villages through clean energy and infrastructure expert technical assistance and support. This support ranges from technical resource analysis, development process assistance, and infrastructure evaluation, to community-wide energy planning, workforce training, and project financial support.

DOE START Programs seek to spur clean energy and infrastructure project development by providing Tribes with tools and resources needed to foster energy self-sufficiency, sustainability, and economic competitiveness. With core support of technical experts from NREL, START works hand-in-hand at the community level with tribal leadership and staff.

Other On-the-Ground Technical Assistance

In addition to START, the DOE Office of Indian Energy routinely pulls in the diverse array of expertise across the DOE complex, including its national energy laboratories and other expert partners to offer Tribes unbiased technical expertise on energy projects. Other assistance has included installing renewable energy systems, facilitating strategic partnerships and discussions, and implementing solutions to energy and environmental challenges.

START team members conduct a wind site assessment on the Campo Indian Reservation in San Diego County, California. From left to right: Bob Springer, NREL; Laura Quaha, Campo Kumeyaay Nation: Melissa Estes, Campo Environmental Protection Agency; Robi Robichaud, NREL. *Photo by Alex Dane, NREL 22724*

Tribal Leader Education Programs

To enhance tribal leaders' understanding of energy project development, including DOE's role, business processes, and project frameworks, the DOE Office of Indian Energy works with numerous partners to develop education and technical assistance materials available to tribal leaders and staff through regional workshops and online webinars. These partners include other DOE offices, laboratories, and programs, such as NREL, Sandia National Laboratories, the Office of Energy Efficiency and Renewable Energy's (EERE) Tribal Energy Program, the Office of Electricity, Western Area Power Administration, and Bonneville Power Administration.

Attendees at one of the DOE Office of Indian Energy's Tribal Leader Energy Forums. *Photo by Dennis Schroeder, NREL 23633*

Tribal Leader and Best Practices Forums

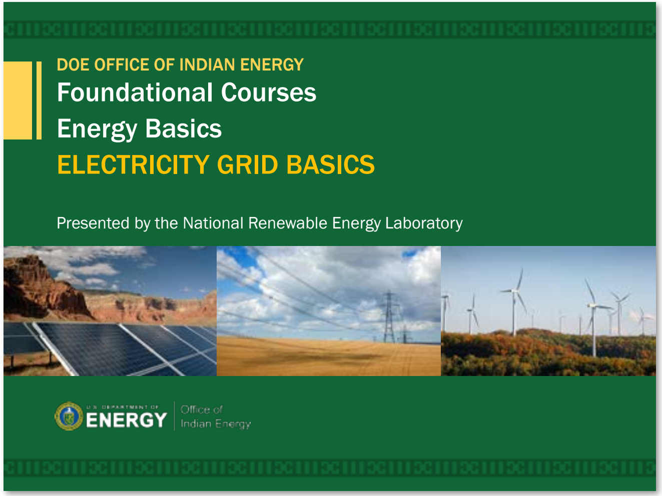
To further support smart tribal energy development through collaboration and information sharing, the DOE Office of Indian Energy hosts strategic best practices forums on energy technologies and energy project development and finance. The forums are designed to give tribal leaders an opportunity to receive the latest updates from and interact directly with, Tribes, industry, utilities, DOE, and other federal agencies on tribal energy deployment efforts.

Resources for Tribes

The DOE Office of Indian Energy offers a number of resources to support the development of renewable energy resources on tribal lands.

Energy Resource Library

The DOE Office of Indian Energy's Web-based Energy Resource Library provides links to more than 100 publications, websites, and other helpful resources for Tribes on energy project development and financing in Indian Country. Topics include community-scale development, legal and regulatory issues, project checklists, strategic energy planning, renewable energy technologies, transmission, tribal case studies, and more: *www.energy.gov/indianenergy/resources/energy-resource-library*.



Renewable Energy Curriculum

DOE Office of Indian Energy has developed an educational training program that provides tribal leaders and professionals with an overview of the project development process and financing of renewable energy projects on tribal lands. The program includes foundational courses that give a baseline understanding of energy strategy, planning, and resources, as well as advanced leadership and professional courses that take an in-depth look at the energy project development framework and various financing options. The webinars are available on the National Training & Education Resource (NTER) website: *www.nterlearning.org*.

Resources for Tribes *(continued)*

Tribal Renewable Energy Webinar Series

The DOE Office of Indian Energy, the EERE Tribal Energy Program, and Western Area Power Administration sponsor a series of free webinars on tribal renewable energy. The webinars are designed for tribal leaders and staff members who are interested in developing commercial-scale projects, responding to utility offered requests for proposals, and/or learning more about the competitive power market. To see a schedule of upcoming webinars and links to register, visit *www.energy.gov/indianenergy/resources/education-and-training*.

Newsletter

The DOE Office of Indian Energy quarterly newsletter, *Indian Energy Beat,* highlights opportunities and actions to accelerate energy development in Indian Country: *www.energy.gov/indianenergy/resources/newsletter*.


U.S. DOE OFFICE OF INDIAN ENERGY

INDIAN ENERGY BEAT

News on Actions to Accelerate Energy Development in Indian Country

FALL 2012

INSIDE THIS ISSUE:

DOE Office of Indian Energy Provides Tribes with **Hands-On Support** to Advance Tribal Energy Projects

The DOE Office of Indian Energy (DOE-IE) is taking a hands-on approach to advancing next-generation energy development in Indian Country, providing on-site strategic technical assistance for Tribes on renewable energy project deployment.

Through an application process, DOE-IE selected 11 Tribes in Alaska and the contiguous United States to receive tailored technical assistance through the Strategic Technical Assistance Response Team (START) Program. The Office is working with DOE national laboratories and other partners to offer various Tribes unbiased technical expertise on potential energy projects, as well as help with installing renewable energy systems, facilitating strategic partnerships and discussions, and implementing solutions to energy and environmental challenges.

TECHNICAL ASSISTANCE: ON THE GROUND

At Tohono O'odham Nation

In August, the DOE Office of Indian Energy technical team attended the Tohono O'odham Nation Tribal Council meeting to discuss the Tribe's renewable energy projects, provide technical assistance, and answer questions regarding projects under consideration on the reservation. The presentations are part of a series of educational courses DOE-IE is developing to provide a framework for tribal renewable energy project development and financing. The meeting gave the more than 25 tribal council members, staff, and tribal members an opportunity to ask questions about renewable energy job creation, technology options, policy actions, funding opportunities, and preferred business structures for Tribes. Phil Hobbs of the Tohono O'odham Planning Department also summarized potential renewable energy projects for the Tribe during the meeting. In a closed-door session the next day, the council voted to move forward on two projects.

START team members conducted a wind site assessment on the Campo Indian Reservation in San Diego County, California, in September. From left to right: Bob Springer of NREL, Laura Quaha of the Campo Kumeyaay Nation, Melissa Estes with the Campo Environmental Protection Agency, and Robi Robichaud from NREL. Photo by Alex Dane, NREL/PIX 22724

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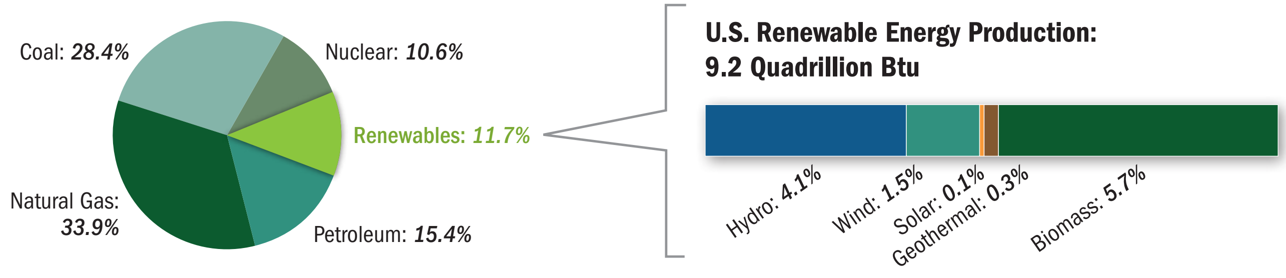
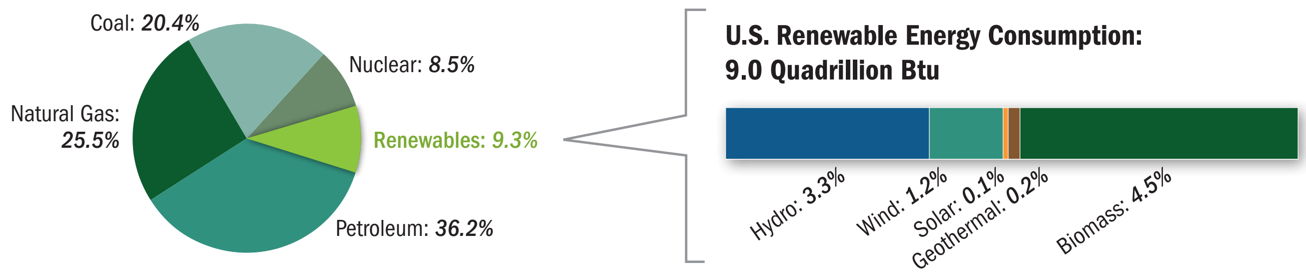
U.S. Market Context and Clean Energy Investments

U.S. Energy Production and Consumption (2011)

U.S. Energy Production (2011): 78.0 Quadrillion Btu



U.S. Energy Consumption (2011): 97.5 Quadrillion Btu



Source: EIA; full references are provided starting on p. 72. Note: Energy consumption is higher than energy production due to oil imports. All data reported as primary energy.

U.S. Energy Production by Energy Source (2000–2011)

	Coal	Natural Gas*	Petroleum	Nuclear	Renewables	Total Production (Quadrillion Btu)
2000	31.9%	31.2%	17.3%	11.0%	8.6%	71.3
2001	32.8%	31.7%	17.1%	11.2%	7.2%	71.7
2002	32.1%	31.0%	17.2%	11.5%	8.1%	70.7
2003	31.5%	31.4%	17.2%	11.4%	8.5%	70.0
2004	32.6%	30.7%	16.4%	11.7%	8.6%	70.2
2005	33.4%	30.1%	15.8%	11.8%	9.0%	69.4
2006	33.6%	30.2%	15.3%	11.6%	9.3%	70.8
2007	32.9%	31.1%	15.0%	11.8%	9.2%	71.4
2008	32.6%	31.6%	14.4%	11.5%	9.9%	73.1
2009	29.8%	32.6%	15.6%	11.5%	10.5%	72.6
2010	29.5%	32.9%	15.5%	11.3%	10.9%	74.8
2011	28.4%	33.9%	15.4%	10.6%	11.7%	78.0

*Source: EIA. *Includes natural gas plant liquids. Note: Annual totals may not equal 100% due to rounding.*

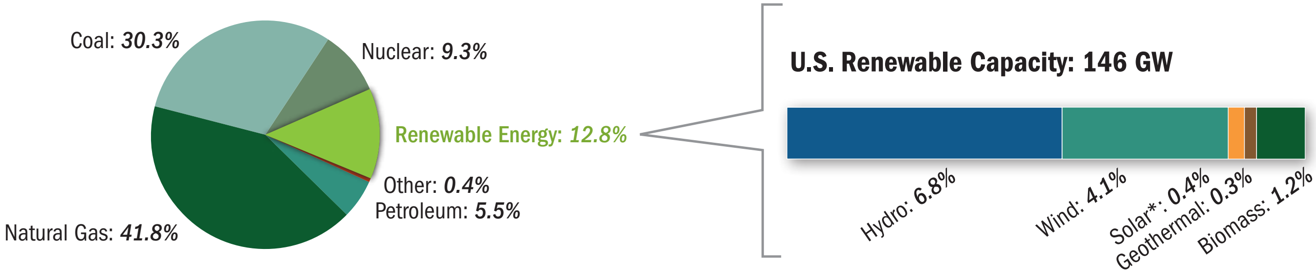
U.S. Energy Consumption by Energy Source (2000–2011)

	Coal	Natural Gas	Petroleum	Nuclear	Renewables	Total Consumption (Quadrillion Btu)
2000	22.9%	24.1%	38.7%	8.0%	6.2%	98.7
2001	22.8%	23.7%	39.7%	8.4%	5.4%	96.1
2002	22.4%	24.1%	39.2%	8.3%	5.9%	97.6
2003	22.8%	23.3%	39.6%	8.1%	6.1%	97.9
2004	22.5%	22.9%	40.3%	8.2%	6.1%	100.0
2005	22.7%	22.5%	40.3%	8.1%	6.2%	100.2
2006	22.5%	22.3%	40.1%	8.3%	6.7%	99.6
2007	22.5%	23.4%	39.3%	8.3%	6.5%	101.3
2008	22.5%	24.0%	37.6%	8.5%	7.2%	99.3
2009	20.8%	24.8%	37.4%	8.8%	8.0%	94.5
2010	21.4%	24.8%	36.8%	8.6%	8.3%	97.7
2011	20.4%	25.5%	36.2%	8.5%	9.3%	97.5

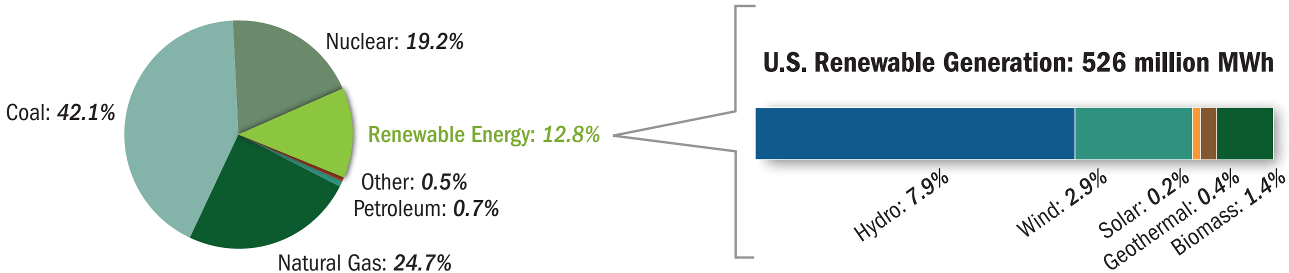
Source: EIA

U.S. Electricity Nameplate Capacity and Generation (2011)

U.S. Electric Nameplate Capacity (2011): 1,146 GW



U.S. Electric Net Generation (2011): 4,117 million MWh



*Sources: EIA, GEA, LBNL, SEIA/GTM, Larry Sherwood/IREC. Other includes: pumped storage, batteries, chemicals, hydrogen, pitch, purchased steam, sulfur, tire-derived fuels, and miscellaneous technologies. *On-grid capacity only.*

U.S. Electric-Generating Capacity by Source (2000–2011)

	Coal	Petroleum	Natural Gas	Other Gases	Nuclear	Renewables	Other	Total Capacity (MW)
2000	39.6%	8.0%	28.6%	0.3%	12.3%	11.0%	0.1%	848,112
2001	37.6%	8.2%	31.6%	0.2%	11.7%	10.6%	0.1%	895,186
2002	35.2%	6.9%	36.7%	0.2%	10.9%	10.0%	0.1%	960,306
2003	33.2%	6.6%	39.9%	0.2%	10.4%	9.6%	0.1%	1,012,402
2004	32.5%	6.3%	41.0%	0.2%	10.2%	9.5%	0.1%	1,030,056
2005	32.1%	6.2%	41.7%	0.2%	10.1%	9.7%	0.1%	1,047,704
2006	31.8%	6.1%	41.9%	0.2%	10.0%	9.9%	0.1%	1,056,289
2007	31.5%	5.8%	42.1%	0.2%	9.9%	10.3%	0.1%	1,066,961
2008	30.5%	5.6%	41.4%	0.2%	9.6%	11.0%	0.1%	1,083,176
2009	30.7%	5.7%	41.7%	0.2%	9.7%	11.9%	0.1%	1,102,335
2010	30.6%	5.6%	41.7%	0.3%	9.5%	12.3%	0.1%	1,120,188
2011	30.3%	5.5%	41.8%	0.3%	9.3%	12.8%	0.1%	1,145,741

Sources: EIA, GEA, LBNL, SEIA/GTM, Larry Sherwood/IREC

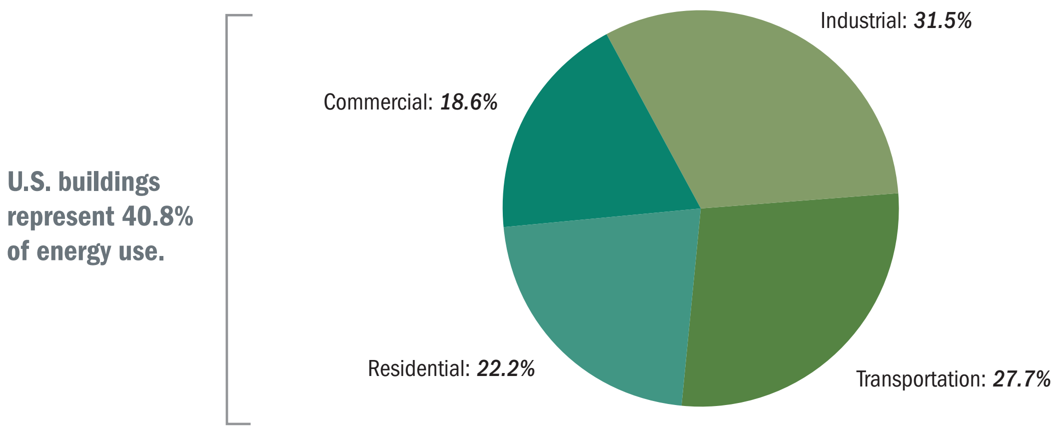
U.S. Electricity Generation by Source (2000–2011)

	Coal	Petroleum Liquids	Petroleum Coke	Natural Gas	Other Gases	Nuclear	Renewables	Other	Total Generation (million kWh)
2000	51.6%	2.7%	0.2%	15.8%	0.4%	19.8%	9.4%	0.1%	3,807,955
2001	50.8%	3.1%	0.3%	17.1%	0.2%	20.5%	7.7%	0.3%	3,745,745
2002	50.0%	2.0%	0.4%	17.9%	0.3%	20.2%	8.9%	0.4%	3,867,498
2003	50.7%	2.6%	0.4%	16.7%	0.4%	19.6%	9.1%	0.4%	3,892,115
2004	49.7%	2.5%	0.5%	17.8%	0.4%	19.8%	8.8%	0.4%	3,979,023
2005	49.5%	2.5%	0.6%	18.7%	0.3%	19.2%	8.8%	0.3%	4,062,458
2006	48.9%	1.1%	0.5%	20.1%	0.3%	19.3%	9.5%	0.3%	4,071,962
2007	48.4%	1.2%	0.4%	21.5%	0.3%	19.4%	8.5%	0.3%	4,164,748
2008	48.1%	0.8%	0.3%	21.4%	0.3%	19.5%	9.3%	0.3%	4,127,019
2009	44.4%	0.7%	0.3%	23.3%	0.3%	20.2%	10.6%	0.3%	3,956,989
2010	44.7%	0.6%	0.3%	23.9%	0.3%	19.5%	10.4%	0.3%	4,133,852
2011	42.1%	0.4%	0.3%	24.7%	0.3%	19.2%	12.8%	0.3%	4,117,287

Sources: EIA, GEA, LBNL, SEIA/GTM, Larry Sherwood/IREC

U.S. Energy Consumption by Sector (2011)

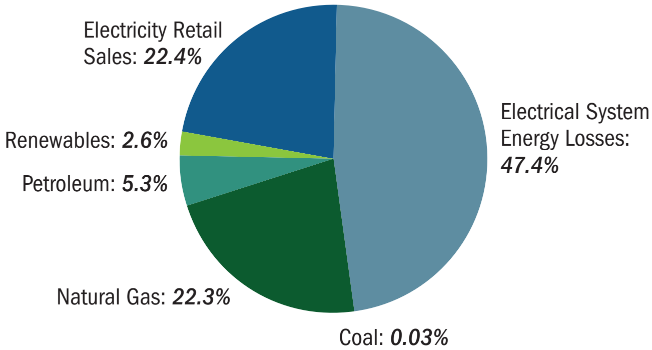
U.S. Energy Consumption in 2011 was 97.5 Quadrillion Btu



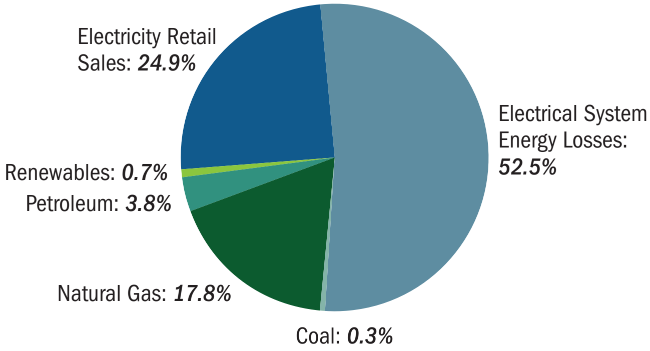
Source: EIA

U.S. Energy Consumption – Residential and Commercial (2011)

Residential Energy Consumption
(21.7 Quadrillion Btu) – 2011



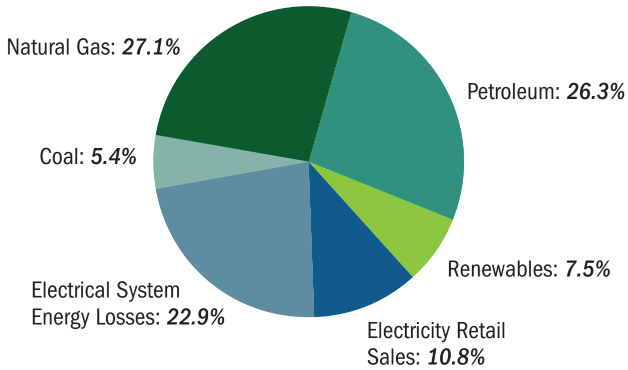
Commercial Energy Consumption
(18.1 Quadrillion Btu) – 2011



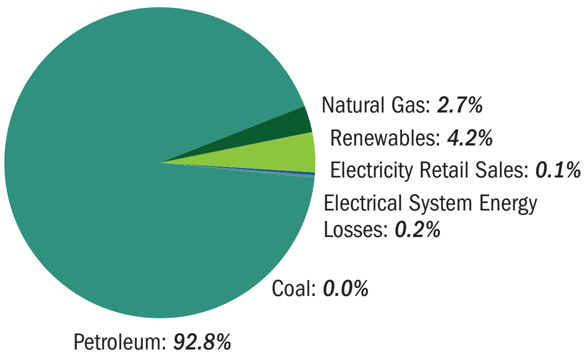
Source: EIA

U.S. Energy Consumption – Industrial and Transportation (2011)

Industrial Energy Consumption
(30.7 Quadrillion Btu) – 2011



Transportation Energy Consumption
(27.1 Quadrillion Btu) – 2011



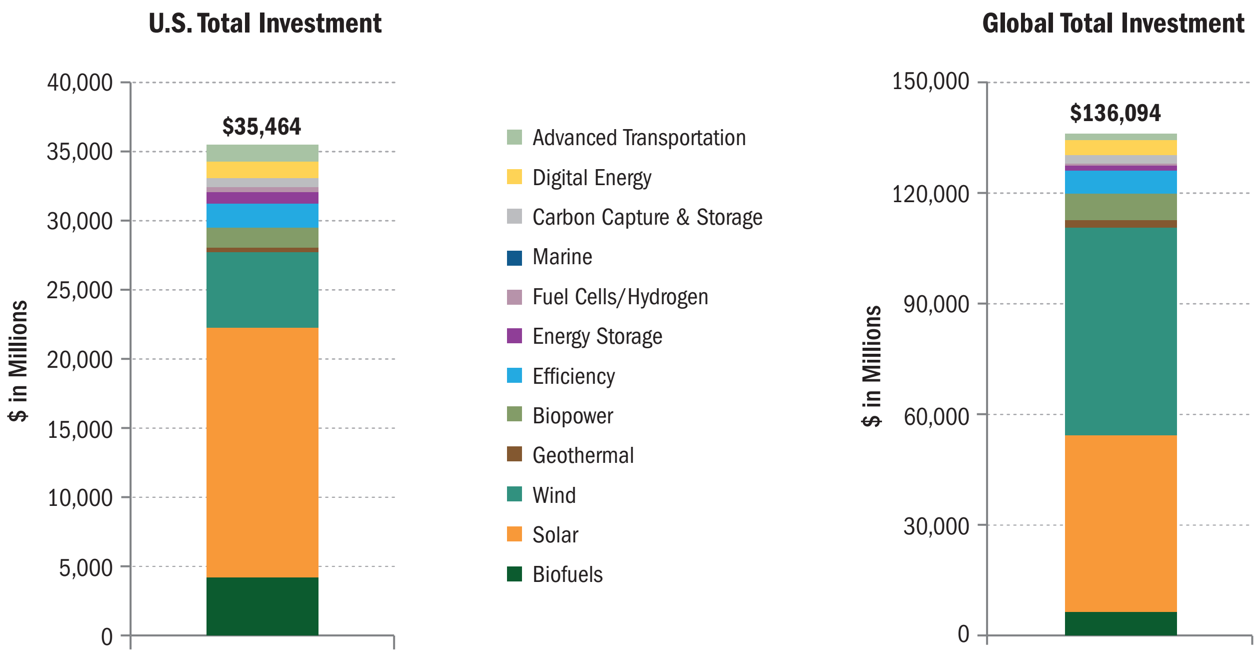
Source: EIA

Clean Energy Investments: Summary

- U.S. investment in renewable energy has grown dramatically in the past decade, and in **2011 annual investment reached more than $35 billion**.
- U.S. investment in wind energy projects **grew from $378 million in 2001 to more than $5 billion in 2011**.
- In 2011, U.S. venture capital and private equity investment in renewable energy technology companies was nearly **$7 billion—up from $253 million in 2001**.
- U.S. venture capital and private equity investment in solar technology companies has **increased from $50 million in 2001 to more than $1.7 billion in 2011**.

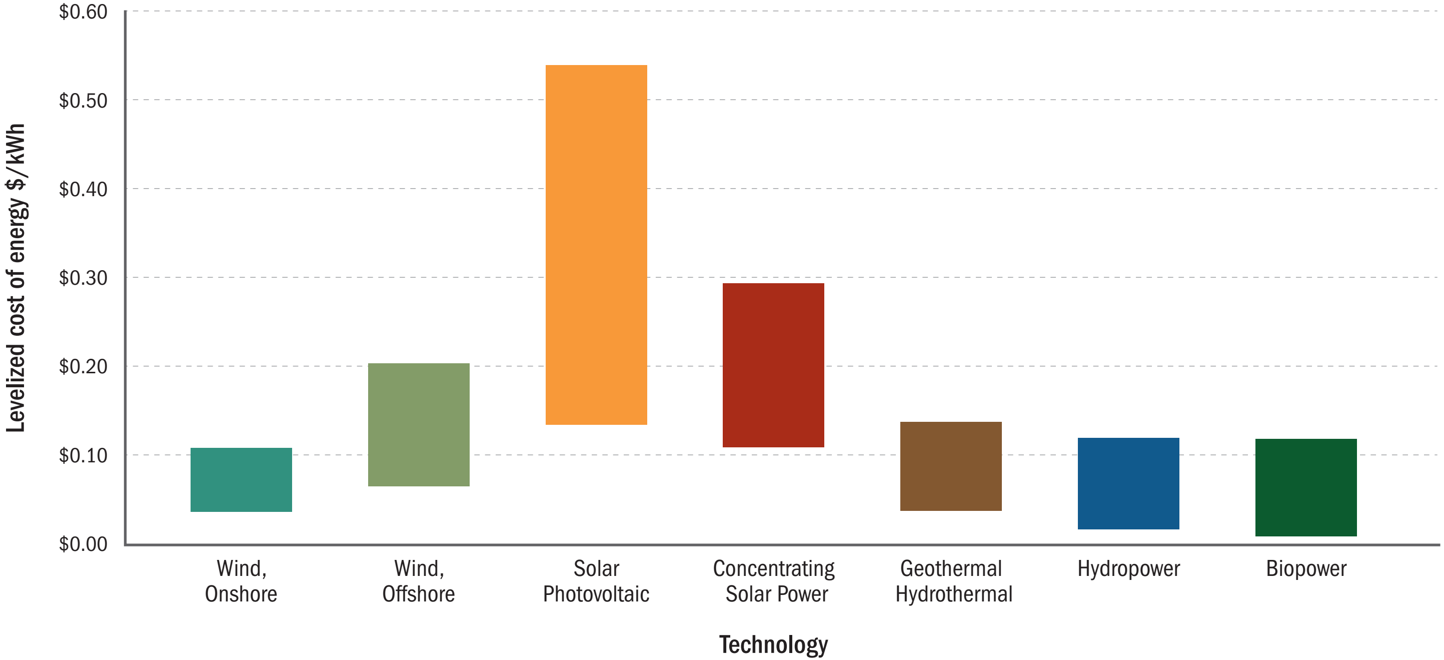
**All figures in 2011 real dollars.*

U.S. and Global Total Investment in Renewable Energy (2011)



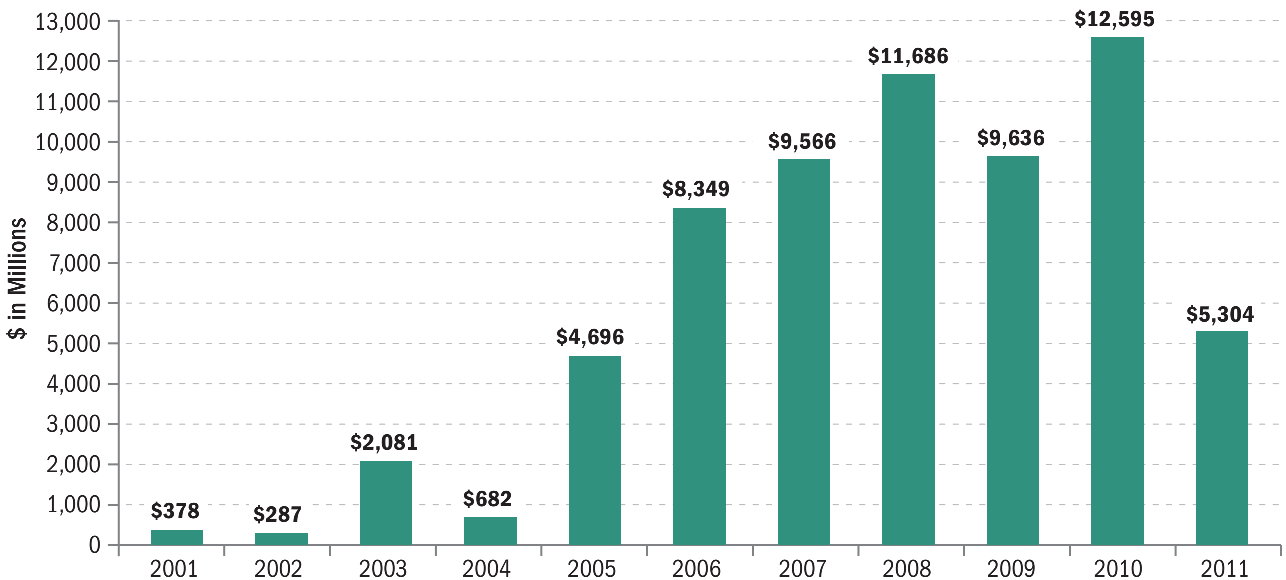
Source: Bloomberg New Energy Finance. Completed and disclosed deals only. Does not adjust for undisclosed transactions. Includes VC/PE, public market activity, and asset financing.

Lifetime or Levelized Costs of Renewables



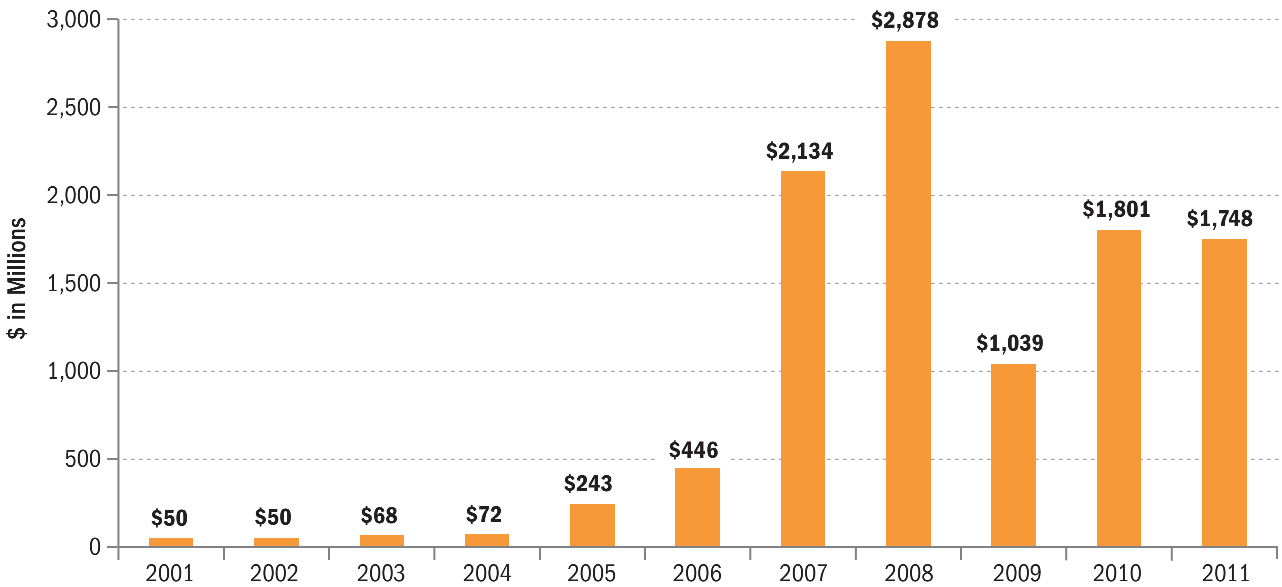
Source: Selected data presented by NREL from "LCOE – Transparent Cost Database." (2012). OpenEI. Accessed February 4, 2013: http://en.openei.org/apps/TCDB/.

U.S. Wind Energy Project Asset Financing Transactions (2001–2011)



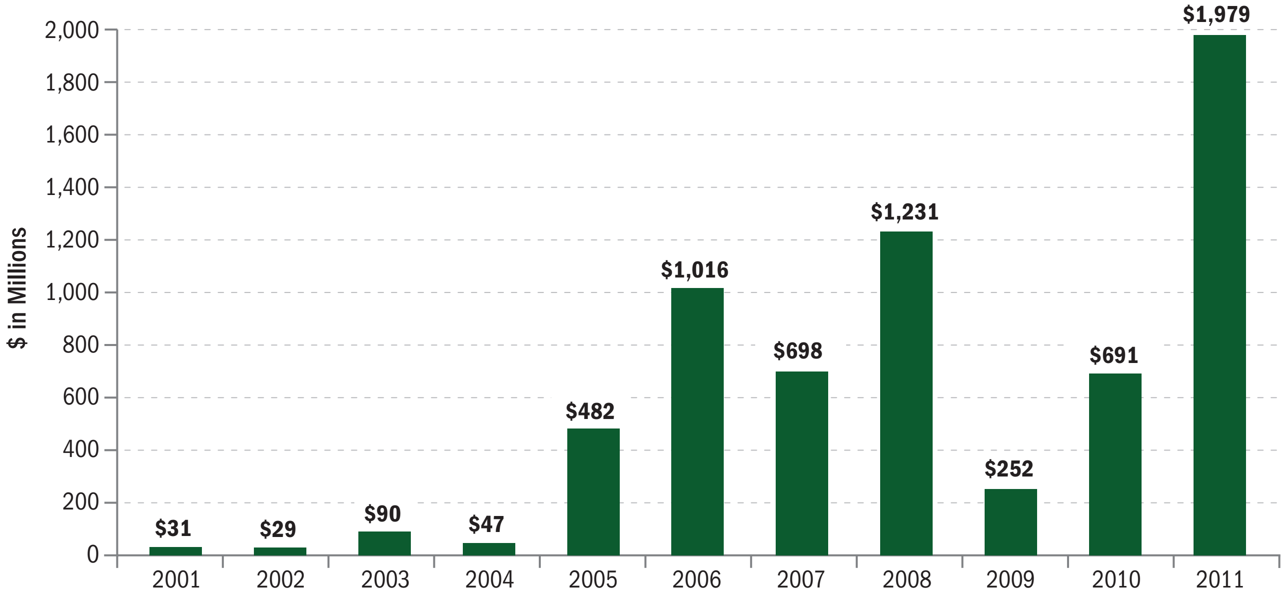
**All figures in 2011 real dollars. Figures represent disclosed deals derived from Bloomberg New Energy Finance's Desktop database.*

U.S. Venture Capital and Private Equity Investment in Solar Energy Technology Companies (2001–2011)



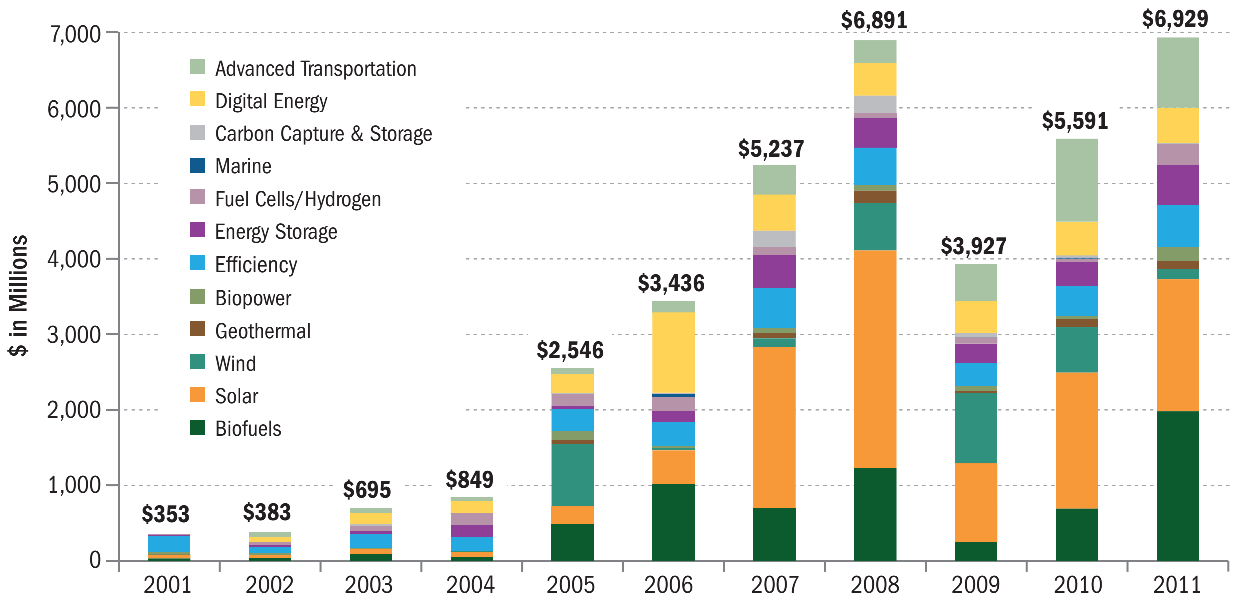
**All figures in 2011 real dollars. Figures represent disclosed deals derived from Bloomberg New Energy Finance's Desktop database.*

U.S. Venture Capital and Private Equity Investment in Biofuels Technology Companies (2001–2011)



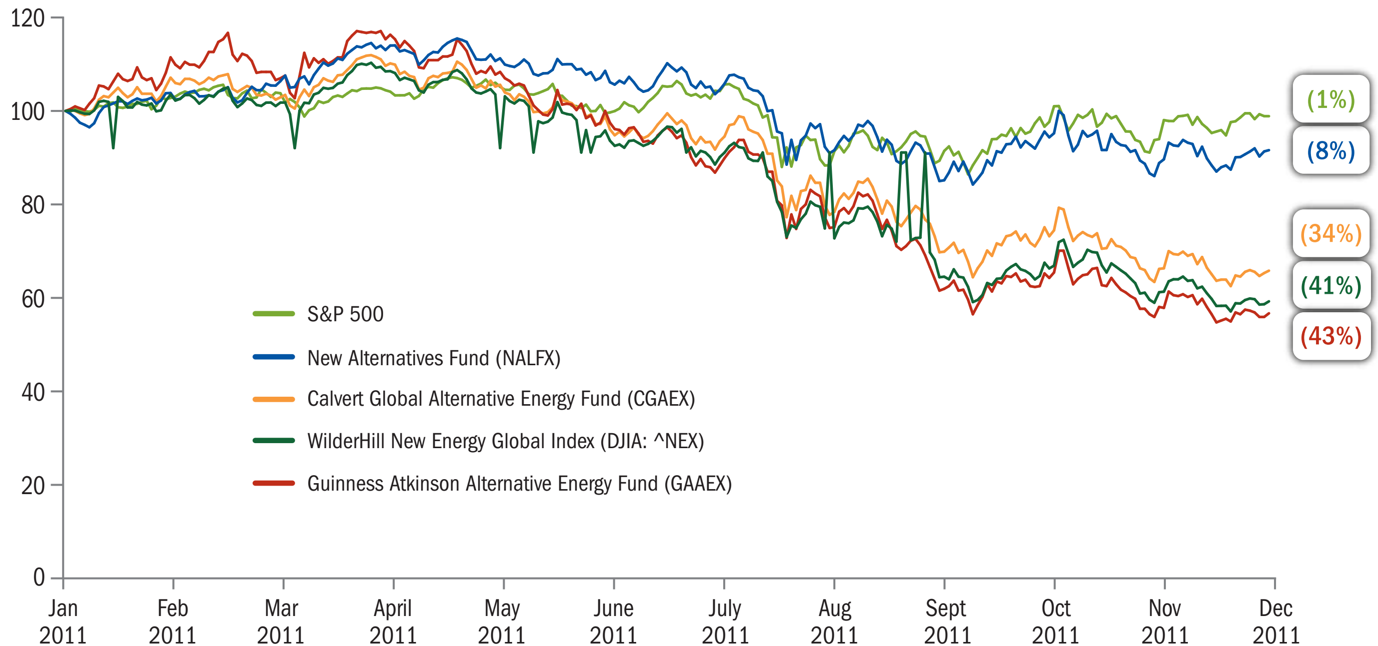
**All figures in 2011 real dollars. Figures represent disclosed deals derived from Bloomberg New Energy Finance's Desktop database.*

U.S. Venture Capital and Private Equity Investment in Renewable Energy Technology Companies (2001–2011)



All figures in 2011 real dollars. Figures represent disclosed deals derived from Bloomberg New Energy Finance's Desktop database.

Public Renewable Energy Index Performance (2011) (Indexed to 100)



Public data. Index performance is calculated as a percentage of the fund or index price as of January 2, 2011. The four indices and funds shown above experienced declines in price while the S&P 500 remained relatively stable in 2011.

Renewable Energy Resource Technical Potential on Tribal Lands

Analysis of Renewable Energy Resource Technical Potential on Tribal Lands

DOE Office of Indian Energy, in coordination with NREL, has prepared a geospatial analysis of the technical potential of renewable energy on tribal lands. According to the analysis, **American Indian land comprises approximately 2% of U.S. land but contains an estimated 5% of all renewable energy resources.**

How Can Tribes Use This Information?

Tribes that wish to pursue renewable energy projects can use this information to determine the market or developable potential of renewable energy. This includes:

- Conducting an assessment of broader tribal interests in development (e.g., scale of project, purpose of project, cultural sensitivity avoidance)
- Understanding the energy environment in which the project would function as a way of assessing potential project viability and economics
- Working with the local utility and regulatory authorities to understand renewable energy needs.

Benefits of Pursuing Clean Energy Development on Tribal Lands

- Long-term stabilization of energy costs
- Economic development
- Revenue generation opportunity
- Opportunity to conserve and sustain natural resources
- Energy self-sufficiency
- Strengthened tribal energy infrastructure

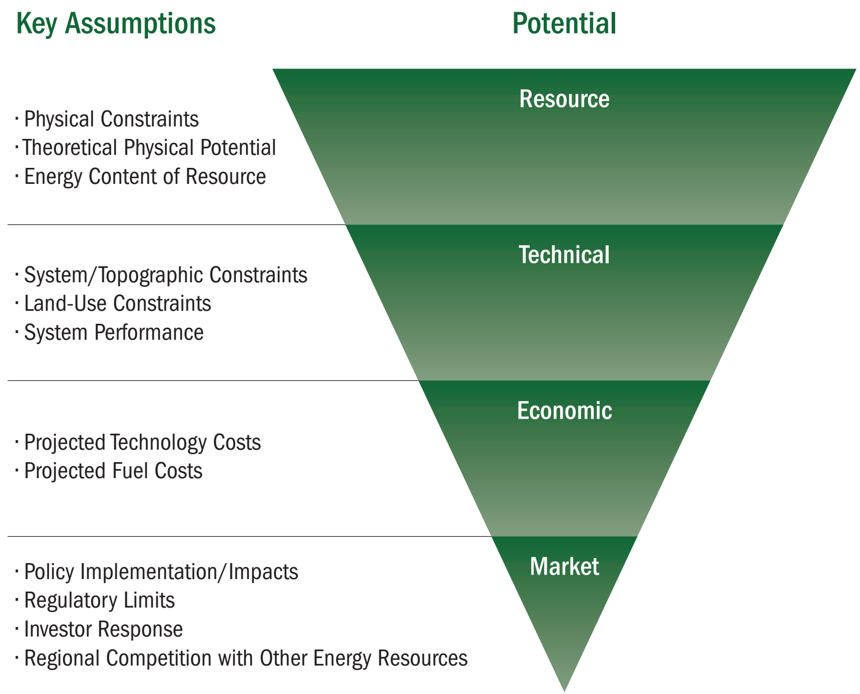
During a START site visit, START team member Alex Dane (NREL) repaired the tracking motor of the community-owned solar photovoltaic array in Venetie, Alaska. *Photo by Brian Hirsch, NREL 20893.*

What Is Technical Potential?

Technical potential identifies the types of renewable energy resources available in a specific location and how much energy those resources can produce. This is important for helping Tribes prioritize which renewable energy resources to develop and how those resources can generate revenue for the Tribe.

Technical potential is determined by narrowing the resource potential to exclude topographic constraints and land-use constraints while taking into account system performance. The data in this brochure was generated using geospatial methodology, which is an approach to analyzing information that incorporates data that has a geographic component and allows for a more refined analysis of technical potential for all Tribes by parsing it to individual tribal lands.

This brochure includes summary information on specific renewable energy technologies. Detailed information can be found in the full report, which will be available on the DOE Office of Indian Energy website in early 2013.

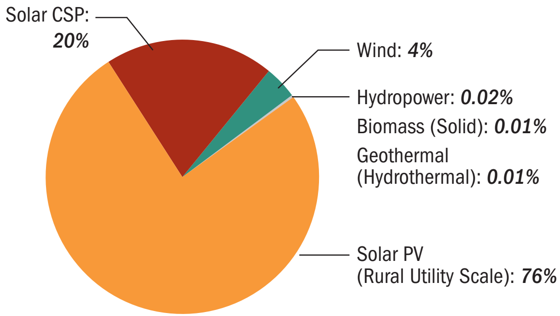


Summary of Tribal Renewable Energy Installed Capacity[1]

American Indian land comprises 2% of U.S. land but contains an estimated 5% of all renewable energy resources.

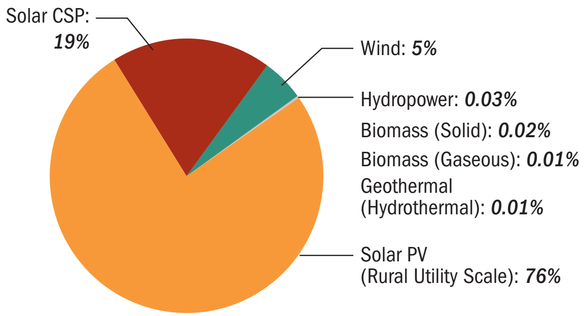
Megawatts (MW) of Tribal Capacity Potential[2]

Total[4] = 9,083,993



MW of National Capacity Potential[2]

Total[4] = 202,146,961



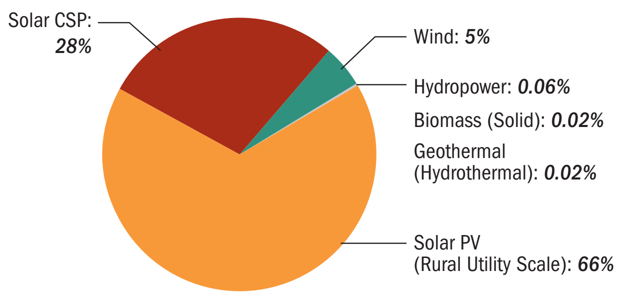
Notes: Numbers may not add up to 100% as a result of rounding.
Urban PV and geothermal Enhanced Geothermal System (EGS) were not included in the estimates.

References on page 74

Summary of Tribal Renewable Energy Generation Potential

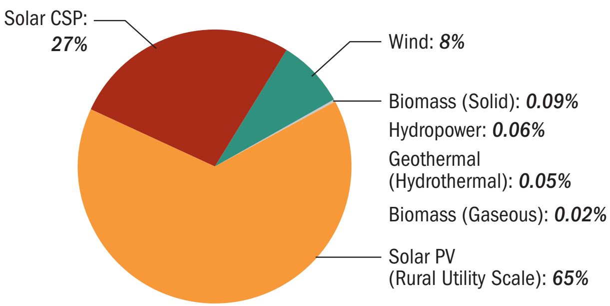
Megawatt-hour (MWh) of Tribal Generation[3] Potential[2]

Total[4] = 21,631,785,869



MWh of National Capacity Potential[2]

Total[4] = 430,527,524,682



Notes: Numbers may not add up to 100% as a result of rounding.
Urban PV and geothermal EGS were not included in the estimates.

References on page 74

Biomass

Biomass

Biomass has been used for electric power generation for many years. It can be a cost-effective, carbon-neutral dispatchable source of electrical power. Most biopower plants use direct-fired systems to generate electricity from biomass. They burn bioenergy feedstocks directly to produce steam. This steam drives a turbine, which turns a generator that converts the power into electricity.

In some biomass industries, the spent steam from the power plant is also used for manufacturing processes or to heat buildings. Such combined heat and power systems greatly increase overall energy efficiency.

Types of Biomass

- Wood from various sources (beetle kill, slash, lumber waste)
- Agricultural residues
- Animal and human waste (methane)
- Municipal solid waste and landfill gas

Benefits of Biomass

- Reduced greenhouse gas emissions
- Less dependence on foreign oil
- Supports the U.S. agricultural and forest-product industries

Electricity Production

- 1 megawatt (MW) to 10 MW of biomass energy can power community-scale facilities like lumber mills, tribal villages, or casinos.
- Larger systems (>5 MW) typically have better economics and can power commercial-scale facilities such as hotels, schools, and recreation centers.

Costs

- Installed costs are $1,900–$5,500/kW for a community-scale facility.
- A larger, commercial-scale biomass application can cost approximately $40 million for 10 MW.
- The levelized cost of energy (LCOE) for biomass is $.08 to $0.94/kilowatt-hour (kWh) depending on feedstock cost. A more typical range is $0.08 to $0.20/kWh.

Learn More

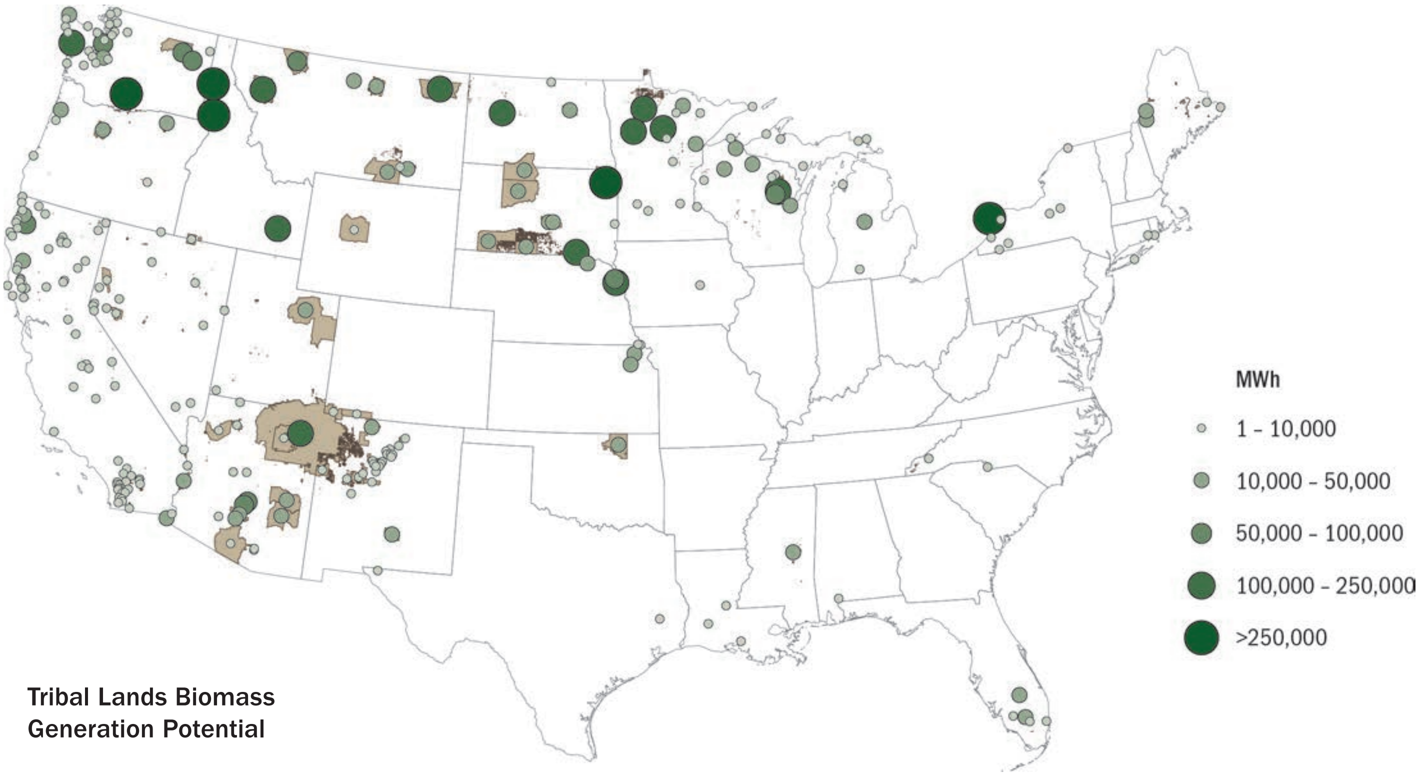
Get an overview of biomass renewable energy by accessing DOE Office of Indian Energy's Renewable Energy Curriculum for Tribes at *www.nterlearning.org*.

Biomass

The total technical potential for electricity generation from solid biomass on tribal lands is about 4 million MWh or about 1.1% of the total U.S. technical potential. Developable potential of biomass resources is often limited by the market costs of transporting the fuel.

Top Five Tribal Lands with Biomass Capacity and Generation Potential

Name	State(s)	Biopower from Solid Residues (MWh)	Biopower from Gaseous Residues (MWh)	Biopower from Solid Residues (MW)	Biopower from Gaseous Residues (MW)
Nez Perce	ID	336,781	104	43	0.01
Lake Traverse (Sisseton)	MN, ND, SD	300,466	97	38	0.01
Yakama	WA	274,750	329	35	0.04
Coeur d'Alene	ID, WA	264,737	84	34	0.01
Menominee	WI	246,145	42	31	0.01



Tribal Lands Biomass Generation Potential

Concentrating Solar Power

Concentrating Solar Power (CSP)

Concentrating solar power (CSP) technologies use mirrors to reflect and concentrate sunlight onto receivers that collect solar energy and convert it to heat. This thermal energy can then be used to produce electricity via a steam turbine or heat engine that drives a generator.

While CSP offers a utility-scale, firm, dispatchable renewable energy option that can help meet demand for electricity, it is most economical in the southwestern United States. How economical varies by each site and includes factors such as the cost of the technology, the quality of the solar resource, and the cost of the energy being displaced. CSP systems can be successfully installed on landfills, brown fields, and green fields, with minimal disturbance to native vegetation and wildlife.

Types of CSP Systems

- Linear concentrator
- Dish/engine
- Power tower
- Thermal storage

Benefits of CSP Systems

- Can easily be integrated into conventional thermal power plants by connecting the “solar boiler” either in a series or in parallel with a fossil boiler
- Not affected by abrupt changes in the output of power, which is common in solar photovoltaic (PV) plants

Power Plant Considerations

- Viable only for large (50+ MW) plants
- Limited geographic applicability
- Normally requires water for cooling towers

Cost

The LCOE for CSP ranges from $.11 to $.29/kWh.

Learn More

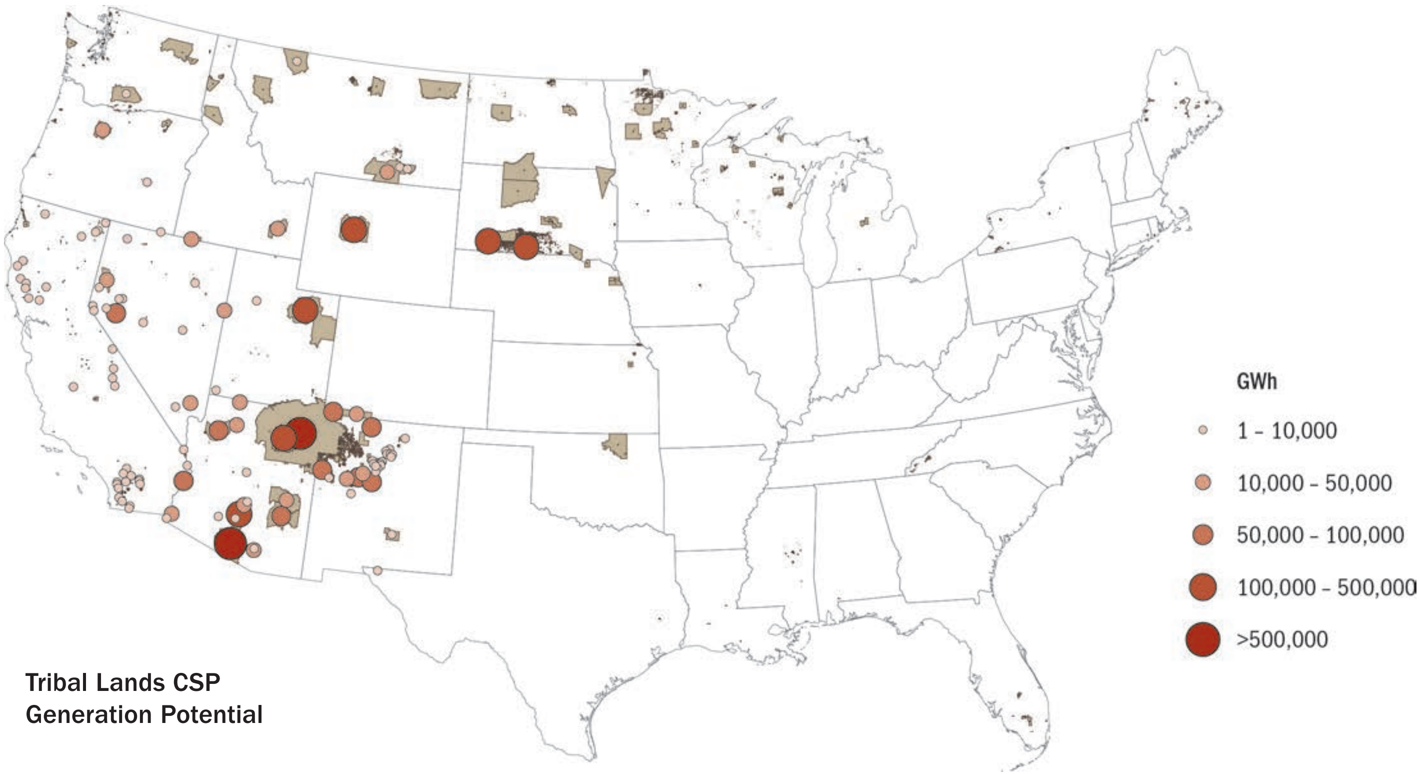
Get an overview of solar renewable energy by accessing DOE Office of Indian Energy’s Renewable Energy Curriculum for Tribes at *www.nterlearning.org*.

Concentrating Solar Power

The total technical potential on tribal lands for electricity generation from CSP resource is about 6 billion MWh, or 5.3% of total U.S. generation potential. Developable potential of CSP is often limited to utility scale and by transmission availability and access.

Top Five Tribal Lands with CSP Capacity and Generation Potential

Name	State(s)	Concentrating Solar Power Potential Annual Generation (MWh)	Concentrating Solar Power Potential Installed Capacity (MW)	Concentrating Solar Power Available Land (Square Kilometers [km^2])
Navajo	AZ, CO, NM, UT	2,872,729,112	830,414	25,950
Tohono O'odham	AZ	950,059,233	259,526	8,110
Hopi	AZ	332,743,795	95,030	2,970
Pine Ridge	NE, SD	193,254,076	69,913	2,185
Uintah and Ouray	UT	196,030,481	70,663	2,208



Tribal Lands CSP Generation Potential

Geothermal

Geothermal

Geothermal technologies use heat from the Earth. Geothermal is a highly efficient method of providing electricity generation. High-temperature geothermal is ideal for power plant production levels, but low-temperature heat pumps can provide heating and cooling energy in any part of the United States. Lower-temperature resources are best suited for heat applications.

Geothermal technologies exist commercially for either small-scale (distributed) or large-scale (central) electricity generation. As of 2012, 248 U.S. geothermal systems produce 9,057 mean megawatts of electricity (MWe). There are 30,033 MWe of undiscovered geothermal resources in the United States.

Types of Geothermal Energy

Direct-Use

- Heating buildings
- Growing plants in greenhouses
- Drying crops
- Heating water at fish farms
- Industrial processes such as pasteurizing milk.

Electricity Production: Power Plants

- Dry steam power plant
- Flash power plant
- Binary power plant

Power Plant Considerations

The process of bringing a geothermal power plant online can be lengthy and involves permitting and land use law, exploration and drilling temperature gradient holes to determine whether a reservoir exists, and drilling a full-diameter well into the potential reservoir to test its commercial viability.

Cost

The LCOE for geothermal is $.04–$0.14/kWh depending on siting, soil, work space, and local economies.

Learn More

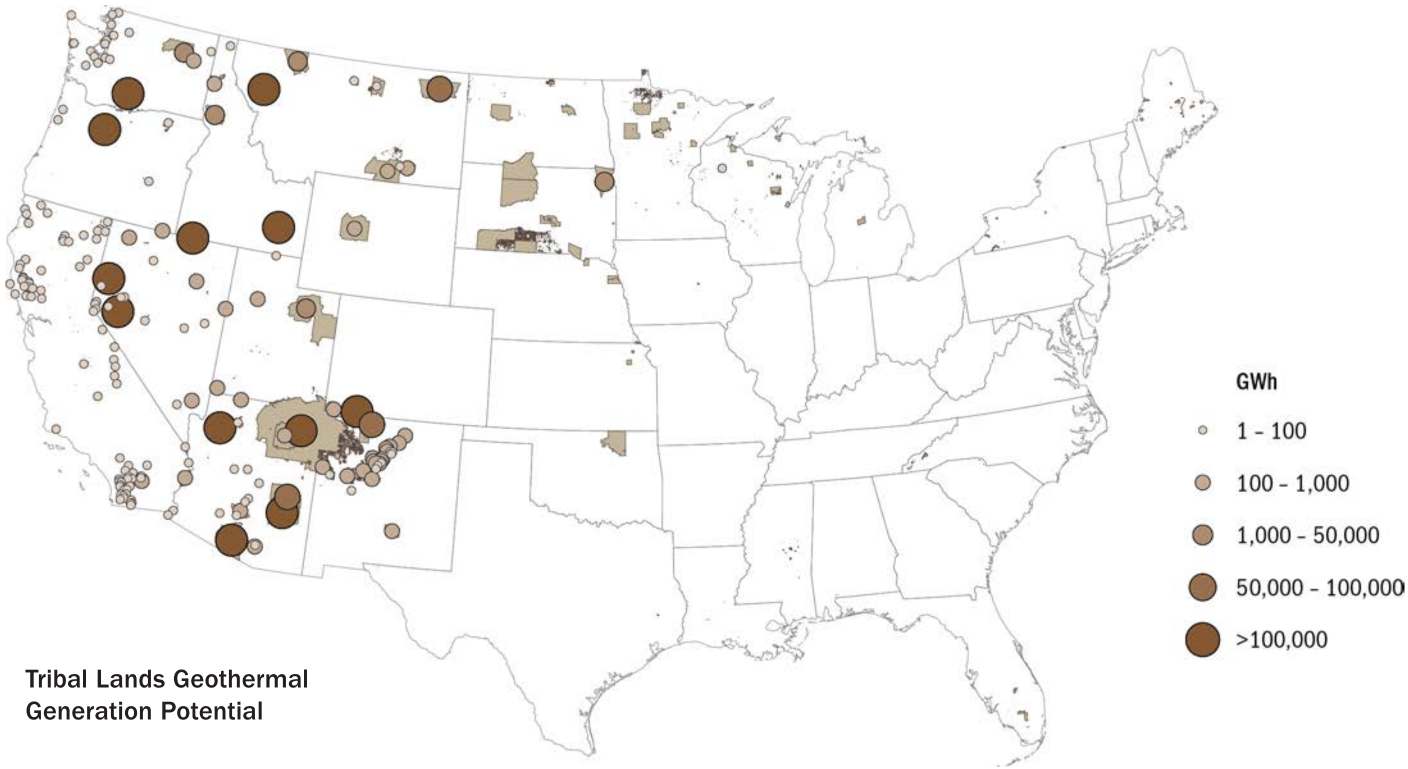
Get an overview of geothermal renewable energy by accessing DOE Office of Indian Energy's Renewable Energy Curriculum for Tribes at *www.nterlearning.org*.

Geothermal (Hydrothermal)

The total technical potential on tribal lands for electricity generation from hydrothermal geothermal resource capacity is about 5 million MWh, or about 2.1% of the total U.S. technical potential. Geothermal resources are widely distributed across tribal lands, with 196 distinct lands having technical potential.

Top Five Tribal Lands with Geothermal Capacity and Generation Potential

Name	State(s)	Unidentified Hydrothermal Potential Annual Generation (MWh)	Unidentified Hydrothermal Potential Installed Capacity (MW)
Navajo	AZ, CO, NM, UT	597,545	76
Tohono O'odham	AZ	510,243	65
Warm Springs	OR	405,953	51
Pyramid Lake	NV	324,409	41
Walker River	NV	246,481	31



Tribal Lands Geothermal Generation Potential

Hydropower

Hydroelectricity

Hydroelectricity refers to electricity generated through the use of the gravitational force of falling or flowing water, called hydropower. Both large and small-scale power producers can use hydropower technologies to produce clean electricity.

Types of Hydropower Technologies

- Waterwheels
- Hydroelectricity
- Damless hydro
- Tidal power
- Marine hydrokinetics (wave power)

Scales of Hydroelectric Power Plants

Macro: capacity of more than 30 MW. Current opportunities for macro hydropower are primarily on existing but disused dams

Small: capacity of 100 kW to 30 MW

Micro: capacity of up to 100 kW. A small or micro-hydroelectric power system can produce enough electricity for a home, farm, ranch, or village.

Benefits of Hydropower

- Can be a clean, carbon-neutral fuel source
- Provides a domestic source of energy
- Generally available as needed; engineers can control the flow of water through the turbines to produce electricity on demand
- Supplies water and controls flooding.

Cost

The LCOE for hydroelectricity is $.10/kWh. While capital costs for hydroelectric projects are higher than typical renewable energy power plant construction in general, there is typically a much higher capacity factor, resulting in lower LCOE. An advantage of hydropower is that maintenance costs are extremely low. As the scale of hydroelectricity decreases, cost of energy increases, but it may still be cost effective when compared with a grid extension.

Learn More

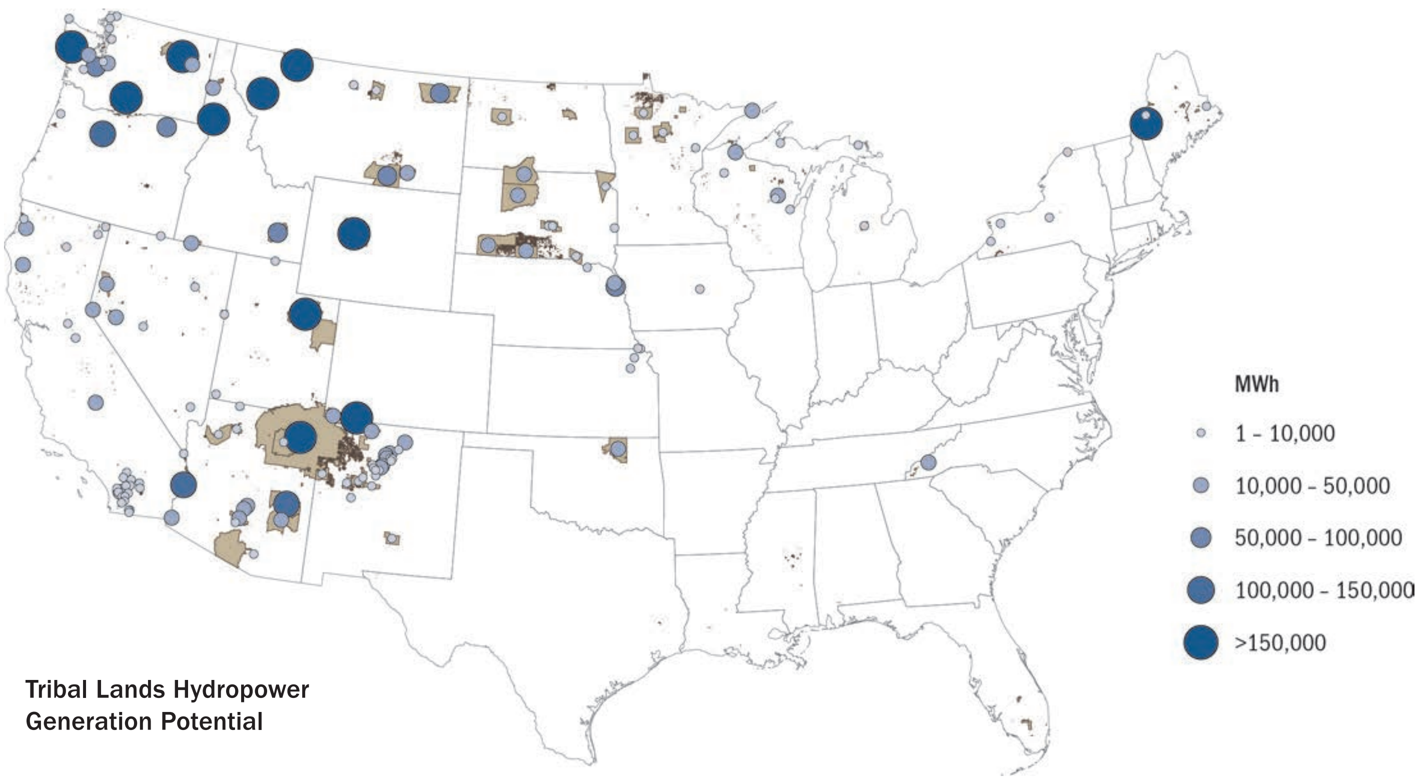
Get an overview of hydroelectric renewable energy by accessing DOE Office of Indian Energy's Renewable Energy Curriculum for Tribes at *www.nterlearning.org*.

Hydropower

The total technical potential on tribal lands for electricity generation from hydropower resource is about 7 million MWh, or about 2.9% of the total U.S. technical potential.

Top Five Tribal Lands with Hydropower Capacity and Generation Potential

Name	State(s)	Hydropower Generation Potential (MWh)	Hydropower Capacity Potential (MW)
Nez Perce	ID	1,445,260	330
Flathead	MT	816,341	186
Yakama	WA	669,640	153
Blackfeet	MT	445,893	102
Uintah and Ouray	UT	442,276	101



Tribal Lands Hydropower Generation Potential

Solar Photovoltaics

Solar Photovoltaics (PV)

Solar energy technologies produce electricity from the energy of the sun. Small solar energy systems can provide electricity for homes, businesses, and remote power needs. Larger solar energy systems provide more electricity for contribution to the electric power system.

Solar technologies work in all parts of the United States, but economics of solar energy are dependent on technology cost, quality of solar resource, and cost of energy being displaced. There are two types of solar energy technologies: CSP (see page 21) and photovoltaics (PV).

Types of Solar PV Systems

Flat-Plate

This is the most common PV array design, which uses flat-plate PV modules or panels that can be fixed in place or allowed to track the movement of the sun. An off-grid, flat-plate solar PV system would be useful for remote locations or for self-sufficiency in the event of an emergency.

Concentrator

Concentrator PV systems use less solar cell material than other PV systems because they make use of relatively inexpensive materials such as plastic lenses and metal housings to capture the solar energy shining on a fairly large area and focus that energy onto a smaller area—the solar cell.

Where to Install Solar PV

- Existing unshaded residential, community, and commercial buildings, such as existing building roofs and parking garages
- New residential, community, and commercial buildings
- Compromised lands such as landfills and brown fields, which saves green fields for nature

Cost

The LCOE for solar PV ranges from $.14 to $.54/kWh. The price of PV technologies is dropping due to scale of deployment and technological advances. Projected costs for PV in 2020 are $1.50/watt (W) for residential and $1.25/W for commercial.

Learn More

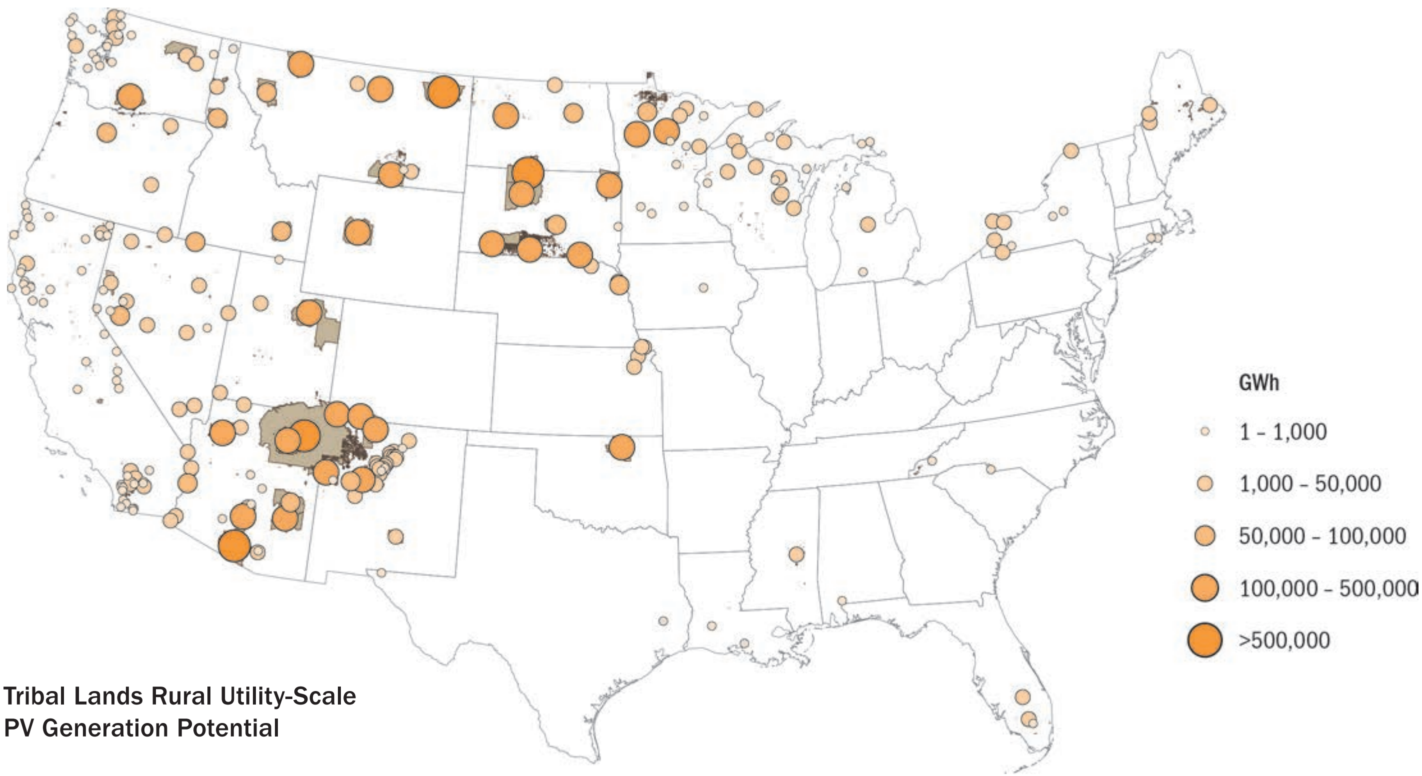
Get an overview of solar renewable energy by accessing DOE Office of Indian Energy's Renewable Energy Curriculum for Tribes at *www.nterlearning.org*.

Solar PV: Rural Utility Scale

The total technical potential on tribal lands for electricity generation from rural utility-scale solar resources is about 14 billion MWh or 5.1% of total U.S. generation potential. Developable potential of utility-scale solar is often limited by transmission availability and access.

Top Five Tribal Lands with Rural Utility-Scale PV Capacity and Generation Potential

Name	States	Rural Utility PV Power Potential Annual Generation (MWh)	Rural Utility PV Potential Installed Capacity (MW)	Rural Utility PV Available Land (km^2)
Navajo	AZ, CO, NM, UT	2,494,474,583	1,087,316	22,652
Hopi	AZ	2,295,637,379	998,053	20,793
Tohono O'odham	AZ	986,595,977	427,892	8,914
Standing Rock	ND, SD	932,953,632	503,395	10,487
Fort Peck	MT	609,883,158	327,966	6,833



Tribal Lands Rural Utility-Scale PV Generation Potential

Wind

Wind

Wind energy technologies use the kinetic energy in wind for practical purposes such as generating electricity, charging batteries, pumping water, and grinding grain. Most wind energy technologies can be used as stand-alone applications, connected to a utility power grid, or even combined with a PV system. Wind energy today is cost competitive in many locations throughout the United States.

Types of Wind Installations

Utility-Scale

Utility-scale wind consists of a large number of turbines that are usually installed close together to form a wind farm that provides grid power. Several electricity providers use wind farms to supply power to their customers. Total installed costs for utility-scale projects currently average approximately $2 million–$2.5 million/MW (e.g., community campus or two rural hotels).

Stand-Alone Turbines

Stand-alone turbines are typically used for water pumping or communications. However, homeowners and farmers in windy areas can also use small wind systems to generate electricity.

Scale	Size	Cost	Types
Remote, On-Site Power	< 10 kW	$6 –$12/W	Water pumping, electrification ***Examples:*** Water pump = 1 kW House = 5 kW Farm = 10 kW
Grid-Connected Facility Scale	1 kW – 50 kW	$7 – $3.50/W	Residence, business, farm/ranch
Community Scale	100 kW – 1 MW	-	Facility, community, industrial ***Examples:*** Convenience store = 50 kW School = 250 kW
Commercial Scale or Energy for Sale	>1MW	$2 – $3/W	Wind farm

Learn More

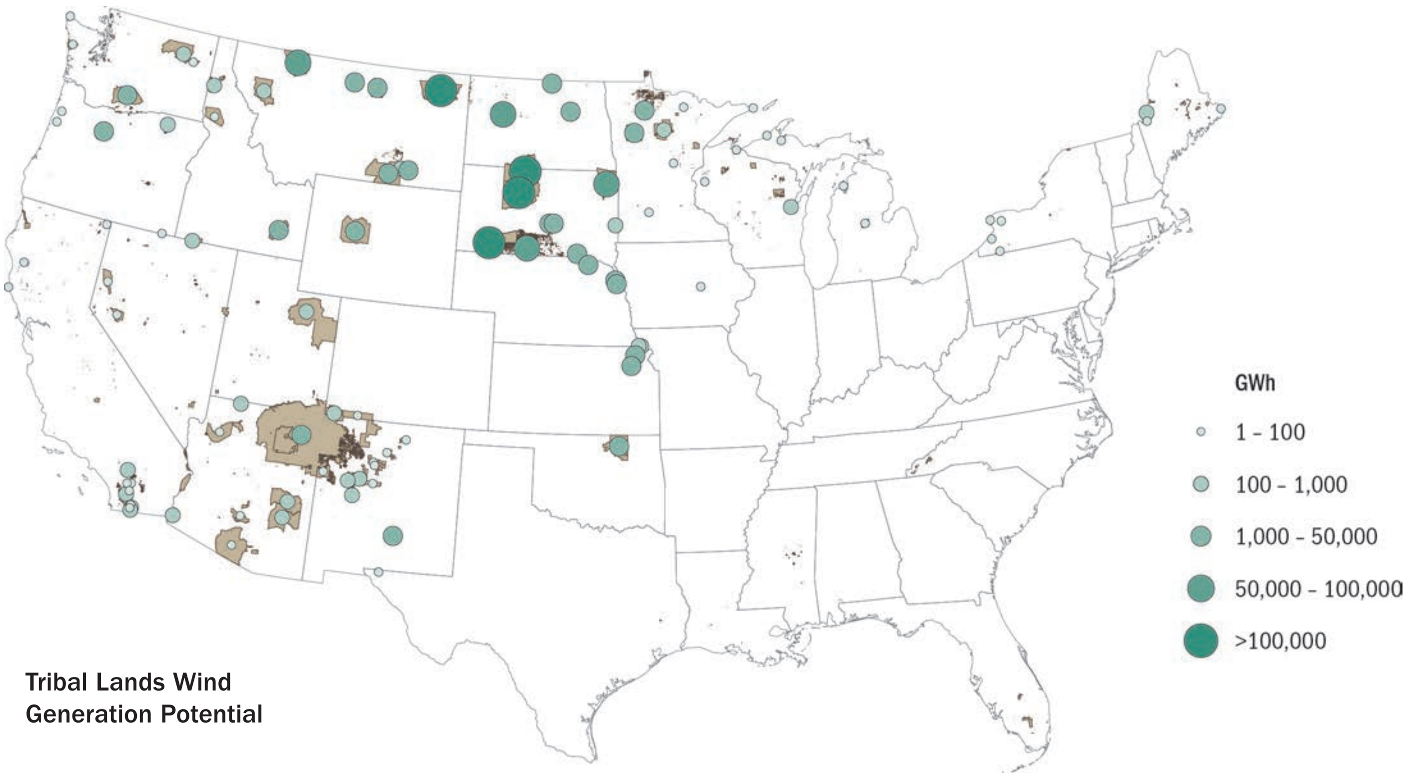
Get an overview of wind renewable energy by accessing DOE Office of Indian Energy's Renewable Energy Curriculum for Tribes at *www.nterlearning.org*.

Wind

The total technical potential on tribal lands for electricity generation from wind resources is about 1,100 million MWh or about 3.5% of the total U.S. technical potential. Developable potential of utility-scale wind, particularly in the Midwest, where the resource is strongest but typically far from energy intense population centers, is often limited by transmission availability and access.

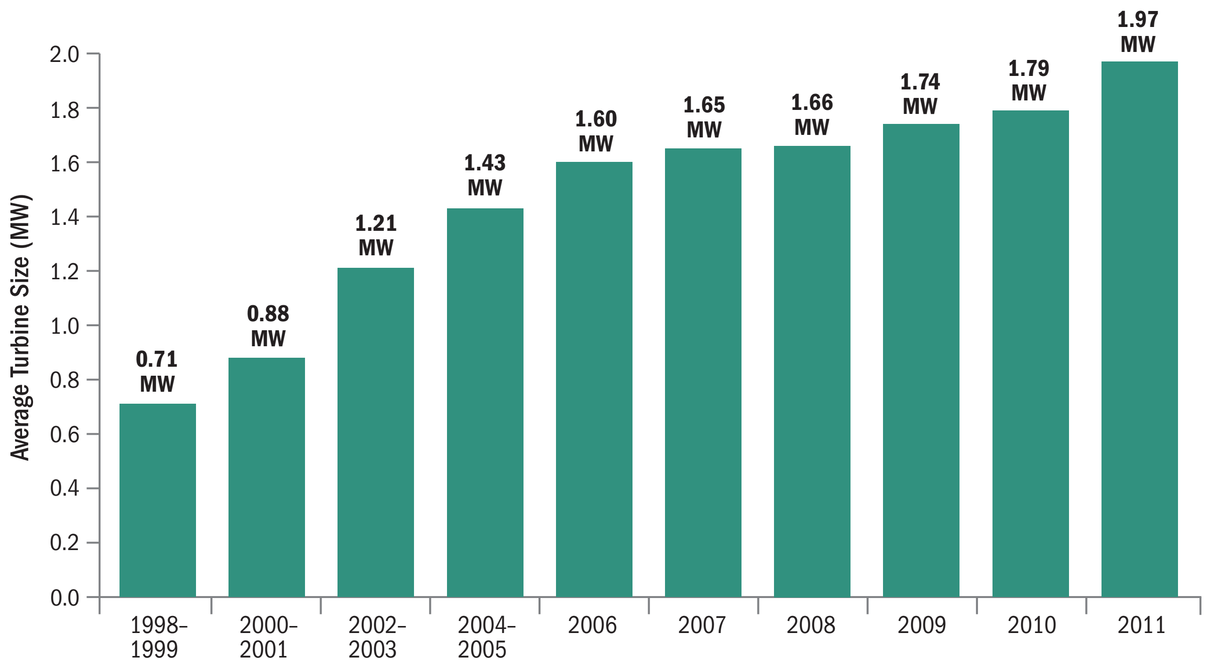
Top Five Tribal Lands with Wind Capacity and Generation Potential

Name	States	Wind Potential Annual Generation at 80m and GCF>= 30% (MWh)	Wind Potential Installed Capacity at 80m and GCF>= 30% (MW)	Wind Available Land at 80m and GCF>= 30% (km^2)
Cheyenne River	SD	188,088,492	57,806	11,561.1
Standing Rock	ND, SD	149,093,091	45,972	9,194.4
Fort Peck	MT	126,258,677	41,331	8,266.2
Pine Ridge	NE, SD	113,398,124	38,029	7,605.7
Rosebud	NE, SD	87,002,780	25,833	5,166.7



Tribal Lands Wind Generation Potential

U.S. Average Installed Turbine Size



Source: AWEA

Capturing the Potential: Key Questions and Next Steps

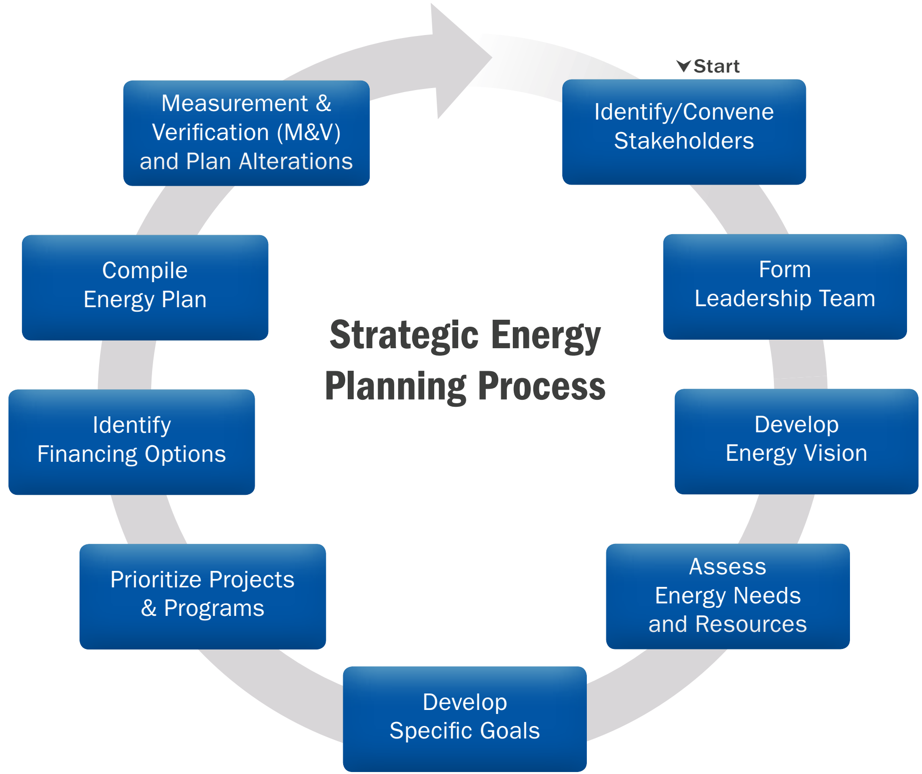
Renewable Energy Project Considerations

The next step for a Tribe interested in developing available renewable energy resources on their land is to answer the following key questions, which are critical to ensuring project success:

- What are the benefits to the Tribe?
- Who will use the energy?
- How will electricity be delivered?
- How much will it cost?

What Are the Benefits to the Tribe?

Renewable energy projects can stabilize prices, contribute to economic development, and produce revenue for the Tribe. Prioritizing the tribal goals for a project through a tribal leader- and community-driven strategic energy plan can help shape the project. For more information and examples of strategic energy planning for Tribes, visit *www.energy.gov/indianenergy/energy-resource-library/strategic-energy-planning*.



Who Will Use Energy?

Answering this question helps determine the appropriate size of the project as well as the economic viability of project. Potential users include the Tribe, local utilities that have renewable energy mandates, or large nearby electricity loads, such as casinos and military bases. According to the U.S. Department of Defense, there are more than 50 Tribes located adjacent to or near military bases.

How Will The Electricity Be Delivered?

Determining how the electricity will be delivered involves working with the utility. DOE Office of Indian Energy, in collaboration with the DOE Office of Electricity Delivery, commissioned ICF International to identify tribal sites that may have potential for cost-effective renewable energy generation in relation to transmission facilities located on Indian lands. The study revealed that:

- There are 192 potential wind sites on 10 reservations; the majority are on Blackfeet, Fort Belknap, and Crow lands.
- The 24 most cost-effective sites for wind energy development are concentrated on 10 reservations, and the 25 most cost-effective sites for solar energy development are concentrated on 14 reservations.

Tribal Renewable Energy Transmission Webinars

The DOE Office of Indian Energy, the EERE Tribal Energy Program, and Western Area Power Administration sponsor a series of free webinars on tribal renewable energy—many of which focus on transmission. For a list of webinars and to register, go to *www.wapa.gov*, and click the Renewable tab, and then click on the Tribal Webinar Series links.

How Much Will It Cost?

To successfully implement a renewable energy project, it is important for tribal leaders and staff to understand project development costs and financing structure options.

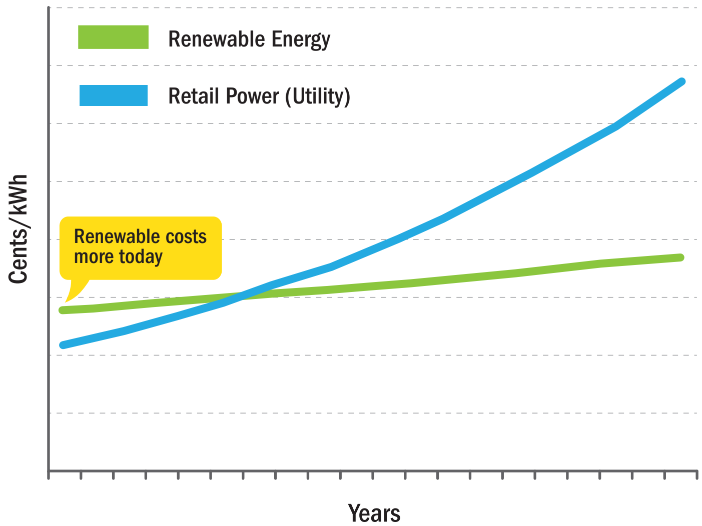
LCOE is an important concept to consider when developing a project. LCOE is a calculation to capture all the costs, including capital investment, operations and maintenance, and fuel, over the life of an energy system or plant. It provides an "apples-to-apples" comparison for various systems with different kinds of costs.

LCOE explains that while renewable energy technology installations are typically more expensive than what you are paying now for energy, their costs escalate at a much slower and more predictable rate than what you would otherwise be paying for fuel or electricity. At some point, energy from the renewable project will be less expensive than the cost of fossil fuel or electricity from the grid.

More on LCOE

- See the chart on the following page for the LCOE for renewable energy technologies in 2012.
- Calculate the LCOE for your project using NREL's Web-based tool at *www.nrel.gov/analysis/tech_lcoe.html*.
- Access DOE Office of Indian Energy's Renewable Energy Curriculum for Tribes at *www.nterlearning.org/*.

Cost of Energy Comparison *(constant demand)*



Direlle Calica of the Confederated Tribes of Warm Springs engages in a discussion during a pilot presentation of the DOE Office of Indian Energy renewable energy project development and financing courses. *Photo by Dennis Schroeder, NREL 21020*

Renewable Energy Project Development and Finance Education Program for Tribes

DOE Office of Indian Energy has developed a series of renewable energy project development and finance educational courses specifically for Tribes that:

- Provide a framework for renewable energy project development and financing for Tribes
- Set and manage expectations of project development
- Identify decision points and the information needed to effectively make decisions
- Identify available tools for use in project development
- Provide examples of relevant projects.

These courses are available at no cost as on-demand webinars on the National Training & Education Resource (NTER) website *www.nterlearning.org* (search “Indian Energy”).

Who Should Take These Courses

Tribal Leaders

- Primary decision makers
- Understand terminology
- Understand key decision points and factors influencing them

Staff/Project Management

- May be self-managing project or managing consultants
- Communicate at key points with decision makers
- Require in-depth knowledge of process

Foundational Courses

These courses provide an overview of foundational information on renewable energy technologies, strategic energy planning, and grid basics.

Topics

- Assessing Energy Resources
- Biomass
- Building Heat and Hot Water
- Electricity Grid Basics
- Geothermal
- Hydroelectric
- Solar
- Strategic Energy Planning
- Wind

Benefits

- No cost to attend
- Watch at any time
- Take at your own pace
- Share with others

How to Access the Webinars

Visit the NTER website at *www.nterlearning.org* and search for “Indian Energy.”

Leadership and Professional Courses

These courses cover the components of the project development process and existing project financing structures. Tribal leaders and staff members can pick and choose which courses make the most sense for them based on level of knowledge and the type of project.

Essentials

Basic process, decisions, and concepts for project development

Audience: All involved in project

Advanced/In-Depth

Detailed academic information for deep understanding of concepts

Audience: Project and contract managers

Facility

Comprehensive, in-depth process pathways for project development and financing by project scale

Audience: Decision makers and project and contract managers

Community

Comprehensive, in-depth process pathways for project development and financing by project scale

Audience: Decision makers and project and contract managers

Commercial

Comprehensive, in-depth process pathways for project development and financing by project scale

Audience: Decision makers and project and contract managers

Types of Projects

DOE Office of Indian Energy's leadership and professional courses cover three types of projects: facility, community, and commercial, which are defined below. When thinking about the goals of your renewable energy project, it is critically important to discuss project scale and how it relates to overall tribal energy goals, because it has a big impact on how a project is developed.

Facility

Definition: Single building system

Primary motivation/purpose: Offset building energy use

Community

Definition: Multiple buildings, campuses

Primary motivation/purpose: Offset community energy costs, achieve energy self-sufficiency

Commercial

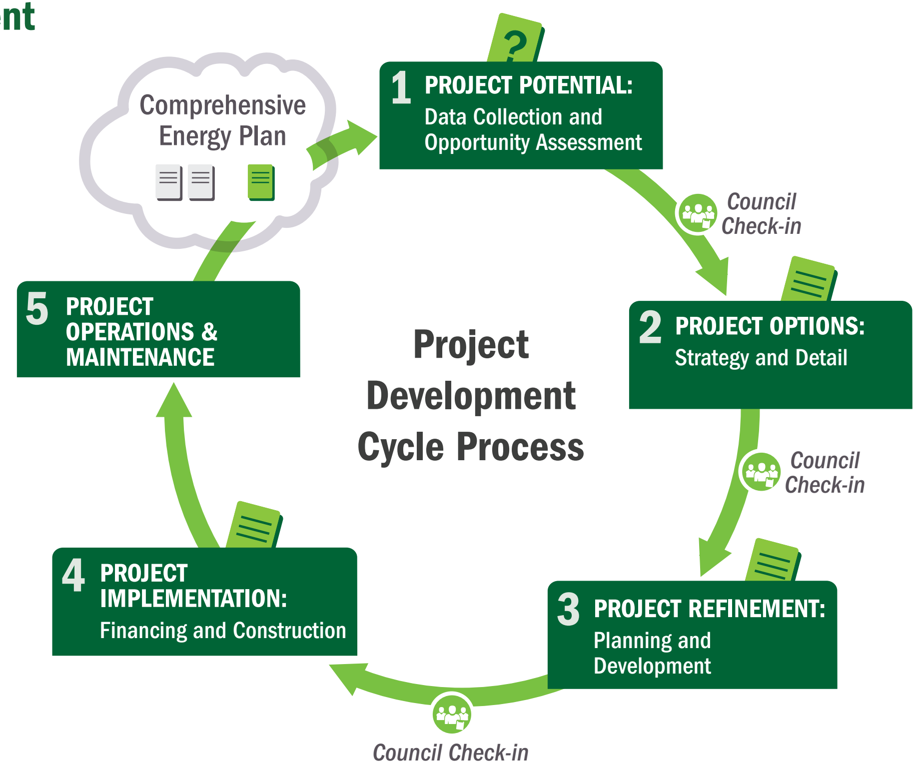
Definition: Stand-alone project

Primary motivation/purpose: Generate revenue, achieve financial self-sufficiency

Tribal Energy Project Development and Financing Strategy

The DOE Office of Indian Energy leadership and professional courses all follow this project development and financing strategy developed by DOE Office of Indian Energy that:

- Provides a framework based on experience
- Focuses on key decision points
- Shows that project development is iterative
- Incorporates council check-in points to emphasize that delaying or deciding against a project that does not meet current goals is a viable outcome and option.



Project Development Phases

Project Potential

What is the potential for doing a project at a scale that meets my goals?

Data Collection and Opportunity Assessment

Determine whether the project is viable by evaluating:

- Possible sites for project
- Renewable energy resource data
- Tribal facility electric cost data, regulations, and interconnection requirements
- Potential markets and paths to market for project power and renewable sales
- Risks and utility rules.

Project Options

How do I interpret these options?

Strategy and Detail

Narrow down the project options, including:

- Final resource
- Tribal role/ownership structure
- Tax equity structure
- Financing options
- Procurement process
- Permits.

Project Refinement

How do we get the specifics to our environment?

Planning and Development

Make decisions about:

- Ownership structure and project team
- Permitting (including environmental reviews) and interconnection agreement
- Technology, financing, and development costs
- Economics
- Vendors.

Project Implementation

How do we build it?

Financing and Construction

Complete physical construction of project, which includes:

- Project agreements
- Vendor contracting process
- Preconstruction tasks
- Construction and equipment installation
- Interconnection
- Commission project leading to commercial operations.

Project Operations & Maintenance

Who will maintain it once it is built?

Long-Term Management

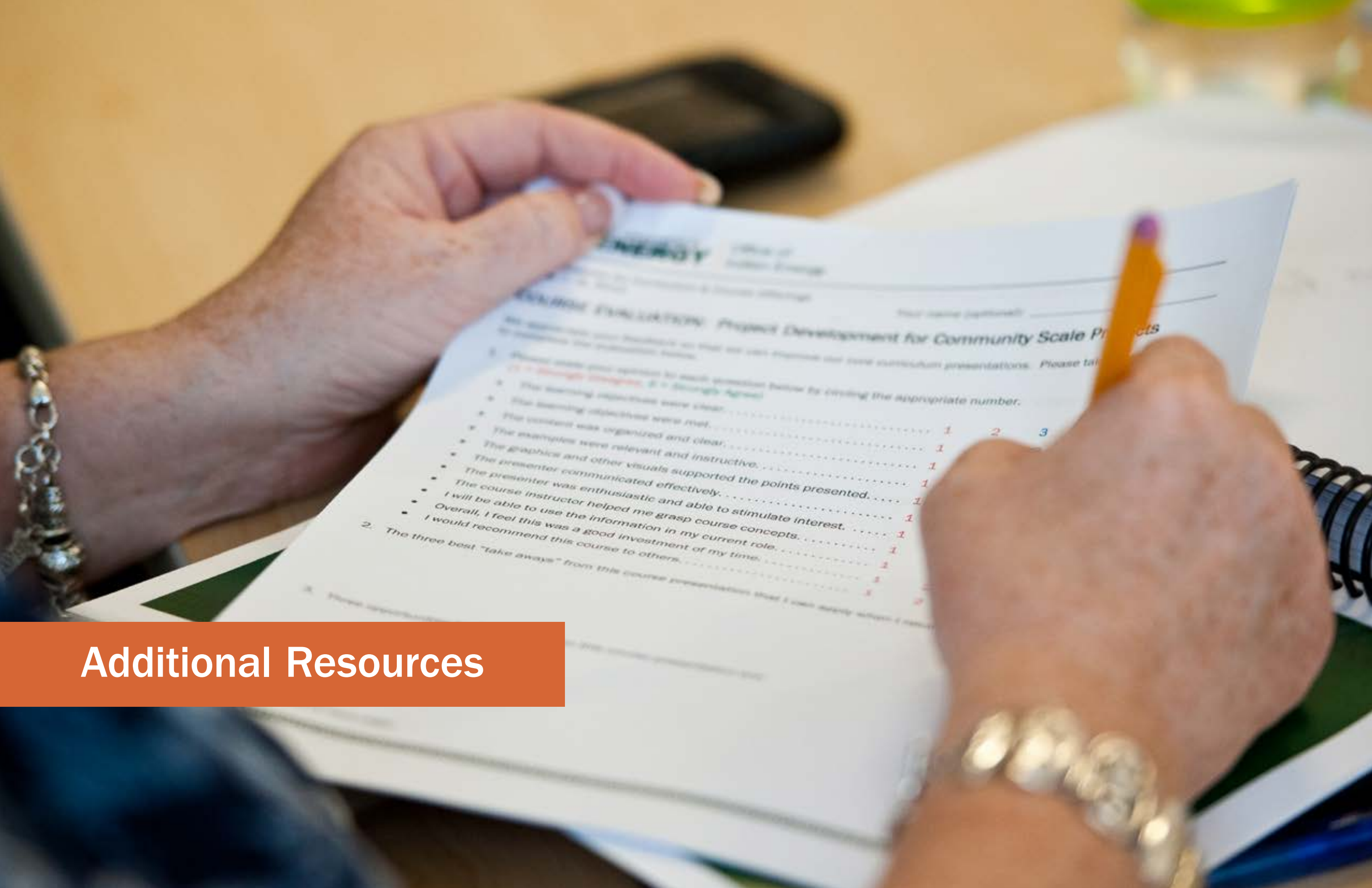
Implement operations and maintenance plan that accounts for:

- Equipment maintenance and upkeep
- Inverter replacement
- Insurance
- Labor and staffing
- Extended warranty agreements.

What Role Can the Tribe Play in Project Development?

Role	Opportunity	Constraints	Comments
Project Developer	Control and self-determination of project; potential for profits	Investors require experience Development risks without portfolio diversification may not make business sense Community investment portfolio may not seek high risk/return investments	Tribal interests may be best served by outsourcing this risk Assembling a portfolio of projects is a typical method to mitigate risk
Lender/Capital Provider	Participate financially in project with lower risk	Requires ready capital May be cost prohibitive to document and manage a single debt transaction	Requires knowledge of lending practices
Investor	Provide cash for project development	Requires ready capital, or unique source of capital that provides market advantage (like NMTC)	Must compete with other investment opportunities Option for Tribes with limited lands
Resource Owner (Lessor)	Low risk, known reward, consistent income	Limited project control	Limited upside, limited risk
Off-Taker	Purchasing clean energy from an “on-site” provider; security	Limited investment, economic development, and capacity-building opportunity	Implies load-serving entity (utility) or some other purchasing demand

Additional Resources



Additional Resources

DOE Office of Indian Energy Website
www.energy.gov/indianenergy

DOE Office of Indian Energy Resource Library
www.energy.gov/indianenergy/resources/energy-resource-library

Indian Country Energy and Infrastructure Working Group
www.energy.gov/indianenergy/services-0/indian-country-energy-and-infrastructure-working-group

DOE Office of Indian Energy Newsletter
www.energy.gov/indianenergy/resources/newsletter

DOE Office of Indian Energy Renewable Energy Curriculum
www.nterlearning.org

DOE Office of Indian Energy START Programs
www.energy.gov/indianenergy/resources/start-program

On-Demand Technical Assistance
www.energy.gov/indianenergy/technical-assistance

Tribal Leader Energy Forums
www.energy.gov/indianenergy/resources/education-and-training

Tribal Renewable Energy Webinar Series
www.wapa.gov
Click on the Renewable tab, then the Tribal Webinar Series links

DOE Office of Indian Energy Deputy Director Pilar Thomas listens to a presentation during the Tribal Leader Energy Forum entitled "Exploring the Business Link Opportunity: Transmission & Clean Energy Development in the West." *Photo by Dennis Schroeder, NREL 23636*

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[2] Electricity capacity is a measure of how much electricity a generator can produce under specific conditions.

[3] Technical potential is calculated for each technology individually and does not account for overlap (i.e., the same land area may be identified with potential for wind and solar and would be counted twice in the total). Some technologies may be compatible with mutual development.

[4] Electricity generation is how much electricity a generator produces over a specific period of time.

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Revised April 2013 · DOE/IE-0015

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