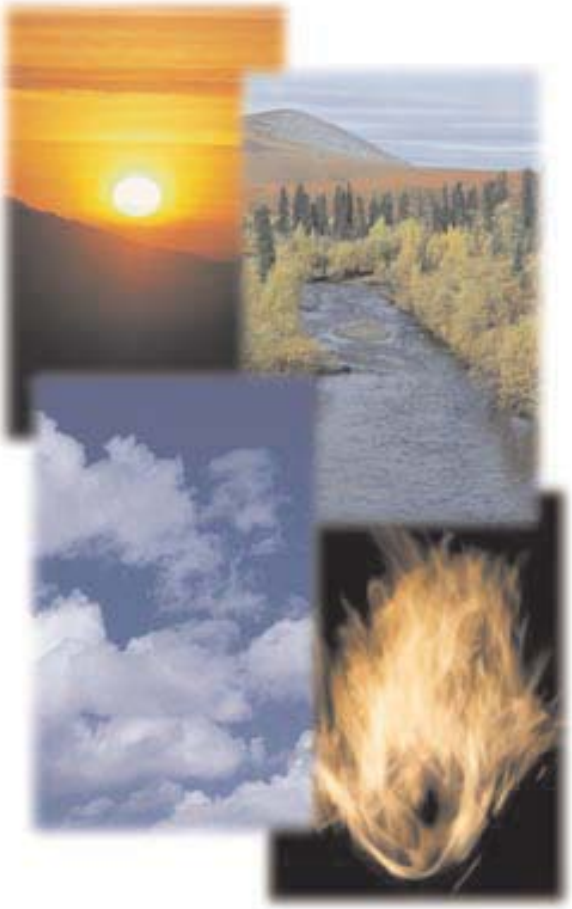
Council of Energy Resource Tribes

Sustainable Energy Solutions Conference



Report

June 19 - 20, 2001

Santa Fe, NM

COUNCIL OF ENERGY RESOURCE TRIBES

FOUNDED 1975

Acknowledgements

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Introduction

The Council of Energy Resource Tribes (CERT) is comprised of 47 federally recognized American Indian Tribes and four Canadian First Nations. The Tribes created CERT in 1975 to have an organizational platform through which they could work together in developing their governance and management capabilities for using their energy resources to build stable, balanced, self-governed economies. Since 1975 Tribal populations have increased by over 100% and Tribal economies are experiencing dramatic growth. These two historic trends have increased the Tribal need for more reliable supply of electricity at reasonable costs.

As the North American energy industry moved away from federal and state regulated monopolies toward open, competitive markets, the CERT Member Tribes recognized the inherent dangers and opportunities. Therefore, they directed CERT to develop new networks among Tribal organizations and energy companies, and to begin to advocate for new federal Indian energy policies.

CERT and a large number of regional inter Tribal organizations, whose collective Tribal membership exceeds 250 Tribes, joined to form the ad-hoc Inter Tribal Energy Network in 1996. By February, this coalition crafted a National Tribal Energy Vision that puts forth that each Tribe should have the ability to secure sufficient energy to support their economic and social well-being by the year 2010. The Tribes also provided a well-defined strategy to successfully realize their vision. This strategy has three distinct components:

1. Accessing low-cost federal hydropower produced from federal water projects in the west.
2. Implementing strict energy management and conservation measures to reduce Tribe's energy costs.
3. Developing new generation with the emphasis on renewable and distributed generation techniques.

This strategy requires Tribes to actively participate in the electricity restructuring debate and advocate for new federal Indian energy policies. It also requires Tribes to develop new institutional and human resource competencies to manage the new responsibilities of Tribal energy self-determination.

As an integral part of the National Tribal Energy Vision, Tribes all across the country are beginning to focus on sustainability to meet their community's long-term community and economic developmental goals. With the Tribal populations virtually exploding at a rate three times the national average and with economic development a priority for every Tribe, energy sustainability is a critical piece of the overall picture. Sustainability for Indian Tribes goes beyond the concepts understood by mainstream thinking. The meaning of the term weaves around Tribal cultural values induced relationships to community and relationships to the natural environment. Sustainability must also take into account the Tribal imperative to survive as a separate cultural and political as well as economic community. Therefore, Tribes approach the complex energy policy, technical and financial issues from a more holistic world view while defining sustainability in terms that have meaning and value to the Tribal community.

CERT, as a multi-Tribal organization, views sustainability as a complex issue. The need for consistent and affordable energy requires Tribes to make complex decisions and find creative solutions. For CERT, this offers an opportunity to accomplish its Tribally mandated mission by developing a program to incorporate new technologies and planning methods and mold them to Tribal values and aspirations. Therefore, CERT is facilitating Tribal dialogue concerning sustainable energy development as part of its conference and workshop schedules.

Tribes recognize that true sustainability requires learning more about global environmental and developmental issues. Tribes require access to reliable and pertinent information to support their values and priorities. The "Sustainable Energy Solutions" conference agenda was developed with this need in mind. The agenda includes information on renewable energy generation technology, utility formation, federal and Tribal energy policy, energy conservation and efficiency, and accessing federal hydropower.

The topics discussed in the "Sustainable Energy Solutions" conference are an excellent starting point for the tribal sustainable energy development dialogue.

Executive Summary

The Council of Energy Resource Tribes (CERT) and the Inter Tribal Energy Network (ITEN) convened the Sustainable Energy Solutions Conference (SES) in Santa Fe, New Mexico June 19-20, 2001. Over 35 Tribes, primarily located in the West, gathered to learn and discuss sustainability in a tribal context. Tribes are strong supporters of energy conservation and efficiency to save scarce financial resources and to contribute to a cleaner environment. Many Tribes are also interested in exploring new technologies for developing renewable energy resources for Tribal use and larger-scaled generation to sell power to customers in an open market.

The SES conference included workshop presentations on developing wind, solar, geothermal, and biomass renewable energy options. There was also a panel discussion regarding federal hydropower allocations for Tribes. The panel included federal representatives from the Bonneville Power Administration, Western Area Power Administration, and inter-Tribal organizations working on this power supply opportunity. After brief presentations, the audience asked questions of the panel participants that engendered open discussion on current issues around Tribes receiving and using their federal power allocations. Power generation and Tribal utility development were also addressed through workshops at the conference.

Wind Energy

Wind energy is one of the United State most abundant renewable energy resources. Wind is an intermittent resource, meaning only when wind blows between 16 mph to 60 mph can wind turbines can generate electricity. There are several benefits to development of wind generation including: short construction time (six to eight months); modularity (expand generation capacity by simply adding more turbines); no fuel costs, no air emissions; and, higher customer approval. Wind resources can be well matched with peak loads because wind usually blows hardest in the afternoon, which is when electricity usage is at the highest for the day.

Wind energy depends on a few key factors before it can be competitive with fossil fuel electricity production. The first factor is manufacturers developing equipment that is economically competitive with other sources of generation. Currently, there are few companies that manufacture wind turbines thereby inflating the price for turbines. Also, a production tax credit of .017 kWh is needed to make wind energy affordable for the customer. Wind power will cost $.03 per kWh if offered with a production tax credit. Other electricity is running for $.015 to $.03 per kWh. Wind technology has improved greatly with new bird-friendly, quiet and efficient turbines. There are also space saving turbine available and in use.

Geothermal

Geothermal renewable energy is one of the less known renewable resources in America, however, geothermal energy production has many benefits for development. Geothermal energy is available 24 hours a day, 365 days year, which gives geothermal an advantage over intermitted renewable resources such as wind and solar. Once a geothermal plant has been constructed, energy costs about $.015 per kWh to produce and can be sold at $.03 to .035 per kWh, which is competitive with fossil fuel production. Geothermal energy production is also environmentally friendly producing only 1/6 CO_2 emissions compared to natural gas fueled power plants. The by-products of a geothermal plant are excess steam, which can be used for space heating or green houses, and some solid material wastes that can be sold for industrial uses.

Geothermal resources can be produced in areas that have high subsurface temperatures gradient, or elevated temperatures near the surface. A typical geotherm is 25° to 30°C/km. Areas with geothermal resources have temperatures that exceed 75° to 100°C/km. High geothermal temperatures, greater than 180°C, are suitable for generation of electrical power exceeding 20 MW. Intermediate temperatures of 90°-180°C is suitable for small scale electrical power generation

producing up to 10 MW. Low temperature geotherm, the most common geothermal resource found, can be used for a variety of geothermal direct-use heating applications, including greenhousing, aquaculture, space and district heating ground-coupled heat pumps. The downside to geothermal energy production is significant initial capital costs, however, the upside to the equation is no fuel costs and low operation and maintenance costs.

Biofuels

Biofuels are fuel products created from agriculture sources, including ethanol, biogas/biomass and biodiesel. Biofuels can be produced in two months, are 100% renewable and carbon neutral. Plants that are grown to produce biofuels help reduce CO2 levels and replace oxygen in the atmosphere. Biofuels have a duel benefit for the environment by discontinuing harmful emissions and using materials previously considered waste in need of disposal. Biofuels relieve dependence on oil refined for vehicle fuel. The US could decrease its annual trade deficit by over $53 billion and create 1.43 million jobs in biofuels and supporting services by producing 100% of its fuel domestically.

Solar

Solar energy has great potential for domestic household uses, as well as large-scale generation potential. Photo Voltaic (PV) systems have been installed in many homes across American for the last twenty years. Concentrated solar power is a new technology able to convert solar energy into electricity. For example, the Solar Dish Stirling is a dish concentrator that focuses the suns's energy on a receiver. The Stirling engine then converts the thermal energy into electrical energy. This patented balanced concentrator design is mass producible and lends itself to automotive-type manufacturing efficiency. They may be mass-produced for low cost and is scalable to meet market demand.

PV systems prove to be an excellent alternative for Tribes with families living in remote areas without access electrical power lines. Both NativeSUN (Hopi Foundation enterprise) and Navajo Tribal Utility Authority have services for the customers to install and maintain residential-sized PV systems for families living off the electricity grid.

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Welcome

***Christopher Wentz*, Director, Energy Conservation and Management Division (ECMD), Energy, Minerals and Natural Resources Department, State of New Mexico, Santa Fe, NM**

Good Morning. On behalf of Governor Gary Johnson, let me welcome all of you to Santa Fe and to New Mexico. This is really an impressive turnout, and we are honored to host all of the organizers, sponsors, and other conference participants and their families. Santa Fe has so much to offer you during your stay. There's the historic Plaza and the Palace of the Governors; art galleries galore – more galleries per capita than New York City; museums, such as the new Georgia O'Keefe Art Museum, the International Folk Art Museum, and the Institute of American Indian Arts; and, of course, there are a number of Indian gaming facilities all within about a half-hour or so of where we are right now. Several of these facilities have been getting some pretty good entertainment in recently, so you may want to check them out as well. And if you don't have ground transportation to get around town, no need to worry: you can just hop on a clean, energy-efficient bus here. The Santa Fe Trails bus system was the first transit system in the Nation to field an entire bus fleet on alternative fuels – compressed natural gas or "CNG" to be precise. So, please get out and enjoy yourselves while you're here.

Governor Johnson sends his sincere regrets for not being able to be here today. However, the Governor wanted me to convey his best wishes for a productive, successful conference. I honestly believe the Governor would have enjoyed being here with us this morning. Governor Johnson has sponsored or supported a number of measures to promote energy efficiency and renewable energy. This past legislative session, ending in mid-March, the Governor included in his package of legislation a bill to increase the purchase and use of cleaner-burning alternative fueled vehicles – vehicles that run on such fuels as CNG, ethanol or electricity. He also successfully proposed amendments to an existing law that should increase the use of Energy Performance Contracting - a mechanism to finance energy efficiency improvements in buildings with no up-front or direct costs to the building owner. Energy Performance Contracting has saved our school districts here in New Mexico tens of millions of taxpayer dollars, all while reducing energy usage and costs.

This latter bill was passed by the Legislature with a unanimous vote of approval – a stellar example that acting in the best interests of all our citizens can be bi-partisan, transcending everyone's frames of reference and inherent biases. Such cooperation to achieve a common vision will be needed to stimulate the development of technology and markets for renewable energy.

Our own New Mexico Legislature has a number of Native American leaders who have exhibited this cooperative, collaborative spirit which is so important in any enacting significant legislation into law. New Mexico State Representative James Roger Madalena, a member of Jemez Pueblo who chairs the Legislature's Energy and Natural Resource Committee, has long been a friend of renewables. I first met Representative Madalena while he was serving on a geothermal policy advisory group convened by former Governor King in 1991. The group helped develop a comprehensive, statewide Energy Policy for New Mexico. I mention Representative Madalena not only because of my respect for him, but because our work together on Energy Policy in the early 1990s reminded me recently of a relevant saying by that world-renowned energy expert Yogi Berra: "It's *déjà vu* all over again."

Unfortunately in America, it always seems to take a so-called "crisis" to put an issue into perspective. Energy supply and energy cost are critical issues for virtually every individual and business; issues which should be given priority attention on a continual basis because they impact our quality of life and our economic well being. Yet many Americans are complacent when it comes to energy, seemingly content with the status quo as long as energy is available and prices are low.

Unfortunately, for many living on Indian reservations across America and in rural parts of the country, electricity availability and reliability still persist as issues. As the New Mexico State Energy Office, we commissioned a study about two years ago that estimated there were almost 5,000 families in New Mexico without electricity. In this day and age, what

a shock this was! It was like finding out for the first time that people still starve to death in America or don't have basic health care.

Given what has been happening in California and what is going on at the national level, this conference is extremely timely.

What we are witnessing now in California is a shortage of energy supply, exacerbated by an electricity deregulation law and corresponding rules that were not properly structured. One good thing to come out of California's failed experiment, however, is that it has focused everyone's attention back on energy. Energy is something we have all taken for granted for way too long.

Over the next decade or so, many tens of thousands of megawatts of new electric generation capacity are projected to be needed. Similarly, demand for both natural gas and gasoline is expected to continue increasing over this period. It is my strong belief that much of this projected increase in demand for energy could be met through greater energy conservation, greater energy efficiency, and the increased use of renewable energy and alternative fuels.

Energy conservation remains as perhaps the most cost-effective mechanism for increasing energy supplies-with little or no pain on the part of the consumer. Mostly what we're talking about with energy conservation is simple behavioral changes. And in the case with energy efficiency, it a matter of taking advantage of new technologies that use less energy or use it more effectively. A key example is traditional electricity production at a central station power plant. Such plants are generally only 30-35% efficient due to energy losses in the generation, transmission, and distribution processes. In contrast, combined heat and power facilities (what we used to call co-generation facilities), which put waste heat to direct use in thermal applications such as space heating, have efficiencies of 80% or greater. We need to start taking advantage of the technologies available to us, including micro-turbines and fuel cells.

The same holds true with renewable energy technologies. It is amazing how the cost for renewables has decreased over the last 20 years. Some examples: in 1980, wind-generated electricity cost about 40 cents per kilowatt-hour; that cost now is in the 4-6 cents per kilowatt-hour range competitive with new coal-fired generation. For geothermal, the cost in the early 1980s was on the order of 16-17 cents per kilowatt-hour; now it's down to about 5-8 cents. And for solar photovoltaic electricity, the cost has dropped from about $1 per kilowatt-hour in 1980 to about 20 cents per kwh today-still expensive in comparison to traditional energy sources, but nonetheless cost-effective in many niches applications. So the prices of renewables has declined substantially cover the years, a trend that will only continues as technologies improve and markets expand. Renewables could be even more cost-competitive if their environmental benefits were truly recognized and factored into the pricing equation.

In closing, I believe that all of us – and particularly Natives Americans – have a unique opportunity to help lead the United States to a sustainable energy future. As sovereign Nations, you have greater control over your destiny than many state and local governments in terms of energy production and uses. Many of you certainly have the necessary resources. And there has not been a more opportune times, what with the current focus on energy in both Congress and the Executives branch As most of you are aware, the National Energy Policy was released only last month by the Bush Administration. Although its focus is primarily on energy supply, there are a number of recommendations we could all get behind, including appropriate incentives for renewables development. Hearings con the effectiveness of the U.S. Department of Energy's Energy Efficiency and Renewable Energy Programs are currently in progress. Now is your chance to weigh in on what you likes or don't like in these programs; the deadline for comments is June 29. I should also emphasize that the motivation for leading by example does not have to be altruistic: A concerted effort toward a sustainable energy future will not only spur others to action, it also will benefit the members your tribes, pueblos and nations from an economic and environmental perspective. Many of state federal levels and us at the local are eager to work cooperatively with you in making this dream a reality. I believe this conference is as good a place as any to start. So let's takes advantage of this opportunity, to exchange ideas, learn from cones another, and establish new alliances. Thank you, and have a great conference!

National Energy and Policy Overview

***Elizabeth Bell*, Senior Associate, Troutman, Sanders, LLC, Washington, DC**

Tribal Energy Self-Sufficiency Act

Purpose

Implementation of Tribal energy projects and the realization of the National Tribal Energy Vision requires legislation to remove certain regulatory and policy barriers, create incentives to boost development of energy projects on tribal lands and establish a grant making and policy office at the Department of Energy to assist Tribes with their energy projects and develop Tribal capacity for energy management and planning. The Intertribal Energy Network (ITEN) worked with Tribes to develop TESSA, to resolve some of the impediments to creating tribal electric utilities, developing tribal generation resources, establishing energy efficiency programs to upgrade the building stock, adopting building energy codes that push new construction toward higher efficiency levels, developing renewable resources and to remove unequal tax burdens on Tribal energy production.

TESSA Summary

Tribes must overcome many barriers to participate in the energy industry. TESSA would mitigate some of the policy, regulatory, financing, and infrastructure difficulties for Tribes when developing energy projects. TESSA amends DOI financing programs so Tribes can obtain loans and grants under the Indian Finance Act for energy projects. Very importantly, TESSA establishes an Office of Indian Policy and Programs within the DOE. The Office will oversee grant programs and have the responsibility for promoting Indian energy development. Currently, DOE has no program specific for Tribes, nor do they have an Indian desk. Advocacy for Tribes depends on appointments made by the Secretary. A permanent Office will enable Tribes to lobby for appropriation dollars and will establish continuity at the DOE for Indian programs. The alternative of funding the DOE Indian Energy grant programs by creating a set-aside out of energy appropriations is being explored with Congress.

Tribes are tax-exempt entities, and therefore cannot take advantage of federal tax incentives programs. TESSA creates tax incentives for tribal energy projects, including allowing Tribes to trade or sell tax credits to industry partners or to use the tax benefits to satisfy any federal debt the Tribe may have. TESSA has provisions for conservation and weatherization programs on Tribal lands. One provision will allow Tribes to apply for weatherization dollars directly, rather then going through state programs. In short, TESSA gives Tribes the tools necessary for achieving energy self-sufficiency through a development process rather than a welfare process.

Section-by-Section Analysis of HR 2412, Tribal Energy Self-Sufficiency Act

Title I-Establishment of Indian Energy Programs

Sec. 101—Indian Revolving Loan Fund-Amends Indian Financing Act for energy development. Removes loan caps for secured lands and Indian Business Grants.

Sec. 102-Transfer of Ownership of Water and Power Projects-Allows DOI to transfer ownership of water and power project to Tribes at the election of the Tribe.

Sec. 103—Review of Certain Provisions Related to Oil, Gas, and Coal on Indian Lands--Requires that DOI accept Tribally commissioned documents and studies during review of tribal energy agreements and sets a timeline for DOI to complete the review for Secretarial approval. FOGRMA Review-DOI will conduct a study of current royalty system and make recommendations for increasing royalties to Tribes and individuals and assuring their timely and accurate payment.

Sec. 104—Siting—Clarifies Tribal siting regulatory authority for projects located on Indian trust lands.

Sec. 105—Dams Analysis—Requires DOI to conduct a study of all dams and located on Tribal lands to determine their suitability for siting electrical power projects

Sec. 106—Application of Buy Indian Act to Energy

Products—Allows DOI to give preference to purchase of Indian produced energy products and by-products at fair market prices.

Sec. 107—Transmission of Wind Power from Indian Lands—Directs WAPA to construct, operate, and maintain electric power transmission facilities to facilitate wind power generation.

Sec. 108—Taxation of Extraction of Energy Resources—Limits taxing authority of Indian energy resources produced by non-Indian operators to Federal government and Tribe.

Title II—Comprehensive Indian Energy Programs

Sec. 201—Comprehensive Indian Energy Program—Establishes a new Office of Indian Energy Policy and Programs at the Energy Department. The Office is to establish programs to assist tribes to meet energy needs through education, research and development, planning and management. The Office will provide grants for renewable and conventional energy development, energy efficiency, and conservation programs, studies and other activities supporting tribal acquisition of energy supplies, services and facilities, and planning, constructing, developing, operating, maintaining, and improving tribal electrical generation, transmission, and distribution facilities.

Sec. 202—Amendment to Renewable Energy Production Incentive Program—Allows Tribes to be eligible for program and expands the program, which creates financial incentives for renewable energy production.

Sec. 203—Renewable Energy Study—Mandates DOE to conduct a study on energy consumption and renewable energy development potential on Indian lands.

Sec. 204—Loan Guarantees—Allows DOE to guarantee up to 90% of unpaid principal and interest due on any loan made to any Indian Tribe for energy projects.

Sec. 205—Net metering for Indian Tribes—Requires suppliers who own renewable generation facilities on Indian land to make net metering services available to customers.

Sec. 206—Transmitting Electric power to and From Indian Reservations—Requires the Commission to establish reasonable and appropriate technical standards for the interconnection of any generating facility owned/operated by Tribe with transmission and distribution facilities owned or operated by any other person or entity.
—Wheeling of Electric power to and from Indian Reservation—Tribes may apply to Commission to require any persons or entity owning transmission or local distribution services to provide services to Tribe.

Title III—Tax Incentives for Tribal Energy Projects

Sec. 301—Expansion of Credit for Electricity Produced on Indian Lands from Emerging Technologies and Waste Product; Increased Credit for Facilities on Indian Lands; Tradable Credits for Indian Tribes—a) Applies production tax credit to generation from other renewable sources, doubles credit for electricity produced on Indian land to 3 cents kWh. b) Enables Tribes to trade tax credits.

Sec. 302—Credit for Producing Indian Oil or Gas—Creates a tax credit for producers of Indian oil, gas, and coal to offset state taxation.

Title IV-Tribal Government Conservation and Infrastructure

Sec. 401—Community Development Assistance for Infrastructure Projects-Allows Tribes to use HUD Community Development Block Grant funds for energy projects that are designed to benefit members of Tribe by increasing energy efficiencies or by lowering or stabilizing electric rates.

Sec. 402—Energy Efficiency and Conservation in Federally Assisted Housing—HUD and BIA, Indian Home Improvement Program, to develop energy efficiency and conservation measures for homes built or improved under those programs.

Title V—Rural and Remote Communities Electrification Grants

Sec. 501—Rural and Remote Communities Electrification Grants—Amends the Rural Electrification Act of 1936 allowing Dept. of Agriculture to provide grants and zero interest loans to Tribes for energy efficiency, lowering or stabilizing electric rate to end users, or updating energy infrastructure.

Tribes and Renewable Energy Resources

***Adam Capage*, Director of Green Services, E-Source/FT Energy, Boulder, CO**

Planning, siting, and constructing generation facilities –renewable energy powered or otherwise— requires answers to a series of questions. Below, I have listed and briefly described some of the questions tribes should try to answer before going too far through the process of constructing new renewable energy generation.

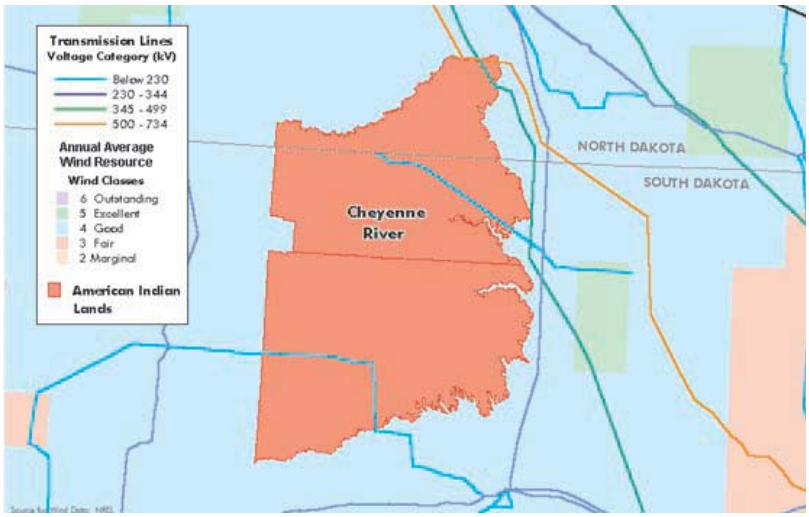
What is the purpose of the generation?
Generation for a local population will likely look quite different than generation for sale in wider markets. Different technologies will be better suited for each goal, and development costs will depend on how important it is to make power available all the time.

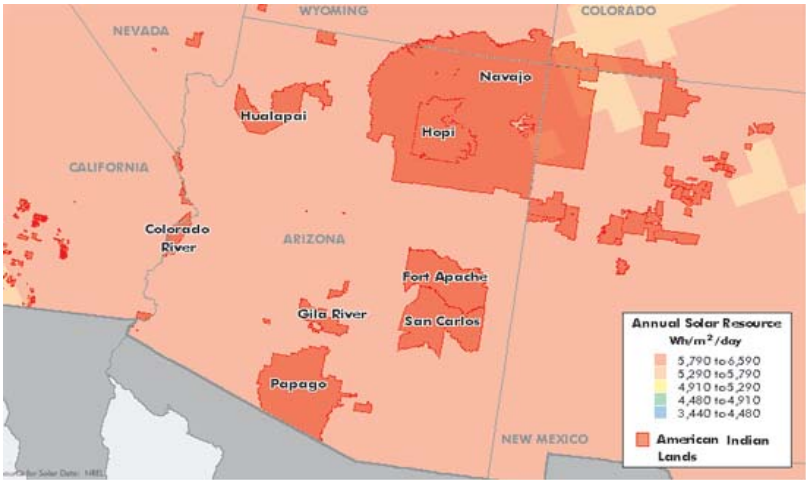
What are the available renewable resources?
Different areas of the country will have markedly different resources available and able to provide inexpensive generation. Geothermal energy is relatively abundant in the west, but virtually non-existent east of the state of Colorado. Maps are available that chart resources for solar and wind energy, as well as biomass in various forms.

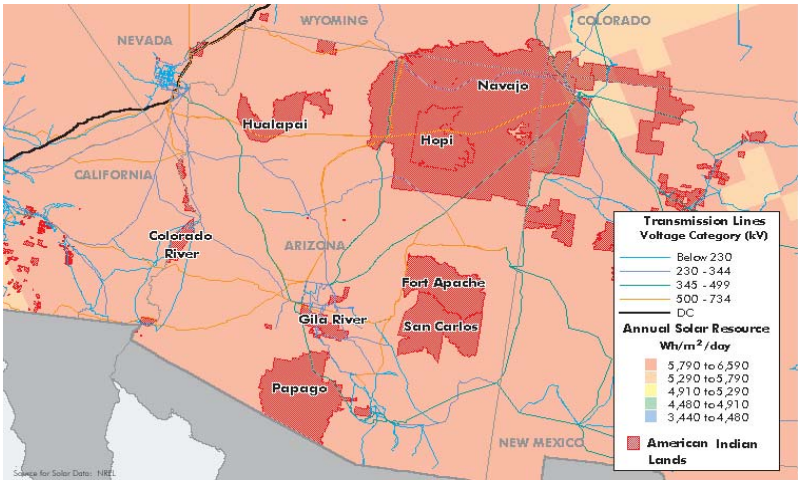
What are the characteristics of the chosen generation?
Once a generation form is chosen (solar, for example) it is important to know up front costs, on going maintenance costs, and the expected lifetime of the equipment. For example, batteries for PV systems are notoriously demanding and require careful, prescribed use.

What is the transmission availability if the goal is to sell the energy?
This is only relevant if the goal is to sell the energy outside tribal boundaries. If this is the case, transmission constraints are a very important consideration. Sometimes these costs can be prohibitive.

After these first five steps are addressed in some detail, the process gets much more site specific and depends quite a bit upon local politics and the financial characteristics of the specific project.







Funding and Financing Renewable Energy Projects/Financial Modeling

Marlene Lynch, Division of Finance and Administration, National Tribal Utility Authority, Fort Defiance, AZ

Financing Options for Renewable Energy Project
Navajo Tribal Utility Authority Experience

Introduction
Navajo Tribal Utility Authority (NTUA) was created in 1959 as an enterprise of the Navajo Tribe by resolution of the Tribal Council. The mission of NTUA is to provide electric, photovoltaic, natural gas, water, wastewater treatment and related services at competitive prices, while contributing to the economy of the Navajo Nation, consistent with the improvement of the health and welfare of the residents of the Navajo Nation, and the employment of the Navajo people. NTUA operates on a non-profit basis and reinvests any net margin on its electric revenues into expanding its electrical distribution system throughout the Navajo Nation. Presently, the Navajo Nation does not own one megawatt of generation. Ironically, Navajo Nation is the biggest tribal producer of coal for electric power generation. The electric power that NTUA provides to its customers is either purchased from Pacificorp, Western Area Power Administration (WAPA), Tucson Electric Power Company, Salt River Project, or Public Service Company of New Mexico.

We service the people in Northeastern Arizona, Northwestern New Mexico and Southeastern Utah. Navajo Nation is the largest reservation in North America and spans across tri-state boundaries. Navajo lands are rural and undeveloped or used for agricultural purposes. Tribal members homes are very scattered making it uneconomic to provide power and running water to every location. The average cost per mile of electric line for NTUA is $25,000. It takes, on average, 55 years for NTUA to recover the investment per mile of electric line for one customer. The average life of a power line is less then 55 years before the line needs to be replaced. Most tribal member homes currently not served are 5 or more miles from current power lines. Much of the terrain that electric lines would pass over is rough and difficult and, in many cases, electric lines cannot be safely built to reach the customer.

NTUA started looking at development of renewable resources as means of providing service for tribal members that live several miles away from electric lines. Located in the Southwest, Navajo has some of the best solar renewable resources in the world. While NTUA is exploring development of concentrated solar systems for large scale generation, NTUA focused on options to provide electricity for tribal members that are currently not served due to cost of running electric lines to their homes. NTUA found that passive solar energy using solar cells and batteries provide an economical and viable solution for more remote locations. NTUA began providing photovoltaic service in 1994.

Financing Options
NTUA explored all financing options available for the development of passive solar energy systems. There are four financing options available

- DOE Grant—Experimental Basis
- RUS Loan Programs
- CFC Loan Programs
- Rate Design and Tariff

To build five miles of electric line to serve one customer costs about $125,000. NTUA is able to install one PV until at a cost of about $10,000. The economics make it more cost feasible to install a PV system then to build an electric line. NTUA's challenge is to find a viable way to pay for the PV system that is financially feasible for their customer. In the past, passive solar systems have been installed through other program for remote Navajo families. The problem that NTUA discovered was the most systems failed within a few years and the families returned to using small generators and living without dependable electricity. NTUA focused on developing systems that are sustainable.

The DOE Office of Energy Efficiency and Renewable Energy (EERE) make available grants for renewable energy under an experimental equipment basis. The grants provide for technical assistance for design and system requirements. EERE also offers training for operators of the new systems. However, the grants are only for purchase of equipments and do not cover operations and maintenances (O&M) costs. The EERE program at DOE has authorization to develop an Indian program, but a comprehensive program has not been developed that serve the needs of Tribes. Instead, EERE has developed special initiatives to test renewable technologies that companies hope to com-

mercialize on the open market.

The Rural Utility Services has a hardship loan program that NTUA qualifies for. RUS provides loans for the development of energy projects at 5%, if they are able to meet both tests listed below

- Rate disparity test of hardship
  - Average revenue per KWh is greater then 120% of all electric utility in state and
  - Average residential revenue per KWH is greater then 120% of all electric utility in state
- Consumer income test
  - Average per Capita Incorporated is less then the State's average or median household income
- OR meets the extremely high rates test
  - Residential revenue exceeds 15 cents per KWh sold.

RUS also has an insured loan program. This program provides loans at very low interest from lenders that are approved by RUS to carry the loan. The current interest rates are

- 1-Yr 3.375%
- 5-Yr 4.000%
- 10-Yr 5.000%
- 20 +Yr 5.125%

Another program that RUS offers is the guaranteed loan program. The FFB Rates are

- 1-Yr 3.530%
- 5-Yr 4.880%
- 10-Yr 5.340%
- 30-Yr 5.730%

RUS loan programs are good options if the utility is able to meet the requirements.

Cooperative Finance Corporations offer another option for rural municipalities or co-ops to secure financing for energy development projects. The National Rural Utility Cooperative Finance Corporation (NRUCFC) provides a variety of services and financial products. It is also a supplemental lender for the RUS. The NRUCFC CFC loan program offers

- Variable Rate at 6.700%
- Interest Rate Re-pricing Option at various specified terms
- Fixed Rates:
  - 5-Yr 7.850%
  - 10-Yr 8.550%
  - 30-Yr 9.150%

NTUA secured financing and grants to begin the PV program of customers. However, the actual PV system must be either leased or bought by the customer. NTUA was challenge to develop a program that is affordable for their customer and still economic to cover equipment, instillation, operation and maintenance costs incurred by NTUA. This can be achieved through rates and tariff charges. NTUA developed two options for their customers, a rate charge or a lease purchase options. The rate charged estimated for a customer was set at $40 per month. That included two visits to each site per year to check water level and batteries and to clean solar panels (minimal O&M charges). It also included a very nominal amount for replacement cost of the batteries every five years. The lease purchase option was a 15-Year installment plan at $95 per month financed at 7.5%. The customer would own the system after 15 years and NTUA would cover the O&M costs for the system.

Lesson Learned

NTUA experienced some successes and problems when implementing the program. One problem was a high account delinquency. The operation and maintenance costs were higher than anticipated due to customer abuse of equipment by inexperienced users, overloading the capacity of the system (too many appliance running at the same time) causing the system to shut down and a high frequency of battery replacement. Many customers were dissatisfied with the systems and would rather return to what they have previously using for their energy needs. NTUA also found that there are cultural issues to be considered when installing the PV systems. Some families do not want strangers coming to their homes to service the equipment.

On the positive side, NTUA saved about $37.6 million in new construction costs, assuming 8 average miles of electric line construction avoided and 200 PV systems installed. NTUA was also approved for a hardship loan by the RUS for 4.8 million at 5.0%. After 1.3 million as reimbursement for all units previously installed, NTUA has 3.5 million to invest in 350 more PV units. NTUA will concentrate on increasing consumer education before installing a new system. Also, NTUA will visit homes every month for the first 12 months to make sure that the customer understands their system and the setup is working correctly. Also, NTUA will only offer the lease purchase agreement for new PV units installed with an O&M service option. Customers can choose to pay a monthly serve installment plan at a set rate or pay full service costs as needed.

Green Credits

***Jan Hamrin*, Executive Director, Center for Resource Solutions, San Francisco, CA**

These recommendations come from a White Paper on Tradable Renewable Certificates (TRC) that include voluntary participation by 27 people representing 20 organizations. The working group members developed the recommendations they thought appropriate for the issues discussed in their particular section of the White Paper. While working independently of each other, the working groups developed a consistent set of approaches and mitigation strategies that address key TRC issues and concerns. The group as a whole discussed the recommendations and agreed upon the set outlined below. The following is a summary of the general recommendations made in this White Paper.

Legal Recommendations

- A TRC should be deemed to come into legal existence at the moment the electrical output of the renewable energy facility is measured, either by physical metering or at the moment the energy is delivered to the grid or other load without metering.
- In the absence of specific legislative, regulatory, or contract provisions a TRC should be deemed to be owned by the owner(s) of the renewable energy facility that generated the accompanying electrical energy.
- TRCs may be transferred by private, specific contractual agreement; by acts deemed to have accomplished a transfer under law or regulation; or, in the absence of such agreement or legal authority, according to general principles of commercial law. Under these principles, the purchase of TRCs assumes the transfer to the final consumer of the renewable power including all of its attributes unless otherwise noted by contract. In the early stages of TRC market development, rules governing TRC transactions may be established through patterns of practice in private negotiations.

A comprehensive accounting and verification framework for TRCs is the best way to eliminate double counting. The best alternative would be a mandatory, national accounting and verification system or database for all renewable generators. A second-best alternative would be to establish compatible regional accounting and verification systems that:

- Use the same accounting and tracking framework for all regulatory requirements and green claims within a region; and
- Are compatible with and communicate with neighboring systems to reduce double counting threats.

Ideally, such accounting systems would:

- Recognize that the "null" power created when a TRC is sold separately from its energy is power without attributes (i.e., the electricity itself cannot be claimed as "renewable");
- Apply on an all-or-none basis to a particular generator (all kWh are accounted for but may not all be sold as TRC products);[1] and
- Assign all renewable energy attributes and emissions credits to generators, who can then pass on those credits to wholesalers, retailers or end-use customers or indicate contractually that the credits have been retired.

All cases of Full Double Sale and Actual Partial Double Sale should continue to be prohibited in law and discouraged in practice.

Sale of Desegregated TRCs (Perceived Partial Double Sale) Emissions attributes should remain bundled with the renewable power or TRCs for all mass-marketed products. For individual contracts to knowledgeable consumers, the disposition of any environmental attributes should be clearly stated in the contract and fully understood by both buyer and seller.

Double Use. Many forms of double use should be allowed to the extent consistent with the intent of the applicable regulatory obligations or contract provisions. Alternatively, they should be addressed in the context of specific requirements to achieve environmental compliance or in implementing regulations adopted by RPS or GPS regulators.

A requirement for adequate information carried on renewable energy certificates. If insufficient information accompanies a TRC (or is unavailable via cross-referencing TRC databases), mandatory disclosure rules or prohibitions could be difficult to enforce. Certificates should include all primary attributes such as unit of measure (MWh is the

minimum size unit recommended); fuel source, technology; location of plant (e.g., state or, if international, country); date of generation, date of certificate issuance; and web site or toll-free number where additional information can be obtained. A more aggressive approach would also require information on the face of certificates related to the disposition of environmental credits (i.e., whether they are or are not bundled with the TRC).

Product-based regulatory requirements. To reduce the threat of "double use" discussed earlier, regulatory requirements that apply to retail suppliers such as RPS and GPS should be imposed on a "product" rather than "company" basis.

Banking. Banking periods should track true-up periods.

TRC Product Disclosure should include the fuel source, technology, and location of generation (if combined from multiple sources then percentage from each technology) and location by technology; period of product true-up (annual or otherwise); and website or toll-free number where additional information about the product can be obtained.

Certification programs should examine how best to handle the disclosure of mixed TRC products that combine certificates from different generating technologies located at various geographic locations.

TRC-Only Products should be held to the same level of consumer disclosure to which their electricity supplier counterparts are held.

SO_2 Benefits (or similar cap and trade credits) by retail marketers should be expressly prohibited unless SO_2 allowances are bought and retired or unless the SO_2 benefits of the product can be otherwise conclusively demonstrated.[2]

Company-based RPS Requirements should be avoided. RPS regulatory requirements imposed on retail electricity providers should be placed on each electricity product offered by the retail supplier. Renewable power claims should be associated only with supplies of renewable energy that exceed regulatory mandates.

A summary of the White Paper as well as the full TRC document is available on the CRS website: www.resource-solutions.org/CRSprograms/T-RECS.html

Endnotes:

[1] To avoid loopholes and assure that a credit registry will actually be useful in mitigating double-counting threats where contract-path tracking is used, it is critical that generators opt-in fully to registering the total generating output during that period of time, even though some portion of the output may not be involved in any type of TRC transaction. . If this does not occur, a generator may be able to claim the renewable energy attributes of a single MWh twice, once through the use of a TRC and another time with the use of a power sales contract. By requiring that generators opt-in fully, a purchaser from that generator will know that it has a right to make green power claims only if it purchases the generator's TRCs.

[2] It is important for those working on the design of new cap-and-trade programs as well as refinements to existing programs to understand that as presently designed, such programs do little to encourage the construction and operation of non-polluting power plants. Instead they transfer the costs of pollution reduction to non-polluting renewables while polluting plants benefit by being able to pollute more at no additional cost.

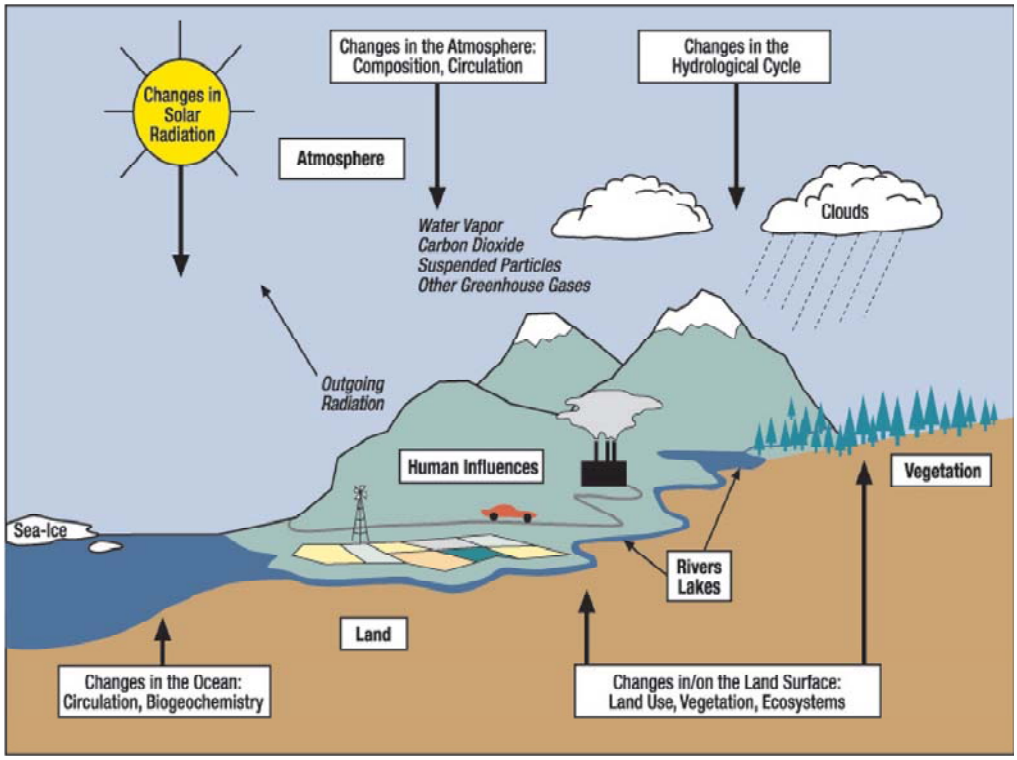
Global Climate Change

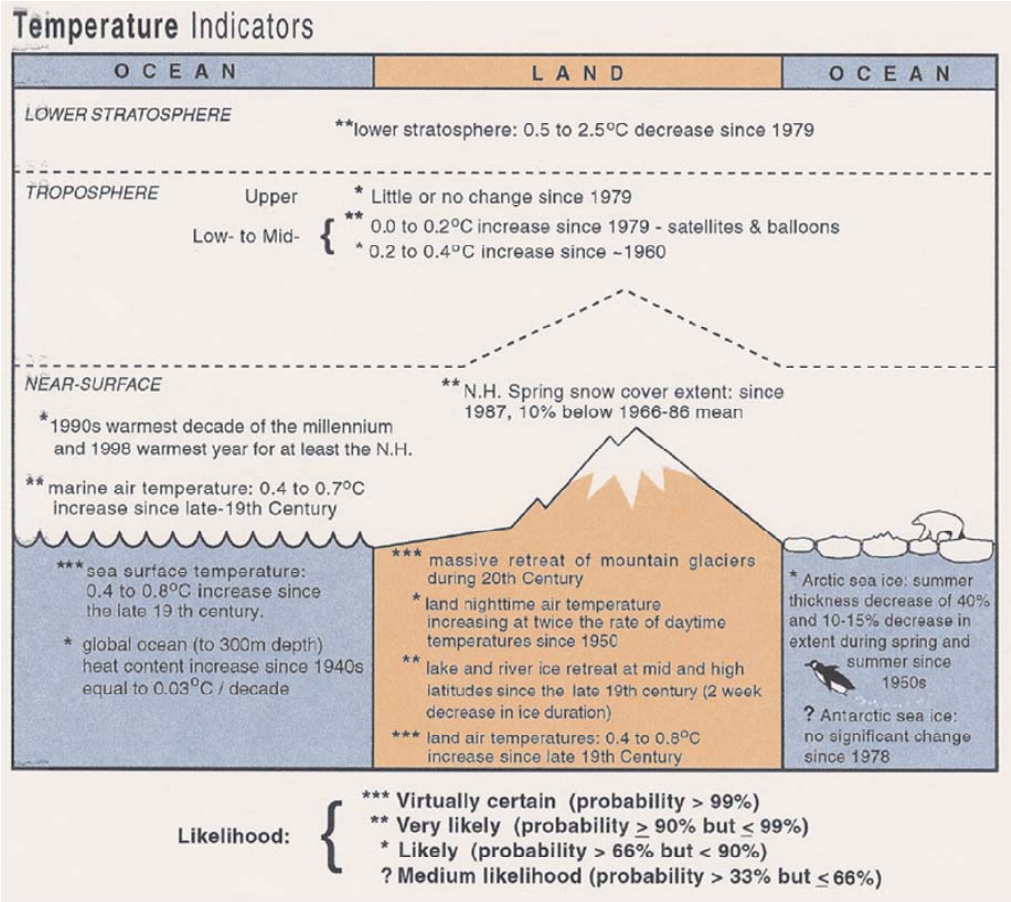
***Jerry Meehl*, Senior Scientist, National Center for Atmospheric Research, Boulder, CO**

(Power Point Presentation Summary. Entire paper is located in Appendix E.)

According to the IPCC WGI Third Assessment Report, there is an increasing body of observations giving a collective picture of a warming world and other changes in the climate system. Emissions of greenhouse gases and aerosols due to human activities continue to alter the atmosphere in ways that are expected to affect the climate.

Recently, confidence in the ability of models to project future climate has increased. There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities and that human influences will continue to change atmospheric composition throughout the 21st century. Global average temperature and sea level are projected to rise under all IPCC SRES scenarios. Even if we decide to change human activities to reduce global warming, anthropogenic climate change will persist for many centuries.

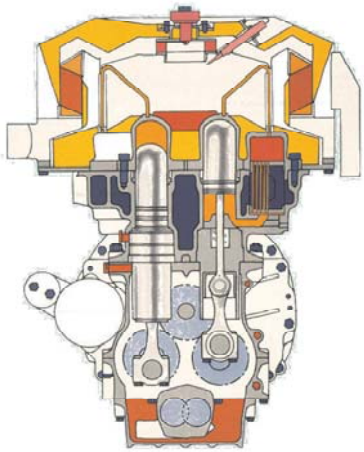




Solar Energy Session

***David Slawson*, Chairman of the Board and CEO, Stirling Energy Systems, Phoenix, AZ**

Each year the US we consume 20,000 MW per year of new US capacity. This is the equivalent to 400,000 MW over the next 20 years, and 2,000,000 MW outside the U.S. over the same period of time. The challenge is where will this energy come from?



Stirling Engine: External heat source; Hydrogen working fluid - closed loop; long life; low maintenance; omnivorous – can use multiple fuels.

With the production of energy there is also an environmental challenge. Pollution from energy generation constitutes over 50% of all pollution. This pollution contaminates all media: air, water, and land/soil. Energy generation is the largest contributor to global warming and importing energy drains the US economy. So how will we handle these challenges?

There are many possible solutions to the energy and environmental challenges. Among these are: coal, oil, hydropower, nuclear, natural gas, geothermal, solar, wind and biomass. Each of these options have pros and cons. Both oil and coal have a very destructive impact on the environment, they are polluting in their production and consumption as major contributors to the "Greenhouse Gas" problem. For coal the environmental impact costs are 10.5 cents per kWh.

With regards to hydroelectricity, there are no new large hydroelectric opportunities available and it produces a negative impact on fish and game.

No new nuclear reactors are planned for the US, and 40 existing plants are being decommissioned. Aside from a long lead time necessary to build new capacity, there are environmental issues with regards to hazardous waste disposal and high water use for cooling.

There is an increasing demand for the limited supply of natural gas. Natural gas prices are also unstable. Currently natural gas is $6 – $14 per million btu. That is up from $2.50 in January 2000. Six dollars equals four cents/kWh in fuel costs.

Geothermal energy is environmentally friendly, available 24-hours a day and it complements other renewable energy sources.

Outside of these options we are left with sun, wind and biomass. Sterling Energy Systems (SES) focuses on the best renewable energy options including solar, wind, biomass and hydrogen. These choices are currently the most environmentally responsible options for power generation and offer competitive energy prices.

SES answered the energy and environmental challenges by being solution oriented, analyzing energy needs, evaluating all available natural resources, providing an integrated solution with scalable options and mostly by providing clean, renewable technologies that meet market demands.

Vestas Wind Systems is another clean, renewable energy option. SES solar can be integrated with

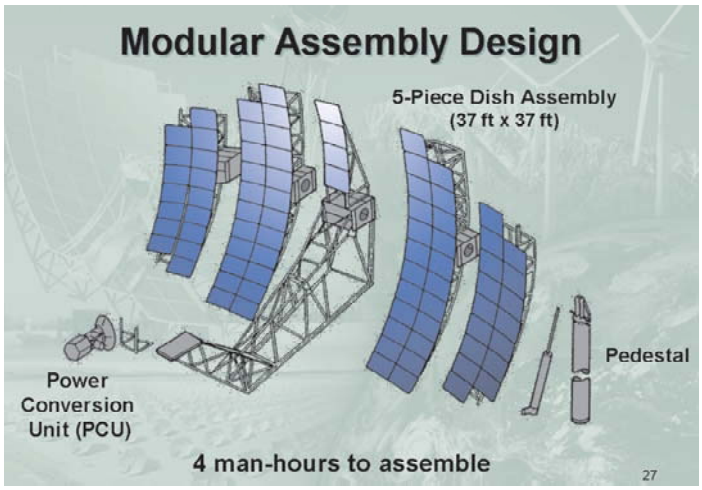
The SES Solar Sterling System holds world record for most efficient solar electric generation (16+ years), is proven reliability in US DOE long-term field testing, is patented balanced concentrator design, is mass producible, lends itself to automotive-type manufacturing efficiency (high volume, low cost).

Vestas wind systems and BioStirling. Wind energy has a proven track record of effectiveness. It is cost competitive at 5 – 8 cents/kWh and easily financed.

Amount of land required to displace US fossil fuel consumption with solar-produced hydrogen. (Assumes 30% efficient solar dish Stirling systems; and 84% efficient electrolyzers to produce hydrogen.)

The Solar Dish Stirling has a dish concentrator that focuses sun's energy on a receiver. Then the Stirling engine converts thermal energy to electrical energy. This patented balanced concentrator design is mass producible and lends itself to automotive-type manufacturing efficiency. They can be produced at high volume for low cost. The volume of dishes is scalable to meet market demand. A Solar Dish Stirling Power Plant may be created with a multitude of dishes.

The Stirling Distributed Generator is highly efficient, quiet, reliable, with competitive costs and ultra-low emissions. It is designed to meet all California emission specification standards and has fuel options including, but not limited to, wood chips, peanut shells and switchgrass. These types of biogas may be used in conjunction with other renewable energy options creating environmentally sound use of waste products.



Modular Assembly Design

SES has combined the best renewable energy technology available with a strong management team, experienced management and personnel, solid strategic partnerships, enormous market potential, and sensitivity to important environmental issues to create a successful renewable energy program.

Dave Melton, President, Diversified Systems MFG, LLC, Albuquerque, NM

Native Americans possess a vast amount of the United States' natural energy resources including renewable energy, at the same time there are tens of thousand of Native American families without access to power and communication. Native Americans have the self-determination to solve their own power energy issues.

Diversified Systems Manufacturing, a division of Sacred Power Corporation, both Native American owned and operated companies, demonstrate some of the current energy efficiency efforts and renewable energy projects they are installing or completed.

These include the largest (most powerful) commercial PV Array in the city of Albuquerque, in the state of New Mexico and on Native Lands across America. The 11 kilowatt (kW) Solar Carport located at the Indian Pueblo Cultural Center (IPCC). It is a grid-connected system that supplements the power requirements of the IPCC.

The Majors Ranch project which is currently under construction, demonstrates village electrification and communication. The renewable energy systems and components includes a 4.6 kW PV array tied to a 24,000-watt battery bank. It will also include a 1.5 kW wind turbine, a 1.2kW stand-alone two-axis tracking system to pump water, a water pumping and purification system and a Satellite Telephone communication system.

The Dish Stirling Solar Thermal Array will provide 10kW stand alone power in which a tribe could pump water in remote locations. And, there are distributive energy solutions as well with the 75kW Parallon 75 gas turbine which Diversified Systems Manufacturing is installing at Laguna Industries, Laguna, NM.

Doran Dalton, Chair, Hopi Foundation, NativeSUN Solar, Kykotsmovi, AZ

Hopi ceremonies are performed for the Hopi people and are also performed for the world. The Hopi approach is holistic, a vision for the world. Everything is connected. Thus the Hopi Foundation, (a 501(c)3 nonprofit corporation), was established to consider projects to help meet the needs of Hopi and to encourage self-sufficiency.

In considering projects and out of respect for cultural values as well as respect for the natural environment, the Hopi Foundation established its first and most successful project, NativeSUN Solar Electric Enterprise, in 1985. Through the utilization of renewable energy resources, NativeSUN is making a contribution to safeguarding our global environment while satisfying cultural values and meeting the needs of contemporary life. NativeSUN provides a method for societies to move toward empowerment and greater self-sufficiency.

Thousands of people living in isolated locations have no electricity. NativeSUN provides electric power to those who have none. The goal of NativeSUN is to apply the use of modern, ecologically sensitive technology, incorporating traditional cultural values, to help maintain the health and comfort of people. The objective is to increase the awareness of communities about renewable technologies locally, nationally, and internationally, and demonstrate the ability to sustain an ecologically healthy environment for future generations.

Earlier this year, a new public policy was established in Arizona to encourage renewable resources. This "Environmental Portfolio Standard" requires utilities to utilize solar, wind and other renewables in its electric supply resource mix. Utilities have gone to the marketplace to acquire these resources and, as a result, are buying down the cost of PV - allowing larger solar electric systems to be utilized on the reservation at a lower cost.

The NativeSUN business consists of installation and maintenance of residential-sized systems both on and off the electric grid; installation and maintenance of larger systems on schools, child-care facilities, and so on; and training of Hopi and non-Hopi tribal members to install and maintain PV systems.

Our vision for the future is to replicate this successful business model on other reservations in Arizona and the Southwest. The concept is to create jobs, increase self-sufficiency, and begin to develop energy independence for these tribes. Together, this network of affiliated Native-American owned and operated companies can capture volume purchase discounts, establish manufacturing facilities, maintain the most current training techniques and refer potential customers to each other.

Wind Energy Session

***Soren Cristensen*, Assistant Manager of Sales and Marketing, Vestas-American Wind Technology, North Palm Springs, CA**

The wind industry is growing at an incredible rate all over the world. The need for power, the increasing awareness of our changing environment and the price increase on fossil fuels has contributed to the boost in North America.

The future development of the industry will depend on manufacturers developing equipment that will stay economically competitive with all the other sources of generation and the effectiveness of such equipment. We believe electricity from wind power will have the cheapest kwh within the next 5 years. This alone will ensure that the wind power generation industry is here to stay.

There is more than enough available land for reaching these goals, the increasing size of the wind turbines will ensure that less land is needed. If you were to take North Dakota and plot a piece of land 200 by 200 miles, this would be enough to generate all of California's annual power consumption.

The beauty of wind power is the fact that it brings value to the remote communities, where many are suffering from closed and relocated manufacturing facilities, dying industries, etc.

A 100MW wind farm generate more than 1 Million dollars in property tax each year, 80 six month fulltime construction jobs, 20 permanent full time operations and maintenance jobs and 265 thousand dollars in direct payment land leases.

Whether your neighbor is a 280 pound wrestler or a 20 ounce squirrel, you need to find arrangements which will work for both of you.

Involve neighbors and respect their land. The new equipment makes it easier to agree, fewer turbines and less noise. With the new equipment you do not need to be on top of communities. Space saving Wind Turbines are now available and in use.

Annual pollution savings:

Carbon dioxide (CO_2):	approx. 27,000 tons
Sulphur dioxide (SO_2):	approx. 225 tons
Nitrogen dioxide (NOX):	approx. 150 tons
Slag & flyash:	approx. 1,890 tons

This table shows how much annual pollution is avoided when using 15 V47-660 kW wind turbines instead of producing the equivalent amount of energy from a coal-fired power station. The figures are based upon an annual production of 1,800,000 kWh/wtg.

Pollution offset:
1 kWh of Coal-Produced Energy Creates:

Sulphur dioxide (SO_2):	8.3 grams
Carbon dioxide (CO_2):	1,000 grams
Nitrous oxides (NOX):	5.5 grams
Slag & flyash:	70 grams
Dust:	0.1 grams

The environment is very important to all of us. The slides in the presentation indicates the level of pollution offset by wind power, it is quite magnificent.

***Roger Hill*, Senior Technical Staff, Wind Energy Technology Department, Sandia National Laboratory, Albuquerque, NM**

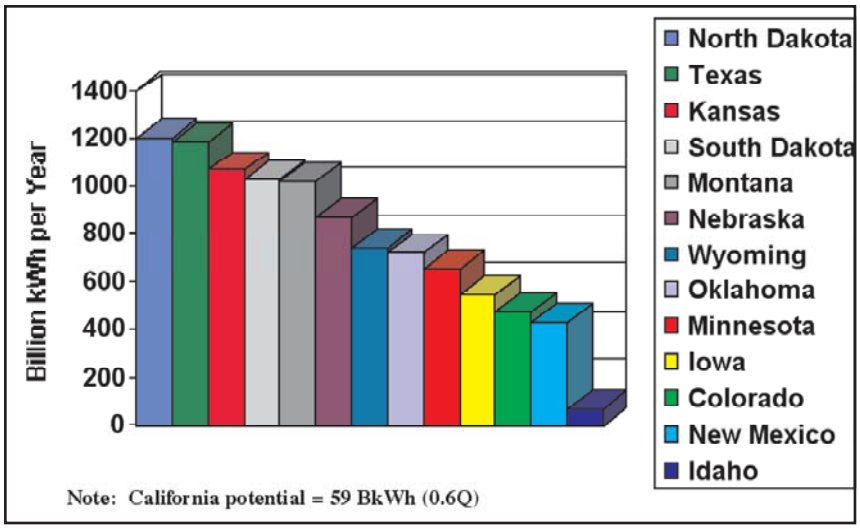
Sandia National Laboratories work with Tribes in the area of wind is part of Wind Powering America Program. Wind Powering America is a commitment to dramatically increase the use of wind energy in the United States. This initiative will establish new sources of income for American farmers, Native Americans, and other rural landowners, and meet the growing demand for clean sources of electricity.

Through Wind Powering America, the United States will achieve targeted regional economic development, protect the local environment, reduce air pollution, lessen the risks of global climate change and increase energy security.

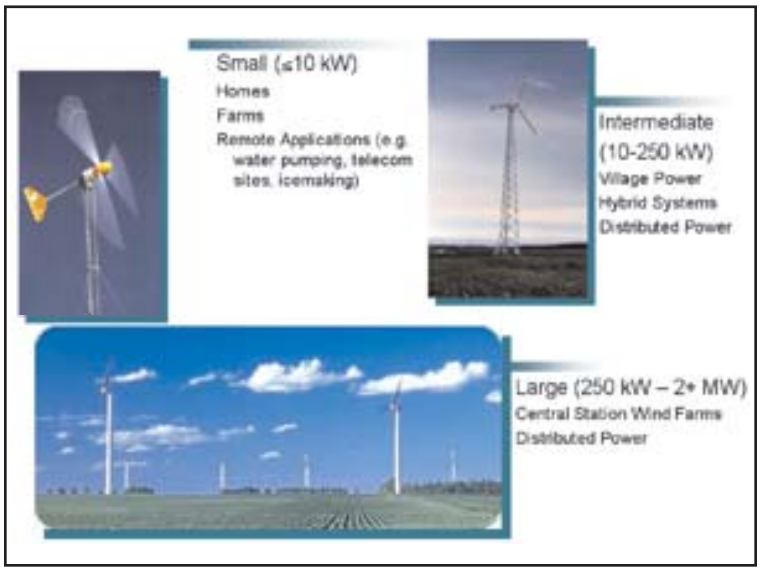
Question: What happens when the wind stops blowing?
Answer: Wind energy is an intermittent resource. When the wind blows between about 7 meters per second (16 miles per hour) and 27 meters per second (60 miles per hour), wind turbines can generate electricity. When the wind doesn't blow, or blows too hard, the turbines cannot generate electricity.

Power producers that are installing wind turbines understand and plan for the intermittent nature of wind energy. They also appreciate that wind turbines offer a number of benefits that conventional generation does not: shorter construction lead times, modularity (more turbines can always be added if loads grow), no fuel costs, no air emissions, and higher customer approval. If the wind resource is well matched to peak loads, wind energy can effectively contribute to system capacity. Winds are often higher in the afternoon, for example, when electricity usage is high.

Question: If this technology is so great, why isn't it everywhere?
Answer: Wind technology is, in fact, the fastest-growing generation source in the world. In the United States, growth is slow because power producers have delayed construction of all types of new generation until uncertainties about utility deregulation are resolved.



Despite the slowdown in new generation, the United States is experiencing the largest surge in utility-scale wind development since the 1980s. Low wind energy costs, combined with a Production Tax Credit of $0.017 per kilowatt-hour, have made wind energy projects financially attractive.



Question: Is wind power cost competitive?
Answer: Today, the cost of electricity from wind at the best wind sites is about $0.03 or less per kilowatt-hour when offered with the Production Tax Credit. Wind must compete on a cost basis with other generation sources with costs of about $0.015 to $0.03 per kilowatt-hour or more.

Wind energy offers many benefits that add to its value. It is a clean, renewable technology that does not pollute the air with greenhouse gasses or other emissions. Wind energy projects bring economic development in the form of jobs, tax revenues, and land lease payments to rural areas. The wind is a free and domestic resource, which can reduce US reliance on foreign fuel imports.

Geothermal Energy Session

***Roger Hill*, Senior Technical Staff, Wind Energy Technology Department, Sandia National Laboratory, Albuquerque, NM**

Sandia National Laboratories work with Tribes in the area of geothermal energy and is part of Geo-Powering the West Program. GeoPowering the West is a new initiative to capitalize on the abundant geothermal resources found in the West, including Alaska and Hawaii. The initiative will provide new sources for generating electric power and space heating, crop processing, and aquaculture. This will fuel sustainable development, create jobs in rural areas and on Native American lands, and support cleaner local and regional environments.

Question: What are the benefits of using geothermal energy?

Answer: Several attributes make it a good source of energy.

First, it's clean. Energy can be extracted without burning a fossil fuel such as coal, gas or oil. Geothermal fields produce only about 1/6 of the carbon dioxide that a natural-gas-fueled power plant produces and very little if any, of the nitrous oxide or sulfur-bearing gases.

Geothermal energy is available 24 hours a day, 365 days a year. Geothermal power plants have average availabilities of 95% or higher, compared to 60%-70% for coal and nuclear plants. Geothermal power is homegrown, reducing our dependence on foreign oil.

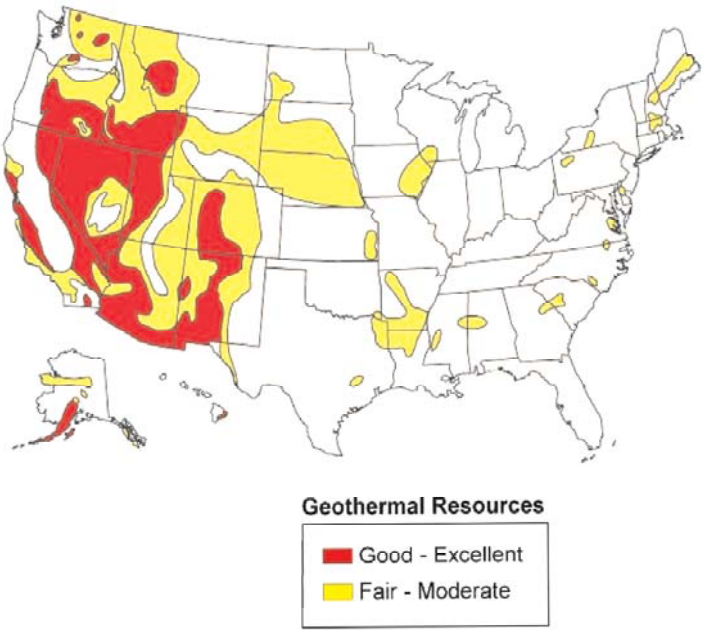
Question: What are the environmental effects of using geothermal energy?

Answer: Geothermal technologies offer many environmental advantages over conventional power generation. Emissions are low. Only excess steam is emitted by geothermal flash plants. No air emissions or liquids are discharged by binary geothermal plants, which are projected to become the dominant technology in the near future.

Salts and dissolved minerals sometimes contained in geothermal fluids are usually reinjected with excess water back into the reservoir at a depth well below groundwater aquifers. This recycles the geothermal water and replenishes the reservoir. The City of Santa Rosa, California, pipes the city's wastewater up to The Geysers power plants to be used for reinjection fluid. The system will prolong the life of the reservoir as it recycles the wastewater. Some geothermal plants do produce some solid materials, or sludges, that require disposal in approved sites. Some of these solids are now being extracted for sale (zinc and sulfur, for example), making the resource even more valuable and environmentally friendly.

Question: How much does geothermal energy cost per kilowatt-hour (kWh)?

Answer: The lowest cost of geothermal electricity is now about $0.015 per kWh. At The Geysers, power is sold at $0.03 to $0.035 per kWh. A power plant built today would probably require about $0.05 per kWh. Some plants can charge more during peak demand periods.



Geothermal resources are typically found where hot rock or magma has come near the surface through geologic activity. We gain access to the resource by drilling into it, unless there is a surface manifestation, such as a hot spring, that can be used directly.

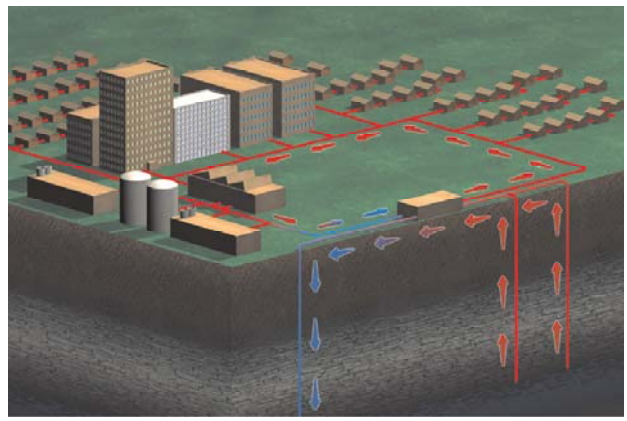
***James C. Witcher*, Southwest Technology Development Institute, New Mexico State University, Las Cruces, NM**

A vast amount of thermal energy is stored and continually replenished in rock and water in the upper 10 kilometers (km) of the earth's crust. If only 1 percent of this energy could be economically tapped it would be hundreds of times greater than all oil and gas resources. This thermal energy is geothermal energy. Native American lands across the western United States, Alaska and Hawaii have potential for near-term beneficial geothermal use. Areas most favorable for geothermal have high subsurface temperature gradients or elevated temperatures near the surface. A typical gradient or "geotherm" is around 25 to 30°C/km. Areas with geothermal resources usually have temperature gradients that greatly exceed 75 to 100°C/km.

Geothermal resources exist in many different geologic and hydrogeologic settings. Active or young volcanoes are not required for geothermal resources. For the purposes of this discussion, geothermal resources may be classified according to temperature. Many other classifications also exist. High temperature resources are greater than 180°C and can be suitable for electrical power generation, exceeding 20 megawatts (MWe) size. Intermediate temperature resources are between 90 and 180°C and may be suitable for small-scale electrical power generation at rates mostly less than 10 MWe size.

Low temperature resources are less than 90°C and at least 10 to 15°C above the local mean annual surface temperature. Low temperature resources are the most common and can be used in a variety of geothermal direct-use heating applications to include greenhousing, aquaculture, space and district heating, ground-coupled heat pumps and many industrial uses that require large amounts of low grade or low temperature heat such as in curing or drying. High and intermediate temperature geothermal resources may also be used in direct-use applications by "cascading" residual heat from power production to other lower temperature applications.

Because geothermal resources offer many economic benefits beyond energy production, geothermal should also be viewed as a potential tool for economic development on Indian lands. A comparison of the cash flow from geothermal electrical power production and from geothermal direct-use greenhousing shows that an acre of geothermal greenhouses has the same cash flow as 1 to 2 MWe of continuous power generation over the course of a year. Only the greenhouse shows true energy savings when compared with conventional energy. Also, the greenhouse will provide employment for about 8 people per acre. In terms of benefit and value-added economy, the geothermal direct-use approach holds much greater promise than stand alone geothermal electrical power generation.



District Geothermal Heating

Geothermal can have significant initial capital costs. However, the advantage is found in the very low costs associated with use. No unpredictable fuel costs accrue and the operating and maintenance (O&M) costs for a well-designed system are minimal. Initial capital costs include exploration, well drilling and heating system construction costs. Typically, production and injection wells are drilled and heat exchangers are used. This insures a closed and isolated loop for the geothermal fluids which can lower O&M costs and protect the environment. With geothermal, the wells and heat exchanger essentially take the place of a conventional fossil fuels boiler without escalating fossil fuel costs and pollution.

Indian geothermal development approaches should be geared to benefit tribal needs and priorities. The first step is a sound assessment and confirmation of the geothermal reservoir or resource. While engineering feasibility is needed, a well thought out business and marketing plan is absolutely essential. Issues such as day-to-day management and financing are crucial for the plan.

If geothermal energy use can enhance and strengthen tribal needs and culture and bring income and jobs, then geothermal resources on Native American lands may have much value in the near future beyond just the intrinsic energy that geothermal would provide.

Alan Mandell, Tribal Chairman, Pyramid Lake Paiute Tribe, Wadsworth, NV

The Pyramid Lake Paiute Tribe is governed by 10 elected Tribal Council members and is located approximately 30 miles North and East of Reno, Nevada. Our reservation encompasses over 500,000 acres of land with Pyramid Lake located entirely within the boundaries of the reservation. Our Tribe has approximately 2100 Tribal members, of which nearly 1500 live in one of the three communities of the reservation. These communities are Sutcliffe, Nixon, and Wadsworth with a majority of the population living in the Wadsworth community.

Pyramid

Pyramid Lake is one of the natural wonders of the region and the aboriginal home to the Pyramid Lake Paiute Tribe. Our people are called the Cui-ui Numa Ticutta after the Cui-ui, a species of fish native to the Lake and our aboriginal food source. Unfortunately the Cui-ui is also listed as an endangered species. In addition to the Cui-ui, the Lake is known for the Lahonton Cutthroat Trout (which is listed as a threatened species). Our well-established fisheries department is managing the recovery and restoration of these two fish. One of the Lakes most distinctive natural features are its tufa formations (calcium carbonate deposits formed by precipitation over hot springs, including the Pyramid and the Needles Rocks indicating geothermal activity).

Two other features of the Tribe are:
1. The designation of the Pyramid Lake Scenic Byway, established in 1996 by the U.S. Secretary of Transportation as a National Scenic Byway, one of the first in the country and the only one sponsored by a Native American Tribe

2. Anaho Island, a National Wildlife Refuge, which is the breeding ground for the largest colony of American White Pelicans and other shore birds. The lake and island is also a resting place for other migratory birds along the pacific flyway.

The impressive Pyramid Lake is the terminus for the Truckee river watershed. This watershed begins at Lake Tahoe and flows North and East for 105 miles ending in Pyramid Lake. This year a state of drought conditions is widespread throughout the Pacific Northwest region as well as on the tributaries of the Truckee River. The Truckee River and the Pyramid Lake remain in a natural state and the role of the fisheries enhance the very important conservation efforts to the Lake and River areas.

In our overall economic development plan, it is one of the goals of the Pyramid Lake Paiute Tribe is to gain a better understanding of their renewable resources and what it would take to properly develop and use them for the generation of electricity. In general terms, any energy infrastructure is to be developed as a means for Tribal advancement but not specifically as an end in itself. The choices offered by any energy infrastructure represented choices that the Tribe could make either for Tribal benefit directly, or in turn as spin-off opportunities for individual Tribal members (such as establishing Tribally owned business to support the energy facility). The social implications of any development would be an important factor and must be consistent with the natural state of Pyramid Lake and the Tribes cultural and traditional uses of the area.

The Pyramid Lake Paiute lands are at the crossroads of electrical transmission, a natural gas pipeline corridor, and other infrastructure facilities that could offer synergistic or complementary benefits for the development and utilization of both fossil fuels as well as renewable energy resources. The Tribe has been investigating both fossil fuel and renewable energy possibilities as a means of economic development.

The Tribe has electrical power service provided by Sierra Pacific Power Company with distribution lines at Nixon and the Sutcliffe locations. Areas north of Sutcliffe do not have power nor are they developed although this area appears to be an excellent area to explore for and develop the potential geothermal resources. Two 345 kV lines cross the Pyramid Lake Paiute Reservation southeast of Nixon. Additionally, a 500 kV DC (known as the Pacific-Intertie) line intersects this location as well. While these electrical transmission lines do not directly provide elec-

tricity to the Pyramid Lake Paiute facilities, the transmission lines offer the excellent possibility for accessing energy markets with locally generated electricity.

There are existing AC transmission lines west of the Lake area at a distance that might offer possibilities for future interconnection depending on the eventual siting of any wind or geothermal generating plants in the Northern portion of the reservation.

Also, at the north end of Pyramid Lake a string of natural tufa formations called the Needles (large tufa or calcium carbonate structures) have developed throughout the geologic past. A venting hot geyser is located in the lake water among the tufa structures. There are many tufa structures throughout the Pyramid Lake area. In fact, a large tufa structure in the body of the lake water is pyramid shaped and hence gives the Lake its name. This pyramid-shaped structure is still active and can be seen emitting steam on cold winter days. Many of the tufa structures on land create linear alignments when viewed from a distance and indicate that the tufa structures are aligned along faults and faulted regions, which appear to be coincident with the earlier release of geothermal water at the surface.

Reviews of geothermal maps indicate that the Pyramid Lake Paiute Reservation is one of many geothermal sites in northern Nevada. Clusters of hot well or springs exist in the Needles, Nixon, and Little Valley areas. There are also neighboring areas of geothermal activity in the northern Nevada region such as the Empire valley to the north, Walker River and Fallon to the south and east, and Reno itself to the west. In Bulletin 91 of the Nevada Bureau of Mines and Geology (1979) titled "Thermal Waters of Nevada", Larry Garside and John Schilling reported that divers have noted underwater hot springs are present near the Needle Rocks today. Springs at the Needle Rocks are reported to range from 151°F to 208°F, which is near boiling for the elevation at this location on the Pyramid Lake. In the early 1960s, Western Geothermal, Inc. drilled three geothermal wells at the Needle Rocks. The deepest well was 5,888 feet and the maximum-recorded temperature was about 240°F.

What would our marketing areas be? Northern California /Eastern Nevada (mines) via the two 345kV East/West AC lines and the Pacific Northwest/Los Angeles areas via the 500 kV DC line running North/South. The new Renewable Portfolio Standard (RPS)

Hot Springs - Needles

for Nevada, i.e., SB 372, signed into law in June 2001 will enable the Tribe to benefit from renewable energy marketing. Under this law, in 2003, 5% of total megawatt hours of electricity sold by a utility or alternative seller must be provided by renewables with 10% of that to be generated from solar. The standard increases by 2% every other year until it reaches 15% in 2013. As enacted, existing renewable energy capacity, which is about 3%, is counted in the standard. A copy of the bill is available online at: http://www.leg.state.nv.us/71st/bills/SB/SB372_EN.html.

This RPS offers opportunities to the Pyramid Lake Paiute Tribe. With wind and geothermal resources on the reservation and nearby lands, the RPS will create a market for these renewable energy resources. The transmission lines that cross the reservation boundaries become important as a collection point for electrical energy, which can then be transmitted to other locations throughout Nevada, and possibly California, for delivery to the system customers under the terms of the RPS.

Even though energy development provides tremendous opportunities to the Tribe, we realize that any development MUST fit into OUR VISION and be consistent with our Cultural and Natural resource management plans. It is with this vision and understanding that we discuss energy development projects with potential investors.

Protection, preservation and a holistic approach are techniques utilized by the Tribe that ensures potential projects are viable and sustainable and more importantly recognizes, understands, and integrates the Culture, Traditions, and Values of the Pyramid Lake Paiute Tribe.

Distributed Generation Session

***Ed Henderson*, Director of Sales, Honeywell, Albuquerque, NM**

(Power Point Presentation Summary)

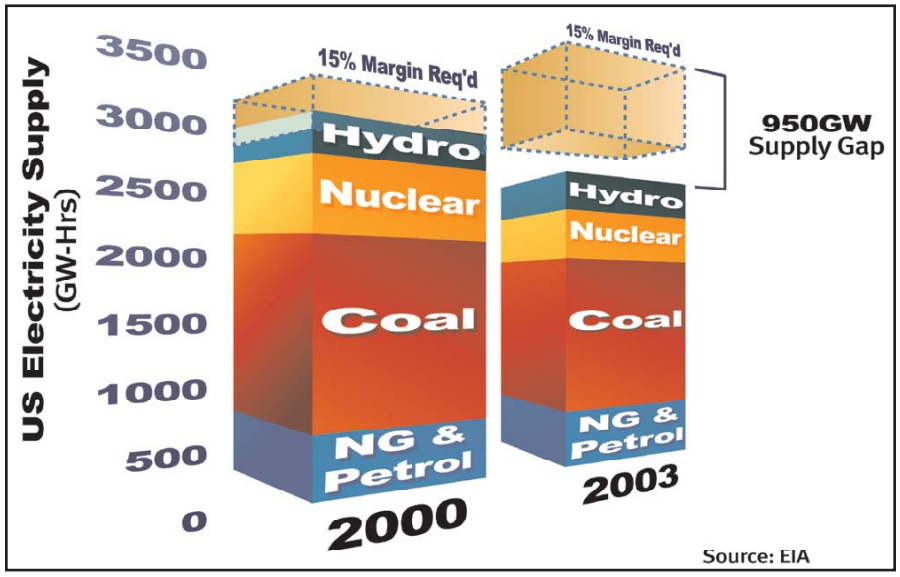
Honeywell, Inc. is the commercial developer of Parallon 75, which is advanced micro-turbine generator. Parallon 75 is a modular, onsite generation producer that creates value by producing high quality electrical and thermal power. It has multi-fuel capability being able to use natural gas, diesel, kerosene or propane.

Clean Baseload Power

Electricity demand is exceeding current supply in many countries (example below). Presently, 2-3 billion global citizens do not have access to "city grade" power. Rural users pay a premium due to high cost of transmission and distribution to remote areas. It is more important than ever to reduce harmful emissions. Thus, Parallon 75 is an environmentally friendly, enabling technology to address local power.

Outage Risk Mitigation

Eighty-eight percent of small businesses experienced one power outage with 26% of them reporting 2 or more outages (1998 survey data). The frequency of power outages is growing due to constraints on the current supply infrastructure. The Parallon 75 provides an effective mitigation tool to eliminate the economic loss due to a power outage.



Filling the Demand Gap

Combined Heat and Power

Hot Water Thermal System
Output: 185°F water
Typical User: Motel, school, hospital

Absorption Chiller
Output: 40 °F water
Typical User: Office Bldg., commercial space greater than 50K sq. ft.

Desiccant System
Output: Dehumidified air
Typical User: Grocery store, AC for commercial space in humid climate

The Parallon 75 provides a variety of applications for businesses such as Bunge Food, La Quinta, Honeywell Tech Center and Wiser Oil.

Peak Savings

During high demand periods, energy rates peak. Operating costs of the Parallon 75 are stable throughout the day, thus, a customer can arbitrage fuel versus electricity to reduce their operating expenditures.

Optimization and Stabilization of Energy Expenses

Fuel tariffs are volume based. One Parallon 75, on a six hour per day peak usage, consumes the same amount of fuel annually as 70 to 140 residential customers. A Parallon multi-unit installation could move a customer from a commercial gas tariff to an industrial gas tariff. It also has the added benefit of lowering the cost of all gas used for operations.

***Bruce Wiegmann*, Systems Engineer, NASA, Glenn Research Center, Cleveland, OH**

Throughout all energy distribution systems the amount of power delivered at any given time to a customer can fluctuate considerably. This fluctuation requires the electrical system provider to have an electrical production capacity above the average load required and this capacity must be available within milliseconds. Thus to accomplish meeting the customer's needs at a moments notice, the power grid has extensive over-capacity built in.

When renewable energy systems are designed, the excess produced energy is either dumped into the grid, dumped into a "dump load" such as a large water heater, stored via chemical batteries, or lost. Dump loads are usually located in a major facility; whereas, the battery storage scheme can allow for a distributed energy storage system.

Chemical batteries have been in existence for over one hundred years and these batteries are life-limited by various factors. A normal chemical battery can last from 5 to 7 years. But this life is dependent upon many parameters. Some of these parameters include- 1) Nominal depth of discharge level of the battery (usually 20 to 40 percent), 2) Total number of cycles that the battery will see over its life, 3) The surrounding thermal environments, 4) The rate of power dissipation from the battery, and 5) The rate of recharging the batteries. Therefore, all chemical batteries are life-limited to a range of five to seven years due to the chemical nature of these devices.

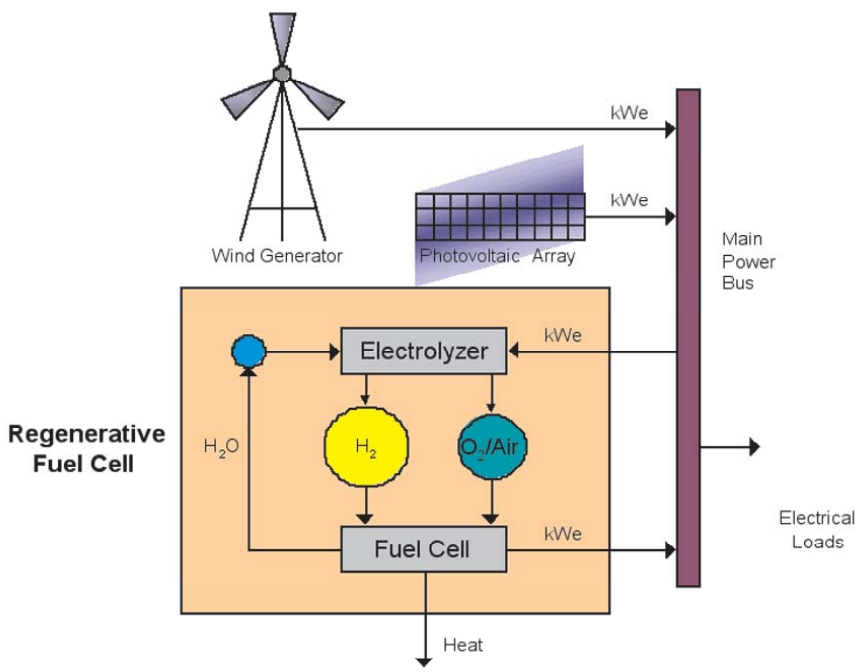
To make a longer lasting battery, many engineers throughout the past 80 years have sought a battery that is not chemical in nature but is electro-mechanical instead. By utilizing an electro-mechanical battery instead of a chemical battery, a longer life in the ranges of tens of years (20 to 30 years) can be achieved. In addition to longer life, other technical parameters such as larger depth of energy discharges, larger numbers of cycles, and greater efficiencies (85% compared to chemical batteries efficiency range of 60% to 70%) are improved when compared to the chemical batteries. These devices are also known as flywheels. In these systems, the excess energy that is now dumped or wasted is instead used to speed up a circular, dense flywheel via a shaft connected motor. Once the flywheel is spinning at the required speed, energy is removed via the same shaft connected motor but now the motor is acting as a generator. The amount of energy that can be stored within such devices is proportional to the angular speed squared and is only limited by the strength of the flywheel material. These flywheels have be designed and tested to 60,000 RPM by NASA GRC personnel.

Aerospace Technologies are synergistic to terrestrial power systems:

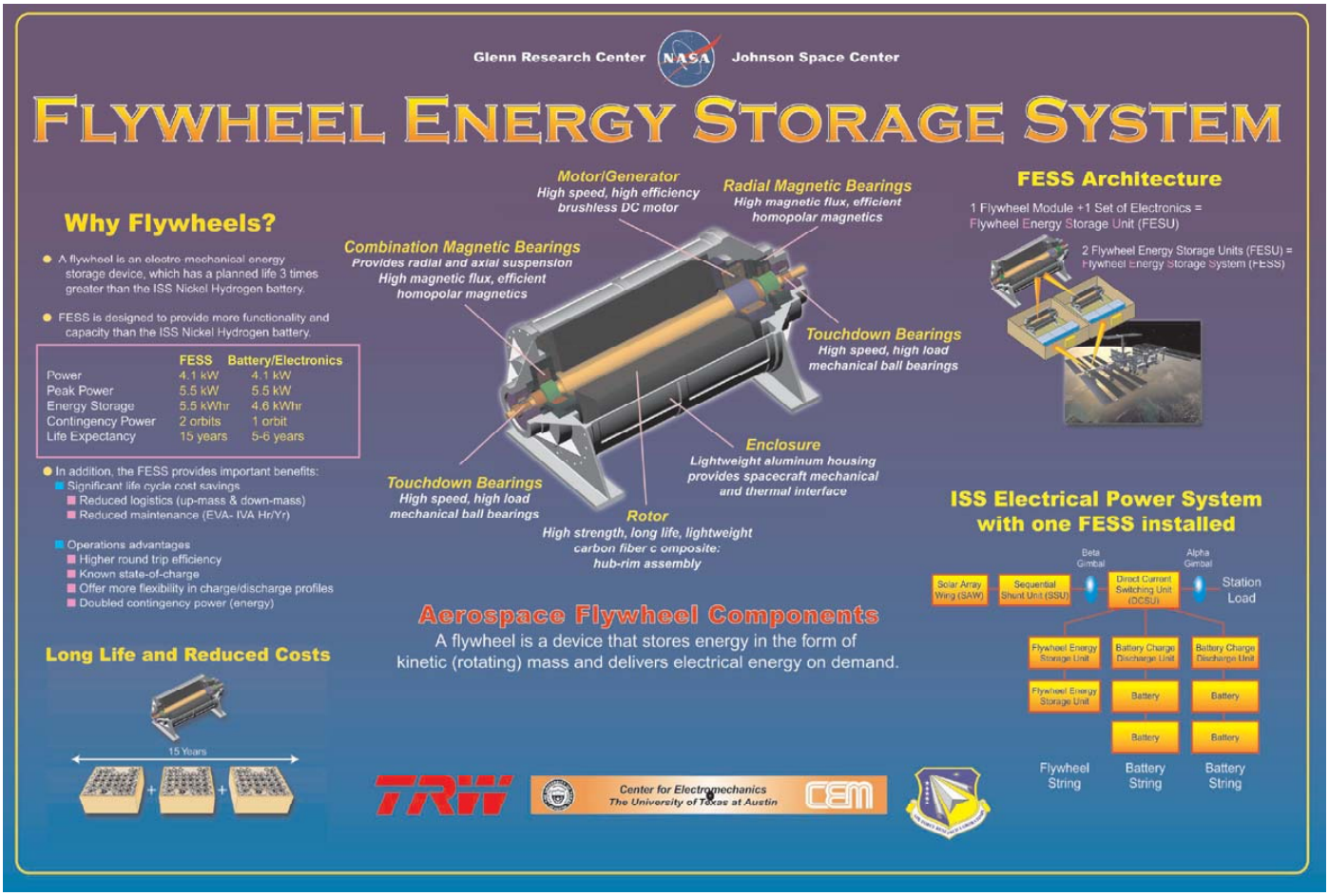
- Power Management and Distribution (PMAD)
- Inverters, Converters, Rectifiers, Controllers, etc.
- Energy Storage Devices
- Batteries
- Flywheels
- Regenerative Fuel Cells

Flywheel Design Considerations

Each flywheel is a 'Point Design', much like that of a truck or boat. Each flywheel is designed to met a certain set of requirements. Flywheels have been recommended for decades as an energy storage



How Regenerative Fuel Cells Fit Within A Renewable Energy Architecture



device, but they have not been practical in years past because an efficient flywheel is dependent upon advanced materials (high strength metals or composites), advanced magnetic bearing technology and the controls, and advanced Motor/Generator controls and algorithms. These three areas have been attained by new materials, computer speeds, and complex microchips

Flywheels are used in place of batteries on the international space station because they have a longer life (15 years vs 5 years for NiH2), lower life cycle costs, higher energy storage capacity, lower depth of discharge limits, and greater operational flexibility. Their charge/discharge profiles not limited by battery chemistry and it is easily to measure the state of charge.

GRC regenerative fuel cell (RFC) work is primarily, space focused. GRC has worked as independent consultants in the renewable energy design aspects of the Oberlin College that has PV System connected one of their buildings electrical supply. In the future the GRC Growth path may involve use of RFCs as a demonstrator.

Use of Regenerative Fuel Cells for Terrestrial Applications

NASA Partnership grant project allows the Lac Courte Oreilles Ojibwa Community College (LCOOCC) to establish the Renewable Energy Sustainable Development Institute (RESDI) on the Lac Courte Oreilles Reservation near Hayward, WI. GRC personnel assessed the solar & wind resources at this site and designed two distinct RFC. One design is to provide energy for a building located off grid, and the second design was use of a RFC for backup power supply. Renewable Energy resources are marginal at this site, but the second phase of project to be awarded in a few months.

Bipolar Ni-MH Battery Development

The design goals for bipolar Ni-MH battery development include having 2.5 times the energy density of Ni-H2 and one-fifth the cost of current ISS batteries Ni-H2. The design objectives was to have a1 kW, 28 Volt Ni-MH battery with a specific energy of 100 Wh/kg, an energy density of 250 Wh/l, and a five year life in Low Earth Orbit (LEO) at a 40% Depth of Discharge (DoD).

Biomass Energy Session

Rico Cruz, **Department of Natural Resources, Environmental Restoration and Waste Management Program and Cultural Resource Program, Nez Perce Tribe, Lapwai, ID**

Biodiesel: A Simple Answer to a Complex Environmental Degradation Problem and the Energy Crisis

I. Goals and Scope

The dynamics of environmental degradation and the increasing demand for energy require humans to find alternative sources of energy. One can compare one source of energy, fossil fuel, with food. If there were a finite amount of food on Earth, people would probably store the food in few places and, instead of sharing it, the controlling institutions or governments would give it out to the highest bidders (basically the most powerful and rich people). There would be chaos and power struggles to control what is left. There would be black markets, and shortages.

Our world is beset with three major energy-related problems: fossil fuel is running out; a reduction in fossil fuel would harm world economy; and the earth is getting warmer due, in part, to the increase of carbon dioxide in our atmosphere. The extraction of and demand for oil increased exponentially as new uses for oil were found. What is outrageous is that it will take only 200 years to consume the oil that Mother Nature took 300 million years to create. With the current global consumption rate of 24 billion barrels/yr, we will run out of fossil fuel by 2040. In 1997 worldwide reserves were at 997 billion barrels. By 2010, fossil fuel could become unaffordable for most people (Campbell 1998). Our dependence on fossil fuels harms our nation's economy, since we import a high percentage of the fossil fuel we consume, plus sending military troops, jobs and infrastructure. The US gives the fossil fuel industry $5,000,000,000 in tax money annually (Tickell 1999). For the military intervention during the Persian Gulf War, the cost was about $70 billion of US taxpayer money, up to 200,000 Iraqi lives, and approximately 150 NATO countries' lives. Each year, the US spends $50 billion to maintain its military presence in the Middle East (Ramsey 1998). If we had to fully pay for these military expenses, gasoline prices would be at least twice as what we are paying now at the gas pumps (CERI 1990). Planet Earth is currently undergoing a period of global warming due to the greenhouse effect of emissions from engines. Carbon dioxide levels in the atmosphere alone increased from 280 parts per billion in 1750 to 360 ppb in 2000 (Consumer Reports 1996).

One solution to environmental degradation and energy crises is the development of renewable forms of fuels or energy sources. There is almost an infinite supply of renewable energy (e.g., ethanol, biogas/biomass, biodiesel, photovoltaics, wind and hydro power). Fossil fuel availability is limited, while biofuels are constantly grown and replenished. Fossil fuels took at least 40 million years to produce, while biofuels can be produced in two months. Renewable fuels are carbon neutral. Plants can capture CO_2 emitted by fuels whereas fossil fuels emits about 22 lbs of CO_2 per gallon burned, while every gallon of vegetable oil produced, plants capture 22 lbs of CO_2 for growth and development (Gordon 1991 and Smith 1920). Renewable fuels strengthen the economy by creating jobs and infrastructure, and reducing the petroleum deficit. The US could decrease its annual trade deficit by over $53 billion and create 1.43 million jobs in biofuels and supporting services by producing 100% of its fuel domestically (Campbell 1997). The U.S. ethanol industry alone adds $51 billion to the economy; allows farm income to increase by $2.2 billion; creates 5,800 direct jobs and 50,000 indirect service jobs; generates $555 million federal taxes; and reduces the trade deficit by $1.3 billion (Urbanchuk, 1996).

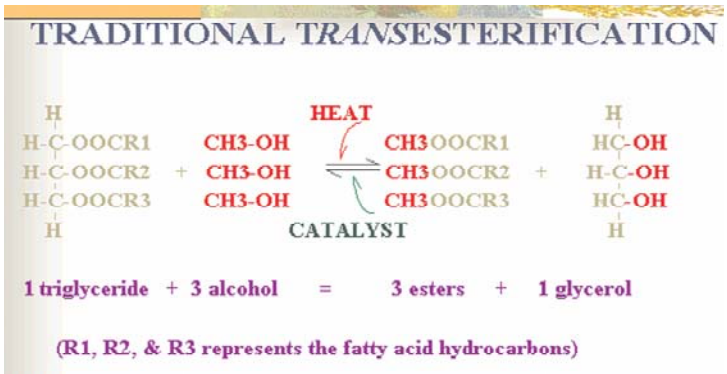


Fig. 1. Transesterification process

One of the promising renewable fuels is biodiesel, which is composed of fatty acid esters of triglycerides (vegetable oil or animal fat). In 1995, The Nez Perce Tribe responded to a Request for Proposal (RFP) under USDOE Title XXVI of the Energy Policy

Act (Indian Energy Resources Program) to pilot the production and demonstrate the use of biodiesel from waste cooking oil. The scope of the project was to establish a pilot plant for the production of biodiesel; demonstrate the use of biodiesel in diesel engines; train and educate people on biofuels production; and transfer a simple pollution prevention technology to indigenous people.

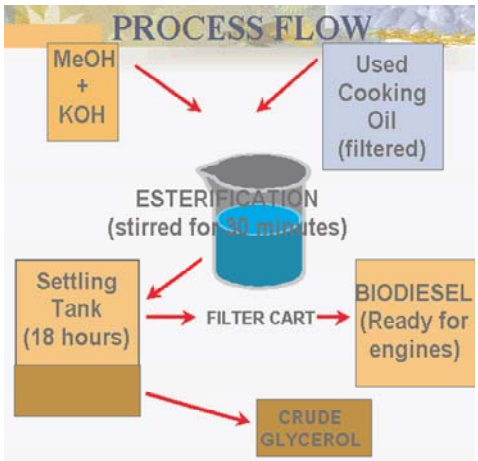


Fig. 2. Biodiesel Process Flow

II. Methods

The Nez Perce Tribe in 1995 responded to a Request for Proposal by the Energy Policy Act of 1992 Title XXVI (Indian Energy Resources Program) to work on renewable energy. Biodiesel was chosen because of available resources at that time and continued the novel work of a postdoctoral investigation on biofuels (Cruz 1992, and Peterson, et al 1992). Biodiesel was produced through a process called transesterification, which is basically reacting a triglyceride with an alcohol in the presence of a catalyst to produce fatty acid esters (commonly termed biodiesel) and glycerin (Fig.1). The project embraced a simple short fuel-making process that uses simple equipment, no heat application and no fuel washing (Fig. 2). The unit composed of two tanks, one as a reactor and the other for mixing the catalyst and alcohol (Fig. 3). The source of oil was waste cooking oil from area restaurants. The unit can produce 300 gals of fuel per day. For demonstration purposes, a new vehicle was purchased for 100% usage of biodiesel. Tribal vehicles were used in regular trips to USDOE Richland Operations Office for tribal involvement purposes. One tribal vehicle used 50% biodiesel, and the project provided biodiesel to run field and maintenance engines of a nearby city parks and recreation service.

III. Results and Conclusions

In less than two years the project was able to produce almost 3,000 gals. biodiesel (Table I). The fuel produced was utilized on two new vehicles (1996 Dodge Ram2500 at 100% and 1997 Chevrolet Suburban at 50%) and field vehicles (tractor, mower/snowblower). The Dodge Ram made two round trips to Nashville, TN and Orlando, FL, and frequent trips to Richland, WA for meetings and other tribal involvement-related work. Except for extra fuel tank, no engine and accessories modifications were done to the vehicles.

The short project was successful in meeting its objective. Implications of the project will be an enterprise in biodiesel production. It can also go into ethanol production and other agricultural products. Our estimate indicates that used cooking oil from area restaurants and other food providers covering a radius of 75 miles will be approximately 10,000 gallons per month. If the Tribe sets aside 1000 acres of idle land for oilseed production, it is feasible to produce 250,000 gals of biodiesel per year. However, the tribe does not have start-up money to go into massive production of biodiesel or other biofuels.

IV. Recommendations and Outlook

Biodiesel is environmentally friendly, renewable, easy to produce and is safer to use. While fossil oil fuel takes at least 40 million years to create, vegetable oil or animal fat can be produced in less than 3 months. While fossil fuel requires complex processing and gargantuan machineries to produce, biodiesel can be produced with simple equipment in less than one day. For each kilogram of biodiesel

Fig. 3. Dual Tank Biodiesel Processor

fuel produced, up to 3 kilogram of carbon dioxide are consumed during the biodiesel fuel life cycle ((Krawczyk, 1999). Thus, biodiesel recycles CO_2, and may consume more greenhouse gasses than it emits. In summary, biodiesel when compared to petroleum diesel has the following emission characteristics (Korbitz 1993): a) reduction of net CO_2 by 100%; b) reduction of sulfur dioxide (SO_2) emissions by 100%; c) soot emission reduction of 40-60%; d) carbon monoxide (CO) and hydrocarbons (HC) emission reduction of 10-50%; e) reduction of polycyclic aromatic hydrocarbons (PAHs) emissions of 13-97%; and f) reduction or increase of nitrous oxides (NOx) emissions by 5-10% depending on engine's age, design and tuning. Biodiesel tail pipe emissions is similar to gasoline emissions, except that the former has no sulfur dioxide, zero carbon dioxide net, 20 times less CO and more free oxygen, (fuel is already oxygenated). At the tailpipe, the emissions smells like barbecue or popcorn, and smoke opacity is just a third that of diesel fuel. Biodiesel is safer to use than gasoline, and based on its Material Safety Data Sheet (MSDS), biodiesel is identified as fatty acid alcohol esters, hazard boiling point at over 400°F, flash point at 321°F, treated as oil fire, and hazardous polymerization will not occur. With such attributes, massive biodiesel utilization is a key strategy and simple solution in facing environmental degradation and energy crisis.

Table I. ***Pilot Production and Demonstration of Biodiesel From Waste Cooking Oil***

A. Biodiesel Produced:
2985 gals
Aug '96 – May '97

B. 100% Biodiesel Vehicle:
36,000 miles plus
1996 Dodge Ram 2500
Sep '96 – Jun '97
Roundtrip Lapwai, ID to Nashville, TN
Bioenergy '96
Roundtrip Lapwai, ID – Orlando, FL
Eco-Informa '96

C. 50% Biodiesel Vehicle:
7,500 miles
1997 Chevrolet Suburban
Mar – Jun '97

D. Lewiston Parks & Recreation:
750 gals
Yanmar Mower/Snowblower, and Ford Tractor
Oct '96 – May '97

E. Heat Content:
9-11% lower than Diesel #2
39 megajoules/kg

F. Power:
9% lower than D2

G. Fuel Efficiency:
4% lower than D2
17.2 miles/gal

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Bob McClenachan, President and CEO, Energy Developments, Inc., Houston, TX

Background

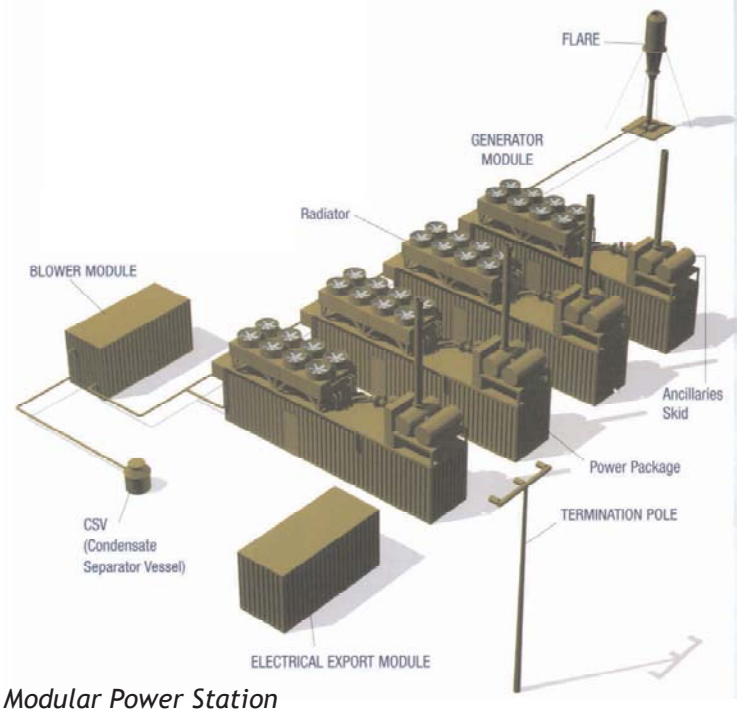
Energy Developments, Limited ("Energy Developments") commenced operation in 1988. Energy Developments has established itself as a market leader in independent power generation utilizing renewable fuels and is the world's leader in the generation of electricity from coal mine methane. Energy Developments owns and operates 32 power plants in the US, Australia, the United Kingdom, and Taiwan with a combined generating capacity of over 300 MW.

In 1998 Energy Developments's US subsidiary, Energy Developments, Inc. ("EDI") acquired the rights to develop energy generating facilities at 34 landfills. At present, EDI is operating and constructing landfill gas to energy projects exceeding 50 MW with several projects in advanced stages of development.

Energy Developments's operational sites include 30 landfill gas power plants with a combined capacity of 105 MW, and two coal seam methane power plants with a combined capacity of 97 MW.

Energy Developments is currently developing 36 landfill sites in the US with a potential generating capacity to exceed 100 MW. Fifty five MW will be on line by the end of 2001 and 55 MW of Long-term (10+ years) power purchase agreements are in place. EDI is also seeking to develop other renewables and coal seam methane projects.

Installed Power Plant



Modular Power Station

Energy Developments integrates all aspects of landfill gas power generation in a single project entity including the design construction, operation and maintenance of modular power stations and landfill gas collection systems. Energy Developments utilizes an innovative modular power station design and undertakes all aspects of design, fabrication, construction, commissioning, operations and maintenance (Series 2000 Modular Power Station).

EDI has extensive operations and maintenance capability with both power generation and landfill gas production plants. EDI's focus on operations and maintenance results in feedback to continually refine the product and maximize production. Power Plants are maintained by mobile, multi-skilled operators utilizing mobile workshops and all minor services and repairs can be done on site.

EDI's gas collection system features improved gas recovery and management, reduced operation and maintenance costs and lower capital cost. EDI's design innovations include a manifolded well collection system, water tolerant well design and landfill movement tolerate well/system design.

Using the Energy Developments Landfill Gas Management System will encourage better field management, improved field understanding, greater operator confidence, and enhanced collection of methane.

Environmental Policy

Stewardship of the environment is a core component of Energy Developments's business strategy. Energy Developments will constantly seek to achieve standards of environmental performance that exceed the expectations of regulators, customers and the community. Power Plants operated by Energy Developments are providing greenhouse gas emission reductions equivalent to approximately 6 million tons per year of carbon dioxide (CO2).

Typical Well Head Manifold

Conclusion

EDI is a fully-integrated developer and owner of environmentally beneficial "green" power projects and is currently developing several efficient and competitively priced landfill gas power projects in the US. EDI's proven track record as a developer, owner and operator of "green" power projects is consistent with CERT's philosophy.

Conservation/Energy Efficiency Session

***Larry Kinney*, Research Manager, E-Source, Boulder, CO**

In 1999, a group of educators from ACEEE and EPA set a goal to be accomplished by 2010. There goal was five fold:

- understand the link between energy use and the environment;
- understand that energy efficiency is a way to help the environment—with accompanying benefits of reduced use and cost, and increased human productivity;
- know specific actions they can freely choose;
- understand the consequences of their actions; and,
- associate energy efficiency with higher quality.

Energy is a measure of the quantity of heat, work, or light. Potential energy can be thought of in terms of a barrel of oil, a cord of wood. Kinetic energy is energy that a body or system has because of its motion. Flame is an example of kinetic energy.

Energy can be measured in many ways such as "Btus", "kWh" of electricity, "therms" of gas, or "tons" of coal. A British thermal unit (Btu) is the energy needed to raise a pound of water 1°F. A million Btus is roughly the energy equivalent of a person year of labor. A gallon of gas is the energy equivalent of about 2 person months of labor. Annual consumption of a standard residential house in Santa Fe is about 100 Mbtu.

An Mbtu's is also the amount of energy necessary to heat 100,000 pounds of water 10°F, and the amount of energy necessary to heat 500,000 pounds of aluminum 10°F. Mbtu is one billionth of a quadrillion (Quad), and a Quad is 106 x 109 = 1015 Btu!

Fuel	Unit	Btu/Unit	Cost/ Unit	Cost/ MBtu
Coal	Ton	28,000,000	$35	$1.25
Crude Oil	Barrel	6,300,000	$29	$4.60
Heating Oil	Gallon	140,000	$1.20	$8.57
Propane	Gallon	92,000	$1.43	$15.43
Gasoline	Gallon	125,000	$1.75	$14.00
Natural Gas	Therm	100,000	$0.71	$7.10
Electricity	kWh	3,412	$0.08	$23.44

Energy equivalents and costs for common fuel types in Santa Fe, 2001.

Snug houses are energy efficient because they are coupled to the earth-and decoupled from the earth around them. This means they are super insulated with cellulose or fiberglass, or both.

This house is located in Northern New York and cost $40,000 to build. Its annual heating bill is $100.

They are carefully air sealed with a continuous air-tight vapor barrier. Snug houses utilize pole barn construction techniques, so they are fast, easy, and inexpensive to build.

Deep earth temperatures in Albuquerque is around 52°F. Surface temperatures follow air temperatures. As depth increases, seasonal variations decrease and approach average annual air temperatures.

The construction of the foundation includes 6 x 6 poles on 8 foot centers with the concrete slab poured to top edge of closed-cell Styrofoam© (blue board™). Computer-designed trusses make for fast work and can handle large snow loads.

Snug houses have a continuous vapor barrier. This design solves moisture, radon and air-flow problems and minimizes convective losses. A vapor barrier can be installed between inner 2x4s and poles. This option allows for free installation of wiring, ventilation

ducts, and piping. Then R-11 batts are installed before dry wall. Tyvek™ on the outside helps, but the vapor barrier does the real work of limiting convective losses.

With no heat, this house doesn't get below 55°F when it's well below zero outside. Owner built for $25,000.

Windows in Snug houses are few and they are chosen for view and day-lighting. They are always high quality, double glazed with low-e coating or triple glazed. Exterior overhangs on south and west-facing facades prevent overheating. Thick walls leave room for plants and stereo speakers on window ledges

Small, airtight wood stoves heat 1100 square foot homes in cold climates and an interior brick wall provides useful thermal mass to modulate heat from stove.

Earth coupling in addition to a well insulated, tight envelope keeps a home warm in mid winter even without auxiliary heat. Temperature also builds up under home for several years after construction.

Earth coupling enhances summertime performance, too. In effect, Snug houses have all of the virtues of a cave without the shortcomings of living under ground.

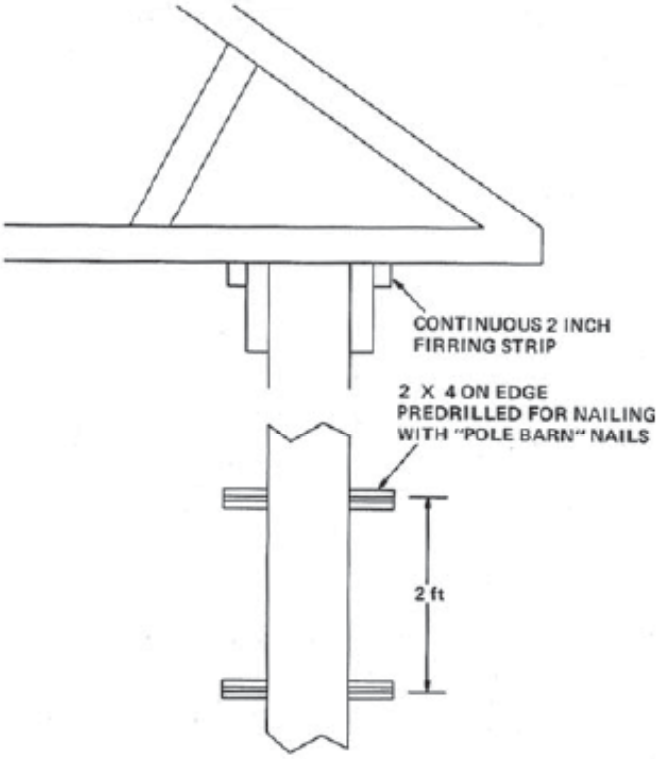
Passive solar may be added to an existing snug home/machine shop. Simple solar concentrating troughs yield 3.6 MBtu/hr using flat plate collectors that function well for most applications.

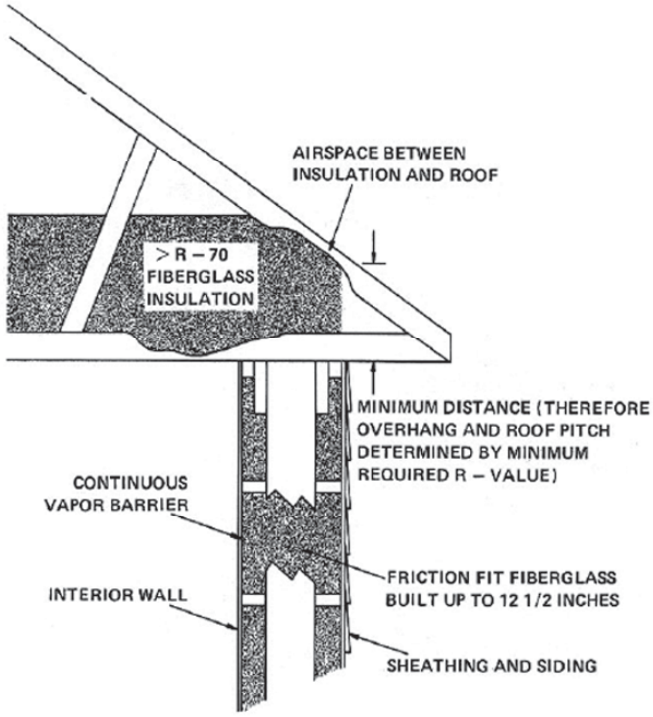
When it comes to ventilation there are two general choices. The first is a simple system with traditional bathroom and kitchen fans. This system operates adequately with low velocity, it uses passive inlets and combustion air supply (with damper) for a wood stove. The second choice is an elegant heat recovery ventilator. This can be controlled to come on when using bathrooms, cooking, when humidity is high, or manually with a wind-up timer this system also uses combustion air supply (with damper) for wood stoves.

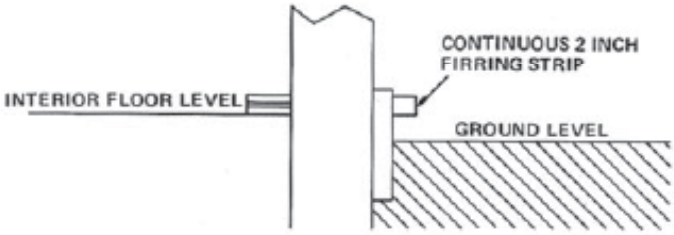
Radiant heating is a way of heating the home via pipes imbedded in floors, walls or ceiling panels. Often this technique solves awkward distribution problems and is consistent with overall simplicity of the house system. If the pipes are imbedded in the floor, modest insulation is required beneath, but it is still the least expensive option. Radiant heating provides excellent comfort and efficiency at relatively low supply water temperatures. Individual control of spaces are simple and inexpensive. Small gas-fired boiler or active solar can provide both space heat and domestic hot water.

District heating is another promising option for a group of homes in the same vicinity. Tribal community could use solar heating with efficient gas boilers for back up. Super insulated piping would be run to each dwelling, where heat exchangers would supply domestic hot water and space heating. Each house would have a simple energy metering. District heating would be more cost effective to build and run and it would create a true green community!

This house burns a cord of wood for the whole winter. (Paul Howell's home, the first "snug home" ever built.)







Section details: cellulose and fiberglass can be used in tandem to good effect.

Tribal Utility Formation Session

***Jeff Easton*, President, Lobo Energy, Inc., Albuquerque, NM**

The University of New Mexico has recognized for several years that its energy utility systems are in need of significant repair, improvement, and upgrade. Initial estimates clearly indicated that the cost of the upgrade projects far exceeded the capital available through traditional University funding sources. The University considered several traditional and creative means to resolve the energy systems issues and carefully analyzed each alternative.

In order to move forward with specific plans to address these energy utility systems issues, the University created Lobo Energy, Inc. and charged it with the responsibility of developing a business plan to identify and address the application of all available economic resources to satisfy the capital requirements for the necessary infrastructure projects.

The University's utility infrastructure can be upgraded and improved by implementing the technical solutions provided within this business plan. The result of the plan's implementation will be a renewed and expanded production capacity and additional distribution capability to relieve current constraints and to provide the ability to expand the campus to meet the 20-year Master Campus Development Plan.

The infrastructure upgrade projects will be partially funded, nearly two-thirds, from the energy savings created by implementing this business plan. The efficiency gains achieved by replacing the inefficient utility equipment, combined with the energy consumption reductions due to the implementation of the energy conservation projects, will provide operating income sufficient to service nearly two-thirds of the debt. The total capital project requirements will be approximately $52.7 million. The project bonds will have an average life of 14.3 years and will be retired as quickly as project cash flows allow. The resulting net present value of the 20-year net income stream will be approximately $7 million.

In addition to the obvious financial benefits discussed above, this plan provides the ability for the University to internally implement a very large capital project without being substantially dependent upon other outside sources for project funding. The University retains the ability to control risks associated with financial performance by controlling its own utility services and generating the necessary income to serve the debt. A further challenge, however, will be to retain and safeguard any excess energy savings in a utilities sinking fund that will provide for major maintenance and future capital renewal projects. These funds should be dedicated solely to utility infrastructure projects.

In summary, this business plan solves the physical and many of the financial challenges of reliably serving properly conditioned building environments for the University's primary mission of providing academic and research activities.

The infrastructure and energy conservation projects can begin as soon as the approval processes are completed and funding is available. This plan anticipates that the approval process can be completed prior to the end of the year 2000 with construction beginning early in the year 2001. It is anticipated that the energy conservation projects will be substantially complete within 3 years (2003). It further anticipates that the infrastructure projects will be substantially complete in 4 years (2004) and fully complete 1 year later (2005).

This plan assumes that the University will obtain the approvals and financing to allow the projects to proceed. Further, the plan assumes that the Utilities Division will eventually become the management center for energy procurement, production, processing, and distribution with the abilities to discharge the elements of this plan. The current University management policies and practices may need to be adjusted to this new paradigm where responsibility and authority are concentrated within an auxiliary enterprise. Lobo Energy will play a central role as the project manager with the responsibility to ensure the construction is conducted efficiently and effectively. Further, it will provide transitional management services to the Utilities Department to assist it in managing the sweeping changes associated with this utilities project.

The solutions to many of the University's utility system deficiencies are provided within this business plan. The technical challenges are addressed and the funding has been identified to solve them.

Green Credits/ WAPA Tribal Allocations

***Ken Maxey*, Senior Planning Advisor, Western Area Power Administration, Lakewood, CO**

Potential Green Tags Program

Western Area Power Administration (Western) has been working with renewable resource managers in the Department of Energy (DOE) to facilitate a different approach to bring new renewable resources to market, but has suspended issuance of an Request for Proposals (RFP) until clear direction is received from the new Administration.

Background

Former Secretary of Energy Bill Richardson directed the Department of Energy (DOE) to purchase 3 percent of its total electricity needs from non-hydro renewable energy sources by 2005, and 7.5 percent of its total electricity purchases from green power sources by 2010. Green power is electricity produced from renewable energy sources, such as solar, wind, geothermal, biomass and hydropower. President Clinton's Executive Order 13123, Greening the Government through Efficient Energy Management, directed "each agency shall strive to use electricity from clean, efficient and renewable energy sources." Western promotes the use of renewable resources throughout its 15-state service territory, consistent with its power marketing obligations to customers. Due to Western's extensive transmission system, ability to aggregate renewable resource acquisitions (at a lower cost than a more complex agency-by-agency approach), and not-for-profit character, Western initially was asked to facilitate the acquisition of renewable resource benefits on behalf of other Federal agencies in the Denver area.

Western responded by developing a program to meet the renewable resource requests of other Denver-area Federal agencies through a concept known as "green tags." Under this concept, renewable power is developed where the potential is the greatest, without regard for where the Federal load is located. Western would purchase the output of the renewable generation at a negotiated price, and the participating Federal agencies would pay Western's administrative costs plus the price difference between the renewable resource and the market price Western would pay for a similar, non-renewable, resource. The green tag resource provider would deliver the renewable resource energy to Western's transmission system, and the renewable energy will become part of Western's overall resource mix.

In return, the participating Federal facility would receive credit for the environmental benefits generated by reducing or displacing pollution from conventional power plants. The Federal facility would not physically receive the renewable power; it would make a payment solely to get more renewable power on the grid. In addition, the Federal facility would continue to pay for the power needed to meet its load from its current supplier without change.

Western would not fund, own, construct or operate renewable generation under this program. No adverse impact on Western's current customers will occur, as Western will be compensated for all services provided and costs incurred. Initial costs, such as preparing and issuing of an RFP, would be met through advanced funds from DOE.

Potential Issues

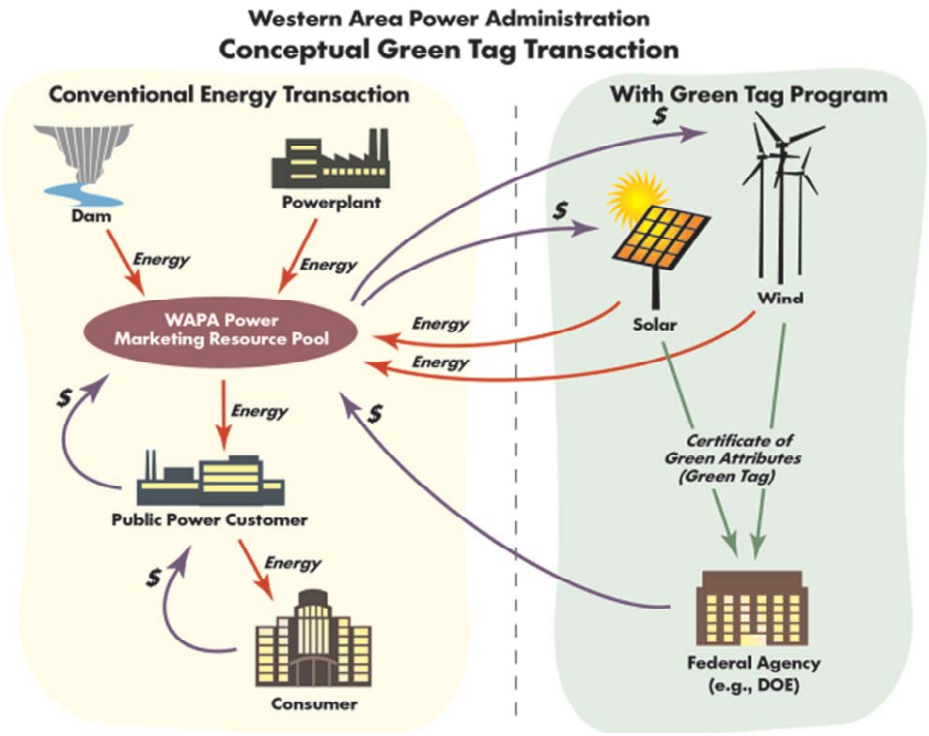
The siting of new generation and associated interconnections to the transmission grid can be difficult and controversial, even if the resource is renewable in nature. The best sites for development of renewables are not always the best sites from a marketing and transmission availability perspective. Due to the intermittent nature of many renewable resources (e.g., wind), the economic value of that resource to serve firm load can be an impediment to its marketability and usefulness. Unique issues with renewables also impact program economics. Federal agencies could be paying a premium to develop renewable energy above the current or long-term market price of conventionally generated power. Additional renewable power will not be received by the agencies; they will only receive recognition that they have helped create the environmental benefits of that energy.

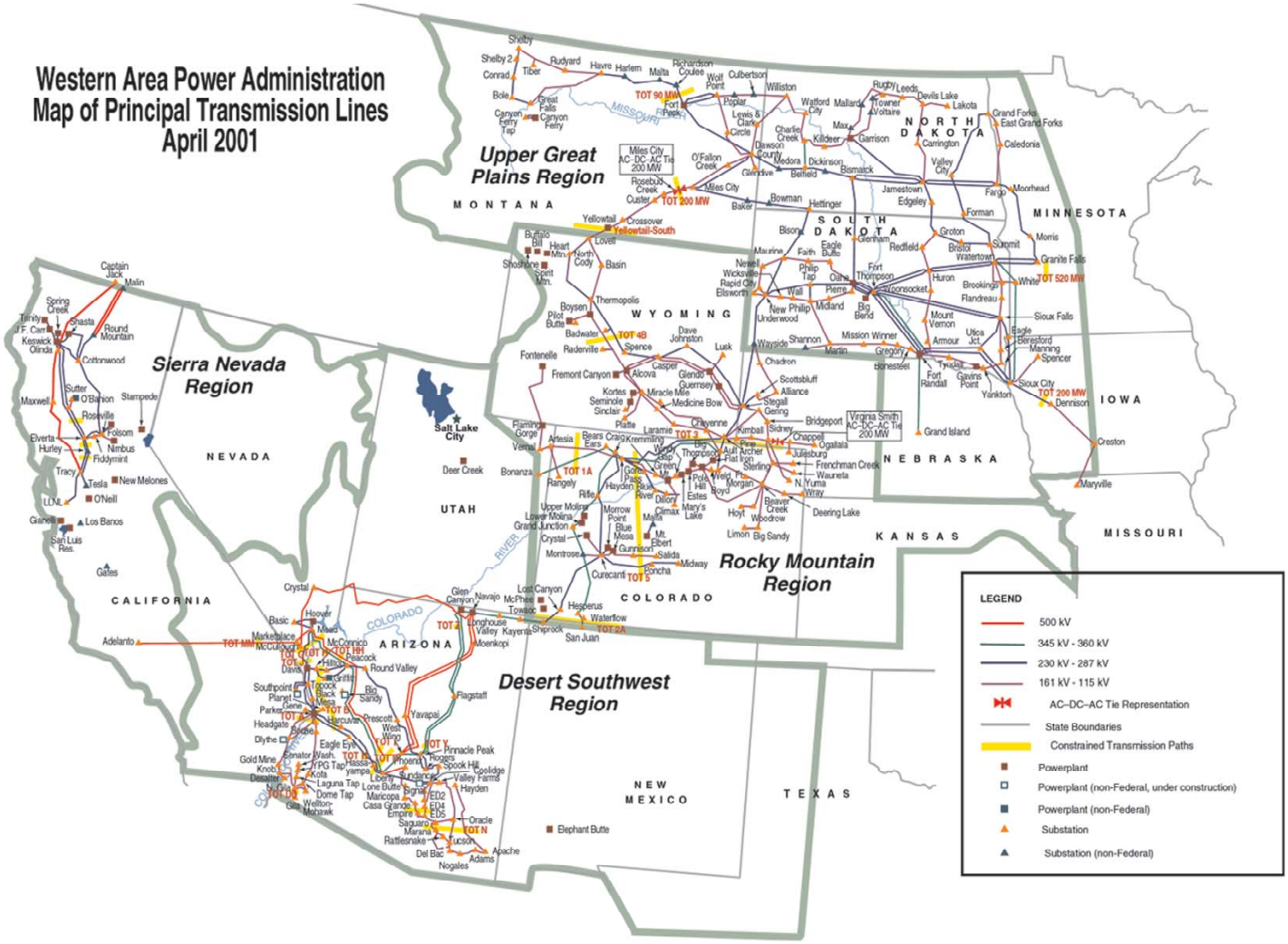
Status

As of this date, the new DOE political management has not provided clear direction as to whether,

and to what extent, this green tag program should be pursued, nor if it should be expanded beyond the original scope of Denver Federal agencies.

Western has developed, but suspended the issuance of, a draft RFP to request energy from new renewable resources. If DOE directs that the green tags program should continue, Western will coordinate the evaluation of the responses to any RFP and then select renewable resource developers. The exact schedule for the construction of renewables and their delivery to the electrical grid is unknown given the suspension of the RFP process as well as external factors such as the renewable energy tax credit due to expire at the end of this calendar year.





Appendices

A: Comments for DOE Office of Energy Efficiency and Renewable Energy
B: Conference Agenda
C: Speakers' Biographies
D: Conference Participant List
E: Vulnerability of Freshwater Resources to Climate Change in the Tropical Pacific Region -Meehl

Appendix A: Comments for DOE Office of Energy Efficiency and Renewable Energy

June, 29, 2001

Ms. Bonny Overton
U.S. Department of Energy
Office of Energy Efficiency
And Renewable Energy
1000 Independence Ave. S.W.
Washington, D.C. 20585

Re: Comments for Department of Energy Office of Energy Efficiency and Renewable Energy

Dear Ms. Overton:

The Council of Energy Resource Tribes appreciates the opportunity to comment on the DOE's Office of Energy Efficiency and Renewable Energy programmatic content and implementation of current programs and initiatives.

The Council of Energy Resource Tribes (CERT) is a tribal organization founded, directed, and controlled by a broad with membership of 46 federally recognized American Indian Tribes and four Canadian First Nations. The mission of CERT is to help Tribes develop sound management strategies in governing use of tribal energy resources that serve as the foundation for building stable, balanced self-governed economies.

The federal government has a trust responsibility to American Indian Tribes and Alaskan Natives. The Department of Energy as a federal agency is obligated to uphold its trust responsibilities, which include: promotion and protection of tribal treaty rights, federally recognized reserved rights, and other federally recognized interests of the beneficiary American Indian and Alaskan Native nations; determining, documenting, notifying, and interacting with tribal governments with regard to the impact of Departmental programs, policies, and regulations to protect American Indian and Alaska Native traditional and cultural life ways, natural resources, treaty and other federally recognized and reserved rights. CERT calls for the Department of Energy to uphold its federal trust responsibilities to Tribes and work with Tribes on a government-to-government basis as stated in the DOE's Tribal Governments Policy.

CERT Tribes have been working on energy issues since the organization was founded in 1975. In 1997 CERT hosted the first of several conferences and workshops to address the deregulation of the electricity market and tribal participation in the new energy market. One conclusion drawn at the conference was that no one Tribe or tribal organization could address all issues facing Tribes and energy development. CERT's tribal affiliates include: the Affiliated Tribes of the Northwest Indians (ATNI), the All Indian Pueblo Council (AIPC), the Intertribal Council of Arizona (ITCA), the Mni Sose Intertribal Water Rights Coalition, the Southern California Tribal Chairmen Association (SCTCA), and more recently, the Great Lakes Intertribal Council (GLITC), Midwest Alliance of Sovereign Tribes (MAST) and the Intertribal Council On Utility Policy (ICOUP) called the Intertribal Energy Network (ITEN).

In 1999, the nationwide ITEN crafted a consensus visions: "By the Year 2010 each self-governing Indian Tribe will have sufficient and reliable supply of electricity at reasonable costs to support

its social and economic well being." The ITEN has worked with each of their respective tribal councils to develop a strategy for reaching the Vision for 2010. The Vision includes:

- Increased power generation for local use that includes renewable energy generation and distributed generation.
- Energy efficiency and conservation programs on tribal lands,
- Full access to existing and new transmission systems, and
- Commercial generation and transmission projects that will bring economic development and give Tribes legitimacy as energy players.

A large component of the Tribal Vision includes developing the vast amount of potential renewable resources on tribal lands. Indian lands are grossly underserved by electricity services and tribal members have the highest percentage of homes without electricity compared to all segments of the American population. Each Tribe has a different approach for solving their energy needs, nevertheless all Tribes agree the energy conservation and efficiency is of vital importance for reaching their energy goals. Environmental protection of their homelands is of great significance to Tribes making developing renewable resources a priority.

The nation is calling for a diverse energy portfolio that includes a large contribution for renewable resources. Tribal lands are prime locations for wind, solar and geothermal renewable resources. Last week, June 19-20, 2001, CERT and ITEN hosted a Sustainable Energy Conference in Santa Fe, New Mexico. The meeting was attended by over 35 Tribes, predominantly located in the western US. The focus of the meeting was developing the world-class renewable energy resources found on tribal lands. Tribes are moving quickly on developing their renewable resources on their own terms. EERE policy and program goals lack provisions that will support tribal energy development. Although EERE is authorized to fund and support a diverse tribal program through Title 26 of the 1992 Energy Policy Act, the spirit of Title 26 has never been realized. Tribes have never received funding under Title 26 that would allow Tribes to develop renewable resources on tribal lands under tribal government authority.

In collaboration with DOE and the EERE program CERT requests the development of a comprehensive program that would support Tribes in the development their renewable resources. The Department of Energy has not only a trust responsibly, but a moral obligation, to assist Tribes in the development of their renewable resources.

CERT offers the following suggestions to DOE for continued excellence in the EERE program.

- Support the Tribal Energy Self-Sufficiency Act. Tribes must overcome many barriers to participate in the energy industry. TESSA would mitigate some of the policy, regulatory, financing, and infrastructure difficulties for Tribes when developing energy projects. TESSA also establishes an Office of Indian Policy and Programs within the DOE to create a comprehensive program to assist Tribes to meet their energy goals.
- Establish energy projects and specific grant and loan programs to support development of renewable energy resources as an integral part of an overall Indian Energy Program.
- Create a human resource development program for tribal technical staff and students. Tribal assumption of the responsibility to govern themselves and to develop their own resources will require increased number of tribal members with the skills and knowledge in science, engineering, business and governance in energy fields.
- Perform renewable energy and efficiency research and development projects on tribal lands. EERE should encourage partnerships between Tribes, National Laboratories and private research industry to use Tribes' abundant renewable resources.
- Fund more feasibility studies on Indian lands, including renewable energy feasibility studies both intermediate and large scale and home energy efficiency.

- Improve and advocate for infrastructure development and upgrades including transmission lines and interconnections.
- Develop and implement Tribal government policy strategy that includes: trust responsibility, government-to-government, outreach, notice, and consultation to ensure Tribes participation in decision making process, cultural resource protection, technical assistance, business and economic self-determination, education and training, and collaboration with other federal agencies.
- Establish a technical assistance hotline or webpage for tribal staff needing immediate answers to technical questions.
- Update EERE webpage to include information specific to Tribes.
- Implement more energy efficiency technology on all federal buildings located on tribal lands.
- Make available new energy efficiency technology to Tribes for tribal housing programs and tribal government buildings.
- Establish an Indian desk within EERE, staff with tribal members to advocate on the Tribes behalf.
- Re-structure federal weatherization program and low-income assistance programs to directly fund tribal governments.
- Develop and make available a National Tribal Lands/Renewables map for Tribes.

Sincerely,

A. David Lester
Executive Director

Appendix B: Conference

June 19, 2001

7:30 - 9:00 Registration
7:30 - 8:30 Continental Breakfast
8:30 - 9:00 General Session/Welcome
9:00 - 9:15 Break
9:15 - 9:45 National Tribal Energy and Policy Overview
9:45 - 10:15 Tribes and Renewable Energy Resources
10:15 - 10:30 Break
10:30 - 12:00 Funding and Financing Renewable Energy Projects and Financial Modeling
12:00 - 1:30 Luncheon Session: The Future of Renewable Energy and the Tribal Participation in the Market
1:30 - 2:30 Break Out Sessions:
Solar Energy Session
Wind Energy Session
2:30 - 2:45 Break
2:45 - 3:30 Break Out Sessions:
Geothermal Energy Session
Distributed Generation Session
Biomass Energy Session
3:45 - 4:00 Break
4:00 - 5:00 Break Out Sessions:
Conservation / Energy Efficiency
Tribal Utility Formation
5:30 - 6:30 Jemez Pueblo Reception:
Moveable Feast and Renewable Energy Exhibit
The Patio at Hotel Santa Fe 201 W. Marcy St.

June 20, 2001

7:30 - 9:00 Registration
7:30 - 8:30 am Continental Breakfast
8:30 - 9:30 General Session:
National Tribal Energy Vision
Inter-Tribal Energy Network
Western Area Power Administration Tribal Allocations
10:30 - 10:45 Break

End of Conference for Government and Industry Participants

This is an opportunity for Tribal leaders, planners, financial advisors, lawyers, consultants, and others invited by a participating Tribe to hold a strategy session in confidence.

10:45 - 11:00 "Tribes Only" Facilitated Sessions
Introduction, Alire Group
11:00 - 12:00 National Tribal Renewable Strategy Facilitation—Creating a Road Map
12:00 - 1:15 Luncheon Session:
Tribal Energy Funding and Grants
1:15 - 3:00 National Tribal Renewable Strategy Facilitation
3:00 - 3:15 Break
3:15 - 4:00 Closing Conversation
Sustainable Energy Solutions sponsored by:
Stirling Energy Systems

Conference Registration Fees

(Before June 6, 2001)
CERT Member $75
Non-Member Tribe $100
Inter-Tribal Organization $75
Indian Business $250
Government $250
Industry $500
Tabletop Exhibitor (Reception) $50

Hotel Information

The following hotels are recommended while attending the conference. Please refer to the "CERT Group" when making your reservation. The deadline for reservations is June 1, 2001. All requests after that date will be made on a space available basis.

Hotel Santa Fe
Rate: $139
Telephone: 1.800.825.9876
Fax: 1.505.984.2211
Email: hotelsf@newmexico.com

Complimentary shuttle service to and from convention center provided.
Camel Rock Suites
Rate: $89
Telephone: 1.877.989.3600
Fax: 1.505.989.1058

Council of Energy Resource Tribes
695 S. Colorado Blvd, Suite 10
Denver, CO 80246
ph.303.282.7576
info@CERTRedEarth.com

Appendix C: Speakers' Biographies

Ashley Brown
Harvard Electricity Policy Group
Harvard University JFK School of Government
Tribal Energy Funding and Grants

Ashley Brown is an attorney admitted to practice in Ohio, Massachusetts, and the District of Columbia. He is the Executive Director of the Harvard Electricity Policy Group at Harvard University's John F. Kennedy School of Government. It is a leading "think tank" on matters related to electricity restructuring, regulation, and market formation. He is an instructor in Harvard's Executive program on "Infrastructure in a Market Economy." He is Of Counsel to the law firm of LeBoeuf, Lamb, Greene and MacRae, 260 Franklin St., Boston, MA, 02110. Mr. Brown has also served as an arbitrator in matters relating to the evolution of competition in infrastructure industries.

Adam Capage
E-Source
Tribes and Renewable Energy Resources

Adam Capage directs the E-Source Green Energy Series while researching and writing about market strategies best suited for selling green energy to end users. Adam has been studying green energy markets for six years and has published numerous articles and papers about this rapidly growing market segment. Prior to joining E-Source, Adam was a project manager at the Colorado Governor's Office of Energy Conservation. His work there involved designing and staffing a governor's task force on renewable energy and a separate task force about redesigning the state's Low Income Energy Assistance Program. Adam has a BA in political science from the University of Colorado at Boulder and is currently working on an MA in public administration at the University of Colorado at Denver.

Soren Bo Cristensen
Vestas – American Wind Technology
Wind Session

Employed by Vestas-American Wind Technology since January 1998. Worked as project Coordinator on all projects in North America for one and one half year. He is currently the Assistant Manager of Sales & Marketing for the NAFTA region. He was educated at Copenhagen Business College, Denmark earning a Degree in International Marketing. He currently is on the Board of Members for Renewable Northwest Project, a coalition promoting renewable energy sources in the Pacific Northwest.

Rico O. Cruz, Ph.D
Nez Perce Tribe
Biomass Session

Rico Cruz has worked with the Nez Perce Tribe on environmental issues since 1994. Began work on renewables in 1980. Involved in biodiesel work since 1989. Projects include: Piloting and demonstration of coconut biodiesel (Philippines, 1994-present), and biodiesel from waste cooking oil (Nez Perce, 1996-97); Pioneered biodiesel production (Bulgaria, 2001). All degrees in Agricultural/Bioprocess Engineering: BS-Philippines; MS-England; & PhD - USA. Awards: World Leaders of Scientific Influence (2001); Outstanding HS Alumni in Science (2000); UNDP TOKTEN Award (1995); International Who's Who of Professionals (1999). Memberships: ASME, ASAE, ASES/ISES, ANS. Consultant on vegetable oil and bio-diesel processing in Philippines (1994-present), Uganda (1993, 1996), Russia (1999), Azerbaijan (1999), and Bulgaria (2001).

Doran Dalton
Hopi Foundation
Solar Session

Mr. Dalton presently serves in the dual capacities of Chairman of the Board of the Hopi Foundation and lead project manager for NativeSUN, the Hopi Solar Electric Enterprise. The Hopi Foundation is a community-based organization whose mission is to promote self-sufficiency, local self-determination, and proactive community participation among Hopi people while also enhancing and preserving the Hopi traditional way of life. Initiated in 1988, NativeSUN was the first project of the Hopi Foundation and was created to place modern solar photovoltaic technology within reach of most Hopi. Mr. Dalton's history with NativeSUN goes back to 1990. He has worked in virtually every aspect of the solar electric enterprise from

accounting to sales to the design and installation of customized systems on housing and businesses. In addition, he helped develop innovative financing and customer "layaway" programs. Most recently, he has spearheaded a solar-powered Hopi radio station (KUYI), and worked with outside experts to help move the NativeSUN business model to a level of sustainability that can be transferred to other tribes. His background includes pre-med and electrical engineering studies at Harvard University and the University of Arizona and work on the Hopi Reservation in health and human services, social work, and legal services.

Jeff Easton
LOBO Energy
Tribal Utility Formation Session

Mr. Easton is the President of Lobo Energy, a special-purpose non-profit corporation established by the University of New Mexico to address the University's failing energy and utility infrastructure. He has developed and is implementing a business plan to rebuild the campus district energy system by replacing aging equipment, adding heating and cooling capacity, solving energy distribution problems, and implementing energy conservation projects. He has experience in managing the development, business activities, operations, and maintenance of international and domestic independent power generation projects. He also has experience operating and maintaining Naval nuclear propulsion plants.

Roger Hill
Sandia National Laboratories
Wind Session
Geothermal Session

Mr. Hill is a Senior Member of Technical Staff of the Wind Energy Technology Department at Sandia National Laboratories and a recent member of the Renewable Energy Office (REO). In his current position, he is responsible for project development in both Wind and Geothermal technologies, with considerations of institutional, economic, and policy constraints. In the recent position with the REO, he was responsible for program development activities and provided renewable and distributed energy customers with a single point of contact. A significant element of this work has been focused on Native American energy projects. The REO built upon earlier work by the Photovoltaic Design Assistance Center that worked to accelerate the adoption of photovoltaic technology. Mr. Hill has a BSEE (Power Option) from Kansas State University and has worked for the Kansas Power and Light Co. in the design and construction of substations. At Westinghouse Hanford, he worked on both fusion and fission projects. At Sandia, he has been active in projects ranging from facility engineering to nuclear waste storage to renewable energy. He has written an article about PV in the Mechanical Engineering Magazine entitled Commercializing Photovoltaic Technology, published in August 1994.

Lyle Johnson
Western Area Power Administration
WAPA and Inter-Tribal Energy Network Roundtable

Lyle Johnson has been a Public Utilities Specialist in Western Area Power Administration's Colorado River Storage Project Management Office in Salt Lake City, Utah for 16 years. Prior to that he spent 5 years as an economist for the Bonneville Power Administration and 3 years for the Bureau of Land Management. For the last three years Lyle has been involved in the Post-2004 marketing program for the Salt Lake City Area Integrated Projects, the program that has made Federal electricity available to tribes in Arizona, Colorado, Nevada, New Mexico, Utah, and Wyoming.

Larry Kinney
E-Source
Conservation/Energy Efficiency Session

Larry Kinney is a Research Manager with the E SOURCE technology assessment group that analyzes energy efficiency and emerging energy technologies. With an academic background in physics and philosophy, Dr. Kinney has been active in energy-related R&D for almost 30 years. He has broad experience in weatherization program operations, energy-efficient housing, refrigeration, lighting and day lighting technologies, air handling and conditioning systems, and controls. Dr. Kinney also has a background in energy program evaluation, from instrumentation design and analysis to program policy research. Before joining E SOURCE, he was the President of the Synertech Systems Corporation, an energy systems RD&D firm

in Syracuse, New York. Prior for founding Synertech in 1983, he was a Senior Research Fellow with the Syracuse Research Corporation where he co-founded and directed the Corporation's Energy Research Center.

Marlene Roanhorse Lynch
NTUA
Funding and Financing Renewable Energy Projects and Financial Modeling

Marilyn Lynch is the Manager of the Finance & Administration Division for the Navajo Tribal Utility Authority in Fort Defiance, Arizona. She is responsible for profit planning, capital procurement, capital allocation, investments, and retirement trust fund management and oversees Accounting, Cash Management, Purchasing, Central Warehousing, Facilities Management, and Customer Accounts & Sales. She has also worked as Assistant Treasurer and Special Studies Analyst.

Marilyn currently serves as Treasurer of the Management Board, Navajo Tribal Utility Authority and is a voting delegate of the National Rural Utilities Cooperative Finance Corporation, Herndon, Virginia. She has a degree in Business Administration from Northern Arizona University and her MBA in Finance from Arizona State University. She is a member of the Association for Financial Professionals, the National Rural Economic Development Association, and the Native American Finance Officers Association.

Robert McClenachan
Energy Developments, Inc.
Biomass Session

Bob McClenachan joined Energy Developments, Inc. (EDI) as President and CEO in 1998 and is responsible for EDI's activities in the United States. Prior to joining EDI, McClenachan led global activities in the acquisition and development of power plant projects internationally for a major energy company. McClenachan's previous experience includes the formation and management of an independent power company on behalf of a publicly listed company that specializes in the utilization of biomass as a fuel, and was the President and CEO of a company that generates hydroelectric power.

McClenachan has more than 20 years of experience in the independent power industries. He holds a degree in environmental science and a master's degree in business administration.

Gerald Meehl
National Center for Atmospheric Research (NCAR)
The Future of Renewable Energy and the Tribal participation in the Market

Gerald Meehl received his Bachelor's (1974), Master's (1978), and Ph.D. (1987) degrees in climate dynamics from the University of Colorado, and is currently a Senior Scientist at the National Center for Atmospheric Research (NCAR) in Boulder, Colorado. Since 1973, he has worked at NCAR in various capacities, including participating in the Tropical Wind Energetics Reference Level Experiment (TWERLE) in Pago Pago, American Samoa, and Christchurch, New Zealand (1975-76), in the Monsoon Experiment (MONEX) in Bintulu, Sarawak, Malaysia, and Kathmandu, Nepal (1978-79), and in the Tropical Ocean Global Atmosphere (TOGA) Coupled Ocean Atmosphere Response Experiment (COARE) in Townsville, Australia; Kapingamarangi, Federated States of Micronesia (FSM); Pohnpei, FSM; and Republic of Nauru (1992-93). Since 1979, as a scientist in the Climate and Global Dynamics Division, he has studied the interactions between El Niño/Southern Oscillation (ENSO) and the Indian monsoon, analyzed the results from global coupled ocean-atmosphere general circulation models at NCAR, and examined the possible effects of increased carbon dioxide and sulfate aerosols on global climate. He is the author of more than 80 scientific papers in peer-reviewed journals, and has contributed chapters to several textbooks. He was a contributing author for the Intergovernmental Panel on Climate Change (IPCC) 1990 and 1992 assessments, was a lead author for the chapter on climate model projections of future climate change for the 1996 IPCC assessment, and is currently a coordinating lead author for the chapter on climate model projections of future climate change for the IPCC Third Assessment Report to be published in 2001. Among his current committee appointments, he is a member of the American Geophysical Union Committee on Global Environmental Change, the World Climate Research Programme CLIVAR Working Group on Coupled Models, and is chairman of the Coupled Model Intercomparison Project (CMIP).

David S. Melton
Diversified Systems
Solar Session

Mr. Melton is an enrolled member of the Pueblo of Laguna in New Mexico and is president of Diversified Systems Manufacturing, a renewable and distributive energy consulting firm, located in Albuquerque, NM. Mr. Melton learned his craft from 10 years at Laguna Industries, Inc. a tribally owned defense manufacturing concern, working in various disciplines as contracts manager, marketing manager, human resource manager and program manager. Created in October 1997 to assist the Pueblo of Laguna Tribe in its pursuit of diversification of business ventures into the renewable and energy efficiency industry, Diversified Systems Manufacturing (DSM) continues to so, in addition to assisting other Tribal entities. Mr. Melton has recently created a new business - Sacred Power Corporation- that partners him with an experienced renewable energy installation contractor. Mr. Melton received his B.A. in Economics from the University of New Mexico in 1986 and has over 30 hours of graduate study from UNM's School of Public Administration. Mr. Melton is the elected chairman of the Laguna Colony of Albuquerque, a Tribal communication support group for Laguna's in the metropolitan area. Mr. Melton has also been appointed to the Pueblo of Laguna Utility Authority Board representing his home village of Paguate. Mr. Melton was also elected vice-chair of the newly created Rebuild Central New Mexico, the local energy efficiency support organization sponsored by U.S. Department of Energy. In addition, Mr. Melton is a member of the NM Solar Industry Association, the NM Solar Energy Association, the Interagency Advanced Power Group, and Leadership Albuquerque Alumni Association.

David J. Slawson
Stirling Energy Systems, Inc.
Solar Session

David Slawson co-founded Stirling Energy Systems in February of 1996. He served as President of SES until he was elected Chairman of the Board and Chief Executive Officer in November of 2000. He has been responsible for securing essentially all of the financing for the Company since its inception, including the financing that allowed SES to acquire the proprietary solar concentrator technology originally developed and patented by McDonnell Douglas Corporation; and the exclusive North American manufacturing and marketing license on the Kockums Stirling solarized engine/generator set. He has also been successful in securing business for SES in a number of domestic and international markets. Prior to his affiliation with SES, Mr. Slawson was Chairman and CEO of Global Environmental Solutions Corporation, a broad-based technology, information and Service Company whose mission is identifying sustainable, clean energy solutions and the necessary financial resources to commercialize those technologies. In 1994, Mr. Slawson co-founded Sustainable Technologies, Inc. located in Maui, Hawaii, which developed bioconversion systems to convert biowaste into usable products.

Christopher J. Wentz
Energy Conservation and Management Division (ECMD)
Opening Session

Chris currently serves as Director of the Energy Conservation and Management Division (ECMD) of the State of New Mexico's Energy, Minerals and Natural Resources Department. ECMD is the division of New Mexico state government responsible for planning, implementing and managing energy efficiency projects and those dealing with renewable energy resources such as solar, wind, geothermal and biomass. Chris holds a Bachelor of Science degree in Biology from Southwest Missouri State University. He represents the State of New Mexico on various committees of the Western Interstate Energy Board (WIEB), Western Governors' Association (WGA), and Governors' Ethanol Coalition. Chris was selected for inclusion in the 1998-1999 (26th), 1999-2000 (27th), and 2000-2001 (28th) editions of Who's Who in the West and Who's Who in America.

Bruce M. Wiegmann
NASA Glenn Research Center
Distribute Generation Session

Mr. Wiegmann is currently a Systems Engineer for the Flywheel Energy Storage System (FESS) that is being developed at NASA's Glenn Research Center in Cleveland, Ohio. He has been in that capacity for the past three years. This energy stor-

age system is being developed to store electrical energy on the International Space Station (ISS) via a system comprised of counter-rotating flywheels. Storage of energy with flywheels has many benefits when compared to chemical batteries; some of these benefits are: longer life, less life cycle costs and a higher energy density. Before coming to the Glenn Research Center, Mr. Wiegmann held numerous positions at NASA's Marshall Space Flight Center (MSFC) in Huntsville, AL. These positions included: Test Engineer at the MSFC Transonic Wind Tunnel, Lunar & Mars mission support, Solid Rocket Motor Resident Office at Brigham City, UT, Technology Transfer Specialist, and served on numerous product development teams. While as a Technology Transfer Specialist, Mr. Wiegmann was successful in implementing many Space Act Agreements between the MSFC and various US firms. Before joining the NASA team, Mr. Wiegmann worked as a wire line field engineer for Dresser Atlas in the oil patches of southern Mississippi and Eastern Texas. He graduated with a Bachelor of Science degree in Mechanical Engineering from the West Virginia Institute of Technology (Montgomery, WV) in 1981.

Jim Witcher
New Mexico State University (NMSU)
Geothermal Session

Witcher has Bachelors and Masters degrees from New Mexico State University (NMSU). In 1978, Witcher joined the staff of the Arizona Bureau of Geology and Mineral Technology (now the Arizona Geological Survey). Witcher compiled and first authored the NOAA/DOE Geothermal Resources Map of Arizona (1982). Since 1986, Witcher has been a project manager at the Southwest Technology Development Institute (SWTDI) at NMSU. An important aspect of Witcher's work is to identify better exploration strategies and methods suitable for the region's geologic setting and resource base. Witcher provides assistance and advice to a growing New Mexico geothermal greenhouse industry that has expanded into largest acreage of geothermally heated greenhouses for any state in the nation. Witcher has conducted geothermal resources evaluations on White Mountain Apache lands in Arizona and Acoma Pueblo, Jemez Pueblo, Jicarilla Apache, and Zia Pueblo lands in New Mexico. Many of these investigations were done in conjuction with CERT (Council of Energy Resource Tribes). Witcher is a member of the GSA (Geological Society of America), AGU (American Geophysical Union), AGWSE (Association of Ground Water Scientists and Engineers), GRC (Geothermal Resources Council), IGA (International Geothermal Association), SEG (Society of Economic Geologists) and NMGS (New Mexico Geological Society). Witcher served on the Executive Committee of the NMGS from 1993 to 1998.

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Appendix E: Vulnerability of Freshwater Resources to Climate Change in the Tropical Pacific Region

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Abstract El Niño events and associated droughts adversely affect freshwater resources on islands in the tropical Pacific region. Particularly vulnerable are low-lying atolls because rainwater collection is the main freshwater source on such islands. During El Niño-related droughts, water can be drawn only from the limited freshwater lenses beneath the islands If drought conditions such as these intensify the depletion of freshwater resources could affect the habitability of atolls. Average climate change in the Pacific region from increased anthropogenic carbon dioxide in a global coupled climate model resembles present-day El Niño conditions as well as the decadal time-scale sea surface temperature and precipitation anomalies observed during the 1980s and early 1990s. These anomalies area consequence of greater warming of sea surface temperatures in the eastern equatorial Pacific than over the western Pacific warm pool with increased carbon dioxide in the climate model. Attendant increases in precipitation in the central equatorial Pacific are also accompanied by precipitation decreases in the northern and southern tropical Pacific (roughly 5 ˚N to 15 ˚N and 5˚ S to 1 5˚ 5), as well as in the Australasian and eastern Indian Ocean regions. Associated effects in the midlatitude North Pacific also resemble El Niño conditions and the decadal time-scale signals from the 1980s. Future possible increases of drought conditions in certain tropical Pacific regions, as indicated by the climate model results, could limit the sustainability of atoll populations in those regions, causing migration and increased urbanization, with all the attendant problems, on larger high islands with more stable water supplies.

Key words: Australasia, Pacific island nations, water resources, El Niño, drought

1. Introduction

Island countries with inhabited atolls are particularly vulnerable to precipitation fluctuations. In particular, droughts associated with El Niño events that typically occur every two to six years disrupt freshwater supplies. Such droughts involve the virtual absence of precipitation for periods of several months to a year in certain regions of the Pacific. If these drought conditions were to intensify, as suggested by some climate model results, there could be implications for habitability of certain islands in the future The purpose of this paper is (1) to draw attention to the vulnerability of freshwater resources on atolls to such precipitation deficits using the, example of Kapingamarangi Atoll; (2) to show, through the presentation of climate model results, that increased carbon dioxide in the model reduces precipitation over considerable areas of the tropical Pacific and Australasia similar to precipitation anomalies associated with present-day El Niño events; and (3) to suggest, using the example of Tau Island in American Samoa, that if habitability of an island is threatened by ecological perturbations (the impacts on Tau from tropical cyclones are used as an analog to the ecological perturbation of precipitation deficits and freshwater depletion on atolls), migrations to main or high islands could increase, thus further contributing to urbanization and associated economic and societal problems on those islands.

Fig. 1. Kapingamarangi Atoll; bridge at left connects the two inhabited islets in the atoll. Typical of Pacific atolls, the highest point above sea level is only several meters.

2. Potential Vulnerability of Kapingamarangi Atoll to Climate Change

Kapingamarangi Atoll lies just north of the equator near 1 54˚ E longitude. It is one of several inhabited atolls that are part of Pohnpei, one of the Federated States of Micronesia. Among the 20 or so small low-lying islets of Kapingamarangi, two are inhabited and connected by a causeway (Figure 1). The roughly 500 people who live on

Kapingamarangi depend on rainfall collected in cisterns (Figure 2) for their freshwater supply. During El Niño events, the region around Kapingamarangi typically experiences drought conditions. When water collected in the cisterns runs out (typically in about a month), the islanders must rely on water from shallow -wells (Figure 3)

Fig. 2. The main source of fresh water on Pacific atolls is rainwater collected in cisterns such as this one on Kapingamarangi.

that draw from the freshwater lens just beneath the surface (Rappa et al., 1995).

At the time the photograph in Figure 3 was taken; in February 1992, drought associated with the El Niño event of 1991- 1992 had resulted in islanders drawing somewhat brackish water from this well for several months. The islanders had to boil the water before using.

The islanders are usually able to subsist on the freshwater lens for a period of months, depending on the hydrology of the lens and the particular details of the islet geography. Yet, during the El Niño event of 19 ~ 8, severe drought conditions on Kapingamarangi resulted in a partial evacuation of islanders to the main high volcanic island of Ponape (now Pohnpei) (Stanley, 1985). These early ecological refugees not only added to the population of Pohnpei Island, but also required services and jobs, and played a part in further urbanization of the main town of Kolonia.

Of course, in 1 918, issues involved with urbanization were virtually nonexistent in the island Pacific due to sparse population and residents widely distributed on islands throughout the various island groups. However, after 1945, rapid population growth coupled with economic migrations from outer islands to main population centers accentuated the problems associated with urbanization (Rappa et al., 1995). If drought conditions become particularly widespread or persistent, the one small instance of islander migration from Kapingamarangi to a main island with a more stable water supply could be multiplied throughout the island Pacific, resulting in more severe problems associated with urbanization in existing population centers.

3. Pacific Region Climate Change Background

It has been noted that decadal time-scale climate fluctuations in the Pacific region have been characterized by a relatively greater warming of the surface waters of the central and eastern tropical Pacific Ocean compared to the western tropical Pacific during the 1980s and early 1990s (Nitta and Yamada, 1989; Graham, 1994; Nitta and Kachi, 1994; Trenberth and Hurrell, 1994; Meehl and Washington, in press). Climate model experiments have shown that these persistent warm ocean surface temperatures have probably contributed to observed global warming during this period (Graham, 1995; Kumar et al., 1994; Salinger et al., 1995). Those studies could not distinguish whether the warming trends were themselves a product of $C0_2$-related global warming, a manifestation of increased frequency of El Niño events in that region, or some other fluctuation of the climate system.

The balance between two processes, the super greenhouse effect (from increased atmospheric moisture - as SSTs warm, evaporation and deep convection increase and pump even more moisture higher in the troposphere and enhance the trapping of infrared radiation due to the greenhouse effect, thus the term "super greenhouse effect") and cloud albedo feedback (from increased clouds reflecting more solar radiation), has been shown to be important for sea surface temperature (SST) response in the warm tropical oceans (Meehl and Washington, 1995). The results of those studies, and the suggestions of other studies (Ramanathan and Collins, 1992), allude to the importance of cloud-albedo feedback for climate change in the pacific region. That is, as SSTs warm, a combination of dynamical and radiative feedbacks leads to increased deep convection and high albedo cirrus cloud anvils that reflect incoming solar radiation and inhibit future warming of SSTs. Thus, if there is a warming of the tropical Pacific Ocean surface, the western Pacific warm-pool SSTs might increase at a slower rate than the SSTs in the tropical eastern Pacific, where this effect is not as strong. If this hypothesis is correct, a mean or decadal

time-scale warming in the Pacific region would be manifested by a relaxation of the SST gradient across the Pacific, not unlike what occurs in a present-day El Niño event. And, like what is observed during El Niño events (Ropelewski and Halpert, 1987; Kiladis and van Loon, 1988), attendant precipitation anomalies would feature enhanced precipitation in the central equatorial Pacific with precipitation deficits to the north and south in the tropical Pacific and over Australasia.

Because of the vulnerability of freshwater resources on atolls such as Kapingamarangi (as noted above), such precipitation deficits could have adverse impacts on atoll populations.

4. Model, Methodology, and Limitations

To test this hypothesis, I analyzed results from an experiment with a global coupled ocean-atmosphere general circulation model (GCM) with increased atmospheric $C0_2$, and I attempted to gain insights into the recent observational results, with implications for freshwater resources, by studying model-simulated phenomena. The changes in mean climate due to increased $C0_2$ described here could also affect phenomena associated with El Niño-like variability in the model (Meehl et al., 1993).

A second-generation global coupled general circulation climate model (Meehl and Washington, 1995) developed at the National Center for Atmospheric Research was integrated for 75 years of atmospheric $C0_2$ increasing at a rate of 1% per year compounded. The last 20 years of this experiment are analyzed (near the time of $C0_2$ doubling at about year 70) and compared to a control integration with present-day amounts of $C0_2$.

The atmospheric model has an approximate horizontal resolution of 4.5˚ latitude and 7.5˚ longitude with nine vertical levels. The ocean and sea-ice components have 1˚ latitude-longitude resolution with 20 levels in the ocean. Sea ice includes a three-layer thermodynamic scheme along with dynamic sea ice. No flux adjustments are used at the air-sea interface in the coupled model (see discussion of flux adjustment in Meehl, 1995). Of particular relevance to this experiment is the inclusion of a simple cloud-albedo feedback parameterization and a mass flux convective scheme in the atmospheric model. The former parameterization accounts for the observed relationship between very warm SSTs, deep convection, and bright clouds (Ramanathan and Collins, 1992; Washington and Meehl, 1993). The latter represents the super greenhouse effect in the model (Ramanathan and Collins, 1992; Meehl and Washington, 1995).

Because of the uncertainty involved with some cloud processes, cloud feedbacks can be tuned to produce a wide variety of sensitivities (Senior and Mitchell, 1993). Even though the cloud effects in the present model are fairly simply accounted for, their inclusion compares favorably to a model with a more sophisticated feedback scheme for cloud optical properties (Boer, 1993), and also reasonably reproduces observed measures of cloud albedo feedback and the super greenhouse effect (Ramanathan and Collins, 1992; Meehl and Washington, 1995).

Fig. 3. When droughts occur, often associated with El Niño events, freshwater collected in cisterns is exhausted in about a month or two. Islanders then rely on water from shallow wells such as this one on Kapingamarangi that draw from a freshwater lens just beneath the surface.

A sensitivity experiment performed with this version of the coupled model, where the cloud-albedo feedback was strengthened, showed that (1) there was a large-scale response of the climate system combining radiative and dynamic feedbacks, and (2) the maximum values of tropical SSTs were a function of the strength of the cloud-albedo feedback as represented by the cloud-albedo feedback parameterization in the model (Meehl and Washington, 1995).

Thus, even though there are limitations and simplified parameterizations in the coupled model, important processes affecting the sensitivity of SSTs in the warm tropical oceans have been documented, compared favorably to observations, and

analyzed in a sensitivity experiment (Meehl and Washington, 1995).

5. Geographical Patterns of Climate Change

The SST anomalies in the tropical Pacific region, with increased $C0_2$ minus control, for the December-January-February (DJF) season (DJF is shown here because observational studies have focused on this season; other seasons in the model show similar results) show least warming (less than 2˚C) where mean SSTs are greatest in the model (Figure 4). These areas include the tropical Pacific near 20˚N in the region of the Intertropical Convergence Zone (1TCZ), in the South Pacific Convergence Zone (SPCZ) region southeast of Papua New Guinea in the tropical southwestern Pacific, and over Australasia and the eastern Indian Ocean (Meehl and Washington, in press). These are not only the regions of warmest SSTs and greatest mean rainfall in the Pacific region, but also where the cloud-albedo feedback effects are greatest in the model (Meehl and Washington, 1995). Meanwhile in the equatorial eastern Pacific, there is relatively greater warming of the ocean surface (2-4˚C). Therefore, the $C0_2$-related surface warming is not uniform at the ocean surface across the tropical Pacific (Meehl and Washington in press). There is a reduction of the meridional SST gradient not unlike what is seen during a present-day El Niño event (Meehl, 1987). This is not due to a first order change of frequency of El Niño-like events in the model since preliminary results from an analysis of El Niño frequency do not show significant changes between control and increased $C0_2$ experiments.

Observations from the Pacific region (Bottomly et al., 1990) show that such differential warming occurred during the 1980s. During this time period, when global temperatures also increased, the mean warming in the tropical western Pacific (about 0.15˚C) was roughly less than one half that in the tropical eastern Pacific (about 0.35˚C). This relatively greater warming of mean SSTs in the eastern tropical Pacific compared to the western tropical Pacific during the 1980s has been noted in other studies as well (Houghton et al., 1992; Kumar et al., 1994; Salinger et al., 1995). This could be interpreted as increased incidence of El Niño events in relation to the mean pre-1980 climate, but more likely represents an increase of the mean SSTs after 1980 (Houghton et al., 1992; Kumar et al., 1994; Salinger et al., 1995) such that warm and cold oscillations continue to occur in relation to the warmer post-1980 mean (Wang, 1995).

Precipitation anomalies from the coupled model, increased $C0_2$ minus control (Meehl and Washington, in press), show that precipitation increased in the central equatorial Pacific and decreased in the warm-water regime regions of the ITCZ (5˚N to 15˚N), SPCZ (5˚S to 15˚S), Australasia, and the eastern Indian Ocean (Figure 5a). These mean climate-change patterns in the coupled model due to increased $C0_2$ resemble those associated with present-day El Niño events in the tropical Pacific region (Figure 5b), as well as similar decadal time-scale changes observed during the 1980s (Kumar et al., 1994; Salinger et al., 1995).

Sea level pressure (SLP) anomaly patterns from the coupled model (Figure 6a) also show the El Niño-like feature seen in the observations of a deepened Aleutian low-pressure center in the north Pacific (van Loon and Madden, 1981; Meehl and Washington, in press), as well as the changes

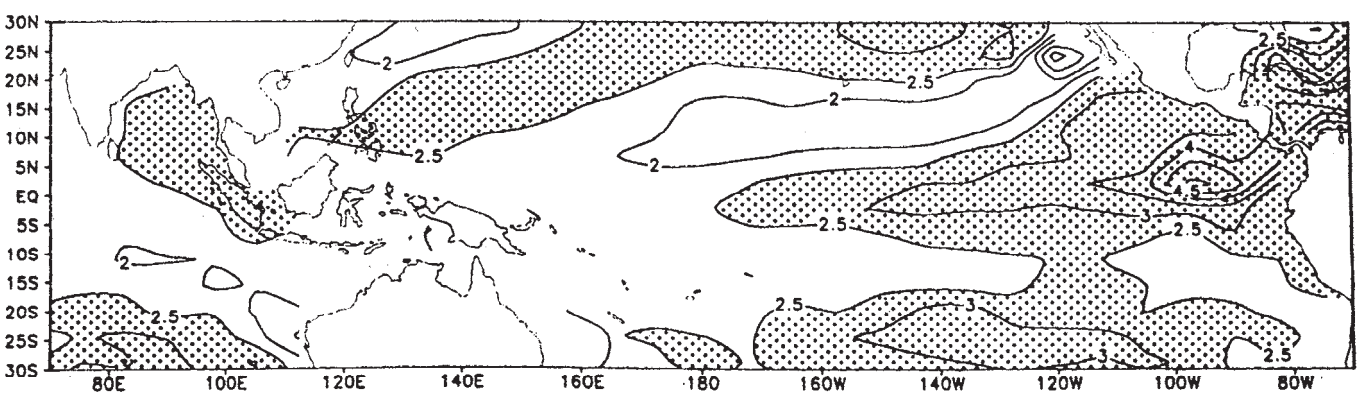

Fig. 4. SST differences (˚C), transient $C0_2$ increase experiment minus control, for DJF, the last 20 years of 75-year transient and control integrations with the coupled model (CO_2 has doubled in the atmosphere at about year 70 of the transient experiment).

in SLP in the model in the North Pacific due to increased $C0_2$ and those seen in the similar decadal time-scale SLP anomalies in that region (Trenberth and Hurrell, 1994; Nitta and Kachi, 1994; Trenberth, 1990; Chen et al., 1992) (Figure 6b). This similarity between the decade of the 1980s in the observations is associated with greater SST warming in the central and eastern Pacific compared to the western Pacific warm-pool region in both model and observations.

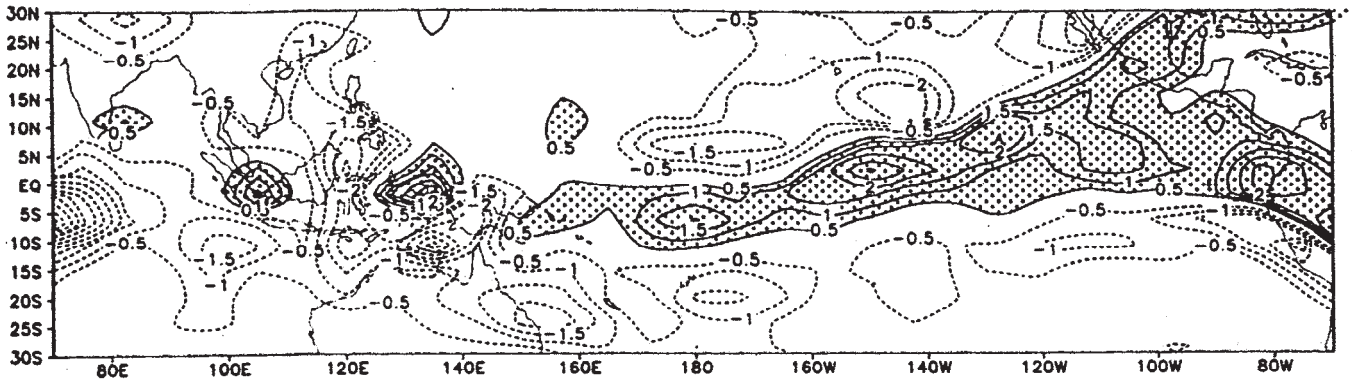

Fig. 5a. Precipitation differences (mm/day), transient CO_2 increase experiment control, for DJF, the last 20 years of 75-year transient and control integrations with the coupled model (CO_2 has doubled in the atmosphere at about year 70 of the transient experiment), areas of precipitation increase are gray-shaded.

6. Vulnerability

As noted for the example of Kapingamarangi, low-lying atolls in Pacific island countries are particularly vulnerable to precipitation fluctuations that result in persistent droughts. Islanders can adapt to such drought conditions for periods of months by subsisting on water from the freshwater lenses lying beneath the surface of the islets in the atoll. However, severe or prolonged drought conditions can deplete the freshwater lenses. In the Kapingamarangi example, a portion of the population was evacuated to Pohnpei during the 1918 El Niño event. That much larger high volcanic island had more stable water resources that were able to sustain the population.

Since World War II, there has been a general trend toward lower outer island populations as islanders migrate to urban centers on main islands (and in some cases to countries outside of the Pacific), mainly for economic reasons (Shankman 1993). This has resulted in increasing problems associated with urbanization, including crime, unemployment, and alcoholism (Stanley, 1985). There are also recent cases of migration due to ecological perturbations that could provide analogs to what some atoll populations may experience in the future. For example, on the island of Tau in American Samoa, a succession of three hurricanes in 1987 (Tusi), 1990 (Ofa), and 1991 (Val) caused

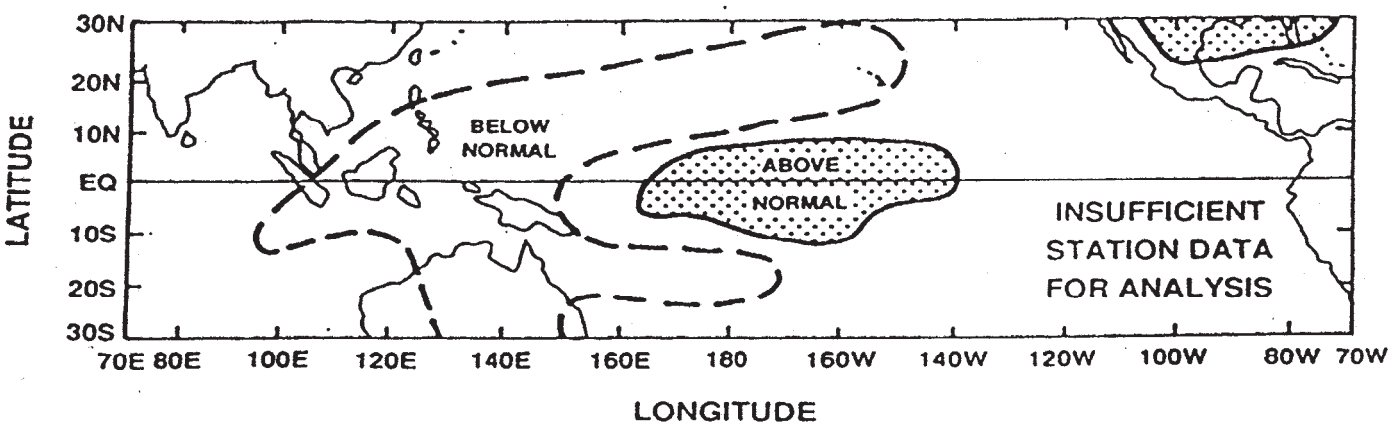

Fig. 5b. Schematic of composite areas in observed ENSO events where there is a consistent precipitation signal during northern winter based on station data (Ropelewski and Halpert, 1987). Stippled areas indicate precipitation increase.

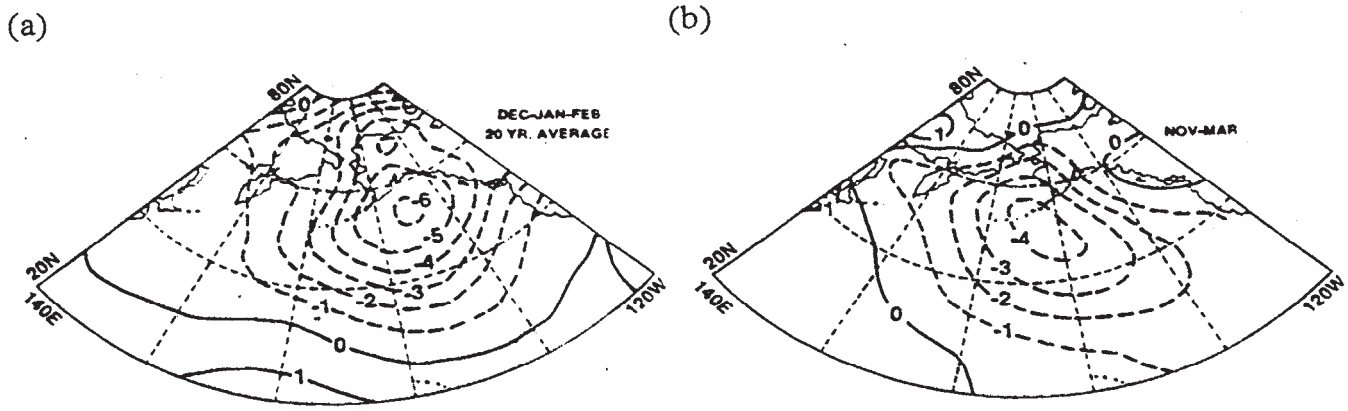

Fig. 6 (a). Sea level pressure (SLP) differences (mb) for the north Pacific region, transient CO_2 increase experiment minus control, for DJF, he last 20 years of 75-year transient and control integrations with the coupled model (CO_2 has doubled in the atmosphere at about year 70 of the transient experiment); (b) observed SLP differences (mb), 1977 to 1988 minus 1924 to 1976, for November to March season. Dashed contours indicate negative differences.

extensive damage to crops and property. Instead of rebuilding on Tau, an estimated one third of the residents of Tau village walked away from their ruined houses and migrated to the main island of Tutuila to live with relatives, and some left the islands entirely (Leui Malae interview 1995). Today, on Tau Island, numerous houses that were wrecked by the hurricanes stand abandoned (Figure 7); many of their owners now live in or near the urban center of Pago Pago on Tutuila. These migrations add to the problems associated with increasing urbanization in Pago Pago, such as lack of economic opportunity, the inability of services to support increase demand, and crime.

The consequences of migration of ecological refugees, in terms of increased urbanization in main island population centers, have yet to be fully studied. Anecdotal evidence, along with historical precedents such as Kapingamarangi, point to vulnerability of atoll populations, in particular, and to intensified drought conditions such as those suggested by the climate model results.

The chief concern of island governments with regard to climate change has been long-term sea level rise due to thermal expansion of the oceans in a future warmer climate (Rappa *et al.*, 1995). However, problems associated with freshwater resource deficits on atolls have not yet been adequately recognized. This vulnerability could result in problems with regard to atoll habitability sooner than long-term sea level rise. Additionally, freshwater lens depletion would be exacerbated by sea level rise since increased sea level drives the freshwater lens higher and thus results in a reduction of the potential water holding capacity of the atoll islets (Rappa *et al.*, 1995). Climate change effects on freshwater resources should be taken into account by island governments in terms of planning adaptation strategies for coping with the possibility of near-term (50 years) enhanced drought conditions.

7. Conclusions

The ecological refugees from Kapingamarangi Atoll during the drought associated with the -1918 El Niño event point to the vulnerability of atoll populations to possible future intensified and prolonged drought conditions in certain regions of the tropical Pacific. The climate model results presented here and elsewhere (Knutson and Manabe, 1995) suggest that a warmer climate in the tropical Pacific could be associated with greater warming of SSTs in the east than in the west, partly due to a combination of cloud-albedo feedback effects and attendant changes in surface energy balance and the large-scale circulation of atmosphere and ocean.

Because of the greater warming of SSTs in the eastern tropical Pacific compared to the western tropical Pacific in the model, the mean changes in Pacific region climate due to increased $C0_2$ resemble not only the climate anomalies associated with present-day El Niño events in many areas, but also the decadal time-scale climate anomalies observed during the 1980s. Recent observations of warming in the Pacific show that a mean warming of SSTs can occur with El Niño-like variability superimposed upon the warmer mean SSTs (Wang, 1995), as also occurs in the coupled climate model.

Though we cannot definitively attribute the recent warming in the Pacific (and associated global warming of the 1980s) to increased $C0_2$ in the atmosphere, the model results lead to the possibility that $C0_2$ climate change in the Pacific region could have this signature There may also be decadal time-scale variability that has elements of this signal as well. Further clarification of these effects awaits more definitive cloud-albedo feedback observational and modeling studies, improved cloud formulations, and a better understanding of observed decadal time-scale climate fluctuations in the Pacific region.

There is evidence that if such enhanced drought conditions occur over wide regions of the tropical Pacific, atoll populations may migrate in significant numbers to main high-island population centers with more stable freshwater resources. This migration of ecological refugees, as has already been noted from anecdotal evidence to be the case from recent tropical cyclone devastation, contributes to urbanization of high-island population centers, with the attendant problems of increasing population density and diminishing economic ability to support such populations.

Island countries have not yet acknowledged the problems that could occur from climate change-related stress on freshwater resources, particularly on atolls, since the majority of attention in the Pacific has been focused on possible sea level rise associated with future climate change. However, climate model results indicate that significant alterations of precipitation patterns over the tropical Pacific could begin affecting atoll populations over the next 50 years.

An essential next step would be to conduct surveys of freshwater lenses on atolls to assess the freshwater storage in these emergency water supply resources. This would help quantify the vulnerability of atoll populations to possible future increases in strength or duration of droughts.

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Fig. 7. Ruined house in Tau village, Tau Island, American Samoa in April 1995.

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