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Executive Summary

The Quinault Indian Nation initiated this study of and planning for conservation and production of energy from renewable resources because this approach created the opportunity:

- To become self-sufficient and gain greater control over the energy the Nation uses;
- To generate good jobs and businesses for its members;
- To better manage, sustain, and protect its resources;
- To express the cultural values of the Nation in an important new area of endeavor.

This plan and its supporting studies affirm these opportunities and define a way to act on them.

The Quinault Indian Nation has relatively small energy needs. These needs are concentrated at two widely separate points: the Quinault Beach Resort and Casino (QBRC) and Taholah on the Quinault Indian Reservation (QIR). Except for the town of Queets, energy needs are small and scattered. Moreover, the needs vary greatly over the season. The small scale, widely dispersed, and variable nature of these needs sets up a unique challenge to the Nation. Meeting these needs requires a resource and technology which is flexible, effective on a small scale, and portable.

Conservation is the most cost-effective way to meet any need, but it is especially effective in a situation like this where production would leave a very high per unit cost. This plan is based on first gaining energy savings through conservation. Major savings are possible through three steps:

1. Upgrading home appliances on the QIR.
2. Weatherizing all homes and facilities.
3. Changes in lighting and ventilation in the pool room at the QBRC.

These elements of the plan are already being implemented. They promise to save the Nation around a quarter of its present costs.

Wood biomass is the best resource available to the QIN for the production of energy for either on-site use or commercial development. It is abundant. As a resource, it is flexible and portable. Its harvesting has relatively high job potential and the possible jobs are a good fit for the present “skill set” of the QIN. This plan focuses on using wood biomass to produce energy and other value-added products.

Our study considered various technologies and approaches to using wood for energy. We considered production for both on-site and commercial production. In the end, this plan calls for commercial-scale production only, with the QIN being the first “customer” for the product. This plan favors employing the pyrolysis technology to produce bio-oil, heat, and char.

We favor this approach and technology because it is the most cost effective way to use the presently available resource. Its main product, bio-oil has proven utility for the production of heat and electricity. It has promise for use as an alternative fuel, which is a much higher value than present uses of wood. Additionally, it meets the QIN need for flexibility, scalability, and portability. Char, the secondary product from the pyrolysis process, has proven value-added uses.

In addition to these direct benefits, the use of wood biomass in pyrolysis technology has significant indirect benefits. These benefits include the fact that the technology is a very good fit with the Nation's cultural values, particularly those related to environmental protection and the holistic use of a resource. It fits well with current QIN enterprises. For example, char could be processed into a charcoal co-product for QIN fish. Finally, the QIN could become a leader in developing and demonstrating this innovative approach to the use of wood.

Leadership and organization is the key to fully realizing the possible benefits for the Nation. This plan proposes key organization steps to insure both excellent implementation of the plan and taking the best advantage of the processes and facilities put in place.

This plan calls for two new QIN organizations: an energy production and distribution corporation and a community development corporation. The production and distribution corporation could be either a utility or a business enterprise. Its purpose is to develop and market renewable energy. The community development corporation would be a not-for-profit. Its purpose is to support the QIN in taking best advantage of its energy opportunities. The production and distribution corporation is the subject of a further business planning effort now underway.

This plan envisions a community development corporation which works directly with the Business Committee on research, education, and project development. Specifically, this corporation would seek grant funding to:

- Research energy matters such as the BPA direct sale of energy proposal;
- Identify key business opportunities like charcoal production and train QIN members in business building;
- Establish a renewable energy education program and center to enhance the education of QIN youth and market to schools and community colleges in Western Washington.

Overall, this final report includes the final Renewable Energy Plan for the QIN, the final Financial Analysis, and several appendices. The two final plans are the culmination of research and planning represented by the appendices.

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Main Report

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QUINAULT INDIAN NATION RENEWABLE ENERGY PLAN

The Quinault Indian Nation (QIN) has undertaken several studies of its potential to produce renewable energy. These studies have pursued three basic goals established by the Business Committee, the governing body of the Nation. They are:

- To achieve energy self-sufficiency.
- To generate new employment and business opportunities for the Nation and its members.
- To create an energy system consistent with environmental sustainability and the cultural values of the Quinault Nation.

The purpose of this plan is to provide a road map for achieving these goals.

The Quinault Indian Reservation (QIR) is located on the central coast of Washington State. It incorporates the towns of Taholah, the seat of the Nation, and Queets. The population of the reservation is concentrated in these towns. However, there is significant development and activities on its borders and along Highway 101 which transverses the Northern area of the QIR. A great part of the reservation is undeveloped. Much of the reservation has been logged in an abusive fashion; it is now closely managed by the Nation. The Nation is presently engaged in a massive re-acquisition and restoration of its historic lands.

Beyond the borders of the Quinault Indian Reservation, the Nation holds scattered trust lands. These trust lands include significant holdings on the beach between Ocean City and Ocean Shores. A casino and hotel have been developed on one of these parcels.

The energy needs of the Nation are modest. The reservation itself uses an average of approximately 24 megawatts per day. Use at the Casino/Hotel is about 15 megawatts per day. The resources necessary to support QIR needs are available to the QIN in the form of wood biomass. On the other hand, entry-level commercial production would require resources sufficient to produce five megawatts or more continually. These are not available to the QIN.

This plan has five sections: *the overall discussion of the Basic Goals, Goals and Objectives for the Development of Renewable Energy, Working Assumptions, Strategy, Implementation Schedule,* and *Action Steps*.

This Renewable Energy Plan is based on the finding and conclusions of the Scoping Study, the QIN Public Buildings Energy Use Assessment, the QIN Casino Energy Use Assessment and Conservation Action Plan, Biomass Options for the QIN, the QIN Energy Plan Environmental Assessment, and the Financial Analysis. They are attached as appendices A, B, C, D, E, and F. This plan incorporates these studies as its supporting documentation.

I. BASIC GOALS

The Quinault Indian Nation established self-sufficiency as a goal for three reasons. First, the Quinault Indian Reservation has a substantial problem with interruption of service. Producing renewable energy is seen as a way to overcome frequent power outages and slow recovery due to the remote and wild nature of the reservation. Second, renewable energy is seen as an environmental goal important to the Nation. Finally, the production of renewable energy is seen as an economical way to use the Nation's resources, saving money and providing work.

At the Casino, the idea of getting off the grid is not an object. However, environmental gains and cost savings remain important. In short, self-sufficiency means somewhat different things at the two places, allowing for different approaches to realizing the goal.

On the Quinault Indian Reservation, the Nation's goal demands an approach that minimizes the transmission of energy and maximizes reliable and consistent production. At the Casino, the goal can be satisfied by trading renewable energy produced elsewhere for the energy used to operate the Nation's facilities.

The goal for commercial development is open-ended. It is governed not by specific outcomes as it is the desire to best use the available resources of the Nation to advance the economic well-being of its members.

The Nation faces significant challenges in working to achieve either goal. In gaining self-sufficiency, the Nation must find a resource and technology which is flexible, scalable to a small need, and readily available as well as cost effective. Obtaining and processing the resource and the technology required to do so must be user friendly. Because the need is so small, cost-effectiveness demands that capitalization and operations are relatively inexpensive.

In developing energy for the commercial market, the Nation must find a resource and technology that can generate an output large enough to be viable in the marketplace and to produce enough income to sufficiently benefit the Nation in order to justify its interest. This puts great emphasis on cost effectiveness, which in turn creates the demand to maximize the value-added to the resource. Simply, the challenge is finding the right technology for the largest resource.

Unlike the first two goals, the third goal does not address what the Nation should do. Rather, it addresses how the Nation should do it. It requires that whatever is done to attain self-sufficiency and economic gain will meet high standards. Resources must be conserved. The environment must be protected. The culture must be manifest in the actions.

For both the first two goals, selecting technology and resources that lead to protecting if not enhancing the environment is required.

II. Goals and Objectives

A. Implement intensive energy conservation on the QIR:

1. Implement the model refrigerator replacement program at Taholah, replacing at least twenty refrigerators.
2. Monitor model project and document results.
3. Adjust and institutionalize the refrigerator replacement program.
4. Plan and create a weatherization program for all structures on the QIR; gain QIN Business Committee approval.
5. Adopt LEED building standards as modified for rural communities for the QIN/QIR and incorporate them into the building code for the QIR.

6. Implement model QIR-wide Weatherization Program, weatherizing twenty structures.
7. Monitor model project and document results.
8. Adjust and institutionalize QIR-wide weatherization program.

B. Implement intensive energy conservation at the Quinault Beach Resort & Casino (QBRC):

1. Continue to define the conservation priorities for the QBRC.
2. Continue with HVAC system renovation and efficiency improvements.
3. Initiate employee participation in simple conservation practices.
4. Direct Resort administrators to present a timeline and feasibility assessment for low-cost measures.
5. Pursue all feasible low-cost conservation measures.
6. Investigate and prioritize cost-effectiveness of moderate higher cost conservation actions.
7. Create schedule for implementing moderate and higher cost conservation measures. Contact energy auditors and local providers.
8. Implement moderate and higher cost conservation measures.
9. Incorporate QBRC conservation plan with the QIR conservation plan. Promote the conservation model.

C. To define and codify an appropriate organizational structure for QIN renewable energy programming and development:

1. Evaluate impact of the QIN on forming a utility to purchase energy from the BPA.
2. Create an organizational plan (or plans) based on the BPA decision for QIN renewable energy development and programming.
3. Review the plan or plans with the QIN Business Committee and adopt appropriate structures for renewable energy promotion, development, and education.
4. Organize and enfranchise a QIR renewable energy development/service enterprise.
5. Build services/projects providing ten jobs.
6. Organize and enfranchise a QIN Community Development Corporation to develop and implement renewable energy promotional and educational programs, training, monitoring, and evaluation services.
7. Organize and build a QIN Renewable Energy Center for education and tourist activities.
8. Provide five jobs in education and promotion.
9. Provide three jobs in energy utility management.

D. To develop and operate small-scale energy/heat production facilities to address QIR needs:

1. Identify and evaluate “best technologies” for on-site small-scale, wood, wind, and/or solar combinations to heat/electricity production.
2. Support and participate in an on-site demonstration of the conversion of a combination of such resources to heat/electricity.
3. Monitor and evaluate demonstration, generate business plan for development.
4. If and when appropriate, develop small-scale conversion facilities for QIR, providing heat and electricity to at least three buildings in Taholah and Queets.
5. Institutionalize the conversion facilities for ongoing energy operations.

E. To develop with a suitable partner a commercial wood biomass conversion project:

1. Pursue the development of a partnership with a commercial entity that commands significant wood resources and has a need for electricity and/or heat; for example, the Crane Creek Mill.
2. Identify and evaluate "best technology" for a five to ten megawatt wood biomass facility to produce heat, electricity, bio-oil, and/or charcoal.
3. If appropriate, develop and fund an on-site demonstration of commercial value-added production from wood biomass.
4. Generate business plans for development.
5. Develop commercial wood biomass conversion facilities at appropriate site on or near the QIR, producing commercially marketable value-added products.
6. Organize and/or institutionalize the commercial wood biomass conversion facilities for ongoing energy/value-added products production operations.

F. To develop a QIN renewable energy research, education, and promotion program:

1. Identify and evaluate aspects of the QIN renewable energy development program which could be incorporated into QIN education and promotional efforts targeted to tourism.
2. Assess QIN needs for training, monitoring, and evaluation with respect to renewable energy.
3. Evaluate Tsalal site for QIN Renewable Energy Center, focusing on a location near Olympic National Park; approach the National Park on a potential partnership.
4. Develop and implement a pilot educational/promotional program targeted to tourists. Evaluate results.
5. Generate a program/development plan for a Renewable Energy Center to anchor renewable energy promotion, education, and research programming.
6. Implement full renewable energy program.

G. To develop high-quality jobs and business opportunities for members of the QIN.

1. Insure all project and development plans consider job and business opportunities.
2. Develop a proposal for a renewable energy job center. Seek foundation funding.
3. Create fifteen jobs or business opportunities in the area of resource harvesting and basic processing of materials used for renewable energy.
4. The QIR-based contracts to leverage outside work or contract opportunities.
5. Generate ten jobs in the area of energy production and management.
6. Generate five jobs in the area of energy services and education.

3. Working Assumptions

A. The QIN will require significant grant support to initiate and implement major parts of this plan.
B. The QIN cannot count on long-term subsidization of renewable energy activities by outside sources. Renewable energy projects and activities implemented under this plan must become self-supporting.
C. The major energy decision the QIN will make is whether or not it will form a utility and purchase electricity from the BPA.
D. Conservation measures can and should be implemented as soon as possible, as they are not significantly affected by the BPA decision.

E. Specific decisions regarding the implementation of other elements this plan should be made in light of a clear decision with respect to the BPA purchase.
F. If the QIN decides to form an electrical utility, part of its mission should be to support the development of renewable energy. A substantial part of the proceeds obtained through the utility should be devoted to renewable energy development.
G. Proceeds obtained through renewable energy development and activities should be reinvested in those activities, particularly to create jobs.
H. This plan and its implementation will be regularly evaluated by the QIN in order to insure that renewable energy activities and development serve to fully meet the aspirations and overall goals of the QIN.
I. The QIN Business Committee establishes a permanent renewable energy working group.

4. STRATEGY

Our strategy is based on three principles of action:

- Build on existing strengths and resources.
- Do the simplest and easiest thing first; take the easiest and simplest approach always.
- Generate economies from synergy rather than economies of scale.

Our strategy is to begin with conservation. We have ranked conservation measures for the QBRC and the QIR by cost effectiveness and simplicity. We have proceeded to implementation, starting at the top of our QIR list and working through it. Next, we will initiate conservation efforts at the Resort and Casino. We expect these measures to generate significant energy and cost savings for the QIN.

The next step is to create the foundation for the QIN's energy future. This step involves, first, determining the relationships between the QIN and regional energy producers and distributors, particularly the BPA. Once these relationships are determined, the QIN will develop the organizational structure that best frames these relationships to serve its needs. This organizational structure will include a mechanism through which the Business Committee can maintain control and accountability and a non-profit corporation to conduct education programs and incubate business opportunities. It may include formation of a QIN energy utility. It may include formation of QIN business enterprises and/or the promotion of enterprises including the QIN or members of the Nation as partners.

As the organizational stage is being carried out, the QIN will be actively involved in business planning, demonstration projects, and field research. This activity will be specifically targeted to advancing QIN renewable energy projects. As this process moves forward, options for action will be constantly evaluated for cost-effectiveness and simplicity.

The enterprise options will be developed according to an established model. The model is:

- Identify an energy resource and define its use/sustainability ratio.
- Evaluate the resource and available technology to determine a system for its use which eliminates waste and generates products adding the greatest value to the resource.
- Evaluate markets and financial and human resources to determine best practical approach to creating a holistic production system.

- Evaluate public and private support to maximize grants and favorable loan packages to help develop that system.
- If necessary, create partnerships to effectively implement project development.
- Co-locate the project's site so the benefits and further development possibilities can be maximized.

As projects are developed according to this model, programs to maximize the job/business opportunities from these projects for members of the QIN will be implemented.

5. Implementation Schedule

Objective	Time From-To	Major Tasks	Outcomes
A. Implement Intensive Energy Conservation on the QIR			
1. Refrigerators	Completed	– Organize Refrigerator Program – Obtain Grant – Place Refrigerators in Homes	– Twenty refrigerators placed on QIR – Demonstrated Program Activities
2. Monitor	Continuing	– Obtain and Install Devices – Read and Report Results	– Completed first report to QIN and BPA
3. Institutionalize Program	Completed	– Place Program on Ongoing Basis	– Refrigerator program now a regular program of QIN
4. Weatherization Program	01/07 – 01/08	– Scoping Study – Program Plan – QIN Program Review	– An approved program plan for grant proposals and implementation
5. Local Standards	01/07 – 01/08	– Review local standards for rural communities – Scoping study, QIN Implications – Proposed amendments for QIR regulations	– Approved building standards insuring maximum feasible environmental protection and benefit
6. Implement Weatherization	01/08 – 12/08	– Organize pilot weatherization – Obtain grant – Initiate weatherizing activities in twenty structures	– Twenty structures weatherized – Demonstrated program activities
7. Monitor Projects		– Evaluate project – Determine benefits – Report results	– Report and document results
8. Institutionalize program	1/09 – ongoing	– Place program on ongoing basis – Make appropriate changes	– An established program – Significant energy and cost savings

Objective	Time From-To	Major Tasks	Outcomes
B. IMPLEMENT INTENSIVE ENERGY CONSERVATION AT THE RESORT CASINO			
1. Define Conservation Priorities	06/06 – 12/06	– Expand present conservation plan as necessary with new priorities for conservation	– Complete conservation action plan for QBRC
2. Continue HVAC Improvements.		– Continue HVAC renovation and improvements – Assess efficiency of system	– Fully operating HVAC system – Known efficiency of operating system
3. Initiate Employee Participation		– Educate employees on conservation in public areas (dimming lights, etc)	– Better employee practices in saving energy
4. Present Timeline and Assessment		– Define priority low-cost measures – Create a timeline and assessment of low-cost measures	– A well-known action plan for low-cost conservation improvements
5. Pursue Low-Cost Measures.		– Complete low-cost conservation measures	– Low-cost conservation measures complete
6. Investigate Cost-Effectiveness of Moderate to High Actions		– Assess QBRC's priorities for moderate to high cost actions	– List of moderate to high cost actions, prioritized by feasibility and interest
7. Schedule for Moderate to High Cost Measures		– Create timeline for implementing chosen actions – Contact energy auditors – Contact local service providers	– Comprehensive plan for moderate to high cost conservation actions
8. Implement Moderate to High Cost Measures.		– Implement above list	– Conservation measures in place and operating
9. Incorporate QBRC & QIR Conservation Plans		– Create Nationwide conservation plan – Create Nationwide conservation model	– Comprehensive energy conservation plan to companion renewable energy plan

Objective	Time From-To	Major Tasks	Outcomes
C. DEFINE AND CODIFY AND APPROPRIATE ORGANIZATIONAL STRUCTURE FOR QIN RENEWABLE ENERGY PROGRAMMING AND DEVELOPMENT			
1. QIN/BPA	10/06 – 06/07	– Scope/analyze BPA dependent opportunities – Evaluate organizational options to maximize benefits	– Report recommending adjustments to QIN organizational Plan
2. Organizational Plan	06/07 – 09/07	– Develop organizational plans	– Plan documents
3. Plan Review	08/07 – 10/07	– Regular review of plan development – Adopt plan plans	– Approved plans
4. Organize Commercial Enterprise	03/07 – 12/07	– Identify partners; develop agreements – Develop project financing – Create organization to carry out QIN role – Staff organization	– An organization capable of joining in and supporting a viable renewable energy development
5. Build Supporting Businesses	01/08 – ongoing	– Identify business/service opportunities created by renewable energy development – Provide training and technical assistance – Provide business incubation services	– Jobs or small business opportunities providing income to ten individuals
6. Organize QIN CDC	06/07 – 12/07	– Incorporate not-for-profit – grant development – Program design and development	– An operating CDC with the capacity to maintain ongoing training, technical assistance, & planning services
7. Build QIN Renewable Energy Center	09/07 – 12/09	– CDC develop Center Plan – Site plan and design – Final Development; grant proposals – Pre-development – Development – Program implementation	– A focus for education activities – Major tourist attraction on QIR – Major buildings/assets – Jobs in development & construction (20 FTE for two years)
8. Education Jobs	01/08 – ongoing	– Education activities	– Five FTEs
9. Energy Jobs	01/08 – ongoing	– Energy development activities	– Three FTEs

Objective	Time From-To	Major Tasks	Outcomes
D. TO DEVELOP AND OPERATE SMALL-SCALE ENERGY/HEAT PRODUCTION FACILITIES TO ADDRESS QIR NEEDS			
1. Evaluate Technologies	Ongoing	– Continuing technical research	– A cost-effective technology that "fits" the QIR
2. Support Demonstrations	10/06 – 10/07	– Contact and join NW Seed wood biomass/wind/solar demonstration – Evaluate demonstration from the perspective of QIR	– An evaluative report of small-scale, integrate technologies
3. Business Plan	08/07 – 03/08	– Perform feasibility study based on demonstration – If warranted, develop business plan	– A business plan for QIN small-scale energy plan
4. Facility Development	Optional	– Identify sites – Project planning – Fund development/grant writing – Pre-Development – Development	– Three operating facilities – Renewable energy production of 500+ kilowatts
5. Institutionalize Facilities	Optional	– Determine appropriate organizational home – Integrate operations into designated organization	– Guarantee Operations

Objective	Time From-To	Major Tasks	Outcomes
E. TO DEVELOP WITH A SUITABLE PARTNER A COMMERCIAL WOOD BIOMASS CONVERSION PROJECT			
1. Pursue Partnership	10/06 – 02/07	– Identify appropriate sites, partners – Develop relationships – Select partners(s)	– Partners that support best possible QIN development option
2. Identify Best Technology	03/06 – 02/07	– Evaluate QIN/Partner resources – Identify technology/products – Analyze resources/products for best technology – Report findings to QIN – Constantly monitor for new developments, changes	– Identify and recommend best technology for QIN project
3. Demonstration	Optional	– Identify technology for demonstration – Fund development/grant proposals – Organize & implement demonstration – Monitor and evaluate	– Further development of best technology for QIN
4. Generate Business Plan	06/06 – 12/06	– Perform feasibility study on "best" technology – Write business plan – Define financial plan	– Business plan for commercial facility
5. Plant Development	03/07 – 06/08	– Fund development, grant proposal – Generate financial package – Pre-development – Development	– An operating commercial facility
6. Organize Commercial Operations	03/08 – ongoing	– Product development & preliminary marketing – Staff plant – Initiate operations – Market products	– Production of products which generate a profit that has a four to five year payback on equity

Objective	Time From-To	Major Tasks	Outcomes
F. TO DEVELOP A QIN RENEWABLE ENERGY RESEARCH, EDUCATION, AND PROMOTION PROGRAM			
1. Evaluate Program Aspects	03/07 – ongoing	– Review program plans – Evaluate present education & tourism activities on QIR	– Information on QIN possibilities
2. Assess QIN Needs	01/07 – 07/07	– Assess needs for training/education related to jobs – Write needs assessment	– Documented needs assessment
3. Evaluate Site	03/07 – 09/07	– Identify possible sites for Center – Evaluate sites and select	– Site for educational center
4. Implement Education Program	08/06 – ongoing	– Develop initial program & project plan – Fund development, grant proposal writing – Implement project – Evaluate program	– Operating education program – Documented evaluation for future planning
5. Plan for Renewable Energy Center	10/07 – 06/08	– Identify & prioritize options – Perform scoping study – Perform feasibility study – Write business/program plan	– A business/program plan for training, education, and tourist development
6. Implement Full Program	06/08 – ongoing	– Fund development, grant proposals – Implement program	– A comprehensive integrated education & training program for QIN members & public

Objective	Time From-To	Major Tasks	Outcomes
G. Economic Development, Jobs, and Business Opportunities			
1. Insure Plan Consideration	08/06 – ongoing	– Coordinate with QIN Enterprise Committee – Prioritize economic development in contracts and selection of contractors	– Maximize consideration, evaluation of job and business opportunities
2. Develop Job Center	01/07 – 09/07 (ongoing)	– Identify funding possibilities – Write plan proposals. Submit. – Develop and implement work plan. – Promote jobs and business opportunities	– Maximize QIN member participation – Facilitate best match for and action on opportunities
3. Generate Resource Jobs	01/07 – 12/09	– Analyze resource need production – Structure production to maximize jobs and small business opportunities	– Create most jobs/business benefit for QIN from resource use
4. Leverage Opportunities	06/07 – ongoing	– Work with resource recovery businesses to bid on outside contracts – Use inside contracts to create innovative partnerships and generate jobs	– Maximize opportunity potential of QIN business relationships
5. Generate Production Jobs	01/07 – 12/09	– Analyze energy production operations – Structure to maximize QIN opportunities – Target training for jobs	– Maximize job and business opportunity in QIN developments
6. Generate Service and Education Jobs	01/07 – 12/09	– Analyze service and education programs – Create innovative training opportunities – Structure grants and projects to maximize employment	– Promote renewable energy sector to QIN youth – Create long-term opportunities, especially for youth

6. ACTION STEPS

A. Review and Adopt Renewable Energy Plan. The last step in the planning process is to review and adopt a plan, this is also the first step in the implementation process. The key to this process is to evaluate the proposed plan on three key issues:

- Do the goals and objectives in the plan express the vision and values of the Quinault Indian Nation?
- Is the strategy for implementing the plan realistic in light of the Nation's capabilities?
- Is the implementation schedule doable?

B. Continue Conservation Measures Incorporated in the Plan. The QIN has already made substantial progress in implementing conservation measures resulting from this planning effort. The QIN should continue to aggressively pursue this work by:

- Expanding the refrigerator replacement program.
- Initiating conservation measures at the Casino, particularly in the pool area.
- Proceeding to develop a weatherization program open to all buildings on the QIR.

C. Decide on the BPA Offer. The BPA offer of working with a QIN sponsored utility could be a significant opportunity for the QIN. In any case, what the QIN decides on this offer will affect all further QIN energy decisions. The QIN should begin its process of study and evaluation as soon as possible in order to get the information and take the time necessary to make the best possible decision without losing momentum on other energy issues. Making such a study the first project/contract of a QIN non-profit will insure the QIN excellent control of the project, realize several objectives of this plan at once, and maximize benefits to the QIN.

D. Complete Commercial Business Plan. The QIN has recently received a grant to do business planning in two areas: educational programming and commercial renewable energy development. This fits this proposed plan perfectly. This effort should be undertaken as soon as possible. This plan will implement several parts of the Renewable Energy Plan.

E. Organize a Community Development Corporation. A community development corporation (CDC) is necessary to the implementation of the Renewable Energy Plan in three key areas:

- Training leading to realizing the benefit of job creation for the QIN will be planned, developed, and implemented by the CDC.
- Tourism and educational programs generating jobs and business development will be planned, developed, and implemented by the CDC.
- Research for and the monitoring and evaluation of the implementation of this plan will be conducted by the CDC.
- Create innovative projects to further the QIN goals and objectives, particularly creating job and business opportunities.

Action in these areas will carry the implementation process forward. The sooner a CDC is established, the sooner movement in these key areas will take place.

QUINAULT FINANCIAL ANALYSIS

This study is part of the overall Renewable Energy Plan. The focus of this study is to identify and analyze the costs, benefits, and risks associated with the options available to the QIN for the development of renewable energy. The options considered here are the options identified by the QIN Renewable Energy Scoping Study as viable for further consideration. This analysis will end in the recommendation of an approach to Renewable Energy Development that will be the focus of the Quinault Renewable Energy Development Plan. The study will conclude with a plan for a financial package to support the recommended approach and recommended next steps for action.

There is a major opportunity that must be considered prior to analyzing the finances of developing renewable energy. The QIN could establish a utility which could purchase energy directly from the BPA. The decision will dramatically affect whatever other decisions and actions the QIN makes on energy issues, especially financial issues. The reality this study must consider is divided between a QIN/BPA/GHPUD defined world and the present QIN/GHPUD defined world.

This study will take up these issues in seven sections: *Working Assumptions, Decision Tree, BPA Option, Renewable Energy Development, Risk Analysis, Renewable Energy Programs, and Recommendations.*

I. WORKING ASSUMPTIONS

a. The QIN has minimum equity to invest in energy development. Options selected must be able to be financed externally.
b. Any option selected must not be inconsistent with the goals of the QIN for energy development.
c. Biomass from wood is and will be the primary resource on which the development of renewable energy will rest.
d. It is feasible for the QIN to use one of two technologies for converting wood biomass to energy and other products: a high performing furnace/boiler/turbine technology or a pyrolysis to wood bio-oil technology.
e. BPA and/or GHPUD will be generally supportive of any and all decisions the QIN may make regarding its energy future.
f. The QIN is generally open to working with outside partners in areas of energy purchase, development, and operations/maintenance. The QIN wishes to maintain decisive control of its land and resources.
g. The QIN will aggressively pursue outside financing opportunities, particularly grants. The QIN expects its partners to support such efforts.
h. The QIN will create and support the necessary organizations to carry out its adopted plans and policies.
i. The QIN will organize itself to insure its cultural, environmental, and educational goals will be supported by and realized in its decisions regarding energy policy.

II. Decision Tree

The decision determining the development and financing of renewable energy by and for the QIN is whether or not to enter into an agreement with BPA for the direct purchase of energy. This is important to renewable energy because:

- The relative costs and benefits of developing renewable energy change dramatically. These costs and benefits would be measured against a structure where the costs of energy would be substantially less and QIN control of its energy would be greater.
- The use of the QIN financial and human resource capacity for energy development would be greatly affected. Some part of present capacity would have to be committed to the BPA connection. On the other hand, QIN financial capacity is likely to be greatly enhanced as the project would be implemented.

The decision regarding working with BPA must be the first decision made on energy purchase and development. This decision is so large that it will wholly change the nature of any other decisions the QIN makes. To make other major decisions regarding development and production of energy, except decisions having to do with conservation, before making the BPA decision risks losing time and money in back-tracking to absorb the effects of the BPA decision when it is made. However, this does not mean a BPA supported utility be created before any of the succeeding steps take place. Development of renewable energy can be initiated prior to formation of a QIN utility.

There are several key decisions that follow on the BPA decision. They are:

a. Goals and Objectives. The BPA decision is fundamentally about the relative importance of the basic QIN goals: energy self-sufficiency, jobs and income production, and environmental protection. As this decision is made, goals and objectives should be assessed and the resulting re-evaluation acknowledged, defined, and applied.
b. Self-Sufficiency. Energy self-sufficiency will be defined quite differently depending on the BPA decision. This must be directly applied to whether or not the QIN should continue to pursue the development of micro technology for energy production and use on the QIR.
c. Priorities. If the QIN decides to move forward with BPA, the QIN commits itself to intensive activity to implement that decision. These implementing actions will automatically take first priority in the allocation of QIN financial and human resources. Other activities will be organized around the BPA decision. Activities such as commercial development of renewable energy resources will be reprioritized according to how they “fit” with BPA implementation. Key criteria are relative level of mutual support and demand for the same resources.
d. Technology. Once goals and priorities are reestablished, the technical and design issues for renewable energy development come to fore. The first key decision is the technology that will be used to process wood biomass. Beyond technical feasibility, key factors include the relative importance of short-term versus long-term income and jobs versus profit, tolerable risk, and the capacity to fully develop the resource.
e. Partners. The choice of entering into partnerships will affect the project in two critical ways. First, it will positively affect the capacity to undertake a project. Second,

partnerships will limit QIN freedom to decide key issues. These factors must be weighed together.

f. Scope and Timing. Perhaps the major impact of the BPA decision is its effect on the scope and timing of other decisions. The BPA decision will greatly affect the capacity of the QIN to act on other issues and opportunities. BPA will initially consume QIN capacity, but it will soon generate greater capacity for further action. For example, if the QIN formed a utility with BPA backing, its ability to finance a renewable energy project would be greatly enhanced. This could in turn, effect things like its needs for a partner, possible sites, and the size of the project. This reality could be handled by determining not to pursue other activities or by adjusting the scope and timing of other activities.

III. BPA Option

On its face, the "BPA Option" is simple. BPA is offering the Quinault Indian Nation enough energy to meet all needs at the cost of its production. This cost is less than half of what the Nation now pays. In return, the QIN agrees to take responsibility for its management and distribution. This means assuming the role Grays Harbor PUD now plays.

Assuming responsibility generates costs. These costs include purchasing or replacing the present infrastructure carrying electricity throughout the QIR and other trust lands and the operating expenses associated with that infrastructure. It also includes marketing the energy and collecting the payments. Finally, it includes the cost of replacing the infrastructure.

The financial benefits of taking responsibility and establishing a QIN utility depend on the amount of infrastructure required per kilowatt sold. Serving dispersed small users like remote houses on the QIR is a losing proposition. One or two small residents might require a mile of expensive pole and wire. On the other hand, serving the QIN Hotel and Casino would be a big winner. A short, relatively inexpensive wire brings in – or saves – large monthly payments. Serving Taholah appears to be marginal because of the miles of wire between Moclips and Taholah. Queets, because it is so close to Highway 101 mainline, perhaps a little bit less marginal. In the end, the *financial benefit* of having a QIN utility will depend on how many large users conveniently located near the BPA grid it can serve. Such users are the Casino, large entities along Highway 101 as it crosses the QIR, and large industrial users at a possible QIN industrial park.

The financial dimension of the BPA Option cannot be effectively evaluated without extensive discussions with the BPA and Grays Harbor PUD. This discussion would need to be accompanied by detailed feasibility studies and business planning. That being said, a scenario can be developed illustrating the issues and consequences.

The scenario is simply that the QIN forms a utility to serve the QIR and associated trust lands. On the production/revenue side, the QIR presently consumes approximately 4,700 megawatt hours annually at its public buildings. If the Casino and Crane Creek Timber were added, consumption would more than double to 12,400 megawatt hours (the QBRC consumes 5,400 MWh and Crane Creek consumes 2,300 MWh). Assuming the QIN utility pays BPA $141,000 (at $0.03 per KWh) for the QIR energy and sells it at $0.055 a KWh, it will earn $117,500 or $310,000 if the Casino and Crane Creek were included.

The amount of money the QIN earns must at least equal its annual operating cost – the combination of the cost of capital and operating expenses. Obviously, $117,500 will not cover much. Each $100,000 of capital expenditure would cost about $12,000. Basic operating costs would probably be in the $75,000 to $100,000 range. Without major consumers, the QIN could not afford to pay more than $150,000 for the infrastructure. On the other hand, with major customers, the QIN could afford capital costs of up to $1.5 million.

Beyond the basic cost/benefit analysis of the marketing of energy, there are major economic advantages that could be provided by pursuing the BPA option. These include:

- Providing a platform on which to generate economic development. The relative price of energy is a major factor in considering plant or business location. Competitive rates and service could support the development of a QIN business park, particularly in the Ocean Shores area, south of Taholah, or the 101 corridor.
- Supporting the development and production of renewable energy. The utility could provide a financial platform which would generate maximum federal support for a renewable energy project. This would make the QIN an attractive partner for an energy developer as well as making such a project economically viable.
- Controlling quality jobs, giving members of the nation greater access to employment opportunities.

The benefits possible from any one of these factors could make the BPA option valuable for the QIN to pursue even if the basic cost/benefit ratio were not especially positive.

<u>In the long run, the greatest value of creating a QIN utility is that it would provide the foundation on which the QIN can seriously pursue the development of renewable energy.</u>

The utility would provide the QIN an entity with the capacity to develop a commercial, renewable energy project. Access to BPA energy alone gives it financial credibility. The fact it can effectively organize the federal financial support available to Indian Country for renewable energy greatly extends this capacity. Finally, its relationship with BPA would enhance its ability to break through the red tape and make the connections which would allow it or a partnership in which it were the member to effectively build production facilities and market the energy.

IV. Renewable Energy Development

A. QIN Development and Use

There are two approaches to developing renewable energy for QIN use. The QIN can purchase small-scale technology for producing energy directly for various QIN sites. Or, the QIN can "purchase" energy from a QIN sponsored commercial-scale facility.

Producing energy to be use directly by the QIN is costly .The capital cost of the CPC Biomax technology is $7,500 per kilowatt of rated capacity. The QIN would be required to invest $7.5

million to meet its needs at this cost. The annual cost of capitalization at this level would be $975,000 or $975 per kW per year. At 100% production, this means that a KWh would cost $0.11 in capital costs alone. Already, without considering operating and maintenance costs as well as the cost of the feedstock (high quality wood), the energy would cost four times the cost of purchasing energy from the BPA. Obviously this approach is not cost effective. Even significant government subsidies and environmental payments ($0.015 per KWh) would not create a positive cost/benefit ratio.

Commercial-scale production is a different story. The capital cost of commercial-scale production is considerably lower. The primary reason for this is the capital cost per megawatt of production is about a third of the smaller-scale machines. Moreover, operating and maintenance costs are lower as well; even the feedstock would be less expensive because of higher volume discounts. But still, commercial production of renewable energy could not match BPA produced energy in price. In fact, if the QIN were to produce commercial renewable energy, the QIN would make more money exporting all of its energy to the grid and importing BPA energy for its own use.

The reason for this is simple. Renewable energy already sells for premium prices in the Northwest ($0.06 per KWh). This is because consumer demand for renewable energy expressed through the purchase of green tags or through political pressure has created a specialized market. If Initiative 937 passes this fall, this market will be both enhanced in value and guaranteed for the long term in Washington State. This event is probable. The energy the QIN would export will sell for two, perhaps as much as three times what it will cost the QIN to purchase the same amount of energy from the BPA. Or, put another way, it can sell renewable energy for a little more than it now pays the Grays Harbor PUD. There is one exception to this cost/benefit analysis. The exception is providing energy to consumers who are presently off the grid.

Extending wire to consumers not served by the grid is prohibitively expensive. In this special case, it makes sense to purchase a small individual unit. If the QIN were to serve such consumers, the most cost-effective approach would be to use an electrical generator/heat producing unit that operated on bio-oil. The QIN could then provide the bio-oil from its commercial production.

B. Commercial Renewable Energy Development

There are two basic wood biomass to energy/heat technologies. Pyrolysis processes and wood burning boilers. Both technologies involve significant capital and operating costs. The most significant operating cost is the “feedstock,” of the cost of producing the wood biomass itself.

In comparing the two technologies, conventional wood burning technology produces energy – in the form of electricity – more effectively. The production of heat is relatively the same, as are capital and operating costs. However, the pyrolysis technology has five substantial advantages in terms of productivity. 1) It produces a valuable by-product: char. This can be easily processed into activated charcoal. 2) Its major product, bio-oil, can be processed into other products such as food flavoring or specialty stains and wood resins. These products could be more valuable than the energy that can be produced from the bio-oil. Also, research into using bio-oil as a fuel for various kinds of engines has had promising results. Energy in the form of fuel is more valuable than energy in the form of electricity. 3) Bio-oil, when used to produce electricity, is more flexible because it can be transported and stored. This could conceivably allow several production sites to serve a central facility, cutting down on the cost of transportation. Or, this would allow the use of bio-oil in off the grid applications. 4) Bio-oil based production of electricity lends itself to the off and on capability necessary to take advantage of spot markets. 5) The Quinault Beach Resort and Casino could be a major consumer of bio-oil since it already has an infrastructure for propane tanks and gas water boilers.

The most advanced wood burning technology (produced by Siemens, a German company) was the focus of a recent feasibility study in Forks. The context for the study was quite similar: the same resources, transportation issues, and processing, among other considerations. In the case of Forks, available mill-based resources were almost double those available at Crane Creek. The results of the feasibility study were disappointing. The resources were not sufficient to generate enough electricity to make the project pay. The only by-product – heat – could not be used to the level necessary to overcome the negative cost/benefit gap. The result underlines the importance of value-added by-products to the cost-effective production of renewable energy. It also suggests that the first alternative examined in a feasibility study of the commercial development of renewable energy on the QIR be bio-oil.

A final point reinforcing this conclusion is the pending development of a major biodiesel refinery at Hoquiam. Despite the fact to the owners have stated an interest in producing biodiesel from local resources, they currently plan to use 100% imported material for feedstock. The material of choice – palm oil – is a very economical feedstock. It does, however, produce a lower quality fuel. This suggests the biodiesel will be used in larger engines, such as those on board a ship. These facts open an intriguing possibility. If they are indeed producing a bunker fuel (low-grade diesel), could bio-oil be used in the blend? This would create a very large, high-paying market. A more immediate and real possibility is the use of bio-oil to produce heat for the refining operations. The plant will require significant heating. Bio-oil is cost effective in a boiler designed to generate heat.

C. Financing and Organization

This analysis considers financing and organization together because the three key elements for the QIN in capitalizing and operating a commercial energy project require organizational development. First, the QIN would almost certainly have to have non-Indian business partners to undertake a commercial project. These partners would demand a structure allowing them the protection of state law as well as defining ownership appropriate to their contributions. Second, grants and non-private sector loans will be an essential element of financing. Eligibility requirements of various sources of these grants and loans will lead the QIN into creative organizing to take advantage of key opportunities for funding. Finally, the QIN will need to enhance its internal organization to effectively manage this area of operation.

The primary financial concerns for the QIN are to find the right partner for commercial development and to obtain significant grant funding. The actual capital needs for commercial renewable energy development are unknown. They can only be known for a specific project, as the facilities and equipment are specifically designed for a project rather than being “off the shelf”. A very rough figure is that a million dollars in capitalization buys the capacity to process six to eight tons of biomass daily. At present, the maximum available resource is 150 tons a day. Prudence would dictate that a first facility would be built to a capacity well within what the maximum resource would call for, allowing for expansion to optimum size based on experience. This suggests a plant designed to process a hundred tons of wood biomass a day. Such a plant would require $12 to $20 million in capital to build and operate. This plant would require five to ten million dollars in equity. Loans would provide the balance.

The Quinault Nation has three sources of capital: capital it owns, grants, and capital based on tax credits or other liquid development payments. Grants and payment-based sources are considerable. It is quite possible that half of the capital needed could come from these sources. Access to these sources is a considerable plus that the QIN brings to the table in any possible partnership. However, these sources alone would not provide all the equity for a project. The QIN would, at a minimum, need to provide $2 to $5 million of cash equity.

There is one possible QIN source for this kind of capital – a QIN energy utility backed by BPA power that served a significant customer base. The utility would have assets and bond capacity sufficient to generate the necessary equity capital or near to it.

Otherwise, the QIN would require a partner and/or investors willing to provide equity for a share of ownership. Obviously, the best partner is one that will value what the QIN brings to the table. These are:

- Land and wood biomass resources.
- Access to public and community oriented funding sources. Some of the more important of these sources are specifically tied to the status of being a recognized Indian nation or the location of a project on trust or reservation land.
- Access to BPA energy at the best of prices. Stable and inexpensive sources of energy are increasingly important to any business, particularly manufacturers.

Loan financing is equally important to a development project. Again, significant public or community-based support resources are available. These resources fall into three categories: tax exempt bond financing, low-interest loans directly provided by a public or institutional lender, and loans guaranteed by a public or community-based entity. The attraction is that these sources offer lower interest rates, more favorable terms such as “pay on profit” payment schedules, and/or back-up credit reducing risk. Again, the QIN has strong access to these kinds of loans. However, these sources tend to favor private for-profit businesses.

A QIN utility could play a significant role in loan financing. It could even be the financier through the use of its bonding capacity.

The possibilities provided by a utility point to the importance of organization in developing project financing. The various organizational forms have unique capacities and limitations for financing. More and more, major projects are founded on sophisticated structures that are designed to integrate and take advantage of several different forms of organizational to produce the best possible financial package. Direct access to various sources of finance as an Indian nation with a reservation, trust lands, and rights to resources including BPA energy puts the Quinault Nation in a unique position with great strength. This position is possibly the Nation’s greatest asset; an asset that can best be realized in cooperative agreements with partners that need but lack this asset.

Currently, the QIN uses the Quinault Enterprises Structure to organize businesses like the fish house and the corporate form to organize the Quinault Beach Resort and Casino. These forms could be used for a commercial renewable energy enterprise and include:

- A cooperative of, by, and for members of the Nation. Cooperatives have unique access to USDA grants and loans. This form could be a particularly effective way of organizing individual members who wish to engage in the "cottage" industries that wood biomass technologies open up; for example, individuals who wish to collect and sell waste wood, or produce charcoal briquettes or oil from alder wood. In fact, the QIN might wish to consider a rural electrical cooperative as a form for a Quinault electrical utility to take.
- A limited liability corporation has become the form favored for project focuses enterprises involving several partners. This form would be very appropriate for a renewable energy enterprise the QIN undertook with non-Quinault partners. This form allows a great deal of freedom in terms of action while protecting the QIN from liability and, more important, costly entanglements with outside partners.
- A non-profit community development corporation has extensive access to public and foundation funding. It is a very appropriate form for organizing research, development, and education programs. This is discussed more fully in Section 6, Renewable Energy Programs.

V. Risk Analysis

Wood is probably the first form of "biomass" humans converted to energy. Ironically, the development of technology to convert wood to electricity is still in its infancy. We have only begun to search out ways to use wood for energy beyond burning it. This means that the risks of working with wood to produce renewable electricity are highly bifurcated.

On the one hand, the "risks" of burning wood to produce heat to transfer to a means of turning a turbine to produce electricity are well known; the technical elements are relatively standard and the advances in the technology have been incremental. The aim is to achieve greater efficiency in the incineration process and better ways to capture the heat. There is little risk that current technology will become outdated. Nor is there great risk of machinery breaking down or not functioning up to expectations.

All of this makes for high confidence and predictability; risk factors are easily built into the business plan and plant development. Because the "risks" are accounted for, they are no longer risks but costs.

If the QIN were to select a wood burning technology, it would be at little risk of unanticipated losses.

This analysis reverses for innovative wood use technologies, including pyrolysis technologies. Pyrolysis technologies have a relatively high level of risk in three areas: performance, product development, and marketing.

The area of performance is a concern for pyrolysis technology because:

- It has not been used extensively or for a great length of time in the field. It does not have a track record that can provide reliable information on maintenance and replacement. Nor is there good information on its actual production versus rated output. On the positive side, the technology is relatively simple. There are relatively few points where it can fail.
- Results are known to vary with the feedstock for the process. The range of feedstock to which it has been applied is narrow. Again, there is a wide range of possible results with limited information available.

The bottom line is that performance in a given situation is very unpredictable. Trial is a necessity. Possible failure is likely along the way. The costs of failure are as unpredictable as when, where, and how often it will occur.

These kinds of risks can be relieved by approaches that incorporate extensive field testing where the risks are assumed by the manufacturer and/or a third party. In this case, the government is a likely third party because of the interest in advancing wood biomass technologies.

The other major area of risk (as well as great opportunity) is the marketing of the products produced from pyrolysis – bio-oil and char. The risk is that the bio-oil and char will end up being used at their low-end value because:

- The ability to store and transport bio-oil in relatively inexpensive containers does not materialize.
- High value markets for bio-oil such as for fuels or for food products prove too small or elusive.
- The use of char in high value, high volume applications such as a soil stabilizer and pollution filter does not prove out.

Collectively, such outcomes would undermine the viability of the technology. For pyrolysis to succeed economically it must produce products that can command a higher value market than the production of electricity and heat on a continuing basis as is possible with wood burning technologies. Because pyrolysis costs more, it must get more out of the wood.

The risk that bio-oil and char do not realize any of their value-added potential is very low. Bio-oil as a valuable food additive is proven. Char as a soil amendment has had very promising tests. Bio-oil for use in producing high-value electricity for use in special markets is proven.

The risk that bio-oil and char will not develop high-volume markets of higher value is moderate. However, the possibility that this would coincide with over-production of bio-oil and/or char is unlikely. This is because it is unlikely that there would be significant increases in char and bio-oil production prior to market development.

The greatest market risk is an indirect one. It is possible that a new, competing technology would develop that would make better use of wood biomass. One such technology is a commercially viable way to produce ethanol from cellulosic fibers. This is likely to happen in the next ten years. However, it is unclear what impact such an event would have on a relatively small-scale operation. It could be beneficial. Moreover, reduction in the value of ethanol due to increased production might make a gallon of bio-oil as valuable or more valuable than ethanol.

Overall, the presence and nature of these risk factors can be relieved by proceeding in a prudent and cautious manner. Incorporating a demonstration project in initial development is one step. Another would be starting small, staying within the bounds of a proven market, and ramping up as appropriate as the project unfolds. A third step could be emphasizing co-development of locally unique products. For example, alderwood char could be sold with Quinault wild salmon. The bottom line is that the risks inherent in undertaking a wood biomass renewable energy project can be controlled by a sound risk management strategy.

VI. Renewable Energy Programs

Developing renewable energy opens up the possibility to the QIN of creating education, training, tourist-oriented programs, and innovative projects focused on goals. In some ways, these programs offer the best financial opportunities to the Nation.

These programs are like conservation projects. They have a high benefit to cost ratio. They have little or no risk. And like conservation, they should be the first development the QIN pursues.

Costs of these programs are minimal because:

- They require no capital investment.
- Overhead is low because they can be readily accommodated within QIN facilities and administrative structures.
- Grant funding for their development and implementation is available.

The benefits include:

- Maximizing job creation. Almost all program funds would support salaries and benefits. Funding could reach and pass the one million dollar level annually.
- Enhancing present QIN businesses, particularly the hotel, guided tours, and small scale retail.
- Training and education is necessary to take advantage of renewable energy development including the possible bio-diesel facility at Hoquiam.
- Realizing cultural and environmental values.

The key to pursuing these possibilities is organization. Organization is important to raising the funds necessary for these programs, making the programs work, and integrating them effectively into the QIN.

Important criteria for selecting the best organizational form for these activities and building them are:

- Providing a distinctive and flexible platform for these activities. These programs are different in that they are both public services and entrepreneurial. They need to be treated like a business as well as like a program of the nation. Further, they must be separate in order to allow them to be fully and clearly promoted at the level necessary for success.
- Providing an attractive platform for funding. It is important to capture available grant funding, particularly the funding available from charitable foundations.
- The organization must be of, by, and for the QIN. The lines of communication and accountability to the Business Committee must be clear and direct.
- The organization must be able to act in consort with other QIN businesses and programs. It needs to be on the same footing as its counterparts.
- It must be able to function fluidly and quickly in order to act on energy opportunities.

These criteria clearly suggest a non-profit organization. A non-profit could effectively undertake projects and programs like:

- Coordinating a major research project in determining the value of char as a filtering agent in stream and wetland restoration. The development of natural organic materials to clean water and facilitate rooting and holding in soils is of high interest in salmon restoration and the protection of habitat. The QIR has great opportunities for field testing. This would be an important element in creating value-added products for pyrolysis technology. It would provide high-quality jobs.
- Designing and implementing "education in the field" programs. These programs could integrate education on Quinault culture, the potential of renewable energy, and environmental protection. These field programs are attractive educational opportunities for junior high schools to the college level. Week long field programs would be a way of encouraging off-season touring to the Quinault region. Among other things, it could generate higher off-season occupancy at the Quinault Beach Resort and Casino.
- Organizing a cooperative for small-scale wood contractors. The cooperative could support individual producers by jointly buying and sharing equipment from pick-up trucks to chainsaws. This could make such businesses more profitable.

VII. RECOMMENDATIONS

A. The QIN should explore and consider the BPA offer with all deliberate speed. This decision could be facilitated by appointing a special task force of the Business Committee and obtaining expert advice. The BPA should be approached for support for the QIN consideration process.

B. The QIN should establish a QIN not-for-profit to undertake education, training, and community development activities in the area of renewable energy. This form of non-profit would:
   - Complement the fund development strengths of the QIN.
   - Maintain QIN identity and control.
   - Provide a proven platform for these kinds of programs.

C. The QIN should pursue business planning for commercial renewable energy development. The business plan should incorporate a risk management strategy as a major element.

Quinault Indian Nation
Renewable Energy Plan

Appendices

QUINAULT INDIAN NATION
RENEWABLE ENERGY
FEASIBILITY STUDY

SCOPING STUDY
EXECUTIVE SUMMARY

The purpose of this Scoping Study is to identify those options for producing renewable energy that offer the Quinault Indian Nation (QIN) a realistic possibility of meeting its goals. This study assessed five renewable energy resources that appear on the Quinault Indian Reservation (QIR). They are solar, water, wind, biomass, and energy conservation.

Our assessment eliminated solar and water as realistic possibilities for development. The solar resource is simply insufficient for QIN needs. Water, though abundant, occurs in a manner that makes its development too costly, and in the case of the fresh water resource, an unacceptable environmental risk.

The wind resources present a more complicated picture. Wind measurements taken by the QIN have not identified a developable resource. Moreover, the coastal energy transmission lines will not support the export of electrical energy. But, there remain sites that could have potential for commercial development which have not been studied.

The assessment found several sources of energy that have great promise for the QIN. They are wood biomass, methane, and conservation. Wood biomass and methane are accessible in quantities sufficient to feed technology that will convert them to usable energy in a cost-effective way. Similarly, opportunities exist to conserve energy in quantities that would justify the institution of practices and programs open to the QIN.

This study evaluated biomass, methane, and conservation for their potential for use on the QIR and for commercial development. The QIR energy needs are small-scale and seasonal. They are concentrated at two widely separated locations. These factors make flexibility a high value. This study concluded that the QIN could best achieve energy self-sufficiency through aggressive conservation programs and adopting a system based on electrical generators burning biofuels produced by the QIN from wood waste biomass.

The QIN has good potential for commercial energy development. This potential lies in combining its resources with those outside QIN control but uniquely available to it. It also depends on developing partnerships for financial and marketing purposes.

There are three important opportunities for commercial development. They are producing biofuel from wood waste biomass and producing liquid natural gas (LNG) from either natural methane seeps or methane from solid waste. The fact all these alternatives involve gas rather than electricity reflects economic reality. Generally speaking, gas is from two to three times more valuable in the Northwest than electricity. Moreover, great flexibility and reliability of gas-based

technologies make production of electricity from it competitive in serving the kind of specialty markets open to the export of energy from the QIN.

The best prospect for immediate development is LNG from methane. This is because the QIN has already identified a willing partner, Prometheus Energy Company, financially and technically capable of tapping these resources. Preliminary indications are that the QIN has access to sufficient resources to make this option possible. Though this is not a renewable resource, it is an environmentally friendly resource that could provide the financial foundation for QIN renewable energy development.

Biofuel from wood waste biomass is the most immediate prospect for the commercial production of renewable energy. QIN development of this resource requires that it be able to tap into the wood waste stream of the entire Olympic Coast. This development would be greatly advantaged if is tied to other forest products industry operations. These factors dictate that this possibility requires that the QIN build partnerships that provide financing, enhance the cost-effectiveness of operations, and guarantee marketability. The advantage of pursuing this alternative includes its compatibility with current QIN operations and the proposed plan for energy self-sufficiently. It has good potential for job creation.

The development of energy from solid waste is a longer-term prospect. It requires that the present solid waste management system in the Grays Harbor area be changed. This opportunity exists because there are already outstanding economic reasons to change the present system. The possibility of applying the Prometheus Energy technology to the methane produced by solid waste creates an economic value that could tip the economic scale more strongly to change. Perhaps more important, it would resolve major environmental issues barring the development of a new solid waste facility. This option has high job creation potential. Pursuing this option requires extending the partnership with Prometheus Energy Company and establishing a joint project with LeMay Corporation and other local jurisdictions.

This assessment and evaluation leads us to recommend for this feasibility study:

- Create a QIR energy plan for self-sufficiency on the basis of enhanced conservation programs and the incremental development of a small-scale wood biomass to biofuel to electricity and heat system. This system would be developed for Queets, Taholah, and possibly the Southwest corner of the QIR.
- Focus on further exploring three possibilities for the commercial production of energy: wood biomass to biofuel, the use of methane from solid waste, and wind energy if a resource site exists on the QIR. The wind energy possibility should only be pursued if the necessary wind measuring program be fully supported by the National Renewable Energy Laboratory (NREL).
- Generate a business plan for wood biomass to biofuel production and prospectus for a solid waste project incorporating the production of energy from methane.

QUINAULT SCOPING STUDY

The Scoping Study is the first step in the process of generating a comprehensive renewable energy study and plan for the Quinault Indian Nation (QIN). The Scoping Study identifies the possibilities for renewable energy development available to the QIN; evaluates those possibilities in light of the resources, needs and goals of the QIN; and prioritizes those possibilities according to their potential for success. The results of this study are reported in five sections: I, Purpose, Scope, and Approach; II, Resource Assessment; III, Findings and Evaluation; IV, Conclusions and Recommendations; and V, Next Steps.

I. PURPOSE, SCOPE, AND APPROACH

The purpose of this Scoping Study is to identify the best options available to the Quinault Indian Nation in pursuing the Nation's goals of achieving energy self-sufficiency and economic benefits from sustainable energy production. "Best options" are defined as:

1) Options that use proven technologies, capable for use by the QIN.
2) Options that are cost effective and have the potential for job creation.
3) Options that have positive environmental and cultural impacts.

"Best Options" must be within the capacity – primarily financial – of the QIN to implement, either by itself or with suitable partners. This study aims to move from the world of potential projects to the world of realistic possibilities.

The scope of the study is defined by goals, geography, and time. The goals for this project are set forth by the QIN in the document "Statement of Objectives: Quinault Indian Nation Renewable Energy Feasibility Study" which was accepted by the US Department of Energy and made part of its project agreement with the QIN.

Specifically, this study addresses these objectives mandated to the Institute by the QIN:

- Identify local renewable energy resources. This objective will be the result of studies conducted on the availability and sustainability of biomass (forest residues), wind sustainability studies, solar energy studies keeping in mind our coastal location and weather patterns, and sustainability of ocean wave energy generation utilizing current commercially available technology.
- Identify most realistic sources of renewable energy. This objective will be based on assessing which alternative energy solution or combination thereof proves to be the most viable for the Quinault Indian Nation.
- Assess sustainability of energy generation. This objective will be realized through the identification of the alternative energy technology that best fulfills the energy needs of the Quinault Indian Nation.
- Assess the feasibility of exporting electrical power. There are various factors to consider such as the use of existing transmission lines, the ability to reverse meter as required, fluctuations in energy rates, and associated costs. Exporting potential electrical power is an area of particular interest and will be explored as our project progresses.

- Determine the economic feasibility of providing power purchase agreements beyond our Tribal community. This objective will require electrical energy market research and will be included in the economic benefits assessment portion of our feasibility study.
- Determine the economic and environmental benefits to the Quinault Indian Nation resulting from the future implementation of a Tribal Renewable Energy Project. Applicable data will be complied throughout the duration of our study and matched to our benefits criteria in order to make this determination.
- Develop a network of collaborative partners who will provide ongoing technical support throughout the duration or our feasibility study and future implementation project.

Objective 2, Needs Assessment, will be addressed in a separate report. The other listed objectives will be addressed as the feasibility study proceeds.

The study specifically pertains to the Quinault Indian Reservation (QIR), although it includes areas associated with both the reservation and the Nation. It is being done in conjunction with the study being conducted by the WorldWater Corp, who is dealing with the QIN Casino and its environs. While this study focuses on the reservation area, it takes into consideration the entire western region of the Olympic Peninsula. This broader geographic scope is important in considering commercial potential, particularly in regard to potential markets, additional resources and partnerships open to the QIN.

The Time Horizon for the study is the year 2025. 2025 was selected as the outer limit of the energy requirements that could be reasonably projected for this study. Population growth is expected to remain low within this time period. Specific elements of this study, most importantly the business plan, have a closer horizon.

QIN goals dictate that the study begins with a comprehensive, substantive scope, “essentially all possible sources of renewable energy”. The purpose of this study is to narrow that scope to renewable energy options that are technically and economically practical and environmentally and culturally desirable. Our approach to achieving this purpose in this Scoping Study is:

1. Identify renewable energy resources available on or associated with the QIR.
2. Identify available technologies that could effectively use the resources to meet QIN needs and/or produce commercially marketable energy.
3. Assess the combination of technologies and resources in terms of technical effectiveness, cost effectiveness, environmental impact, cultural value, job creation, profitability, and accountability.
4. Define “best options” utilizing resources and technologies in a specific place and manner in order to create concrete instances to test their practicality and desirability.

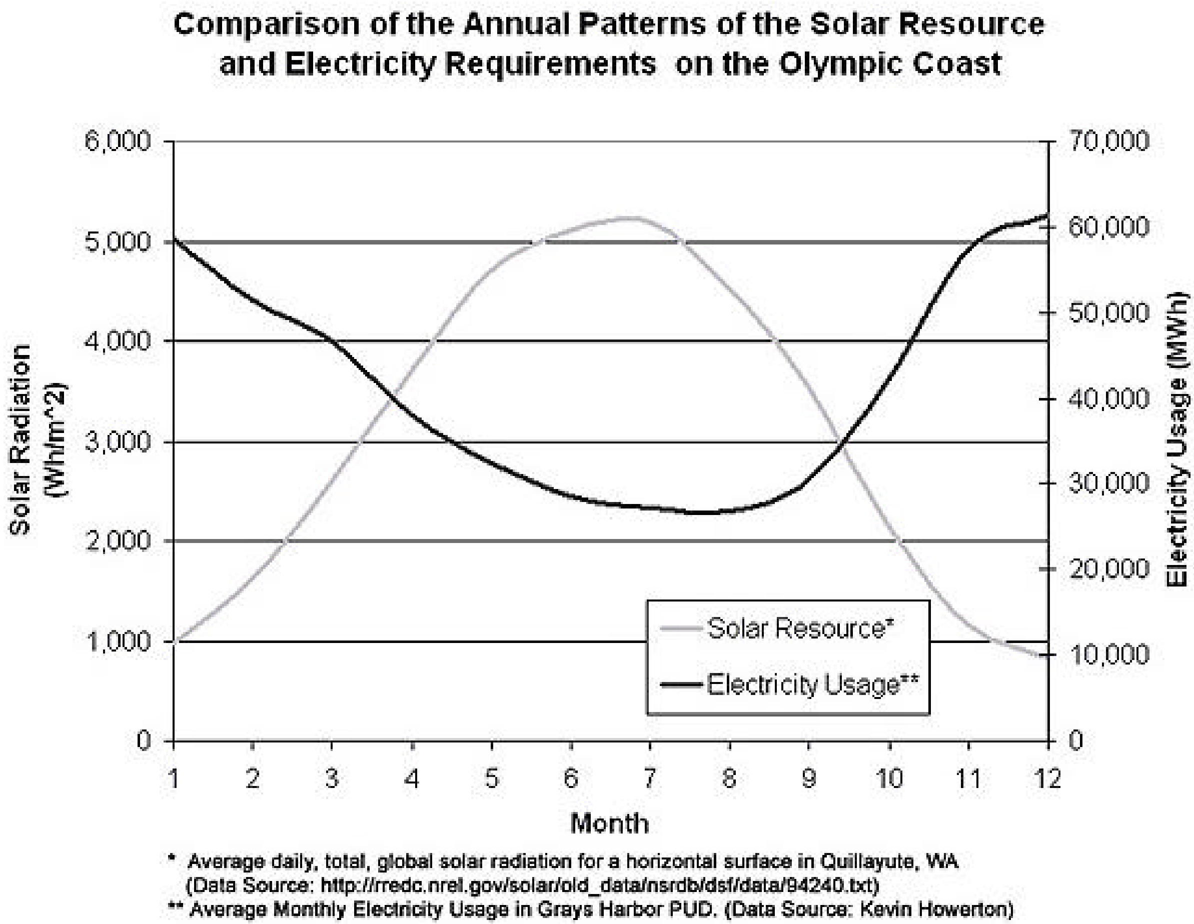
II. Resource Assessment

This study evaluated the resource potential for active solar electric technologies, passive solar technologies, river-run hydroelectric generation, in-ocean hydroelectric generation, wind turbines, and a variety of biomass technologies for use in meeting the energy needs of the QIN. We also consider the possibility of energy savings through conservation. For additional information on specific energy conversion technologies, please see the Technology Appendix. We evaluated these resources according to the following criteria:

- Resource Availability for Local Use: Is the resource available on the QIR sufficient to produce up to 2 MW of electricity in the winter months on an on-going basis? (Given current population and energy use growth trends, this figure gives the QIN a wide margin of error in projecting the electrical energy need to twenty years).
- Resource Availability for Commercial Use: Is the resource available to the QIN large enough to produce sufficient electricity or biofuel to enter a commercial market?
- Transportation and Transmission: Could the resource be effectively delivered to an appropriate production site or sites? For the QIR, can the energy resource or electrical energy produced by the resource be effectively delivered to Taholah and Queets? For commercial production, could the energy be effectively delivered to a ready market?
- Technology Availability: Is technology available to produce energy from a given resource reliably at low risk, with little or no environmental or cultural impact?

Solar:
The study first considered the solar potential of the region for both active and passive solar technologies. The Olympic Peninsula receives an annual average of 3.5 – 4.0 kWh/m^2/day of solar energy. (Source: NREL, http://www.nrel.gov/gis/images/US_pv_annual_may2004.jpg) When compared to the annual average of Phoenix, Arizona at 6.0 – 6.5 kWh/m^2/day it becomes apparent that the solar resource on the QIR is quite limited. Further limiting the potential use of solar technologies is the lack of correspondence between the solar resource and the QIR's energy needs both seasonally and within each day. The energy needs of the QIR peak in the winter when the solar energy resource is at its lowest. (Figure 1) On a daily basis, QIR energy needs peak in the morning and evening while the solar resource peaks in the middle of the day. The storage technology needed to bridge the need vs. resource gap would double the cost of the technology. At this point in time solar energy technologies are unable to meet the needs of the QIR in a cost-effective manner

Figure 1.



Hydro:
Two possible hydro alternatives were seriously considered. First, we considered small-scale turbines which operate on the “run of the river” for the Quinault, Raft, and Queets Rivers. We eliminated these alternatives due to the lack of sufficient river “head” or “flow” to effectively turn turbines of sufficient size throughout the year (see Technology Appendix). Another factor is the possibility that the turbines would negatively impact the fishery. This factor, coupled with the high cost of installation effectively eliminates these possibilities.

Second, we posited the possibility of capturing wave energy from the ocean. The resource for wave energy is not a simple correlation to wave height. The current technologies require consistent swells of sufficient amplitude to pump a turbine anchored in the ocean. Because of the extensive ocean shelf off the Quinault coast, this kind of wave action does not happen near the coastline. In short, the wave resource necessary for today’s technology does not exist close enough to the coast to be cost-effective for QIR use. Our partner, WorldWater Corp, is evaluating a wave technology for commercial use (see Technology Appendix).

Wind:
Wind energy has been under study on the QIR for some time. In addition, an extensive wind energy study is near completion for the Makah Nation located 50 miles north of the QIR. Thus far, neither study has uncovered a commercially viable wind resource. Wind strength is only one of the four factors used to define an area's wind resource. Besides strength, a commercially viable wind resource must blow consistently, have a strong prevailing wind direction, and low turbulence. The wind resource on the Makah Nation does not meet these criteria, and creating significant doubt that the wind on the QIR will as well.

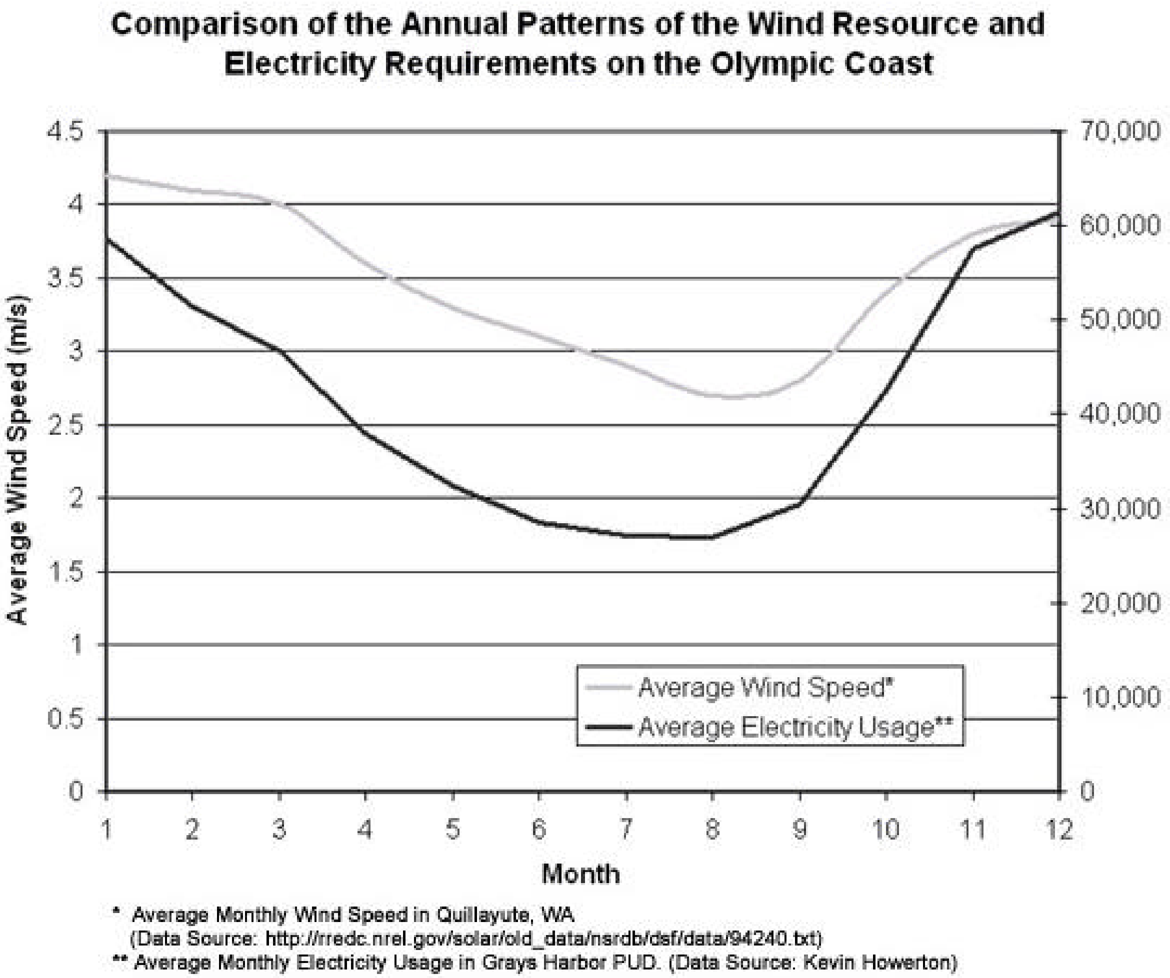
Wind measurements for the QIR have been taken at three sites using a 20 m tower. The measurements from these sites have been marginal. Wind strength has been fair and, especially at Point Grenville, there is reason to believe it could be a good deal better at higher elevations. The consistency of the wind at these sites is less than optimal. At all sites, wind strength varies widely with the season. This variation follows the seasonal variation in electricity usage creating a good match between electric load and resource availability. (Figure 2) The diurnal variations are unknown at this time. There is still no indication that the wind resource is sufficient to produce energy for much of the year (see Technology Appendix).

These findings correspond with the results of the Makah study. The Makah study has also found problems with both wind direction and wind turbulence. Similarities between the two reservations: broken, heavily forested terrain and corresponding weather patterns suggest that the wind resource on the QIR will be similar to that of the Makah. There is a significant chance more intensive study on the QIR would yield similar wind resource findings.

The wind resource has not been measured for either Taholah or Queets. However, wind speeds measured at ground level are not encouraging. No definitive statement about the use of wind for production for on-site use can be made. There is a chance that sufficient wind strength is available at Taholah to run a small-scale wind turbine. Since Queets is more sheltered, there is less of a chance for quality wind. Beyond strength, the consistency of the wind is probably an issue at both places. Moreover, trees and terrain would cause turbulence problems.

While water and solar were found to be inadequate for QIR needs, and are obviously inadequate for commercial development, wind cannot be similarly dismissed. There are one or two untested sites which could be commercially developable. Such a study could dramatically change this assessment of the wind resource, but the factors mentioned above must be taken into account in determining the priority of doing such a study.

Figure 2.



Biomass:
This study examines two forms of biomass with energy production potential: Wood and methane gas.

Wood Waste

The QIN previously conducted a study of its potential to produce electrical energy from wood. That study considered only the resource available on the QIR. The study found there is 15,500 green tons (gt) of wood waste available on an annual basis and a potential for 50,000 gt with expanded commercial harvests. The present resource is sufficient to produce an average of 750kW when burned to produce steam and electricity. It could also be used to produce over 1,000,000 gallons of biofuel (see Technology Appendix).

There is significantly more wood biomass available to the QIN than that located on the reservation. The west side of the Olympic Peninsula produces up to 220,000 gt of wood waste each year. If a quarter of the wood waste was recovered for energy use, this would be enough to produce between 2 and 3 MW of electricity or approximately 4,100,000 gallons of biofuel (see

Technology Appendix). This resource would be available for use in facilities along the Highway 101 corridor.

<u>Methane</u>
This study looked into three possible sources of methane for both on-site production and commercial development. Two of those three sources are considered renewable: methane from solid waste and methane from the treatment of sewage. The third source is non-renewable, but utilizes an untapped resource on the QIR. The QIR has deposits of natural gas occurring in old, stranded wells and natural seeps. These gas deposits appear to be associated with natural formations along the Quinault coast. They have been commercially drilled and tested, and, in some instances, manifest significant gas deposits.

The methane producing waste streams on the QIR are small, reflecting the size of Taholah and Queets. Solid waste is transported from the QIR to a distant transfer station. Currently, there is no methane available to the QIR from this source. The amount of solid waste generated by the entire Grays Harbor area would be sufficient to produce commercially valuable methane.

The QIN is developing a small sewage treatment system (lagoon) at Taholah. This system will generate a small amount of methane. The methane produced will be insufficient for electricity production, but could potentially be used to heat one or more buildings on the QIR.

Methane from stranded wells and seeps on the QIR is sufficient for use in a large building's heating system. The potential for electricity generation for local or commercial use is unknown at this time. (see Technology Appendix). Oil and gas explorations outside of the QIR have produced mixed results. Significant deposits of natural gas were found, but never developed due to insufficient commercial value. Technological advances and higher gas prices could potentially make these deposits commercially viable.

Conservation and Efficiency:
The last energy "source" to be considered is conservation. Conservation is the most cost-effective form of energy production because it meets energy needs without requiring new energy production facilities.

Approaches to conservation include insulating buildings and installing energy efficient windows and doors, encouraging day-lighting to reduce the use of electric lights and replacing incandescent light bulbs with compact fluorescent, encouraging the use of efficient appliances, and promoting conservative use of electric heaters through timed thermostats and other controls. The QIN is actively practicing conservation through its weatherization program and its commitment to efficiency in new construction. Supporting and expanding these programs could be an important step in realizing the QIN energy goals.

The potential for increasing the efficiency of energy use on the QIR is also significant. Electricity on the QIR is used disproportionately for space heating, water heating, and refrigeration. Electric space and water heating systems can be replaced by heat pumps which are 2 to 5 times as efficient. Initiating conservation and efficiency measures is cost-effective, and the decreased energy requirements will be more easily met through sustainable means.

One of the problems with conservation faced by the QIN is that it is highly related to housing. Most of the housing on the QIR is individually owned. This leaves the QIN little control over the implementation of conservation measures. Enhancing the conservation service programs offered on the QIR and promoting those services to all residents could rectify this situation.

RESOURCE AVAILABILITY MATRIX

	Resource Availability Local	Resource Availability Commercial	Transportation and/or Transmission	Associated Impacts of Resource Use	Composite Score
Solar:					
Active	**0**	**0**	**2**	**2**	**1.0**
Passive	**1**	**0**	**4**	**3**	**2.0**
Hydro:					
Run of the River	**1**	**0**	**1**	**0**	**0.5**
Ocean Wave (for QIR)	**0**	**1**	**0**	**2**	**1.0**
Wind:					
Small-scale	**1**	**0**	**3**	**2**	**1.5**
Large-scale	**0**	Unknown	Unknown	Unknown	unknown
Biomass:					
Local Wood Waste	**4**	**1**	**4**	**3**	**3.0**
Peninsula Wood Waste	**3**	**4**	**3**	**4**	**3.5**
QIR Solid Waste	**0**	**0**	**0**	**2**	**0.5**
Grays Harbor Solid Waste	**0**	**3**	**3**	**4**	**2.5**
QIR Sewage Treatment Plant	**1**	**0**	**3**	**2**	**1.5**
Stranded Wells	**1**	**3**	**4**	**2**	**2.5**
Conservation:					
Conservation	**4**	**0**	**4**	**4**	**3.5**
Efficiency Increases	**4**	**0**	**4**	**3**	**3.0**

Ratings are based on a 0 through 4 scale. 0, no capacity for use; 1, poor; 2, good; 3, very good; 4, excellent.

III. Findings and Evaluation

This evaluation weighs the potential of the production of energy from renewable resources to meet the needs and goals of the QIN in two very distinct areas. The first area is energy for on-site use and the second is energy for the commercial market. In researching renewable energy potential to meet on-site needs, the goals are to save costs, to attain self-sufficiency, and to enhance the quality of life on the QIR. In the area of commercial development, the primary goals are job creation and income to enhance the quality of life of the Quinault Nation. These distinctions require separate analyses.

A. Energy for On-Site Use

Energy needs on the QIR are small and local to two, or possibly three sites. This demand must be met with capital subsidies and operating costs at, or lower than, the present cost of energy from the grid. Any potential systems, and the resources from which the energy is to be produced, must be controlled and managed by the QIN. The system and resources must be developed and used within the context of the high environmental and cultural standards established by the QIN and federal environmental policies.

<u>Findings</u>

a. Wind, biomass (wood and other waste), water (ocean), solar (active and passive), and "conservation" renewable resources exist on the QIR.
b. Water (river and ocean) and solar (active and passive) resources are not viable for renewable energy production on the QIR. A viable wind resource for the QIR has not yet been identified.
c. An environmentally attractive, but non-renewable energy source – natural gas – exists on the QIR.
d. Wood is the only resource that has been proven to exist on the QIR in quantities that could meet the reservation's energy needs.
e. The available technologies to use these resources vary widely in terms of cost, load-matching capabilities, and productivity.
f. The main driver of increased energy need on the QIR is population growth which has historically been slow. There are no present plans for large-scale development that would alter this dynamic. This suggests energy needs will increase in a slow and steady manner.
g. Present QIR energy needs are approximately 1 MW, the needs projected to 2025 do not exceed 2 MW. Since a disproportionate amount of this need is for heating, monthly requirements vary widely.
h. The QIN has little capacity to finance energy production for either on-site or commercial production. For purposes of this study, it will be assumed that all financing will come from outside sources or from project revenue.
i. Grant sources available to the QIN for funding capital development are in the low six-figure range. These funds would only be sufficient for funding small-scale, non-commercial development.

These findings and the QIN's goals for this project suggest that the following criteria be considered for the potential development of the available resources.

- Technical Feasibility: The chosen technology must provide high quality energy that matches the load requirements of the QIR.
- Environmental and Cultural Compatibility: Development of the system should have little or no environmental impact. The chosen technology must meet federal air and water quality standards, and present no hazard to endangered species. Development of the system should have little or no cultural impact, and be consistent with cultural values, including sustainability, communal natural resource procurement, and respect for natural cycles.
- Financial Viability: The costs associated with the system and resource procurement should be equivalent to current energy costs.
- Economic Development Potential: The QIN must be able to maintain control of the resource and manage its procurement. The energy conversion system will be owned, managed, and operated by the QIN. The system should also be labor intensive rather than machine intensive to foster local economic growth.

This study began with the common assumption that there are many renewable resources available on the QIR. In order to make a clear assessment of this assumption for production for on-site use, we generated sketch "plans" to serve Queets and Taholah with solar, wind, water, or biomass alternatives. Once we focused on these sites, it became clear that sources for renewable energy production are limited. The small scale of the demand, coupled with large transportation or transmission costs, altered economic considerations dramatically. All possible solar and hydro resources were found to be insufficient for use on the QIR. Transmission and transportation constraints made the use of wave energy impractical. These constraints leave biomass and conservation as viable options, and wind as a possibility dependent on future verification of the resource.

Biomass:

Technical Feasibility

The use of biomass to meet the energy needs of the QIR has two distinct advantages. First, the resource is readily available. As stated in the previous section, biomass is an abundant natural resource on the QIR. Second, the energy in biomass is stored in a form that can be used at any time. Unlike other renewable resources whose availability may be seasonal or weather-dependent, biomass can be converted into electrical energy to match the energy needs of the QIR as they vary from day to day and seasonally.

There are two groups of technologies available to produce electrical energy from biomass. The first is a well-established technology, burning wood to provide the heat for a steam turbine. The second is a newer technology that uses pyrolysis to heat wood to produce a biofuel and other byproducts. Pyrolysis is a process in which wood feedstock is flash-heated to separate the molecules, then reconfigured to produce a biofuel and charcoal. Burning the biofuel in a generator or turbine produces electrical energy. Both technologies generate heat as a byproduct. This heat can be used in local buildings thereby increasing the efficiency of the conversion process.

Both of these technologies can be scaled to suit the needs of local communities. Separate systems could be built in Taholah and Queets to reduce transmission costs. Reduced transmission has the added benefit of preventing prolonged power outages due to falling debris along isolated parts of the transmission line.

Environmental and Cultural Compatibility

The environmental impact of using biomass to produce electrical energy depends on the proper procurement of the resource and the chosen conversion technology. Continuing with the QIN's existing sustainable forest management, the biomass can be harvested with minimal environmental impact.

Air Pollution and particulate emission are concerns on the reservation because the Environmental Protection Agency, the Federal Government, has to permit any technology that exists on the reservation. Machines that have excessive emissions might not be permitted. The particulate emissions can be controlled by technically advanced filters, and are greatly reduced in the pyrolysis process. In such a small operation, deforestation should not be issue. In fact, the use of the waste biomass resulting from commercial activities and thinning for forest safety to create energy is a more efficient use of the resource than is now employed.

Financial Viability

The cost per kWh of biomass conversion technologies increases with decreasing scale. This factor would have to be weighed against the advantages imparted both by decreased transmission and by cost-savings associated with the use of waste heat when sizing a system or systems for the QIR.

The cost of transporting the biomass could be approached in two ways. One, the production of biofuel could be located at a site convenient to timber harvesting operations. The necessity of transporting wood would be reduced substantially. The biofuel itself is a fraction of the volume of the wood it takes to produce it so it can be transported with relatively little cost. Two, a complete biomass operation could be set up at two, even three locations. This would reduce the size of the wood circle necessary to support each site by 50% to 65%, reducing transportation costs proportionately. In the long term, the transporting vehicles can also be retrofitted to run on biofuel, reducing the out of pocket expenses to the QIN.

Economic Development Potential

Wood biomass has the potential to generate jobs and/or cottage industry opportunities on the QIR. This potential stems from the need to produce and harvest biomass, as well as to operate and maintain the machines. Members of the Nation, some of whom already possess many of the required skills, could capture the money spent on operating costs and maintenance.

Conservation:

Technical Feasibility

The technologies available to promote conservation are numerous and well established. New types of thermostats can be programmed to only heat buildings when required. Compact fluorescent light bulbs are inexpensive and widely available. Efficient appliances are clearly marked with the energy star logo to inform consumers.

Environmental and Cultural Compatibility

Conservation has only positive environmental effects, reducing the impacts from electricity generation. It also complements the QIN's commitment to sustainability. Conservation is the highest manifestation of the cultural value of making the fullest use of whatever is taken from nature.

Financial Viability

There are many conservation programs that are cost-effective. An investigation of how programs used in other communities would operate on the QIR should be enough to ensure financial viability. The QIN currently receives conservation funding from BPA. There is potential for more funding from this source.

Economic Development Potential

Conservation does have some economic development potential. Weatherization and rehab programs can make use of the skill sets of QIN members on the QIR. Appliance replacement and disposal programs could create employment as well. Conservation and salvage are labor intensive.

Wind:

A suitable wind resource is not known to exist on the QIR. If a suitable resource were found to exist, its potential for development rests on these factors.

Technical Feasibility

Wind turbines are a proven and reliable technology. Wind turbines require little maintenance and are available in a number of sizes to meet the energy needs of the owners. The drawback lies in the variability of the wind resource. Because the wind resource does not always match the energy needs an energy storage system is required to take full advantage of wind turbine technology. Such a system adds another layer of complexity and cost to the installation.

Environmental and Cultural Compatibility

Small-scale wind turbine developments such as would be required on the QIR have minimal environmental impacts. There are no emissions or toxic chemicals associated with wind turbines. Potential impacts on wildlife are site-dependent, and a thorough investigation of the local avian population should be carried out before siting a wind turbine.

Aesthetic issues should also be considered when installing wind turbines. Wind turbine installations in other areas have met resistance from local landowners opposed to the impact a wind turbine or turbines would have on the view. A public hearing as part of the permitting process can help to placate opposition.

Financial Viability

The cost-effectiveness of a wind development depends on the area's wind resource, the scale of the development, and factors such as the production tax credit. Maintenance costs are low, but initial capital investment is high. The addition of an energy storage system could potentially double the initial capital cost. The need for an initial large investment is a disincentive to the use of this technology on the QIR.

Economic Development Potential

The development of wind energy does not generate employment, nor is it likely to generate cottage industry on the QIR. Almost all the cost of wind energy is in the machinery and construction. The machinery is mass-produced elsewhere, and construction jobs associated with the installation are temporary.

B. Commercial Energy Production

Commercial energy production is defined as production that yields enough energy, or fuel, to support a large-scale project for commercial sale of the end product. Goals, criteria, scale, and working assumptions change dramatically upon entering the world of commercial enterprise. The cost/benefit ratio must be higher than that required for an on-site project. Also, the size of the project is no longer determined by local need, but by market factors. No known resource located on the QIR is available in large enough quantities to support commercial development. However, wood biomass and methane resources available to the QIN, but not located on the reservation could support commercial development.

These findings are the foundation for assessing opportunities for commercial development:

a. Any commercial energy development would require partners (or customers) willing to finance or support the financing of the entire project.
b. There are significant subsidies for production of renewable electrical energy accessible to the QIN.
c. Biomass resources associated with and available to the QIN exist at commercially attractive levels outside of the QIR; these include wood, solid waste, and possibly natural gas resources.
d. The QIN has established a relationship with Prometheus Energy Company, a company technically and financially capable of the commercial development of methane gas derived from solid waste and hydrocarbon resources.
e. The Bonneville Power Administration (BPA) has identified the development of a fuel-based source of energy as the alternative of choice for meeting their needs for back-up power on the Olympic Coast. BPA has a preference for biofuel. ("Assessing Biodiesel in Standby Generators for the Olympic Peninsula," Bonneville Power Administration, July 2004).
f. The pressing need for the production of 30 to 40 MW of electrical energy on and for the Olympic Coast could create a special, sub-market where premium prices would be paid for the local production of energy. Flexibility and low capital costs would be of high value for this market.
g. The QIN/QIR is part of a regional electricity market defined by BPA and characterized by an abundance of low-cost hydroelectricity. The low cost of energy is a significant barrier to the development of renewable electrical energy.
h. The QIN/QIR is part of a regional fuels market with relatively high fuel prices. The local fuels market varies with the regional market, although prices tend to be higher than the average due to costs incurred in transporting the fuels to the peninsula.
i. Commercial production of fuels could generate moderate ongoing employment.

These findings support these criteria for evaluating QIN opportunities for commercial development.

- Technical Feasibility: The resources available to the QIN must be sufficient to produce electricity or biofuel in the quantities necessary to enter the commercial market. The technology used to create the electricity or biofuel and to transport the energy product must be readily available.
- Environmental and Cultural Compatibility: Development of the system should have little or no environmental impact. The chosen technology must meet federal air and water quality standards, and present no hazard to endangered species. Development of the system should have little or no adverse cultural impact, and be consistent with cultural values, including sustainability, communal natural resource procurement, and respect for natural cycles.
- Financial: The costs associated with the system and resource procurement should be consistent with other commercial renewable energy developments. Opportunities for financial partners are necessary for the financing of the project.
- Economic Development: The QIN must be able to participate in the control of the resource and management of its procurement. The QIN must be able to participate through partial ownership of the system, and include management and operational responsibilities. The system should also be labor intensive rather than machine intensive to foster local economic growth.

Wood Biomass:

Technical Feasibility:

Wood Biomass on the QIR is not sufficient to support commercial development of either electricity or biofuel. The wood biomass on the QIR is sufficient to provide significant leverage in attracting a facility that would use this resource along with other available resources. Wood biomass on the Olympic coast along Highway 101 exceeds by a wide margin what is necessary for commercial development. The resources on the QIR, along with the favorable location of the QIR adjacent to major forest products facilities, place the QIN in a good position to utilize the coastal biomass resources.

The technology to use this resource commercially exists. It is larger versions of the technology available for on-site production. At the commercial level, the technology of burning wood to produce steam is more viable than it is for small-scale production.

Environmental and Cultural Compatibility

As was indicated in discussing the use of wood biomass on the QIR, there are environmental benefits from using waste wood. In addition, the development of this industry would stimulate better timber management practices throughout the coastal region. It could support the QIN in increasing commercial thinning on the QIR.

Financial Viability

The capital investment required for steam generation of electricity or the processing of biofuel is comparable. Both require less of an initial capital investment than wind energy. The facilities necessary to convert biofuel to electricity would push capital costs closer to those of wind. Biomass conversion technologies have significant operating and maintenance costs. This makes them significantly more costly annually than wind. These cost factors are relieved in so far as the value of the heat generated by biomass facilities can be used. The higher costs of obtaining and processing wood biomass make direct conversion to electricity economically infeasible.

The creation of biofuels from wood, however, is economically feasible due to the higher value placed on the biofuels. The value of the fuel obtained from the same amount of wood is two to three times the value of the electricity in today's market. If the biofuel were then used to produce electricity, it may still be more valuable than using wood to directly produce electricity. The flexibility of the biofuel and the peculiar electrical energy needs on the coast mean that biofuel generators do not need to be in constant operation. They can be used effectively as a backup source of energy, a specialized market acutely needed on the coast. Steam plants cannot be used to meet this market because the energy facility requires a significant amount of time to begin electricity production. The cost effectiveness of steam plants varies with their use; they are only effective if they are used consistently.

The Bonneville Power Administration (BPA) has strong reason to be interested in the development of a biofuel project on the Olympic Coast. A BPA study has indicated that it is the best option for the development of back-up energy generation for the coast. BPA could be an ideal partner for the QIN. They have ample financial capacity for development, and they would be a large and steady consumer of the biofuels produced by the project. The fact that they are a public agency with a mission compatible with the goals of the QIN would support a positive relationship.

Economic Development Potential

The commercial development of energy from wood biomass has very good potential for job creation. The high and constant demand for wood would be a very strong foundation for supporting employment and/or cottage industries in waste wood recovery and processing. These jobs would be very compatible with the present QIR work force.

Methane Deposit Development:

Technical Feasibility

Assuming the application of a technology that converts methane into a valuable commodity (liquid natural gas), commercial possibilities exist for the use of methane from natural seeps. The use of methane to produce electricity in the Pacific Northwest has been proven impracticable again and again, but Prometheus Energy Company has designed and field-tested a technology that converts methane into CO2 and Liquid Natural Gas (LNG). CO2 is marginally valuable, and LNG has significant value.

Environmental and Cultural Compatibility

Although this resource is not renewable, it is a clean-burning fuel with few environmental impacts.

Financial Viability

This study has identified natural gas deposits that could be effectively used through the Prometheus Energy Company's technology in the Quinault region. It is possible QIR deposits could be used by Prometheus. The QIN is in a position to play a significant role in developing this resource. Prometheus has been identified as a partner by the QIN Economic Development Committee, and has the financial and technical capacity to develop and manage this resource.

Economic Development Potential
The development of this resource would not create significant employment. The great advantage to the QIN in participating in development of this resource is that the profits could support renewable energy development projects.

Methane from Solid Waste:
Technical Feasibility
As of October, 2004 there are 370 landfill gas energy projects operating in the United States with more than 610 more in the planning stages. (Source: EPA LMOP) The methane can be used to generate electricity or as a transportation biofuel. Both of these uses take advantage of existing conversion technologies.

Environmental and Cultural Compatibility
Promoting full use of materials not only has high environmental value, it has high cultural value. It manifests the conservation of resources and materials and the full realization of the benefit of something taken from nature.

Financial Viability
Methane from solid waste is potentially available, but tapping into this resource is a long-term, complex project. The possibility of a project to recover this resource depends on an economic factor unrelated to renewable energy. Solid waste removal in Grays Harbor County is inefficient and costly because it is being transported hundreds of miles to a waste collection facility. The high cost of transporting this waste makes developing a waste dump in the area highly attractive. At this point in time, siting and developing a new waste facility has been stymied by the high capital costs associated with developing a new dump, along with objections based on odor and other undesirable conditions associated with waste disposal. The development of not just a new, but a new kind of waste management facility is a good answer to these problems that should seriously be considered. Potentially useful and marketable products can be separated from the waste stream. The separation of these streams and the use of anaerobic digestion would reduce the odor associated with such a facility and other environmental concerns such as air and water pollution. These factors could make such a development an economic plus for the entire region.

Economic Development: If the QIN could capture the "franchise" for the development of such a facility, it would have significant potential for job creation. This new kind of waste management is highly labor intensive. Added to present collection and transportation jobs, the work of separating, processing and salvaging a great deal of material would increase the number of jobs available. There would also be new work in management and marketing. Much of this new work could be developed as a cottage industry or small business.

While a project based on this resource would have great benefits, there is not a clear partnership for such a development. Besides the QIN, this development would be in the interests of the other governmental agencies that collect solid waste and the LeMay Corporation, which manages solid waste for the entire coastal area. To initiate the process one or more of the interested entities has to act to catalyze this interest into a partnership. Possible keys to catalyzing such a partnership are finding a location for an advanced solid waste management facility and/or finding a funding source to provide significant support for developing such a facility. By taking on the role of catalyst, the QIN could capture many of the job creation benefits.

IV. Conclusions and Recommendations

Conclusions and recommendations fall in three areas: development of a sustainable energy plan for the QIR, options for commercial development, and goals for the continuation of this study.

A. Development of a Sustainable Energy Plan for the QIR

Recommendation #1: Expand current conservation programs and launch new programs to replace old appliances and space heaters. Offer a stand-alone weatherization program to all eligible residents regardless of who owns the housing. Offer the refrigeration replacement program as widely as practical to enhance is economic benefits.
Approach:
Stand Alone Weatherization Program – Currently the Weatherization Program operated by the QIN is administered in combination with the home rehabilitation program. This is an effective way to combine these funds and ensure a high level of energy efficiency work in rehabilitation projects. However, it does not provide weatherization to homes that are not currently undergoing rehabilitation. Given that rehabilitation is considerably more expensive than weatherization, the number of projects completed in any given period is less than what would be completed if a stand-alone weatherization program was also available. If a stand-alone weatherization program – one that made energy efficiency investments in homes without accompanying investments in major rehabilitation – was available, the number of dwellings weatherized could increase substantially. This would mean lower energy bills for these households, and lower energy consumption overall for the QIN. In conversations with Bonneville Power Administration, the possibility of increased weatherization funding seemed likely, in the event that the QIN demonstrated a need and desire for increased weatherization activity. We recommend that the QIN consider implementing a stand-alone weatherization program to go along with its present weatherization program. The project team would be available to assist in this effort.

Refrigerator Replacement Program – An effort to replace inefficient refrigerators represents an enormous opportunity for both energy and cost savings. Spokane Neighborhood Action Programs (SNAP) developed and implemented a refrigerator replacement program which achieved high cost-effectiveness, and could serve as a model for a similar program on the QIR. The design of the program is simple and efficient – old units are metered and energy wasteful units are replaced – and results in high energy savings. The SNAP program relied on outside vendors for old unit disposal and new unit installation, simplifying administration. The average savings was 1860kwh/year per unit. Savings per unit ranged from 1000kwh-3000kwh/year. Metering units prior to replacement and replacing with a highly efficient model guarantees energy savings are realized as projected. This high level of savings and savings certainty make this conservation investment very attractive to utilities and weatherization funders. At SNAP the program also provided homeowners with conservation education and low cost energy saving materials (compact fluorescent light bulbs, weather-stripping, etc.), which provided an additional benefit to participants. We encourage the QIN to consider developing a refrigerator replacement service, and would be available to assist in design and implementation. This program could be integrated with the existing solid waste management program.

These two approaches have these advantages:

- They build on existing QIN programs, facilitating their implementation.
- The fact that existing programs are highly respected would enhance the attractiveness of these new programs for grant sources.
- The new programs would generate new jobs and/or opportunities for their cottage industries on the QIR.
- The refrigeration enhancement program would build the QIN recycling program, creating a stepping stone toward a large-scale reuse/recycle/energy production solid waste effort.

Recommendation #2: <u>This study recommends the QIN install an energy conversion system based on the creation of biofuels from wood waste biomass.</u>
Approach: The establishment of a wood biomass/biofuel system has three components:

1. The development of stand-alone generating systems for both Queets and Taholah and, possibly, for the new housing south of Taholah or similar future centers. This approach has several advantages.
    - It reduces transportation costs.
    - It creates well-defined projects that can be funded through a series of grant proposals.
    - It provides a way to attain concrete results at an early stage of the development process.
    - Finally, it provides on the ground tests of the system and plan before the QIN is totally committed. Construction of a pilot system will facilitate QIN mastery of the technology and pinpoint potential problems.
2. The incorporation, as distinct units, of wood harvesting and processing, conversion of wood biomass to fuel, and generators designed to run on biofuel. The advantages to this approach are:
    - It reduces the risk involved in adopting a new technology, because it utilizes old "tried and true" technology such as wood chippers and electrical generators for much of the system.
    - It more fully realizes the potential of the QIN skill base, as that skill base is familiar with the older aspects of the technology.
    - It reduces capital costs both by allowing purchase and/or conversion of used equipment and by reducing transportation costs.
    - This kind of division would favor the creation of a "cottage industry" by making it easier to develop straightforward, manageable contracts.
3. The design and implementation of a system that can be realized incrementally over a period of years to defer initial costs. This will allow:
    - The formation of capital over time, facilitating increased grant funding and maximizing the use of revenue from the project as capital.
    - Greater precision in putting the parts of the project together, minimizing waste, and in creating the partnerships necessary to successful implementation, especially with Grays Harbor Public Utilities District.
    - Greater opportunity to make adjustments thereby decreasing financial risks

Conclusions: The acquisition of the biomass technology is within the financial capacity of the QIN. Members of the QIN have experience with major elements of such a system – harvesting and processing wood and using and maintaining electrical generators. The technology, which processes biofuel from wood, is operational elsewhere in North America, and is easily transferable to this application. This energy conversion technology also has a relatively high potential for job creation for the QIN. Finally, the technology allows for incremental development of the system in response to changing energy requirements.

There are two alternatives to the approach recommended here. The first alternative is to choose new technologies that integrate several functions, such as processing wood into biofuel and the generation of electricity. This alternative is feasible, but was rejected because the technology is less tested, it is less compatible with job creation, it is not as efficient as the other technologies, and generates less opportunity for cost saving. It could in time become easier to use and cost effective. The other alternative is to fold development of small-scale wind technology into the plan. This was rejected because further extensive study is required to prove that a sufficient wind resource exists to support an appropriate system for the QIR. In our view, the outcome of such a study is too uncertain to justify the potential benefit it could generate.

B. Options for Commercial Development

There are five options for commercial development of energy which emerge from this study. Three options are based on provable resources: biofuel produced from wood biomass, biofuel produced from solid waste, and biofuel produced from natural gas. Two options, wind and wave energy, have unproven resources. The two options that are not based on proven resources obviously need further study before they can be recommended for a feasibility analysis. One of those options, wind, will be further examined in this report. Our partner, WorldWater Corp, is examining wave energy. Of the three options based on provable resources, two options could be developed in the near time frame: biofuel from wood biomass conversion and development of natural gas deposits. Biofuel from solid waste is a longer-term proposition. Of the two short-term prospects, only one of the options – biofuel from wood biomass – is a renewable energy option. We recommend that the QIN act on all three of these biomass options.

Recommendation #1: <u>This study recommends, as the preferred option for commercial development, that the QIN move to establish a Quinault Wood Waste Biofuel Project.</u>
Approach: We recommend that this enterprise be initiated by the development of facilities to produce biofuel from wood, possibly supplemented by food waste. Exploration of the potential to create an integrated forest products facility which is synergistic with a wood biomass/biofuel processing plant is also highly recommended. This option would integrate the production of various products from wood including biofuels from several sources into a unified production system. This option has four key elements:

- Creating a commercial scale wood biomass to biofuel processing plant on a suitable site off Highway 101, near the QIN Salaw Building.
- Creating an advanced wood processing facility on Highway 101 that could include any or all of the working components needed to prepare the wood for a biofuel processing plant.
- Co-locating the biofuel facility with a mill, wood drying operations, and/or a log sort yard. Other facilities that could benefit from the availability of heat or energy onsite could also be considered. Partners, particularly a local mill operator would be required for co-location.

- Identification of consumer partners that would be immediate users of the biofuel such as a BPA energy facility and/or fleet of vehicles willing to convert from diesel to biofuel. This development would require the creation of several key partnerships. Primary possibilities for partners are BPA, Grays Harbor PUD, Grays Harbor County, and one or more local forest products operations. Federal and other governmental agents are possible partners as well.

The co-development of a wood waste biomass facility with other forest products facilities has many advantages. Some of these are:

- Co-development with associated economic functions takes best advantage of the strengths of biomass based technology – its flexibility and the heat it generates.
- It has proven to be a key factor in the profitability of other biomass projects around the region; the greater the use of heat the better the cost/benefit ratio.
- It will greatly enhance the access to the Highway 101 resource stream, insuring that the QIN can more easily purchase or develop off-QIR biomass at affordable prices.
- Co-development of a significant facility will allow the QIN to leverage greater job creation as well as to attract the partners it needs to make development possible.
- It creates a project which is more attractive to potential grant sponsors.
- It is the best approach open to the QIN to achieving a consistent high quality supply of biofuels at a volume that would put it in a strong position to effectively market the product.
- Development of a fully integrated project proposal and pursuit of a sustainable forest products center would generate the most favorable cost/benefit ratios for each of its components, including the wood biomass/biofuel facility.

Recommendation #2: <u>This study recommends the QIN promote the development of a state of the art solid waste management facility for the Grays Harbor region.</u>
Approach: The QIN is in a unique position to open the discussion of the present issues challenging solid waste management in the Grays Harbor region. First, the QIN is a partner in the present system. Second, the QIN owns and manages land that could be suitable for development as a solid waste management facility. Third, it has access to a partner – Prometheus Energy Company – that could significantly enhance the economic viability of a new solid waste facility, at the same time it reduces major environmental liabilities (odor and greenhouse gas emissions). Fourth, it has an interest in and a capacity to take advantage of the employment/cottage energy potential of a solid waste management facility. The QIN should act on these advantages by initiated and leading the exploration of the development of a new solid waste management facility and infrastructure. The QIN can do this by:

- Convening or supporting the convening of a dialogue among the present partners to discuss outstanding solid waste management issues, particularly the high cost of exporting solid waste.
- Partnering in a proposal to study the feasibility of a new solid waste management facility/system.
- Using its access to land to leverage a key role for itself in the development project and the management of the facility and the system.
- Seek grants to enhance the QIN's ability to take advantage of the job and business opportunities generated by the project.

The approach has significant advantages:

- The QIN can take the best advantage of the one resource it can bring to the table (land) and the fact it has a working relationship with Prometheus Energy Company.
- The job creation/business opportunity potential of this is higher than any other possibility studied.
- This project would integrate well with the other projects recommended in this Scoping Study, particularly the natural gas project.
- This project could attract substantial grant funding.
- The QIN has already established programs and skills that are important to a new solid waste facility and system, even though current QIN operations are in a much smaller scale.

Recommendation #3: <u>This study strongly recommends the QIN partner with Prometheus Energy to produce liquid natural gas (LNG) from methane deposits.</u>
Approach: As a non-renewable source of energy, it is not appropriate for further consideration in this study. This study recommends that this option be placed on the appropriate track and that the QIN quickly move forward in exploring its potential. This can best be done by the QIN cementing its partnership with Prometheus Energy and proceeding with a joint feasibility study. There is state and federal funding for such a study. Commercial development of this resource could have benefits for future renewable energy development because:

- The development of this resource could provide a financial engine for renewable energy development on the QIR.
- The development of this resource would provide the QIN with experience and a track record in the energy business.
- The development of this resource would have a positive impact on the local and regional energy market.
- The fuel produced by this project could be used as a backup resource and, thus, insurance for renewable biofuel development

Conclusions:
Either as the centerpiece or a stand-alone project, a wood biomass to biofuel facility is the clear choice for QIN commercial development of a renewable resource in the short term. The reasons for this conclusion are:

- Wood biomass is the only renewable energy resource clearly available to the QIN in commercial quantities.
- Biofuel technology is compatible with the goals for energy development set out by the QIN.
- Biofuel serves the potential markets open to the QIN.
- The present and predicted future trends in the market value of biofuels offer the best chance for profit.

In order to complete such a project the QIN must complete a design and plan for a system that takes best advantage of the technology and resources available, obtain funding to develop the system, and implement project construction and operation. The development of such a project will not be easy but, as shown here, has very real advantages to the long-term, sustainable economic development of the QIN.

The pursuit of a wood biomass to biofuel project should not overshadow the aggressive exploration of a solid waste project incorporating energy production. While this option is at a more preliminary stage than the wood biomass options, its promise – particularly its potential for job creation – dictates action to determine if it is feasible. Key to this determination is whether or not the LeMay Corporation, Prometheus Energy Company, jurisdictions and agencies of state and local government would join in exploring the feasibility of such a project. If and when an appropriate partnership is consummated, the QIN should proceed with a feasibility study. Perhaps the best starting point for pursuing this option would be to join with Prometheus Energy Company in approaching the LeMay Corporation.

Continuing This Study.

This report completes the first of the three stages of the Quinault Indian Nation Renewable Energy Feasibility Study. The project plan calls for a second stage of intensive environmental assessment and a third stage of assessment and pre-business planning. These stages are to be focused on "best options" for further study. We recommend the following selections as "best options" to be studied in the next stages of this feasibility study:

1. QIR Sustainable Biomass Energy Project. We propose to create a five-year plan for achieving the QIN goal of becoming self-sufficient in energy. This plan will be based on a system of small-scale electrical generators located in Queets and Taholah. They will burn biofuel produced on the QIR and be located where their heat by-product can be used. Their development will be integrated with the ongoing QIN construction, rehab, and weatherization programs and, if feasible, the development of the QIN waste treatment lagoon. The Stand Alone Weatherization Program and the Refrigerator Replacement Program would also be a part of this plan.
2. QIN Biofuel Energy Project. We propose to create a prospectus for a biofuel project that will integrate the development and marketing of the production of biofuels by the QIN. This prospectus will be created for the purpose of approaching possible partners and potential grant sponsors. This study will explore several options for producing biofuels and marketable by-products and the associated industries such as solid waste management. Our goal is to generate the support the QIN needs to explore its full potential for the production of marketable biofuel.
3. QIN Wood Biomass Processing Plant. We propose to study the development of a wood biomass/biofuel facility on Highway 101. This study will focus on "best" technologies. The study will determine the cost/benefit ratio of such a facility, locate other sources of biomass for use in the facility, identify appropriate funding sources, and develop a financial strategy. Our objective is to define a specific biomass project which will meet QIN goals and is feasible for the QIN to pursue.
4. QIN Solid Waste and Renewable Energy Project. We propose to undertake a pre-feasibility study of the possibility of the development of a "state of the art" solid waste facility. This study will describe the potential benefits of such a facility based on experience elsewhere. It will outline the economic and environmental considerations involved in developing such a facility. Our end product will be a prospectus, which could

be used by the QIN in further exploring this opportunity.

In addition, we recommend:

5. QIN Natural Gas Project. The QIN should work with Prometheus Energy Company to develop, fund, and implement a study that fully explores potential uses of its natural gas resources.
6. QIN Wind Study. High tower wind measurement instruments should be dedicated to fully examining the wind resource at a possible commercial site. We believe the best site for study is a site southwest of Queets, in a high, clear coastal area. If such a study demonstrated a commercial wind source, the QIN should move to secure and create a wind energy “reserve” for future development.

These five studies will collectively provide the foundation of a QIR Renewable Energy Development Plan, which is the end product of this project.

V. NEXT STEPS

The Renewable Energy Feasibility Study, upon QIN review and approval of this Scoping Report, will:

- Form study teams for the QIR Sustainable Biomass Energy Project, the QIR Conservation Plan, the QIN Biofuel Energy Company, and the QIN Wood Biomass Processing Plant. Ideally, these teams will include QIN members and staff.
- Facilitate Prometheus Energy Company and QIN partnership. Create appropriate liaison relationship.
- Create detailed work plans for the several “projects”.
- Implement the work plans.
- Focus environmental assessments on specific development proposals.
- Incorporate project work into the development of an overall QIR energy plan.
- Continue to explore and develop possibilities of wind for commercial use.

TECHNOLOGY APPENDIX:

I. WIND

Currently available grid-tied wind turbines are rated to produce anywhere from 1 kW to 1.8 MW of electricity. A 1 kW wind turbine will produce only enough electricity to power a few home appliances while a 1.8 MW wind turbine can provide the electricity for a small community. There are several factors that determine what size and type of wind turbine is appropriate for a site. The first determining factor is the wind resource. Smaller wind turbines will perform relatively well at lower wind speeds while larger turbines require strong, steady winds. However, small wind turbines do have a major drawback. The smaller the turbine, the less efficient the system is. The cost effectiveness of wind turbines declines dramatically.

In almost all cases, horizontal axis wind turbines, such as those commonly used today, will perform better than vertical axis wind turbines. This is due to the area of the sky encountered by the wind turbine blades. The bigger this “swept area” the more energy the turbine can take from the wind. Vertical axis turbines have smaller swept areas and are only appropriate for very high wind sites where turbulence is a problem.

While assessing the wind resource, environmental issues, permitting requirements, and utility restrictions should be considered. The presence of migratory birds or endangered species can make the permitting process much more difficult. The federal government regulates these environmental concerns, especially endangered species. The QIN is subject to these regulations.

State and local governments have substantial regulatory authority, particularly for land use. These requirements have created substantial problems for the wind industry in other areas. Since Indian nations are not subject to these regulations, this could make the QIN an attractive partner for a large-scale wind energy producer. Utilities also vary in their net metering policies and their motivation to work with wind projects. These issues are better addressed early so they do not present stumbling blocks later in the process.

Once the turbines appropriate for the site’s wind resource are identified, the load which the electricity will be used to run must be established. If the turbine were to offset the electricity use of a single residence, than a small turbine producing between 1 and 30 kW would be appropriate. To produce the electricity required by a community, a much larger turbine is required. Depending on the size of the community anywhere from one 250 kW turbine to several 1.8 MW turbines may be needed. These larger turbines are also a possibility for a commercial-scale generating facility.

The turbine’s specifications and the site’s average wind speed will determine the capacity factor of the wind turbine. Because the strength of the wind varies, the amount of electricity that a wind turbine produces will also vary. At low wind speeds a 10 kW wind turbine may only produce 2 kW, and at even lower wind speeds may not produce any electricity. If the wind turbine’s production is averaged over the entire year the resulting number divided by the rated capacity gives the capacity factor. If the average output of a 30 kW turbine is 8 kW the capacity factor is, 8 ÷ 30 or 27%. This number can then be used to estimate the proper sizing of a turbine. If the average load is 8 kW the 30 kW turbine will work well, but if the average load is 30 kW a much larger turbine is needed. The capacity factor is important to consider when choosing a turbine.

The next factor to consider is cost, and the effect of economy-of-scale on the project. As stated in the table below small wind turbines can cost as much as $10/Watt to install while large turbines can be as little as $1.50/Watt. Refurbished turbines can bring the cost down even further, but the O&M costs on these machines may outweigh the initial cost-savings. The availability of initial capital costs will, in most cases, significantly narrow the field of appropriate wind turbines. The table below is by no means exhaustive, but does provide a framework in which to discuss project costs.

Table Comparing Wind Turbine Costs

Manufacturer	Model	Approx. System Cost	Approx. Installed Cost	Approx. Installed Cost, $/W
African Wind Power	AWP 3.6, 1kW	$6,190		
Southwest Wind Power	Whisper Link, 1kW		$10,000	$10.00
Bergey	XL-10, 10kW		$40 - $50,000	$4.50
Jacobs	20kW	$33 - 37,000		
Fuhrlander	FL 30, 30 kW		$131,000	$4.37
Atlantic Orient Corporation (AOC) (becoming Entegrity Wind Systems)	15.50, 50 kW		$150 - $160,000 Canadian	$3.10 Canadian
Energy Maintenance Services – remanufactured Vestas	E-15 65 kW		$75 - $80,000	$1.19
Fuhrlander	FL 100, 100 kW		$360,000	$3.60
J.P Sayler and Associates – refurbished Vestas	V-27, 225 kW	$146,000		
Fuhrlander	FL 250, 250 kW		$536,000	$2.14
Fuhrlander	FL 800, 800 kW		$1.4 million	$1.75
Fuhrlander	FL 1000, 1 MW		$1.5 million	$1.50

II. METHANE

Prometheus Energy Company: "The technology licensed by Prometheus has been successfully proven for the conversion of both landfill gas ("LFG") and gas from stranded wells into LNG. An pilot-scale system for conversion of LFG to LNG was successfully designed, manufactured and installed by CryoFuel at a municipal landfill in Victoria, B.C. in November 2000. The system operated as an experimental system during most of 2001. That system successfully purified and liquefied the methane component of a complex LFG mixture into high purity LNG.

"This project led to the design and manufacture of a stranded gas well-to-LNG system with a capacity of 5,000 gallons per day. This system was designed to process gas from a stranded well with various components such as nitrogen, ethane, propane, and small amounts of carbon dioxide, into LNG containing >97% methane. That system was installed at a stranded gas well outside of Sacramento and has produced over 300,000 gallons of high purity LNG." The Prometheus technology also produces about 10,000 tons of CO_2 a year. Both these products are marketable. Prices for LNG vary with the price of diesel. CO_2 brings in anywhere from $30 to $60 dollars a ton.

The value of both the LNG and CO_2 is driven both by costs and the accessibility of markets. The costs of producing these products from stranded wells are low and stable relative to other sources of methane. Producing LNG and CO_2 from landfill gases is moderately higher in cost. Producing LNG and CO_2 from an anaerobic digester is high in cost. Capitalization necessary to capture this resource is high, about 7 million dollars.

The QIN could have a stake in saleable methane and the land required for production. The value of these resources depends on the relationship with Prometheus or a like producer. These considerations are discussed further in the economics section.

III. Biomass from Wood

A. Steam to Power Systems

Creating energy from high-pressure steam is not a new technology and so there are many companies that produce entire systems for power generation. General Electric, Turbodyne, Zurn, and Hurst Boiler are just a few large, US based companies. For the QIN situation there are many designs to choose from, even as small as 200 kW. For construction costs for a new system, an easy estimate is $1,000 to $1,500 per kW produced. This figure is for a large-scale facility, a small-scale operation would be higher, at around $3,500 per kW produced.

These technologies can boil the water from almost any fuel. However, there is not the option for several feedstocks in the same system. Wood waste biomass plants tend to be more expensive because of the residues of burning wood. Wood pulp from mills and biofuel are cleaner. Another option would be to use natural gas as the combusting fuel.

One advantage with steam power is the high feedstock weight-to-kilowatts produced ratio; the excess products of a pyrolysis system must be transported again, while fully burning the wood greatly decreases the byproduct mass. Another advantage with long-proven steam power is the availability of used systems so prices may be lower. Also, the steam can be integrated into a heating system for a larger complex. This promotes an integrated system in Taholah or Queets.

The environmental impacts (air pollution) of steam generation are larger than the other biomass systems explored here, but still much cleaner than traditional energy sources. Advancements are being made to improve the lbs/hr of particulate matter in the exhaust.

Wood Waste to Electricity

	KW per green ton	QIN/QIR*		Olympic Peninsula**	
		low	high	low	high
Boiler and Steam	454.5	~450kw/h	~800kw/h	~6490kw/h	~11,680kw/h

"low" and "high" figures represent the level of technology applied.
* 15,500 green tons of wood waste, based on "Feasibility of a Biomass Energy Project".
** 220,273 estimated green tons of wood waste, based on current forest harvesting practices.

Biomax 15: The Biomax 15, from Community Power Corporation (CPC), uses gasification to convert prepared wood waste directly into combustible gas. The unit then burns the gas to produce energy. This unit is small-scale (15 kW) and relatively inexpensive to purchase. Presently, there are possible environmental concerns (air quality), however preliminary tests are proving Biomax 15 to be much cleaner than any fossil fuel alternative.

The unit runs on wood or woody feed stock. This limits some of the potential sources on the Nation, primarily fish or shellfish residues. The wood must be chipped before it can be fed into the machine, which may pose significant costs compared to the unit cost and energy output.

The advantage with a system such as Biomax 15 is the small footprint (5m x 5m) and easy portability. The kilowatt output is not large enough to meet the entire needs of the Nation, but the simple mobility and maximum output provide the Nation with a good source for local energy needs. This unit would work well as a backup for a large building or several small buildings.

CPC has recently developed a larger Biomax 50 machine. The system produces 50 kW and runs on the same technology as the smaller system. While this is still in development, the larger system will more cost effective than the smaller, however, the cost efficiency is not great for either of the CPC systems.

B. Pyrolysis and Biofuel Systems

The pyrolysis process does not automatically generate electricity from the wood waste. Pyrolysis is similar to gasification except the feedstock is rapidly heated up, to between 700°F and 950°FS. It then goes one step further than gasification, it compresses the vapors to form the out products. The pyrolysis separates the molecules into separate products; charcoal and liquid biofuel are the two main products. Both of these products can be shipped, stored, or used for energy generation.

Ensyn Group Inc.: Ensyn is an established research and consulting firm for the advancement of biofuels. It has a track record of being the first company to put pyrolysis to commercial applications. Since creating biofuels was the first phase of company development, the current phase is to develop refining processes to make biofuels even more valuable and capable of replacing hydrocarbons in other applications.

“Ensyn believes that RTP™ [Rapid Thermal Processing, Ensyn’s registered name for pyrolysis] is the only bio-oil technology in the world that is operating commercially, and that RTP™ is the only technology capable of producing large quantities of bio-fuel from industrial operations.”

Ensyn manages the two largest pyrolysis facilities in commercial operation. The Manitowoc RTP unit has a capacity of 50 green tons per day. Another plant in northern Wisconsin has a capacity of 70 green tons per day; producing 3,745 gallons and 5,243 gallons respectfully. This technology appears to be the industry leader in efficiency, output biofuel weight is 75% of dry feedstock weight (JFBE system is about 27.5%; see chart below). This efficiency means the Ensyn system produces 149.8 gallons per dry ton; or 74.9 gallons per green ton.

JF BioEnergy: The JF BioEnergy unit uses pyrolysis to extract the fuel from the waste. The JFBE system is portable. It arrives on the back of semi and can be set up in less than one day, then moved again a few days later. This is intriguing because the slash from harvesting/thinning in remote areas of the Nation could be utilized on-site rather than transported. JFBE has also developed a larger, non-portable system. The portable system potentially uses 40 tons per day, while the larger system has a capacity of 120 green tons per day.

JFBE does have the added potential of converting more types of waste to energy than the Biomax 15 can. They completed a successful study of railroad ties and produced coal, biofuel, and creosote oil that was reused for more ties and telephone poles. JFBE has begun a demonstration project utilizing sea urchin shells to produce calcium for market. Energy output is still under study.

According to JFBE's web site, the unit can produce up to 27 gallons of quality bio diesel from 1 green ton of wood waste. The QIN's current harvesting techniques will produce ~200,000 gallons of fuel a year; a safer estimate might land closer to ~150,000 gallons.

Comparison: Ensyn & JF BioEnergy

	Gallons* per green ton	Gallons* per dry ton	Efficiency, % dry wt	QIN/QIR**	West Olympic Peninsula***
Ensyn	74.8915	149.7831	75.00%	1,160,818	16,496,581
JFBE	27.4602	54.9205	27.50%	425,633	6,048,746

* 1 gallon of biofuel equals 10.014484 pounds, or 1.2 times the weight of water.

** Potential gallons of biofuel from 15,500 green tons of wood waste, based on "Feasibility of a Biomass Energy Project".

*** Potential gallons of biofuel from 220,273 estimated green tons of wood waste, based on current forest harvesting practices.

C. Biofuel Stand-alone Generators

Stand-alone generators have great potential to meet the needs of the QIN. They can be used as primary or backup energy sources. They can be placed in remote sites to substitute for expanding the grid as well as urban settings to offset PUD electrical consumption during peak usage.

Diesel generator technology can easily be converted to biofuel use without much loss in efficiency. Typically, B100 (100% biodiesel, also known as "neat" biodiesel, compared to B20, 20% biodiesel and 80% regular diesel) is about 10% less efficient than diesel. B20 would be 98% as efficient as diesel fuel. Comparing another fuel, natural gas is about 30% less efficient. These numbers represent biodiesel made from soybean oil, however, biofuel made from wood biomass, according to Ensyn, is about 54% the efficiency of diesel based on BTU potential.

Currently, the Bonneville Power Administration (BPA) is examining biodiesel generators as a backup power supply to the Olympic Peninsula for the times when the grid goes down. They found that the development of a facility would be more cost efficient than improving the electrical transit lines. This federally sponsored program may open some doors for partnership or economic incubation for the entire Peninsula.

The facility size to meet the needs of the QIN would be 3-4 generators running at 300-400 kW capacity. However, this “facility” might be separated to reduce the electrical transit costs across the Nation, or to bring electricity to off-grid areas. To supply the needs of the Olympic Peninsula, as the BPA sees it, would require 12-16 of the same generators running as a backup when the grid goes down.

Modified systems for storing biofuel are required. The fuel generally has a shelf life of six months, after that the exposure to oxygen allows for contaminates to develop in the fuel. Another potential problem is storing the fuel in the Northwest climate. When stored in an environment less than 40°F, the fuel has a viscosity too low for use. A solution to this is to bury the holding tanks to insulate the fuel against the occasional cold spell.

IV. Hydro

There are two types of hydroelectric power we researched. The first is capturing energy from the ocean with anchored buoys floating on the swells. The second is basic river energy and the capturing of the river’s energy as it falls. Our partner, WorldWater, is exploring the potential for Ocean Power Technology’s technology to power the casino. Another company is Aqua Energy Group. In order to reach full efficiency, both of these technologies require at least 150 of ocean depth to operate and find the optimum swell. However, the extensive ocean shelf off the Washington coast makes this very difficult. It appears the equipment would be stationed no less than 12 miles off the shore, which makes this option very cost inefficient, except in very large scale production. The scale issue makes ocean wave technology unavailable for use on the QIR.

Like steam power generation, hydropower has been around for many years and many companies have decades of experience. The trend for micro to small-scale hydro systems is to have a consulting firm design, develop, and construct a custom system for the specific project site. This makes the systems much more efficient, but it also makes an accurate technology and cost analysis difficult. There are several technologies to consider and it is possible to make ballpark estimates of the final project cost. A general rule of thumb is to expect hydropower development to cost about a million dollars for every megawatt of electricity generated. Cost varies by size of the facility and the capacity of the turbines served. Like all technologies studied, there are economies of scale with hydro. Cost effectiveness is very site specific.

Dams obviously have their environmental impacts, but they are also the most efficient method of capturing and improving the electrical capacity of a river. A dam does not necessarily have to block up the river and create a reservoir, it can simply funnel, or divert, the water into a facility. The force of the river must be sufficient enough already to make this type work. The initial flow data for the Quinault and Queets rivers demonstrate sufficient capacity to meet the energy needs of the QIN with this kind of system.

A less obtrusive system would involve tubes in the river that capture the water, divert the flow out of the river into a turbine facility and then back into the river. The tubes can act as a dam and increase the water pressure to increase the river's potential. These systems have far less environmental impact than a traditional dam, however, low flow seasons may inhibit the electrical generation because the water must remain in the river to preserve fish runs or other river ecology.

There is also the potential of a run of the river system that does not require a dam or tubing to create the pressure needed to spin a turbine. This technology is currently under demonstration in Washington State by Canyon Industries, inc. Costs for this technology are high.

V. SOLAR

There are many incentives to include solar technology in any building project. The simple installation of several rooftop panels can reduce the energy consumption of a building completely. They are best used for water and interior heating purposes. The solar development industry boasts a standard efficiency around 30%. The developments use the same basic technology, crystalline silicon wafers, as was developed in the 1950's, however the industry has received many large R&D grants from the government to promote new techniques (see Nanosolar below). These developments have greatly reduced the kW cost and "inefficiency" stigmas of solar energy.

There are also widespread, federally sponsored campaigns to integrate solar technology into everyday life. The "Million Solar Roofs Initiative" was announced in June 1997, to facilitate the installation of solar energy systems on one million U.S. buildings by 2010. There is significant funding for individuals and small groups wanting to integrate solar into their buildings.
In the Northwest, the Bonneville Environmental Foundation (BEF) is the lead promoter of solar energy, sponsoring the "Tour of Solar Homes" and the "green tags" purchase program. BEF's solar initiatives are organized through the Northwest Solar Cooperative.

As time move on, the advancement of technology will make solar more viable. Another large obstacle is a storage system for the energy produced. This is also a problem with wind and hydropower as well. Battery technology is moving faster than most industries in order to keep up with the monumental advancements in portable electronics and decentralized power.

Active Solar: There has been much advancement in active solar technology over the last decade. However, the potential of active solar energy in the Northwest is limited. Because of the seasonal changes in the availability of sunlight, active solar will only run about two-thirds capacity. The low capacity translates into higher costs to produce the energy. Because of these realities, active solar power generation on the QIN is not a viable solution to solving the Nation's energy needs as directed by this study. The costs of implementing a >1 MW plant would far exceed the costs of developing other alternative energy sources making the commercial resale of the electricity less attractive.

Passive Solar: On the other hand, the development at the individual building level of passive solar systems makes long-term sense. Including passive solar in a plan of conservation will make any alternative energy source sustainable for longer. The more buildings that require little to no power for most of the year will substantially lower the energy demand on the QIR which allows the larger alternative source to remain effective. Small solar panels can be installed to ease the power consumption of water pumps or heating. The theory of passive solar design is the best solar option for the QIN because of its practicality in new building projects and higher cost to benefit ratio.

Nanosolar, inc: Nanosolar promotes itself as having "developed proprietary techniques that use nanostructured components and printable semiconductors to make it possible to utilize solution-coating processes ("printing") to deposit all of the most critical layers of a solar cell. Printing processes are simple and robust in comparison with other (e.g. vacuum based) thin-film deposition techniques and can be applied at high speeds in a continuous fashion using roll-to-roll production methods." This technology is still under development, but we predict the commercial availability of these new technologies within five years.

The advantage to Nanosolar's technology is the increased efficiency, smaller panels, and low production cost. The cost to cover a rooftop with solar panels is greatly reduced and produces more energy than conventional wafer technology. This advancement will make the solar option more viable for on-site power, which in turn extends the viability of the Nation's energy sources. A simple reduction in costs makes conservation technologies identifiably more productive.

QUINAULT INDIAN NATION ENERGY USE ASSESSMENT

Prepared by Jessica Raker

July, 2005

Submitted to the Institute for Washington's Future

PART 1: TAHOLAH

As the center of the Quinault Indian Nation Taholah is the site for many of the QIN public buildings. These buildings; the community center, administrative building, roundhouse, maintenance building, school, seafood plant, and health clinic make up the majority of the non-residential electric load in the area. The energy usage data from these buildings can be used to size a renewable energy system that would eliminate or greatly reduce the need for grid electricity to these structures. While these numbers cannot be used to estimate the residential load in Taholah they can be used to track seasonal changes in energy use. The graph on the following page demonstrates how electricity use changes over the course of the year.

Electricity use is at its lowest during the summer when the days are long and no heating is required. Electricity use peaks during the coldest months of the year. This pattern is consistent with the known uses of electricity, specifically with the heating load. For the top three energy users, a rough estimate of the heating load was calculated by subtracting the average energy use during the hottest month of the year from the rest of the monthly averages. The summer temperatures in Taholah remain quite cool because of its coastal location, so there is no need for air conditioning. This fact allowed us to make our rough heating load estimate without worrying about energy use for space cooling.

The data indicates that conservation efforts focused on reducing the amount of space and water heating done with electricity could have a significant impact on Taholah's electric load. These efforts would not only decrease total electricity use, but would also levelize the electric load over the course of the year. Leveling the load would make it easier and less expensive to develop small-scale sources of heat and energy. This is because the production units would not have to be of a larger size to meet high demand which is only occasional.

This data can also be used to design a generator that would meet the energy needs of the public facilities. Generator ratings are based on the maximum instantaneous power load the generators can meet. The size of the generator required by Taholah comes from two years of utility bills for the meters associated with the public buildings. The buildings use an average of 4.5 GWh annually which, when converted to instantaneous power load by dividing by the number of hours in a year, equates to an average power load of 511 kW. Because these are public buildings, it is likely that most of the energy use occurs during working hours or the early evening. Revising the numbers to reflect 10 hours of energy use each day gives an average power load of 1,225 kW. The former measurement provides the size of a generator that could produce the same amount of energy as the buildings use over the course of a year, but not necessarily at the same times. The latter number provides the size of a generator that could meet most of the needs of the building, but could not provide all of the power required at peak times. The maximum demand charge for each building was also available. This number is more useful in defining the upper bound of power use by the buildings. A generator sized to the maximum demand will be able to meet all of the power needs of the buildings and need never be supplemented by power from the utility. For the QIN buildings in Taholah such a generator would be rated at or above 1,290 kW.

We cannot apply this same measurement technique to the residential load in Taholah. The residential accounts are not public and there is no logging system on the substation serving Taholah to measure the total energy use. A rough estimate based on the 2000 census and average household electricity use in our climate area gives an annual energy use of 4.32 GWh, or nearly equal to the energy use of the public buildings.

The following pages include a summary of the energy use in all of the public buildings whose accounts we accessed and a detailed look at each of these commercial accounts. The pages detailing energy use in each building contain a graph of average energy and power use over the course of the year. Each page also contains a chart with the averages seen in the graph and a chart establishing the absolute maximum and minimum load for each building over the two year period.

Conclusions

The potential for renewable energy use in Taholah or Queets can be met through the use of one large generator or several smaller generators built to meet the load of individual buildings. Several of the public buildings in Taholah and Queets are good candidates for renewable energy systems. These buildings use a significant amount of energy each month and have power needs that could be met by a renewable energy system. The size of the system required varies from 10 kW at the Queets Administration Building to more than 470 kW at the main building of the school. Any system built to meet the energy needs of one of the QIN's public buildings must also be able to supply the energy at the appropriate times. In order to do this the energy must be stored, either in the system's fuel or in a battery-type system. Taking into consideration the available resources on the Quinault Reservation it appears that the best option would be to use biomass systems which store the energy as fuel until it is required. Biomass systems also produce heat as a byproduct of the electricity generation process. This heat could be used in the buildings which would further reduce the electric load.

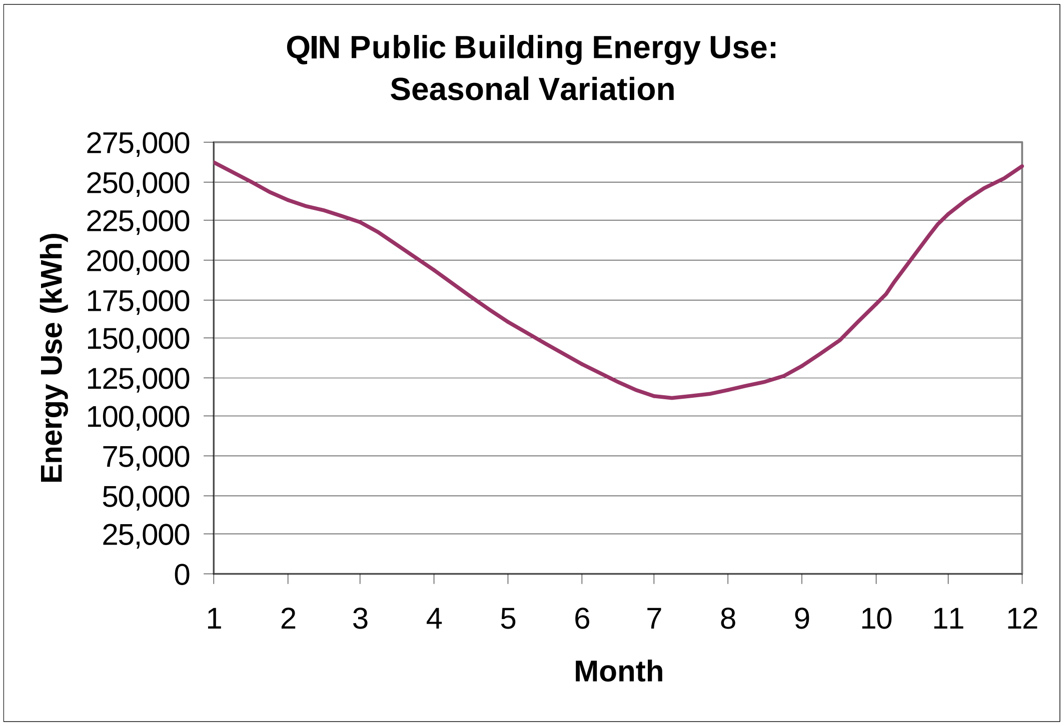
We recommend that the QIN undertake to implement an energy conservation and weatherization program to reduce the electricity needs of the public buildings as well as install a biomass-based renewable energy system on one or more of the public buildings. Such a system installed at the Taholah Health Clinic could have the added benefit of providing electricity to essential systems when the main grid is down as happens several times a year. This system would act as a pilot project which would further elucidate the benefits and drawbacks associated with the use of renewable energy systems on the Quinault Reservation.

Taholah Public Buildings Energy Use

Building	Annual Energy Use (kWh)
Community Cntr	102,600
Admin Bldg	933,640
Roundhouse	116,255
School	888,882
Maintenance Bldg	13,660
Seafood Plant	27,060
Health Clinic	125,842

Building	Avg. Monthly Energy Use
Community Cntr	8,550
Admin Bldg	77,803
Roundhouse	9,688
School	74,074
Maintenance Bldg	1,138
Seafood Plant	2,255
Health Clinic	10,487

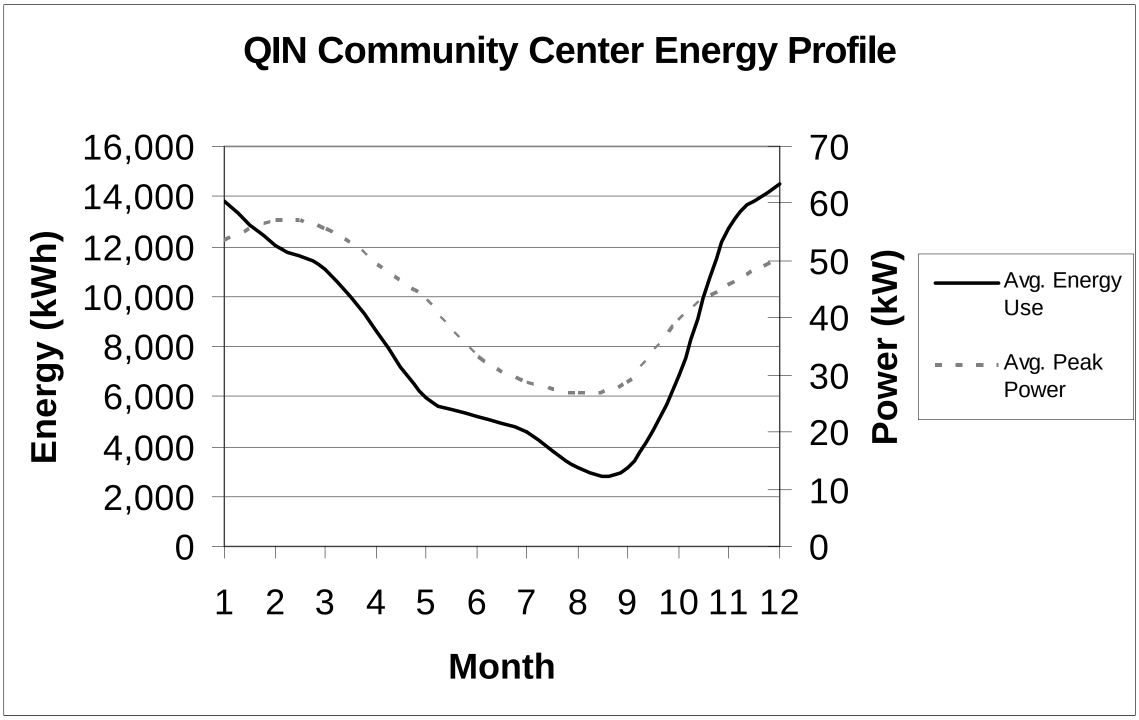
Month	Total Energy Use (kWh)	Cost
January	261,782	$19,231.62
February	237,533	$17,690.69
March	224,153	$16,643.94
April	193,815	$16,725.13
May	160,738	$13,882.82
June	133,856	$11,786.76
July	112,887	$9,041.34
August	117,211	$8,487.74
September	132,628	$9,855.01
October	171,994	$11,312.95
November	228,586	$16,360.53
December	259,975	$16,842.54
Annual	4,470,309	$167,861.06



Potential Generator Sizing	
24 Hour Average	511 kW
10 Hour Average	1,225 kW
Peak Power*	1,290 kW

*Three accounts do not track demand, and were not included

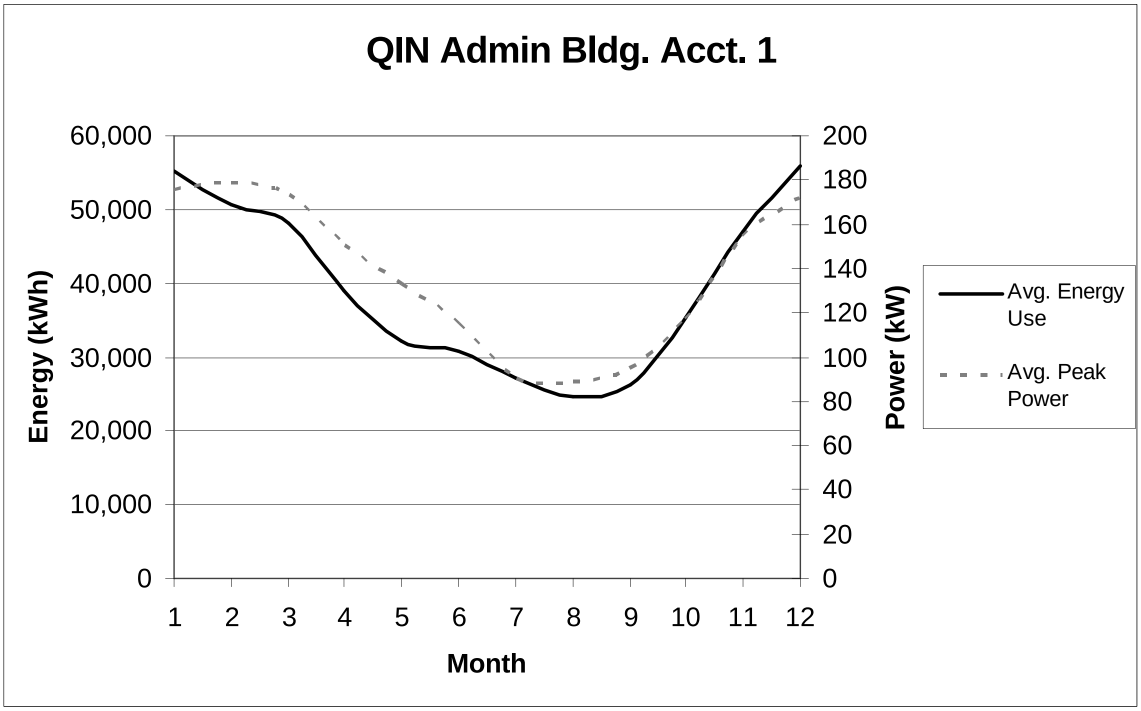
Quinault Community Center



Month	Avg. Energy, kWh	Avg. Peak Demand, kW	Avg. Power, kW (24 hr)	Avg. Power, kW (10 hr)	Avg. Cost
January	13,840	53.5	18.6	44.6	$1,021.14
February	12,060	57.2	17.9	43.1	$904.87
March	11,100	55.6	14.9	35.8	$836.70
April	8,620	49.4	12	28.7	$654.50
May	5,920	43	8	19.1	$453.52
June	5,200	33.2	7.2	17.3	$402.03
July	4,580	28.8	6.2	14.8	$357.57
August	3,120	27	4.2	10.1	$247.33
September	3,140	28.8	4.4	10.5	$249.29
October	6,840	39.6	9.2	22.1	$519.94
November	12,720	45.8	17.7	42.4	$944.62
December	14,467	50.5	19.4	46.7	$1,134.03

Energy		
Highest Monthly Energy Use	Nov/Dec 2004	16,880 kWh
Lowest Monthly Energy Use	Sep/Oct 2004	1,840 kWh
Power		
Highest Demand Reading	Feb/Mar 2004	63 kW
Lowest Demand Reading	Sep/Oct 2004	13.6 kW
Cost		
Highest Monthly Energy Cost	Nov/Dec 2004	$1,193.51
Lowest Monthly Energy Cost	Sep/Oct 2004	$146.08

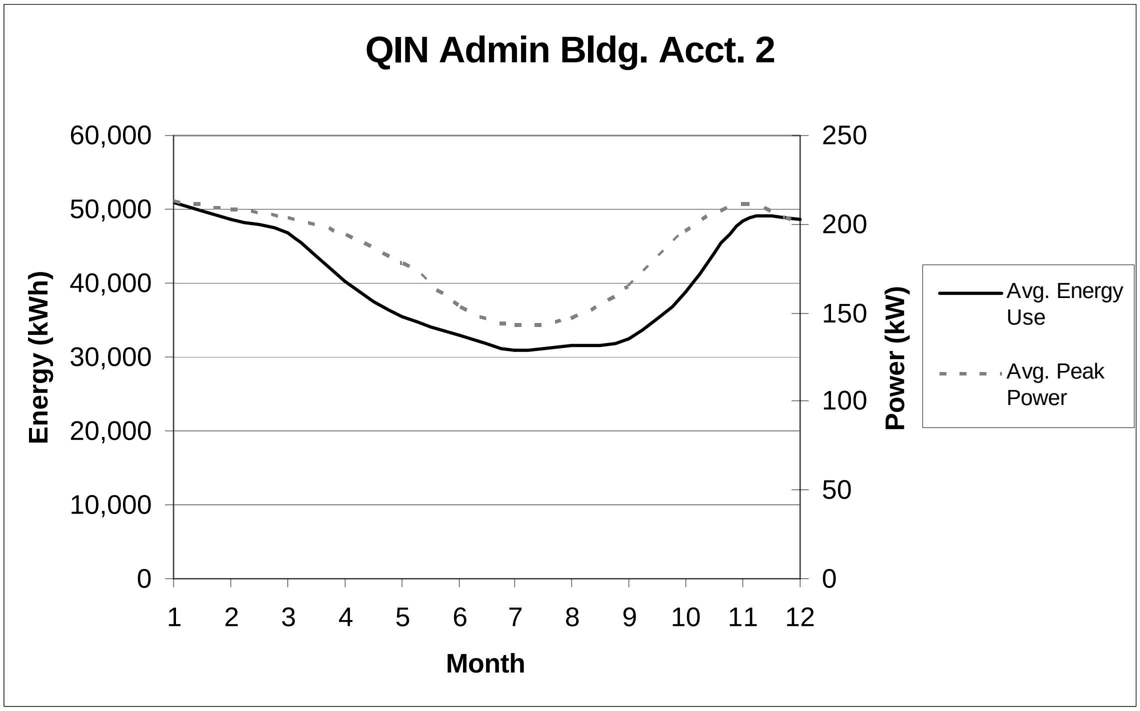
Quinault Administration Building Account #1



Month	Avg. Energy, kWh	Avg. Peak Demand, kW	Avg. Power, kW (24 hr)	Avg. Power, kW (10 hr)	Avg. Cost
January	55,213	175.8	74.2	178.1	$3,545.60
February	50,630	178.8	75.3	180.8	$3,408.29
March	48,040	173.3	64.6	155	$3,261.29
April	38,920	150.8	54.1	129.7	$2,715.06
May	32,220	132.8	43.3	103.9	$2,299.99
June	30,800	114.7	42.8	102.7	$2,123.92
July	27,040	90.3	36.3	87.2	$1,803.53
August	24,550	89.2	33	79.2	$1,685.52
September	26,150	95.2	36.3	87.2	$1,796.09
October	35,320	116.9	47.5	113.9	$2,332.01
November	47,000	154.4	65.3	156.7	$3,075.65
December	55,913	171.7	75.2	180.4	$3,602.65

Energy		
Highest Monthly Energy Use	Dec/Jan 2003	58,760 kWh
Lowest Monthly Energy Use	Aug/Sep 2004	20,680 kWh
Power		
Highest Demand Reading	Feb/Mar 2003	199 kW
Lowest Demand Reading	Jul/Aug 2004	66 kW
Cost		
Highest Monthly Energy Cost	Jan/Feb 2003	$3,842.06
Lowest Monthly Energy Cost	Jul/Aug 2004	$1,397.12

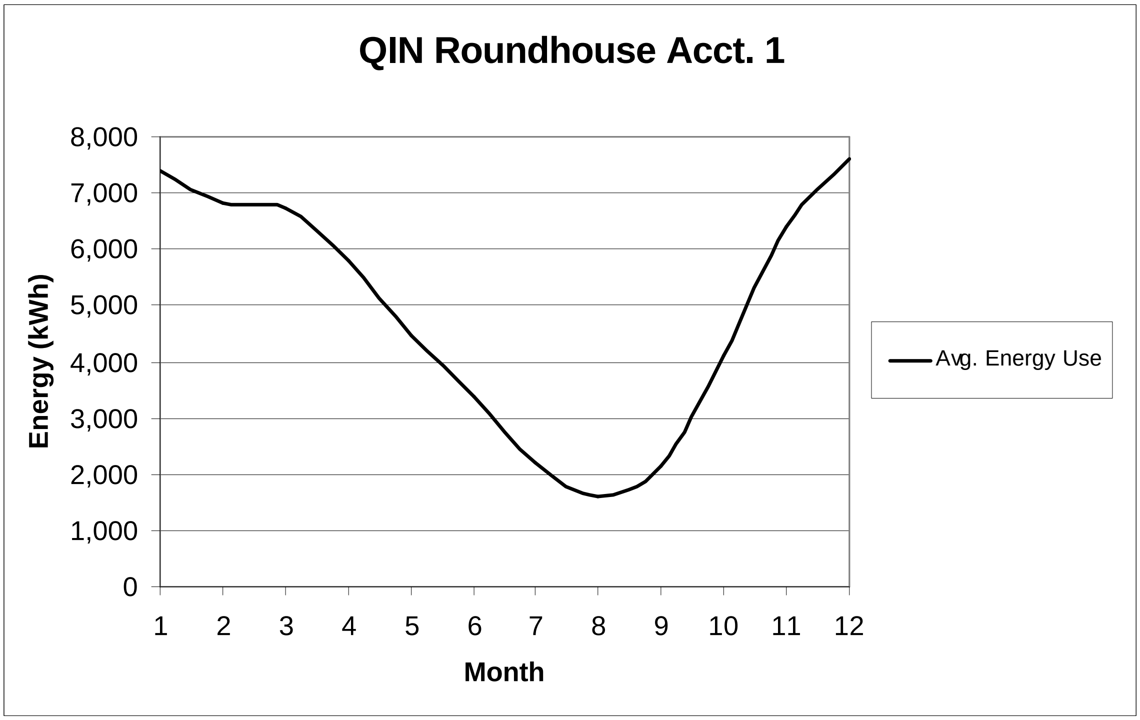
Quinault Administration Building Account #2



Month	Avg. Energy, kWh	Avg. Peak Demand, kW	Avg. Power, kW (24 hr)	Avg. Power, kW (10 hr)	Avg. Cost
January	51,013	212.7	68.6	164.6	$3,583.09
February	48,600	208.4	72.3	173.6	$3,503.81
March	46,920	203.8	63.1	151.4	$3,401.20
April	40,280	193.8	55.9	134.3	$3,041.62
May	35,360	178.2	47.5	114.1	$2,723.11
June	32,960	153.8	45.8	109.9	$2,465.97
July	30,920	142.5	41.6	99.7	$2,300.40
August	31,480	146.6	42.3	101.5	$2,346.93
September	32,520	164.4	45.2	108.4	$2,509.24
October	38,760	195.6	52.1	125	$2,977.00
November	48,520	211.4	67.4	161.7	$3,496.64
December	48,693	201.2	65.4	157.1	$3,459.37

Energy		
Highest Monthly Energy Use	Dec/Jan 2004/5	58,720 kWh
Lowest Monthly Energy Use	Jul/Aug 2004	28,160 kWh
Power		
Highest Demand Reading	Dec/Jan 2004/5	239 kW
Lowest Demand Reading	Jul/Aug 2004	125 kW
Cost		
Highest Monthly Energy Cost	Dec/Jan 2004/5	$3,948.24
Lowest Monthly Energy Cost	Jun/Jul 2004	$2,074.66

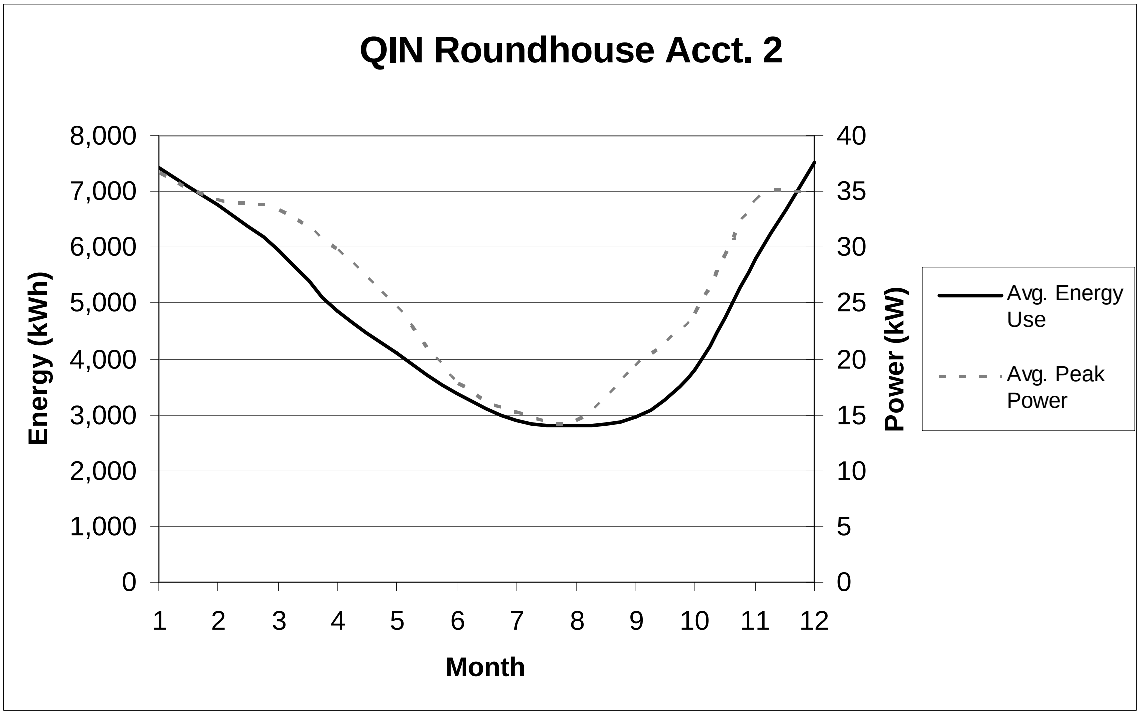
Quinault Roundhouse Account #1



Month	Avg. Energy, kWh	Avg. Peak Demand, kW	Avg. Power, kW (24 hr)	Avg. Power, kW (10 hr)	Avg. Cost
January	7,402	N/A	9.9	23.9	$554.20
February	6,810	N/A	10.1	24.3	$519.43
March	6,743	N/A	9.1	21.8	$514.83
April	5,805	N/A	8.1	19.4	$378.48
May	4,478	N/A	6	14.4	$279.54
June	3,373	N/A	4.7	11.2	$263.91
July	2,210	N/A	3	7.1	$177.40
August	1,615	N/A	2.2	5.2	$133.59
September	2,155	N/A	3	7.2	$174.97
October	4,093	N/A	5.5	13.2	$317.32
November	6,400	N/A	8.9	21.3	$485.31
December	7,612	N/A	10.2	24.6	$576.80

Energy		
Highest Monthly Energy Use	Dec/Jan 2002/3	7,910 kWh
Lowest Monthly Energy Use	Jul/Aug 2003	1,180 kWh
Cost		
Highest Monthly Energy Cost	Nov/Dec 2003	$619.35
Lowest Monthly Energy Cost	Jul/Aug 2003	$104.20

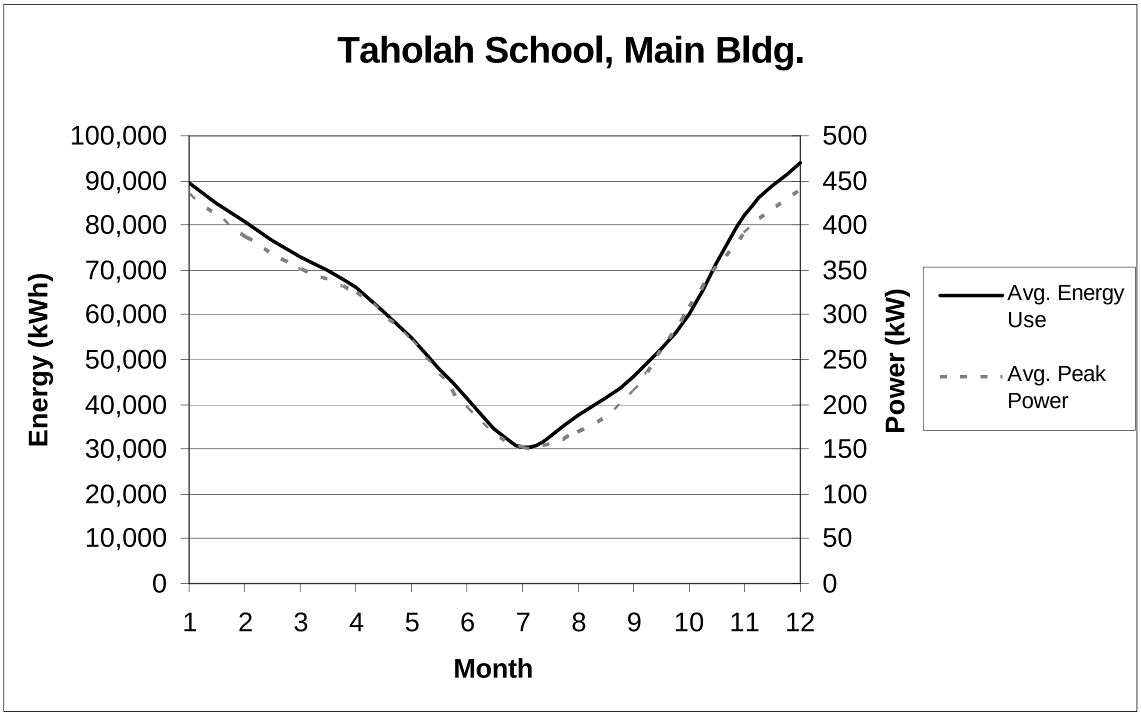
Quinault Roundhouse Account #2



Month	Avg. Energy, kWh	Avg. Peak Demand, kW	Avg. Power, kW (24 hr)	Avg. Power, kW (10 hr)	Avg. Cost
January	7,413	36.7	10	23.9	$554.94
February	6,750	34.3	10	24.1	$515.15
March	5,960	33.4	8	19.2	$456.40
April	4,850	29.7	6.7	16.2	$374.75
May	4,120	24.6	5.5	13.3	$320.85
June	3,380	17.8	4.7	11.3	$265.41
July	2,910	15.2	3.9	9.4	$230.74
August	2,800	14.5	3.8	9	$221.91
September	2,970	19.3	4.1	9.9	$234.29
October	3,800	24.1	5.1	12.3	$294.10
November	5,810	34.1	8.1	19.4	$440.91
December	7,513	35	10.1	24.2	$569.40

Energy		
Highest Monthly Energy Use	Dec/Jan 2004/5	7,920 kWh
Lowest Monthly Energy Use	Jul/Aug 2004	2,280 kWh
Power		
Highest Demand Reading	Dec/Jan 2004/5	41 kW
Lowest Demand Reading	Jul/Aug 2004	14 kW
Cost		
Highest Monthly Energy Cost	Dec/Jan 2002/3	$606.45
Lowest Monthly Energy Cost	Jul/Aug 2004	$177.76

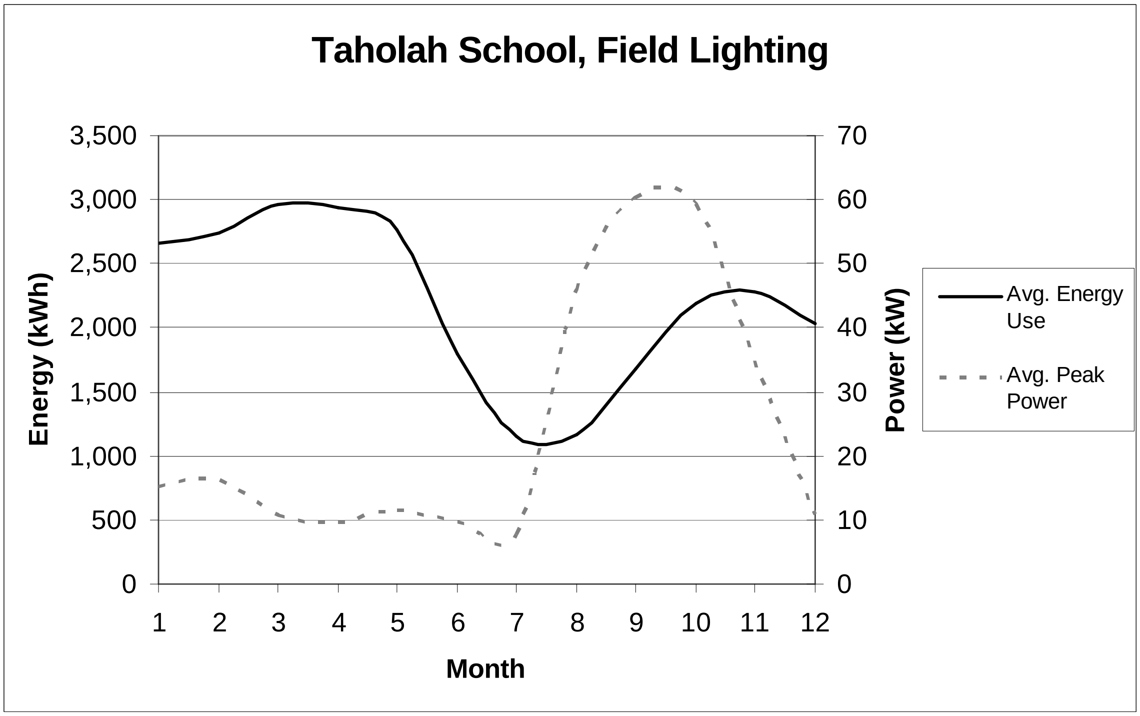
Taholah School, Main Building Account



Month	Avg. Energy, kWh	Avg. Peak Demand, kW	Avg. Power, kW (24 hr)	Avg. Power, kW (10 hr)	Avg. Cost
January	89,650	434.1	120.5	289.2	$6,974.07
February	81,000	386.5	120.5	289.3	$6,114.92
March	73,050	352.4	98.2	235.6	$5,558.62
April	66,167	326.1	91.9	220.6	$5,264.76
May	54,800	270.8	73.7	176.8	$4,462.15
June	41,200	196.3	57.2	137.3	$3,394.59
July	30,300	152.3	40.7	97.7	$2,629.60
August	37,600	169.5	50.5	121.3	$3,066.88
September	46,350	213.5	64.4	154.5	$3,735.41
October	60,250	308.3	81	194.4	$4,954.40
November	82,150	390.3	114.1	273.8	$5,664.88
December	93,900	440.3	126.2	302.9	$6,474.29

Energy		
Highest Monthly Energy Use	Nov/Dec 2003	105,600 kWh
Lowest Monthly Energy Use	Jun/Jul 2004	21,400 kWh
Power		
Highest Demand Reading	Dec/Jan 2003/4	467 kW
Lowest Demand Reading	Jun/Jul 2004	141 kW
Cost		
Highest Monthly Energy Cost	Nov/Dec 2003	$7,498.15
Lowest Monthly Energy Cost	Jun/Jul 2004	$2,153.30

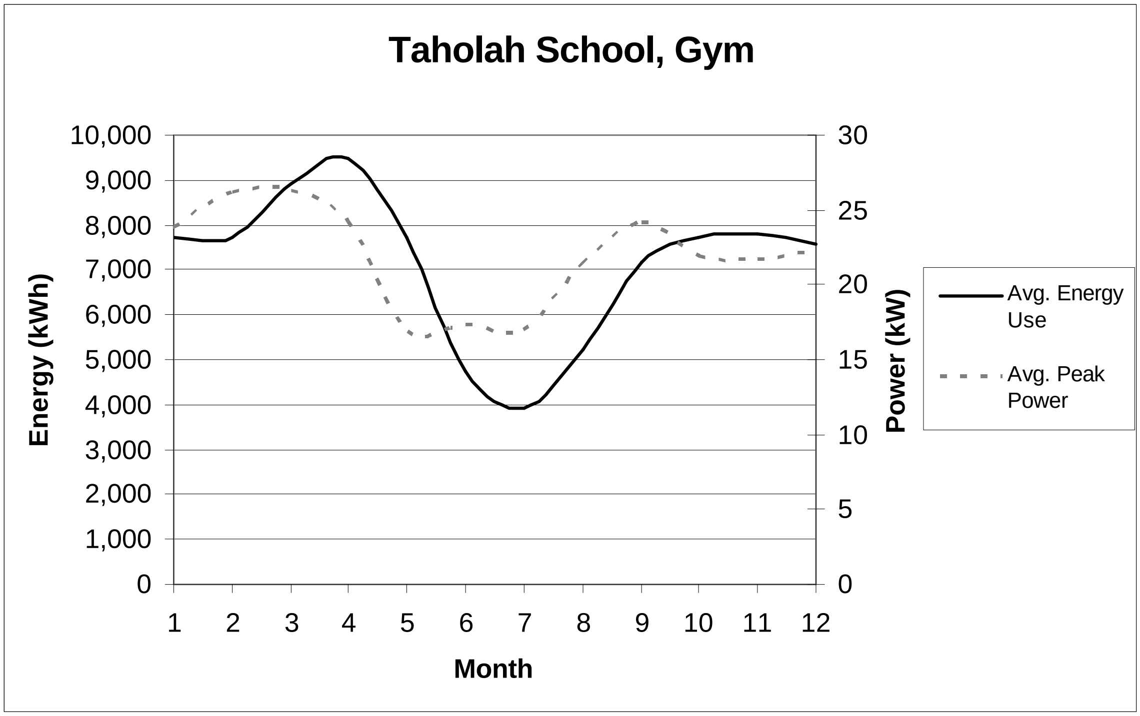
Taholah School, Field Lighting



Month	Avg. Energy, kWh	Avg. Peak Demand, kW	Avg. Power, kW (24 hr)	Avg. Power, kW (10 hr)	Avg. Cost
January	2,663	15.2	3.6	8.6	$242.76
February	2,743	16.2	4.1	9.8	$253.88
March	2,968	10.8	4	9.6	$228.90
April	2,934	9.7	4.1	9.8	$219.06
May	2,762	11.5	3.7	8.9	$225.49
June	1,797	9.7	2.5	6	$171.48
July	1,160	7.7	1.6	3.7	$129.19
August	1,165	45.8	1.6	3.8	$265.40
September	1,673	60.2	2.3	5.6	$472.96
October	2,196	59.4	3	7.1	$512.07
November	2,286	34.9	3.2	7.6	$354.43
December	2,033	10.8	2.7	6.6	$184.78

Energy		
Highest Monthly Energy Use	Mar/Apr 2004	5,312 kWh
Lowest Monthly Energy Use	Dec/Jan 2003/4	522 kWh
Power		
Highest Demand Reading	Oct/Nov 2004	64 kW
Lowest Demand Reading	Dec/Jan 2003/4	3 kW
Cost		
Highest Monthly Energy Cost	Oct/Nov 2004	$659.45
Lowest Monthly Energy Cost	Jul/Aug 2003	$47.48

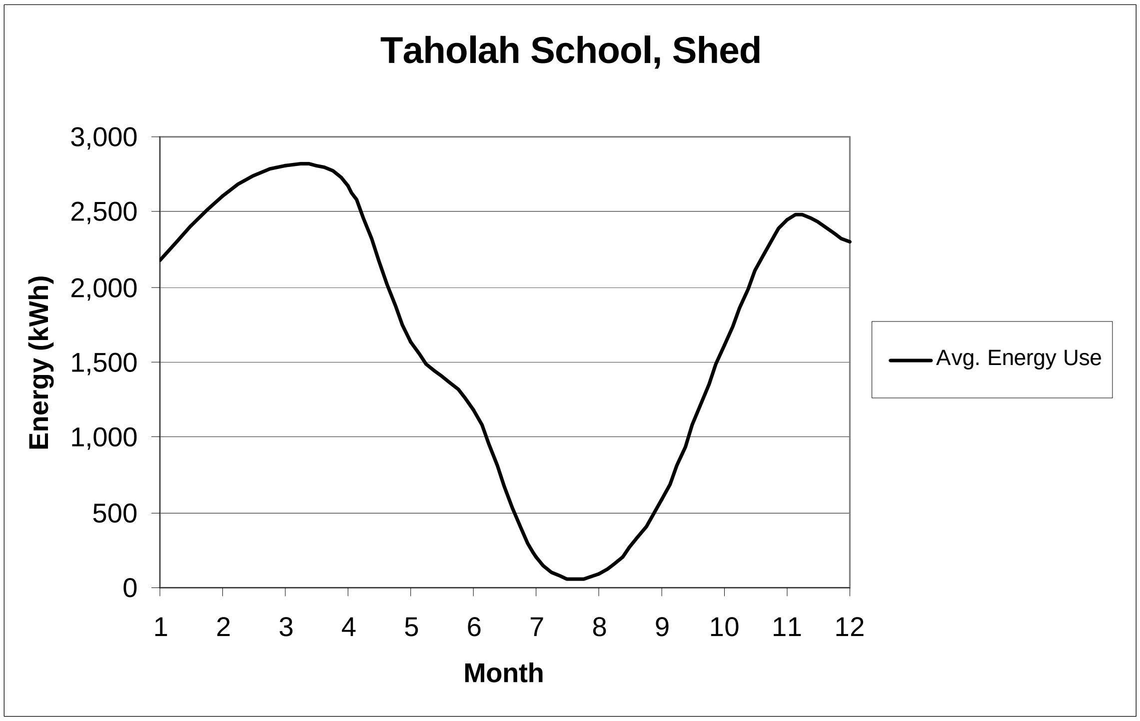
Taholah School, Gym



Month	Avg. Energy, kWh	Avg. Peak Demand, kW	Avg. Power, kW (24 hr)	Avg. Power, kW (10 hr)	Avg. Cost
January	7,720	23.9	10.4	24.9	$596.56
February	7,710	26.2	11.5	27.5	$595.10
March	8,930	26.3	12	28.8	$688.96
April	9,487	24.1	13.2	31.6	$734.62
May	7,720	16.9	10.4	24.9	$604.67
June	4,750	17.3	6.6	15.8	$377.17
July	3,930	17.1	5.3	12.7	$314.69
August	5,230	21.4	7	16.9	$414.23
September	7,170	24.2	10	23.9	$562.46
October	7,710	21.9	10.4	24.9	$601.49
November	7,810	21.7	10.8	26	$605.19
December	7,580	22.4	10.2	24.5	$585.97

Energy		
Highest Monthly Energy Use	Apr/May 2004	14,200 kWh
Lowest Monthly Energy Use	Jul/Aug 2003	1640 kWh
Power		
Highest Demand Reading	Aug/Sep 2003	30 kW
Lowest Demand Reading	Jul/Aug 2003	16 kW
Cost		
Highest Monthly Energy Cost	Apr/May 2004	$1,101.97
Lowest Monthly Energy Cost	Jul/Aug 2003	$139.31

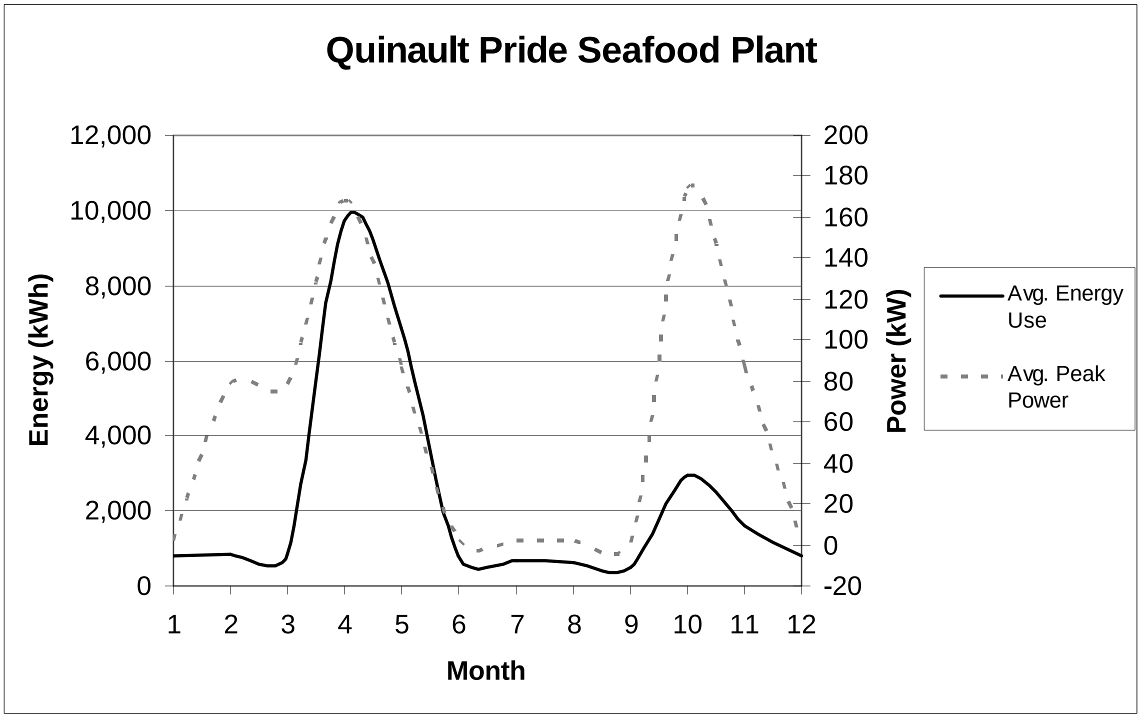
Taholah School, Shed



Month	Avg. Energy, kWh	Avg. Peak Demand, kW	Avg. Power, kW (24 hr)	Avg. Power, kW (10 hr)	Avg. Cost
January	2,173	N/A	2.9	7	$178.58
February	2,603	N/A	3.9	9.3	$210.25
March	2,813	N/A	3.8	9.1	$225.96
April	2,675	N/A	3.7	8.9	$215.35
May	1,640	N/A	2.2	5.3	$139.80
June	1,185	N/A	1.6	4	$104.94
July	208	N/A	0.3	0.7	$36.69
August	93	N/A	0.1	0.3	$29.00
September	585	N/A	0.8	2	$62.03
October	1,615	N/A	2.2	5.2	$137.01
November	2,448	N/A	3.4	8.2	$199.39
December	2,300	N/A	3.1	7.4	$188.42

Energy		
Highest Monthly Energy Use	Mar/Apr 2005	3,340 kWh
Lowest Monthly Energy Use	Aug/Sep 2004	10 kWh
Cost		
Highest Monthly Energy Cost	Mar/Apr 2005	$262.57
Lowest Monthly Energy Cost	Aug/Sep 2001	$18.08

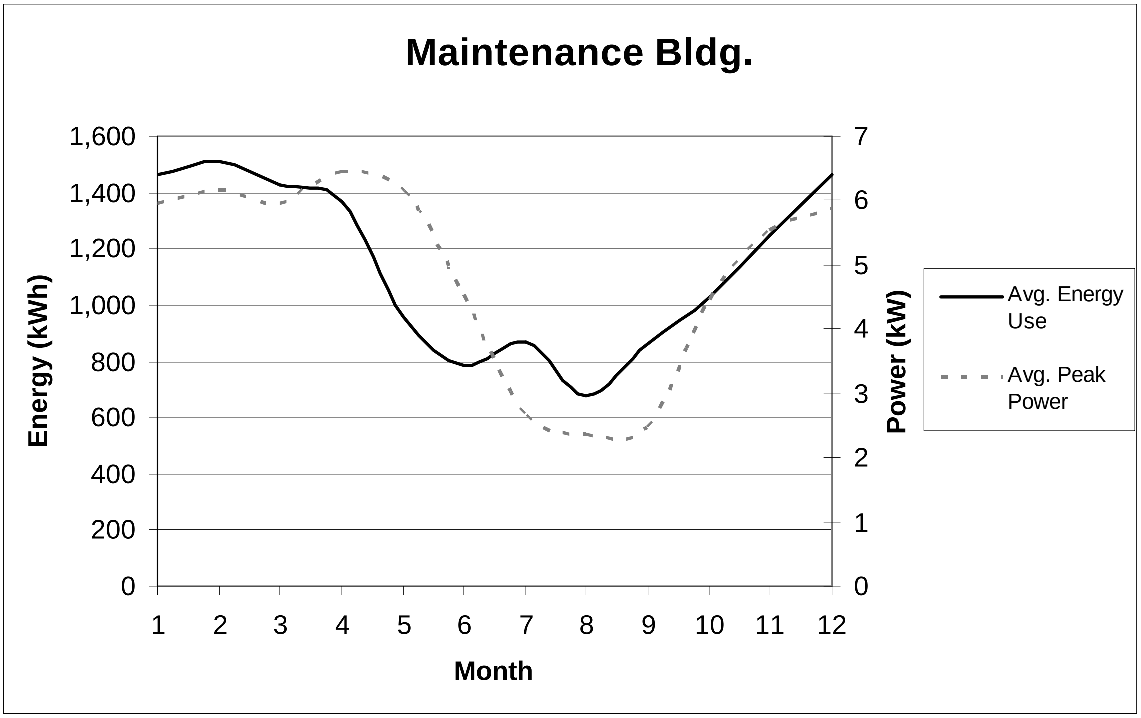
Quinault Pride Seafood Plant



Month	Avg. Energy, kWh	Avg. Peak Demand, kW	Avg. Power, kW (24 hr)	Avg. Power, kW (10 hr)	Avg. Cost
January	800	1.8	1.1	2.6	$72.18
February	840	78.4	1.3	3	$678.89
March	840	78.4	1.1	2.7	$678.89
April	9,720	167.7	13.5	32.4	$1,674.82
May	6,860	87.1	9.2	22.1	$965.33
June	820	2.2	1.1	2.7	$74.20
July	680	2.4	0.9	2.2	$67.79
August	640	2	0.9	2.1	$65.96
September	480	1.3	0.7	1.6	$55.36
October	2,960	173.5	4	9.5	$1,443.40
November	1,620	87	2.3	5.4	$730.87
December	800	1.7	1.1	2.6	$72.18

Energy		
Highest Monthly Energy Use	Apr/May 2004	12,640 kWh
Lowest Monthly Energy Use	Sep/Oct 2004	480 kWh
Power		
Highest Demand Reading	Apr/May 2004	172 kW
Lowest Demand Reading	Jul/Aug 2003	16 kW
Cost		
Highest Monthly Energy Cost	Apr/May 2004	$1,844.57
Lowest Monthly Energy Cost	Sep/Oct 2004	$52.07

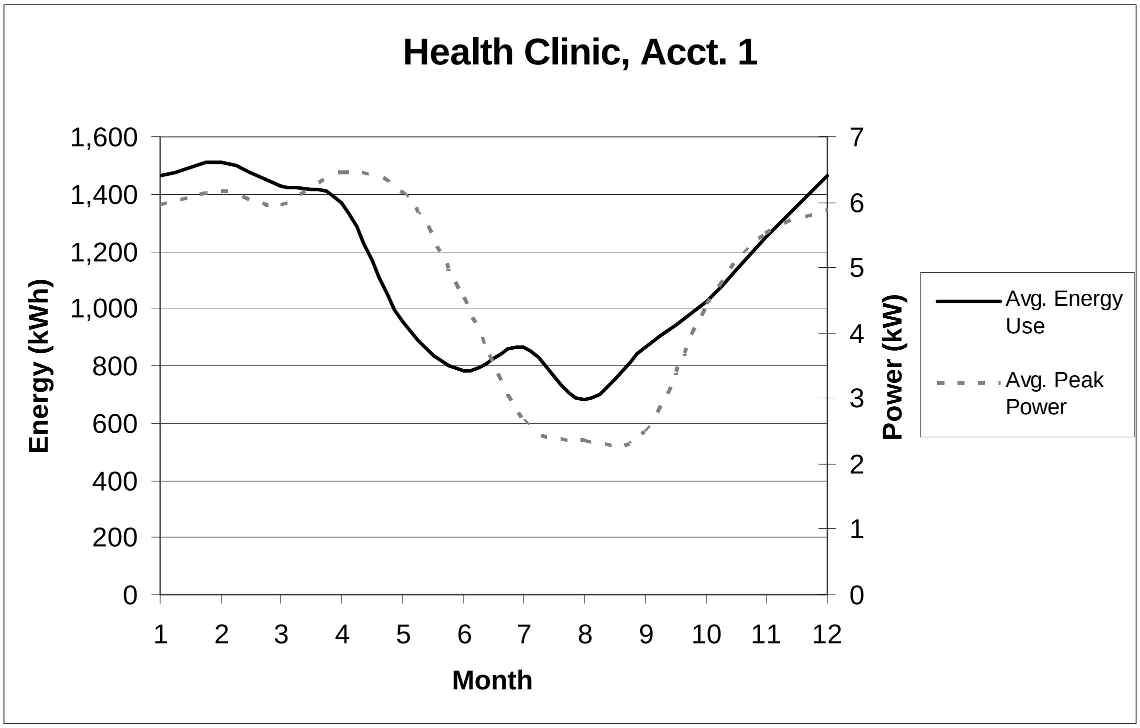
Maintenance Building



Month	Avg. Energy, kWh	Avg. Peak Demand, kW	Avg. Power, kW (24 hr)	Avg. Power, kW (10 hr)	Avg. Cost
January	1,463	6	2	4.7	$117.83
February	1,514	6.2	2.3	5.4	$120.55
March	1,428	6	1.9	4.6	$114.51
April	1,368	6.5	1.9	4.6	$113.51
May	956	6.1	1.3	3.1	$85.20
June	782	4.5	1.1	2.6	$72.08
July	867	2.7	1.2	2.8	$80.37
August	681	2.4	0.9	2.2	$66.76
September	863	2.5	1.2	2.9	$78.40
October	1,028	4.4	1.4	3.3	$90.45
November	1,248	5.5	1.7	4.2	$105.46
December	1,462	5.9	2	4.7	$119.29

Energy		
Highest Monthly Energy Use	Feb/Mar 2005	2,150 kWh
Lowest Monthly Energy Use	Jul/Aug 2004	83 kWh
Power		
Highest Demand Reading	May/Jun 2003	9.5 kW
Lowest Demand Reading	Aug/Sep 2004	1.9 kW
Cost		
Highest Monthly Energy Cost	Feb/Mar 2005	$163.89
Lowest Monthly Energy Cost	Jul/Aug 2004	$26.00

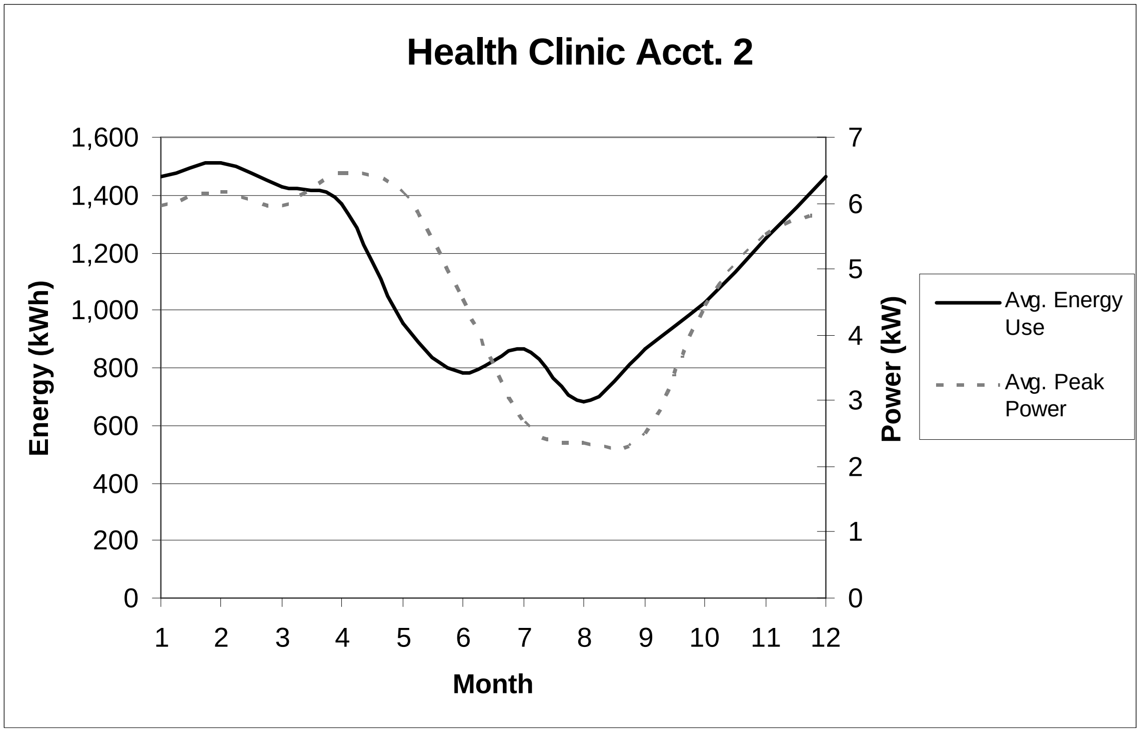
Taholah Health Clinic, Account #1



Month	Avg. Energy, kWh	Avg. Peak Demand, kW	Avg. Power, kW (24 hr)	Avg. Power, kW (10 hr)	Avg. Cost
January	9,350	33.4	12.6	30.2	$702.26
February	9,370	34.1	13.9	33.5	$691.61
March	9,130	34.2	12.3	29.5	$662.33
April	7,893	30.9	11	26.3	$587.03
May	6,960	28.6	9.4	22.5	$529.27
June	6,710	24.7	9.3	22.4	$512.05
July	6,450	22.4	8.7	20.8	$492.42
August	6,240	23.1	8.4	20.1	$475.92
September	6,330	23.3	8.8	21.1	$483.26
October	7,090	25.3	9.5	22.9	$537.86
November	8,540	28.2	11.9	28.5	$640.85
December	9,390	30.7	12.6	30.3	$703.10

Energy		
Highest Monthly Energy Use	Jan/Feb 2004	10,440 kWh
Lowest Monthly Energy Use	Jul/Aug 2003	5,840 kWh
Power		
Highest Demand Reading	Jan/Feb 2004	41 kW
Lowest Demand Reading	Jun/Jul 2004	21 kW
Cost		
Highest Monthly Energy Cost	Jan/Feb 2004	$813.94
Lowest Monthly Energy Cost	Jun/Jul 2004	$451.36

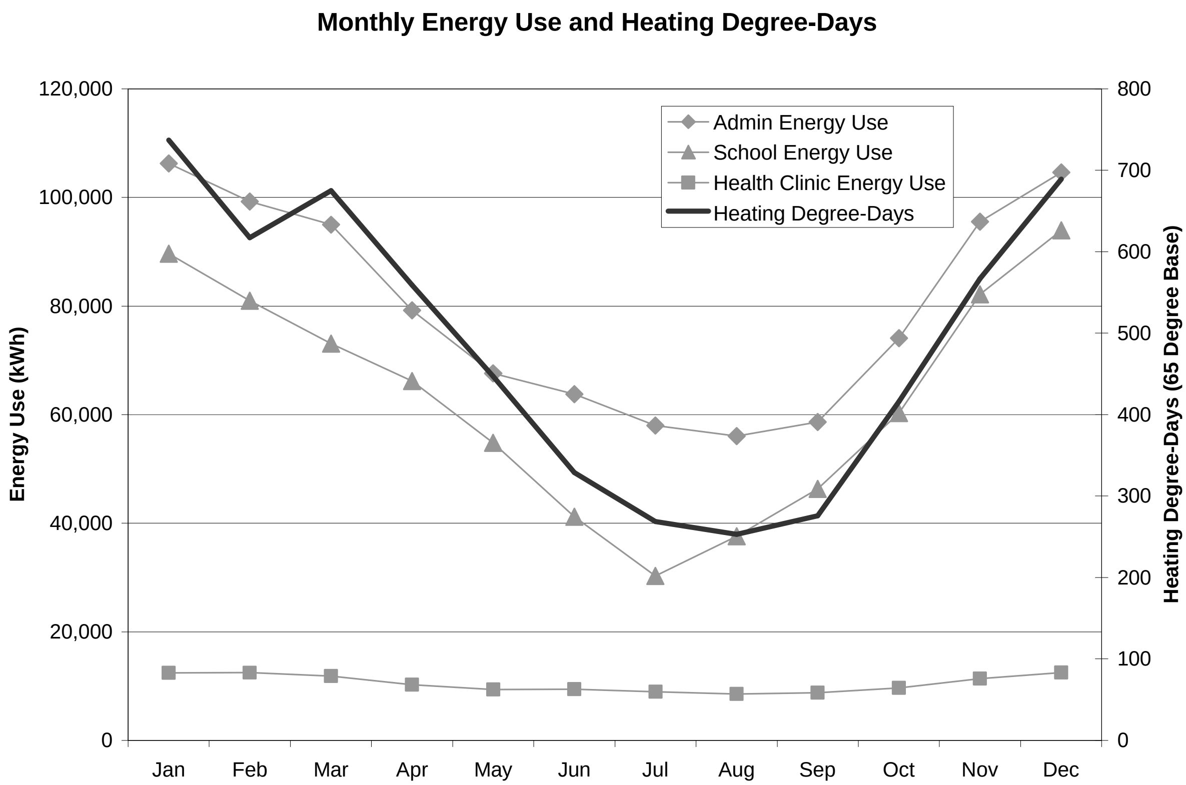
Taholah Health Clinic, Account #2



Month	Avg. Energy, kWh	Avg. Peak Demand, kW	Avg. Power, kW (24 hr)	Avg. Power, kW (10 hr)	Avg. Cost
January	3,088	N/A	4.1	10	$239.56
February	3,120	N/A	4.6	11.1	$238.21
March	2,748	N/A	3.7	8.9	$208.34
April	2,390	N/A	3.3	8	$187.73
May	2,400	N/A	3.2	7.7	$192.02
June	2,768	N/A	3.8	9.2	$219.87
July	2,528	N/A	3.4	8.2	$201.34
August	2,318	N/A	3.1	7.5	$184.93
September	2,483	N/A	3.4	8.3	$197.91
October	2,553	N/A	3.4	8.2	$202.25
November	2,845	N/A	4	9.5	$222.77
December	3,148	N/A	4.2	10.2	$244.46

Energy		
Highest Monthly Energy Use	Feb/Mar 2004	3,700 kWh
Lowest Monthly Energy Use	Jul/Aug 2003	1,370 kWh
Cost		
Highest Monthly Energy Cost	Feb/Mar 2004	$280.00
Lowest Monthly Energy Cost	Mar/Apr 2004	$115.84

Estimated Heating Loads for Top Three Energy Users



A heating degree-day (HDD) is one degree below a base temperature beyond which space heating is required to keep the area comfortable. For example, if the base temperature is 65 degrees and the outside average temperature for the day is 45 degrees, that day would have 20 heating degree days. The greater the number of HDDs, the more space heating is required. In this case, the number of HDDs per month is useful to track the annual pattern of the space heating load. The graph above indicates that the energy use in the Administration Building and the school closely follow the pattern of HDDs. At this scale, the pattern of energy use at the health clinic does not appear to track the pattern of HDDs, but at a smaller scale the pattern is evident.

Estimated Percent of Load Dedicated to Space Heating

Month	Admin Bldg. Estimated Heating Load (kWh)	School Bldg. Estimated Heating Load (kWh)	Health Clinic Estimated Heating Load (kWh)
January	50,196	52,050	12,438
February	43,200	43,400	12,490
March	38,930	35,450	11,878
April	23,170	28,567	10,283
May	11,550	17,200	9,360
June	7,730	3,600	9,478
July	1,930	0	8,978
August	0	0	8,558
September	2,640	8,750	8,813
October	18,050	22,650	9,643
November	39,490	44,550	11,385
December	48,576	56,300	12,538
Total	285,462	312,517	125,842
Percent of Total Energy Use	30%	41%	18%

PART 2: QUEETS

The QIN's other population center is Queets, located in the northwest corner of the Quinault Reservation. While not as large as Taholah, it also has several public buildings that could be candidates for the electricity and/or heat from a renewable energy system. The loads at these buildings are significantly smaller than those at Taholah and the majority of them do not have metered demand numbers. Without these numbers it is difficult to estimate the instantaneous power requirements that would need to be met for the community to be entirely free from the Grays Harbor PUD grid. Information on the total monthly energy use, however, can be used to create an estimate for the size of a grid-tied system that would meet the demands of one or more of these buildings.

In order to meet the 24 hour energy needs of the village store, the administration building, fisheries building, and headstart building a renewable energy generator capable of producing 37 kW would be required. Such a generator would not meet the peak power needs experienced during the day. An 85 kW generator would be capable of providing the majority of the power needs of these buildings, but might still not be able to meet the power needs experienced during severe cold or hot spells. No information about the number of residences in Queets is available, so no calculations were done on residential energy use.

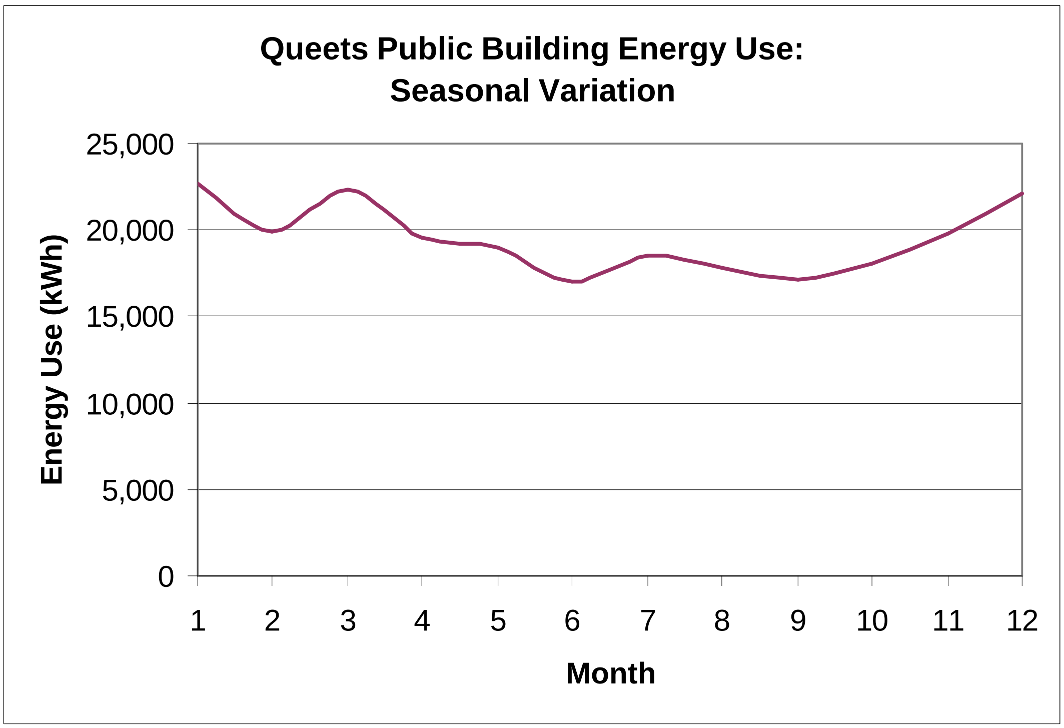
The same calculations that were done for the public buildings in Taholah were also done for the public buildings in Queets. The findings are displayed on the following pages.

Queets Public Buildings Energy Use

Building	Annual Energy Use (kWh)
Village Store	162,762
Admin Bldg	25,511
Fisheries	25,484
Headstart	20,328

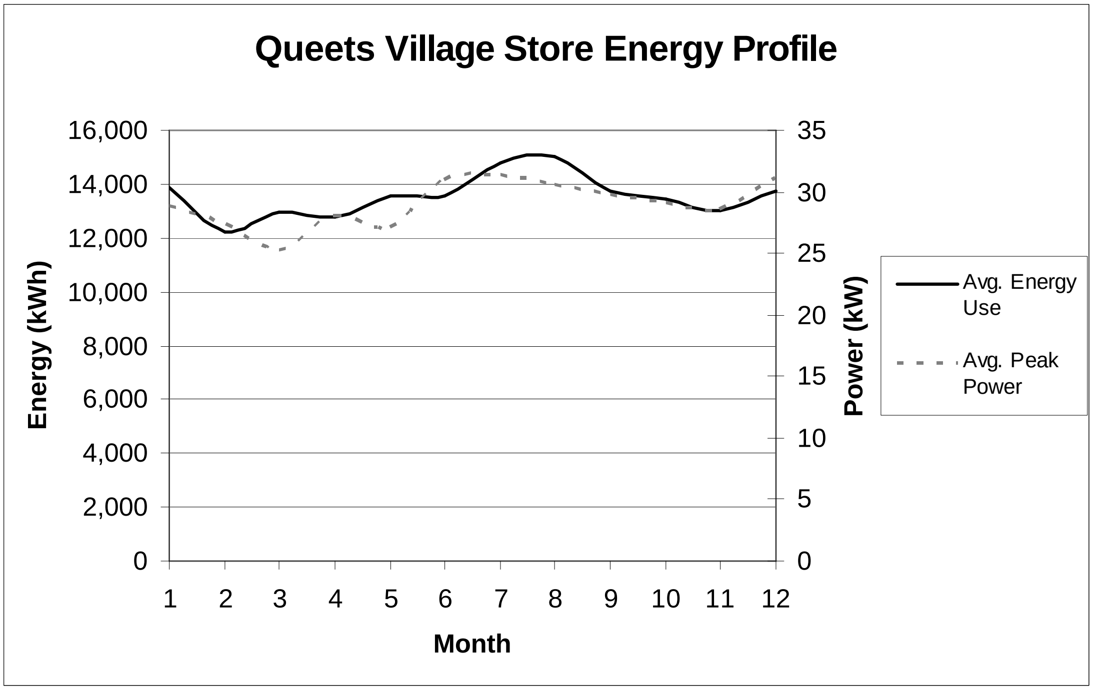
Building	Avg. Monthly Energy Use
Village Store	13,564
Admin Bldg	2,126
Fisheries	2,124
Headstart	1,694

Month	Total Energy Use (kWh)	Cost
January	22,732	$1,475.63
February	19,920	$1,461.09
March	22,378	$1,402.72
April	19,582	$1,241.63
May	18,954	$1,195.72
June	17,015	$1,099.34
July	18,548	$1,411.34
August	17,874	$1,075.53
September	17,167	$1,172.91
October	18,033	$1,182.38
November	19,789	$1,408.36
December	22,092	$1,423.40
Annual	234,085	$15,550.04



Potential Generator Sizing	
24 Hour Average	37 kW
10 Hour Average	85 kW

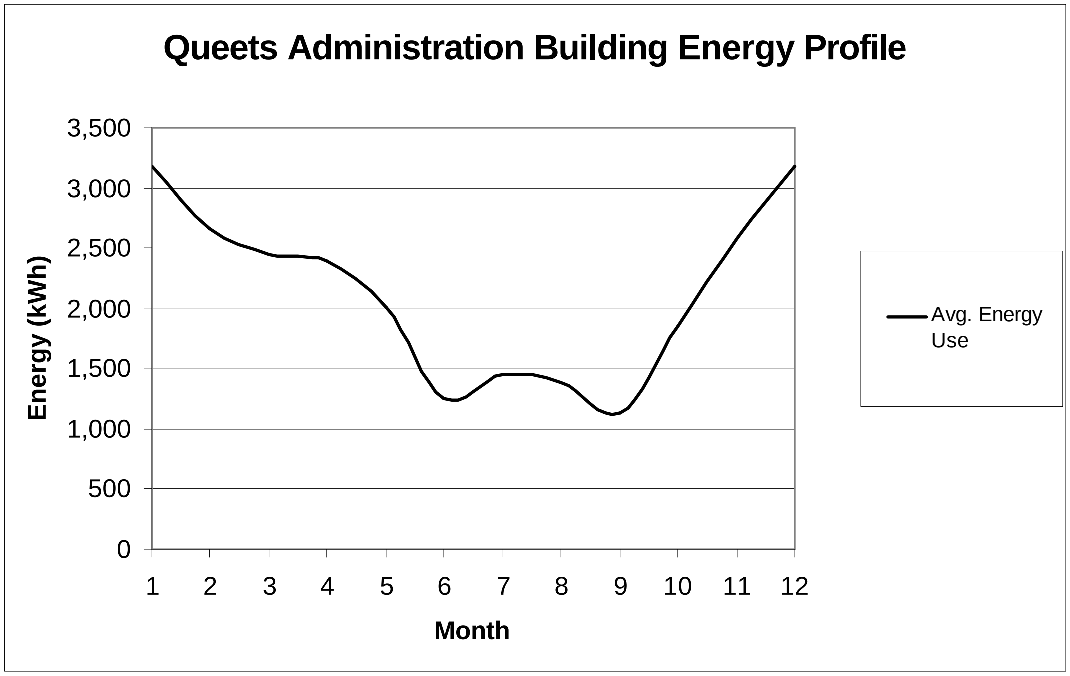
Queets Village Store



Month	Avg. Energy, kWh	Avg. Peak Demand, kW	Avg. Power, kW (24 hr)	Avg. Power, kW (10 hr)	Avg. Cost
January	13,901	28.8	18.7	44.8	$819.88
February	12,228	27.4	18.2	43.7	$812.37
March	12,934	25.3	17.4	41.7	$736.88
April	12,789	28	17.8	42.6	$755.35
May	13,589	27.2	18.3	43.8	$784.66
June	13,581	31	18.9	45.3	$816.07
July	14,811	31.5	19.9	47.8	$1,037.08
August	15,007	30.6	20.2	48.4	$842.65
September	13,737	29.8	19.1	45.8	$868.59
October	13,430	29.1	18.1	43.3	$807.62
November	13,029	28.7	18.1	43.4	$837.25
December	13,727	31.1	18.5	44.3	$806.69

Energy		
Highest Monthly Energy Use	July 2004	17,773 kWh
Lowest Monthly Energy Use	March 2005	11,413 kWh
Power		
Highest Demand Reading	June 2003	34 kW
Lowest Demand Reading	February 2005	24.6 kW
Cost		
Highest Monthly Energy Cost	July 2004	$1,040.50
Lowest Monthly Energy Cost	March 2005	$694.28

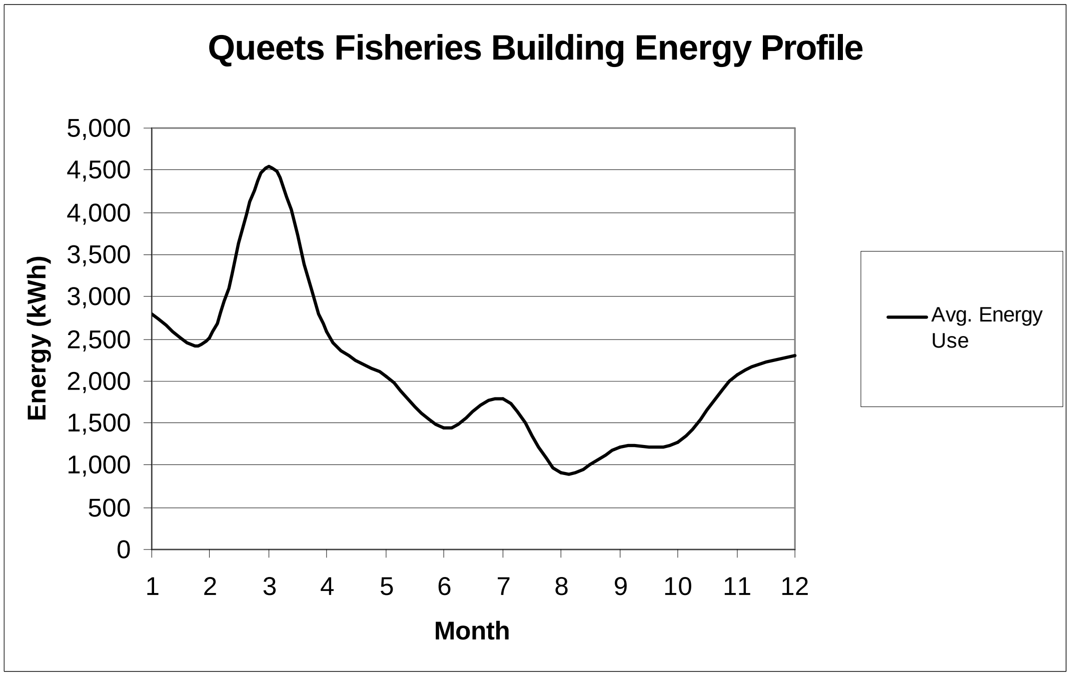
Queets Administration Building



Month	Avg. Energy, kWh	Avg. Peak Demand, kW	Avg. Power, kW (24 hr)	Avg. Power, kW (10 hr)	Avg. Cost
January	3,185	N/A	4.3	10.3	$237.01
February	2,656	N/A	4	9.5	$228.52
March	2,448	N/A	3.3	7.9	$175.83
April	2,398	N/A	3.3	8	$159.97
May	2,009	N/A	2.7	6.5	$152.31
June	1,247	N/A	1.7	4.2	$101.70
July	1,445	N/A	1.9	4.7	$141.55
August	1,378	N/A	1.9	4.4	$105.46
September	1,127	N/A	1.6	3.8	$100.22
October	1,854	N/A	2.5	6	$146.22
November	2,588	N/A	3.6	8.6	$215.93
December	3,175	N/A	4.3	10.2	$230.64

Energy		
Highest Monthly Energy Use	January 2005	3,480 kWh
Lowest Monthly Energy Use	August 2003	900 kWh
Cost		
Highest Monthly Energy Cost	January 2005	$256.85
Lowest Monthly Energy Cost	August 2003	$82.83

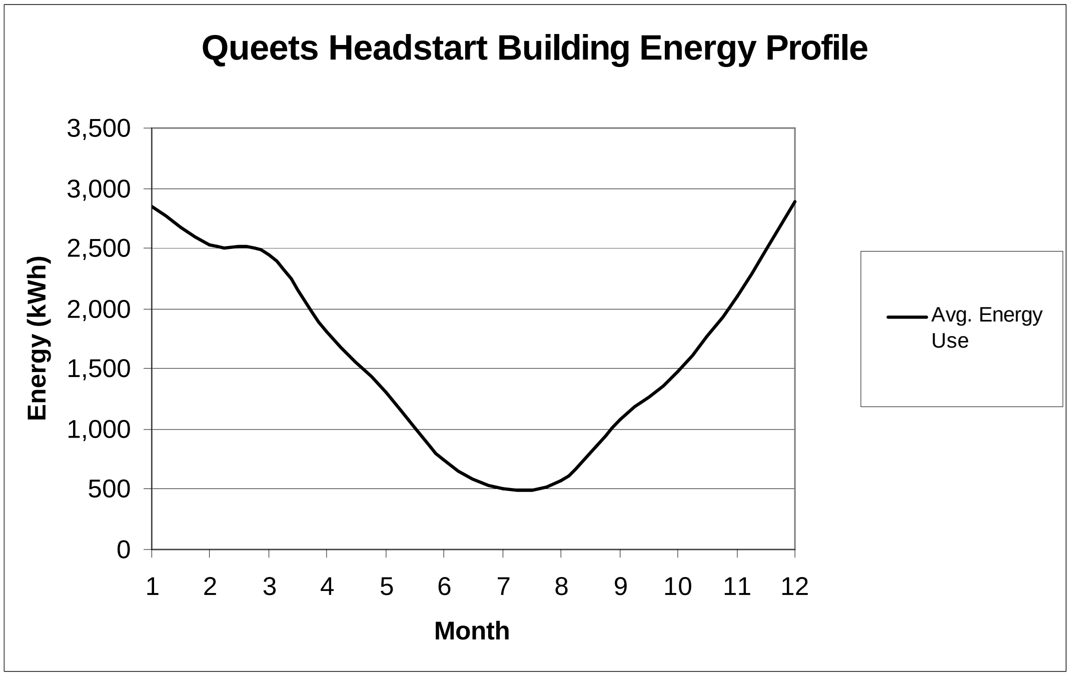
Queets Fisheries Building



Month	Avg. Energy, kWh	Avg. Peak Demand, kW	Avg. Power, kW (24 hr)	Avg. Power, kW (10 hr)	Avg. Cost
January	2,795	N/A	3.8	9	$209.20
February	2,506	N/A	3.7	8.9	$208.29
March	4,543	N/A	6.1	14.7	$313.68
April	2,581	N/A	3.6	8.6	$187.36
May	2,052	N/A	2.8	6.6	$155.36
June	1,436	N/A	2	4.8	$114.94
July	1,786	N/A	2.4	5.8	$174.03
August	913	N/A	1.2	2.9	$74.80
September	1,224	N/A	1.7	4.1	$107.72
October	1,268	N/A	1.7	4.1	$108.55
November	2,075	N/A	2.9	6.9	$177.49
December	2,304	N/A	3.1	7.4	$174.21

Energy		
Highest Monthly Energy Use	March 2005	5,640 kWh
Lowest Monthly Energy Use	August 2003	140 kWh
Cost		
Highest Monthly Energy Cost	March 2005	$407.84
Lowest Monthly Energy Cost	August 2003	$27.28

Queets Headstart Building



Month	Avg. Energy, kWh	Avg. Peak Demand, kW	Avg. Power, kW (24 hr)	Avg. Power, kW (10 hr)	Avg. Cost
January	2,851	N/A	3.8	9.2	$209.55
February	2,530	N/A	3.8	9	$211.91
March	2,453	N/A	3.3	7.9	$176.34
April	1,813	N/A	2.5	6	$138.96
May	1,304	N/A	1.8	4.2	$103.40
June	751	N/A	1	2.5	$66.64
July	506	N/A	0.7	1.6	$58.69
August	576	N/A	0.8	1.9	$52.63
September	1,079	N/A	1.5	3.6	$96.40
October	1,481	N/A	2	4.8	$120.01
November	2,098	N/A	2.9	7	$177.69
December	2,886	N/A	3.9	9.3	$211.87

Energy		
Highest Monthly Energy Use	January 2004	2,880 kWh
Lowest Monthly Energy Use	August 2004	430 kWh
Cost		
Highest Monthly Energy Cost	December 2003	$225.59
Lowest Monthly Energy Cost	August 2004	$44.56

Energy Efficiency Report
Quinault Beach Resort and Casino
Ocean Shores, Washington
August, 2006

I. PURPOSE

The Institute for Washington's Future prepared this report as part of its Quinault Indian Nation Renewable Energy Feasibility Study, a project funded by the US DOE to assess the QIN's options for increasing energy self-sufficiency. It accompanies an electrical energy Needs Assessment for the Quinault Beach Resort and Casino already submitted by IWF, and a companion report describing the energy use for all major facilities owned by the QIN.

As the tribe's largest energy consumer, the Resort and Casino was singled out for this study of energy-saving opportunities to help the QIN slim the facility's energy profile and decrease requirements from the power grid.

This report is not a technical audit estimating the cost-benefit ratios of potential efficiency investments at the Resort and Casino. Rather, it suggests strategies for avoiding conspicuous energy losses and provides links to reputable service providers who can assess costs and follow through on installation. We have checked with industry experts to ascertain whether the recommendations are likely to deliver returns substantial enough to justify their time and expense. We have also consulted with Resort and Casino staff to find solutions that appear doable in the context of other business priorities.

We are aware that comfort and aesthetics are crucial to the Resort and Casino's success. Therefore, we have concentrated on improvements that promise to save energy and enhance guests' experience, especially in the swimming area. We are also aware that the Resort and Casino is already confronting a massive expense to replace its HVAC systems. So we've looked for energy-saving technology that could be implemented in conjunction with equipment replacements that will soon be necessary anyway.

The report includes a narrative describing our observations at the Resort and Casino, our recommended improvements, and then organizes those possible improvements according to cost and priority. An improvement receives high priority if significant benefit would likely be achieved with minimal investment.

Our report focuses the Resort and Casino on priority energy-saving measures that should be attended to, even if its scope does not allow for cost/benefit analyses of all recommendations. With many energy efficiency measures, even experienced auditors cannot precisely predict return on investment. QIN leaders will likely find that their prudent course of action will be guided largely by common sense, aesthetic considerations, and their degree of commitment to energy conservation.

II. Summary and Analysis

The Resort and Casino was not built to high efficiency standards. Consequently, its energy use spikes both as a result of high occupancy and extreme weather, particularly in winter. Efficiency opportunities are limited, since many technologies must be included during construction. The Resort and Casino has already accomplished some of the easiest and most effective retrofit options, including efficient lighting.

That said, the Resort and Casino has options for curbing energy use in major systems that we've outlined below. We believe these are feasible retrofits that will produce cost savings immediately and pay for themselves within a few years. They can also enhance the building's overall environment by making it more continuous with the site's bucolic setting, adding pleasant amenities for resort guests.

This report suggests improvements be explored in the following areas:

A. Swimming Pool Room
B. Climate Control and HVAC systems
C. Hot Water Delivery
D. Exterior Doorways
E. Casino Floor / Great Hall / Slot Machines

Addressing energy consumption associated with these building systems will reduce both weather-related use and the impact of high occupancy periods.

At the end of this report, we include a list of follow-up contacts, many of whom we consulted while preparing our list of recommendations.

III. Recommendations

A. Swimming Pool Room

The swimming pool room is a focal point for a variety of energy-saving options that, taken together, would both prominently demonstrate the Resort and Casino's conservation efforts and transform the room's ambience. These improvements do not require system-wide modifications and so have finite costs. They will also be highly visible to guests.

The swimming alcove offers wonderful beach views and access to an outdoor patio but is unfortunately not designed to take advantage of these features. Especially in summer, the natural lighting and pleasant breezes that surround the building are largely divorced from the pool area, which is hot, dark, and muggy.

Unfortunately, the Resort and Casino is expending a great deal of energy maintaining this environment. Its fifteen 250-watt light bulbs use 90,000 watts per day, and in summer a ventilation system runs constantly to pump out heat and humidity. In winter, heat loss is undoubtedly significant based on the heat loss that can be felt through the doors and windows.

Additional expense is caused by rapid deterioration of the boilers used to heat the pool and hot tub. The sea air combined with constant humidity and chlorine cut the lifespan of the current boilers to about six years, less than half as long as they should last.

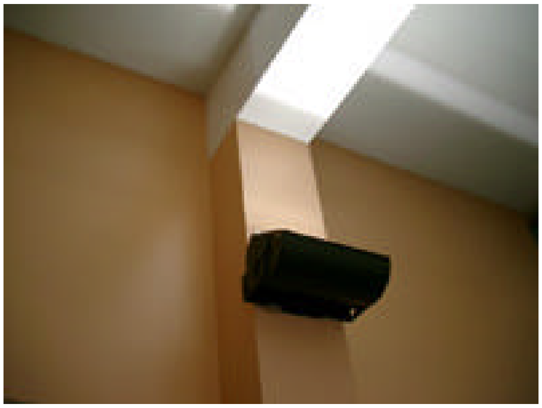
This analysis finds five areas for improvement: *lighting, windows, pool heating, ventilation, and the exercise room.*

1. Lighting

Even with seven large windows and fifteen light fixtures, the swimming area is gloomy. Clearly, the present lighting design does not work despite its intense wattage.

Installation of a skylight in the southern end of the room, which juts about 15 feet past the outside wall of the main building, would be the most effective way to brighten the room, reduce the need for lighting, and produce a more natural environment.

A skylight with ventilation offers another significant advantage in removing heat and humidity from the room in summer.



The easiest cost savings could be achieved through simple reorganization of the fixtures. Presently, most fixtures are mounted on the wall facing the ceiling beams at an oblique angle, creating large shadows overhead. We recommend moving the fixtures so that they more directly illuminate the ceiling – one solution would be raising them higher so they can face outward without causing glare.

The incandescent light fixtures could also be replaced in part with LED fixtures. This has several advantages: LED light arrays can be positioned to enhance attractive features, such as the flagstone walkways, the windows, and greenery. LED arrays also disperse light more effectively. Correctly installed, LEDs could put more light where it's needed, reducing the need for flood lamps. LEDs also have very long lifespans.

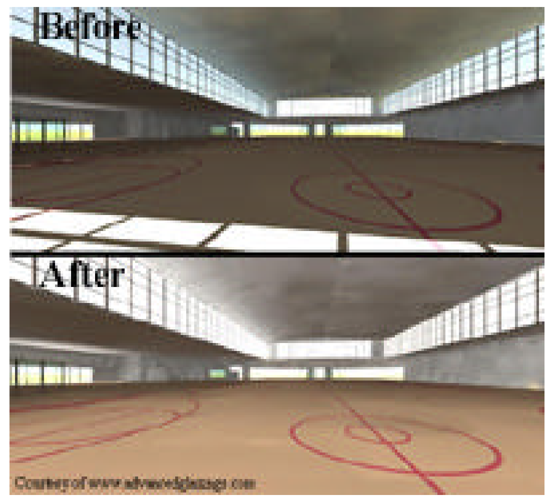
Finally, turning off or dimming the pool room lights while the area is closed would cut energy use by roughly a third, saving 30,000 watts daily (15 lights X 250 watts X 8 hours).

By redistributing the fixtures and adding skylights and light-diffusing windows (see below), it may be possible to reduce the number of bulbs in the room and even turn them off on sunny days. A light-sensitive meter could automatically adjust the bulb intensity based on the available sunlight.

2. Windows

The swimming room has windowed walls facing west and south that are well exposed to natural light. But the sunlight would brighten the room more effectively if refracted through higher-quality windows, which would also improve insulation.

Heat emanating from the pool room can be felt from 20 feet outside the doors, even in summer. While this is not problem in warmer months, winter heat loss is no doubt significant. We recommend installation of “low-e” glass windows that keep heat inside during the winter and block solar heat in the summer. Windows should be Energy Star rated to capture the maximum financial benefits for their installation.



We also recommend light-diffusing glass or window glazing that refracts sunlight to minimize contrasts. The diffusing glass creates a light glow in all directions instead of a single direction. Glazing the top of the windows would not block the view and would greatly improve the natural light on the ceiling and walls.

Mirrors on the pool room walls would also better enhance and distribute natural light, brightening the space and making the room appear larger.

3. Pool Heating

The propane gas boilers currently heating the swimming pool and hot tub water need to be replaced due to salt and chlorine corrosion, creating an opportunity to greatly reduce energy use while adding an attractive amenity.

Solar pool heaters are remarkably effective even in the Northwest and typically save enough energy to pay for themselves in a few years. They can work in conjunction with sealed combustion gas boilers to guarantee consistent heating. One compelling advantage for the Resort and Casino is that solar systems are impervious to corrosion, since the panels are laminated in synthetic materials.

Renewable energy systems offer a market advantage that, though difficult to quantify, should not be underestimated. Current trends indicate that guests are increasingly attracted to “natural” and non-polluting energy sources. Combined with a skylight, the addition of a solar system could convert the look and feel of the swimming area from a conventional “Holiday Inn” aesthetic to one more organic and connected to the natural environment.

A more conventional approach offering energy savings is installation of a heat pump system that uses refrigerant fluid to capture heat from the surrounding air and transfer it to water. This is particularly effective with pool heaters because the temperature requirements for the water are consistent and moderate.

At the very least, the pool should be covered when the swimming room is closed. Pool and hot tub covers are a very simple, cost effective way to insulate the water, avoid heat loss, and reduce unwanted humidity.

4. Ventilation

The pool room's HVAC system runs constantly to evacuate humidity and heat; cooling the room with windows that block solar radiation while allowing circulation of outside air would reduce demands on the system.

The skylight suggested above could provide tremendous ventilation; many models are designed for this. A less expensive option would be installing windows that open near the top of the walls.

Weather stripping should be added around the two large doors that exit outdoors to prevent unnecessary heat loss in the winter.

5. Exercise Room

The exercise room is awash in cold air. The air conditioning is typically on full blast, with the thermostat turned to its lowest setting. We recommend rewiring this thermostat so guests cannot adjust it. Also, the windows should open so the room can be cooled with outside air in moderate seasons.

B. Climate Control and HVAC Systems

The Resort and Casino has had difficulty achieving effective air circulation throughout its main game area and surrounding shops. It is now in the process of replacing the HVAC units that serve this area, and thus in a good position to add an efficiency feature that may help with circulation while lowering energy use.

Heat recovery wheels (also known as enthalpy wheels) that bolt onto commercial HVAC units allow larger volumes of air to be conditioned without increasing energy use. They have proven particularly effective for commercial businesses requiring enhanced ventilation to exhaust cigarette smoke.

Heat recovery wheels pre-cool and dehumidify the outdoor air during the warmer seasons and preheat and humidify it during winter. They are constructed of a desiccant material that absorbs both heat and moisture. Exhaust air passes through one side of the wheel, while incoming ambient supply air passes through the other. As the wheel rotates, heat energy and moisture are transferred from one air stream to the other, significantly reducing the amount of energy needed to condition the incoming supply air. Outdoor air quantity can be increased from 5 to 20 cubic feet per minute without increasing energy costs. The wheels typically capture about 80% of the total energy that would otherwise be exhausted from the building.

Heat recovery wheels are typically packaged as per the following:

- A packaged heat recovery unit (supply fan, exhaust fan, wheel) connected to the outdoor air intake of an existing or new, larger air handling system.
- A complete air handling system, including wheel, supply and exhaust fans, heating coils, cooling coils, humidifier and controls to provide 100% outside air at any desired temperature and humidity to a space or process.
- A stand-alone enthalpy wheel module in a custom-engineered heat recovery system.

Other heat recovery options use condensor coils instead of rotating wheels. Online programs allow a potential buyer to calculate how cost-effective various heat recovery systems are likely to be.

The winter load on the HVAC system could be reduced with radiant heaters that heat specific surfaces with which people interact, such as seating areas or restaurants.

Additionally, control systems are crucial to efficient HVAC operation, and past history indicates the Resort and Casino has had no regular maintenance program to ensure economizer systems function properly. We recommend that the facility either establish a maintenance program or hire a service provider to do regular upkeep. Given the HVAC units' long hours of operation, combined with the opportunity to mix in relatively cool air in the summer, the energy reductions could well pay for a service contract. See Sound Energy Systems (contact list). Ron Miller is the service program manager.

C. Hot Water Delivery

While reducing electricity use is the primary focus of this report, the Resort and Casino could also find significant savings by improving delivery of hot water, which is heated with gas boilers.

The hot water boilers are located at one end of the Resort and Casino, forcing hot water to travel a very long distance to rooms in the opposite end of the building. Staff report that it is often necessary to open a tap at the end of the line early in the mornings so guests will have hot water available when they wake. This is obviously wasteful, but perhaps not to the degree that it justifies the expense of new water lines and pumps necessary to create a continuously circulating hot water supply.

We propose that the hot water problem be addressed when the facility replaces the boilers for the swimming pool, which is located at the end of the building opposite the domestic hot water source.

The solar pool heater we described in the Swimming Pool section could be a solution. The design can easily be modified to route the ambient fluid heated by the solar panels through more than one heat exchanger, allowing the fluid to heat not just the swimming pool water but also an insulated tank containing domestic water – without mixing the two water supplies. This would create a constant reservoir of warmed water for guest rooms at that end of the building, significantly reducing the need to clear the pipes of cold water.

Finally, the hot water pipes in the boiler room are not insulated up to the point where they enter the main building. We presume that the pipes running between the floors are insulated, but we were unable to confirm this. We recommend investigating and finding a way to insulate them if they are not.

D. Exterior Doorways

1. General

Nearly all of the exterior doorways at the Resort and Casino have poor weather stripping, allowing substantial air movement around them. Several of the doors are emergency exits that are rarely used. These doors could be sealed with tape or stripping that would easily give way if the doors were needed in an emergency.

2. Loading Dock

Staff reported that the rush of air through the loading dock door on the north side of the building is sufficient to blow ceiling tiles out of place. They said that interior doors separating the loading area from the main building are kept shut in winter to prevent major air influx, but even so, the constant infusion of cold air seems to make some employees uncomfortable, causing them to use space heaters near their workstations.

We recommend a vinyl curtain suspended a few feet inside the lip of the loading dock, far enough back that workers can unload trucks without passing back and forth through it. This will shield employees in the maintenance offices from the drafts and also insulate the area against the exhaust fumes from idling vehicles.

E. Casino Floor, Great Hall, and Slot Machines

The main casino floor is the largest room in the hotel, the hub of all activity, and the connector between the resort's facilities and public areas. It is connected to the Great Hall by a large lobby; together, these two rooms make up the bulk of the building's public floor space.

The Great Hall is so large that employees begin cooling it several days in advance of weekend performances. During busier seasons, the air conditioning system runs constantly.

The casino is in a similar situation: it is a very large room that must constantly maintain optimal temperatures. Because both rooms must be so carefully controlled, the best way to achieve efficiencies is through optimum HVAC operation, perhaps adding heat recovery wheels, as discussed, but certainly keeping economizer controls functioning properly to take advantage of the coast's relatively cool summer air.

Another strategy for cutting electricity use – as well as heat buildup that adds extra work for the HVAC units -- would be dimming lights when the casino floor is closed and employing greater numbers of Liquid Crystal Display (LCD) slot machines.

Resort and Casino managers say that even though the casino floor is closed from 2 am to 9 am, the lights and machines remain on for security and guest appeal. However, dimming the lights or adjusting the machines would save significant energy during non-use hours.

The casino could implement LED lighting throughout the floor for basic, background lighting effects. The more LED lighting is in place around the walls and walkways, the fewer larger bulbs are necessary.

The casino's 450 slot machines are its largest electricity consumer, which has already prompted the Resort and Casino to experiment with energy-saving LCD models -- with good success. Two LCD machines can fit in the same space as one conventional machine that uses a cathode ray tube (CRT), and research shows that guests tend to stay at them longer. (The Resort and Casino's LCD game banks were busy for our entire visit.) If the casino replaced existing CRT displays with LCD displays, it could host nearly double the machines while using less energy. The cost of retrofitting a CRT with an LCD display is roughly $1,000 per machine.

A less intensive improvement would be replacing the fluorescent bulbs in the machines with more efficient neon cathode bulbs. These are more expensive but use much less electricity and have a longer lifespan. Retrofitting with these bulbs would cost less than $300 per machine.

IV. PRIORITIES

Our recommendations from Section III prioritized according to cost and ease of implementation. As stated in the report's introduction, our scope does not allow for pricing of all alternatives; it will be necessary to follow up with suppliers and contractors to get estimates based on the Resort and Casino's preferences. However, our recommendations can be sorted into the following basic categories:

Low Cost / Simple

- Dim lights at night – Swimming Pool Room and Main Casino Floor
- Reposition light fixtures – Swimming Pool Room
- Install mirrors – Swimming Pool Room
- Regulate thermostat – Exercise Room
- Add weather stripping – Entire Building

Low to Moderate Cost / Some Assembly Required

- Insulate water pipes – Entire Building
- Install vinyl curtain – Loading Dock
- Install insulated cover on swimming pool and hot tub
- Add light sensor and control – Swimming Pool Room

Higher Cost / Professional Contractor Required

- Acquire HVAC maintenance and service plan – Entire Building
- Install Skylight – Swimming Pool Room
- Install light diffusing glass in upper windows – Swimming Pool Room
- Install solar-blocking windows – Swimming Pool Room
- Install LED lighting – Swimming Pool Room and Main Casino Floor

Highest Cost

- Switch to solar or heat pump water heaters and use new system to heat domestic water as well as swimming pool and hot tub – Swimming Pool Room
- Switch to neon cathode bulbs – Slot Machines
- Switch to liquid crystal display games – Slot Machines
- Add heat recovery wheels – HVAC System
- HVAC and ventilation – Entire Building. The Resort and Casino is replacing and upgrading the HVAC system. This is crucial in determining the true efficiency of the system and providing data for other conservation efforts.

V. INCENTIVES AND GRANTS

The QBRC has several options for initiating and including financial incentives into improving the energy efficiency of the resort. These incentives come from three main agencies: the Federal Government, Washington State Government, and the Bonneville Power Administration. Many of the incentives are either tax credits or tax deductions.

This is not an exhaustive list of all possible incentives for renewable energy or energy efficiency improvements. These are the major programs available to the QBRC as a commercial facility for energy efficiency improvements. In addition to the following descriptions of the incentives, a collection of web sites is located at the end of the contact list.

Federal Incentives
The federal government offers incentives in many areas of renewable energy and energy conservation. For the conservation purposes of the QBRC, the two main areas of incentives are the Federal Business Energy Tax Credit (BETC) and the Energy Star Tax Credit (ESTC) umbrella.

The BETC offers a tax credit up to 30% of the installed cost of an alternative energy producing system, including solar water heaters. This is *the* credit for implementing renewable energy systems since it can recover nearly a third of the capital cost. This credit expires December 2007.

The ESTC umbrella includes incentives for the use of appliances and other products that meet the Energy Star efficiency requirements. Many appliances, including dishwashers and dryers, as well as products such as windows are eligible for tax credits. The Energy Star website has a "rebate locator" that lists all the Energy Star incentives for a particular zip code.

There are other incentives available for the production of energy and the use of alternative fuels. The QBRC would be eligible for these credits if it were to produce electricity on-site or if it were to convert its use of propane to an alternative fuel. Converting its use of propane corresponds with the overall goals of the QIN outlined in the Renewable Energy Plan for the Nation.

Washington State Incentives
The State offers a tax exemption for any renewable energy generating system, including solar water heating. This tax exemption includes equipment purchases, labor taxes for installation, and other services related to the installation of systems.

Bonneville Power Administration
The BPA is a partner with the Energy Star programs and helps provide incentives for the installation of energy saving appliances and products. The BPA is also a conduit for the IRS tax deduction for installed energy efficiency improvements. If a certain area claims more than 50% reduction in electricity usage, the QBRC is eligible for a deduction up to $1.80 per square foot. Improving window installation, water heater efficiency, and electricity used for the lighting, the pool room would be eligible for this deduction.

VI. CONCLUSION

We hope the Quinault Indian Nation finds this report helpful in sorting out energy-saving options at the Resort and Casino and deciding which options best suit its business needs. Once priorities are established, contractors and suppliers listed in the next section can provide cost estimates and give greater detail about the potential benefits of improvements.

As stated earlier, exact figures comparing cost and benefits are not always available even from experienced contractors and consultants. Many variables influence how well new systems perform – particularly water heaters and HVACs. However, contractors who perform certain of the recommendations listed in this report should be able to offer "performance contracts" which guarantee a corresponding drop in energy use subsequent to equipment installation. For example, a contractor who installs LED lights and reconfigures the incandescent fixtures in the swimming pool room can probably guarantee measurable results. The same is true with replacing slot machines or retrofitting them with energy-efficient bulbs. The returns from improved windows, insulation, and a skylight are more difficult to show.

Some recommended improvements, particularly those categorized as Low and Moderate cost, are generally accepted as common-sense conservation. We recommend the Resort and Casino form a plan to pursue at least these efficiency measures or show why they are not feasible or cost-effective. Just enacting routines such as dimming lights can make staff more aware of energy use and cause them to adopt energy-saving habits.

For higher-cost improvements, the Resort and Casino administration will have to calculate how well energy efficiency fits into the context of existing priorities. If management agrees that the swimming pool area should be made more attractive, expensive upgrades that increase natural light and ventilation make sense. If not, we cannot guarantee those remodels will pay back their costs in energy savings, and doubt that a contractor could, either. We should add the caveat, however, that solar water heaters for swimming pool are compiling an impressive performance record and should not be dismissed as a mere "feel-good" accessory. How well one would perform as a complementary domestic hot water heater is less certain, but worth discussing with a contractor.

We encourage the QIN to move forward with this report and initiate an administrative discussion about conservation and efficiency priorities at the Resort and Casino. Management has already done an impressive job capturing some of the more obvious efficiencies, such as improved lighting in the main building. That work has made a real impact on energy use that clearly shows on the facility's electric billing statements. We believe more opportunities remain that should at least should be investigated.

We encourage any input or additional questions the QIN feels should be analyzed in this assessment.

VI. CONTACT INFORMATION

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Ph: (206) 267-2213
Seattle, WA, 98104

Products and Systems:

Skylights:

West Coast Services, Inc.
Contact: Larry Whitish
Email: lawrence.whitish@gte.net
Ph: (206) 682-8310 - Fax: (206) 682-8421
Seattle, WA - 98134 - USA

Light-diffusing technology:

Advanced Glazings, Ltd.
http://www.advancedglazings.com/

LED Lighting:

LEDTronics
http://www.ledtronics.com/
23105 Kashiwa Ct
Torrance, CA 90505
Ph: (800) 579-4875 - Fax: (310) 534-1424

Solar Pool Heaters:

Northwest Mechanical, in Shoreline, Washington
http://www.nwmechanical.com/solar/

Puget Sound Solar, in Seattle
http://www.pugetsoundsolar.com/

HVAC and Heat Recovery Wheels:

http://www.bernerenergy.com/pdfs/enthalpywheel.pdf
http://cipco.apogee.net/ces/library/tdew.asp

For further consultation:
Sound Energy Systems, Tacoma, Washington
Dan Newton 253.475.3525
www.ctmgroup.com

Windows:

Champion Windows – Champion of Seattle
http://www.championwindow.com
Email: seattle@ChampionFactoryDirect.com
18436 Cascade Ave. South Suite 120
Tukwila, Washington 98188
Ph: (206) 902-1080
Toll-Free Phone: (888) 323-4642

Slot Machines:

Slot Sales LLC
Contact: Dray Moor
http://www.slotsales.com
Email: draymoor@aol.com
2802 Cartwright St.
Dallas, TX 75212
Ph: (214) 637-6040 – Fax: (214) 631-7568

Grant Incentives:

Database for State Incentive for Renewable Energy (DSIRE)
http://www.dsireusa.org

Federal Business Energy Tax Credit
http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=US02F&State=Federal&currentpageid=1&ee=1&re=1

Energy Star Tax Credit
http://www.energystar.gov/index.cfm?c=products.pr_tax_credits#8

Energy Star Rebate Locator
http://www.energystar.gov/index.cfm?fuseaction=rebate.rebate_locator

Washington State Sales and Use Tax Exemption
http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=WA04F&state=WA&CurrentPageID=1&RE=1&EE=1

Bonneville Power Administration:

Energy Efficiency
http://www.bpa.gov/energy/n/index.cfm

Tax Deductions for Commercial Buildings
http://www.bpa.gov/Energy/N/CommercialTaxDeduction.cfm

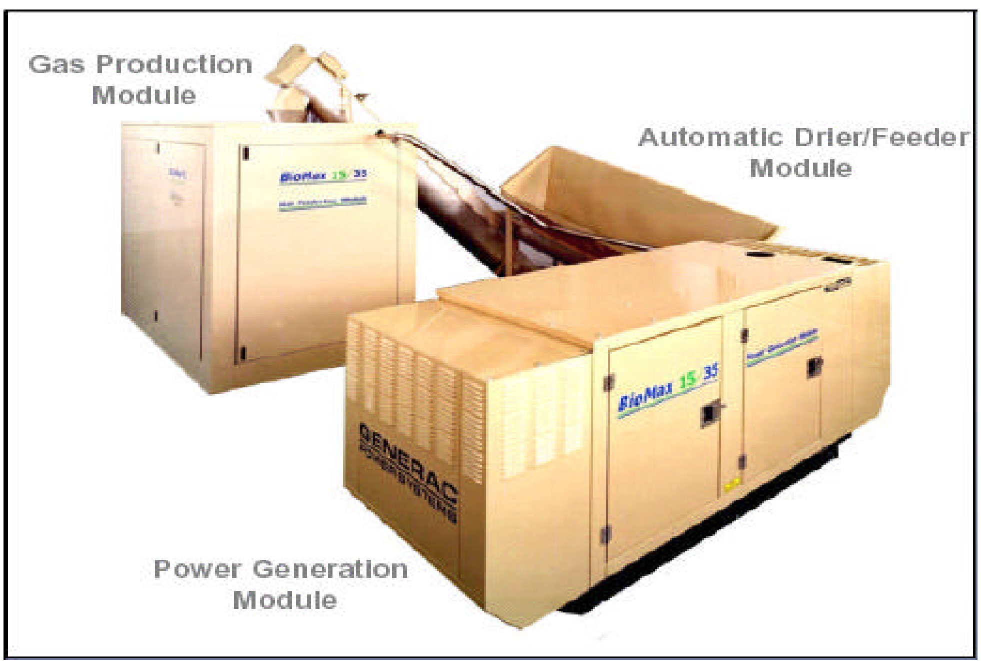
BIOMASS ENERGY OPTIONS FOR THE QIN

INTRODUCTION

The abundance of biomass on the Quinault Indian Reservation (QIR) is apparent to even the most casual observer. How much of this biomass can be sustainably harvested has been addressed in previous reports. This report addresses possible first steps in utilizing this resource for the production of energy and energy products. The QIN has expressed an interest in on-site energy production and commercial-scale production of energy products. Both of these possibilities will be addressed here. The commercially-available technologies to convert biomass to energy and energy products are generally on a larger scale than is needed on the QIR. There are, however, a limited number of technologies in the demonstration phase that would work well in this situation.

SMALL-SCALE ENERGY PRODUCTION: COMMUNITY POWER CORPORATION'S BIOMAX:

The BioMax system uses wood chips to create a low energy-density gas that can be used to run a generator. Systems range in size from 5 kW to 50 kW, but the 15 kW system is closest to commercialization. In addition to the gas that runs the generator, the BioMax process produces heat. The efficiency of the system is greatly increased if the heat is used as well as the electricity. Waste products include ash, char, tars, and soot that are stored and can be periodically combusted into an ash that can be used as a soil amendment. Because this is a modular system, additional components can be added to meet increased loads.



The BioMax System includes an automatic feeder, gas production module, and power generation module. (Photo: Community Power Corp.)

The technology behind the BioMax is gasification of woody biomass. During gasification the biomass is heated in the absence of the amounts of oxygen that lead to full combustion of fuels. Without the ability to combust fully, the biomass breaks down into a gas, referred to as syngas. Because gases mix much more easily with oxygen, the syngas is a more efficient fuel than the solid biomass. It can be combusted in an internal combustion engine or a turbine to produce electricity or mixed with chemical catalysts to be converted into other products. In the case of the BioMax, the syngas is combusted in an internal combustion engine to produce electricity.

The small size of this system makes it a good candidate for use on individual buildings. The QIR Needs Assessment identified several buildings that are good candidates for incorporating a BioMax. In Taholah, the school, the administrative building, and the health center have appropriate loads for a BioMax. In Queets the store has an appropriate load. A BioMax system used in one of these buildings would be a good first step to producing energy on the QIR. Table 1 displays how a small, modular biomass system would supply energy to these buildings, along with the fuel requirements.

Connecting the BioMax

The best option for connection of the BioMax would be a connection to a specific building's grid and a net metering arrangement with Grays Harbor PUD. In such an arrangement the value of the electricity would be equal to the cost of the electricity normally purchased the QIN. Running the BioMax during peak hours could also reduce the demand charges incurred by the building. If the electricity were simply sold to the PUD rather than net metered, the PUD would pay the wholesale price for the electricity which is much lower than the consumer price. For a small system such as the BioMax, receiving wholesale prices for the electricity severely limits the economic viability of the project. Currently, Grays Harbor PUD does not consider small, modular biomass a renewable technology. This situation would have to be addressed before a net metering agreement is reached. The PUD net meters on a monthly basis with any excess energy produced above the needs of the building credited to the following month's bill. At the end of the year any excess balance is paid to the customer at 50% of the normal rate. For this reason the buildings chosen as potential sites all use more electricity than the BioMax would produce. When net metering it is not necessarily a good thing to produce all of one's energy needs.

As previously mentioned, the efficiency of the BioMax is greatly increased if the heat produced during gasification is utilized. In the case of the QIR, using this waste heat would also offset the electricity that is currently used to provide space and/or water heat. The tricky part is channeling the heat into the system. For most of the buildings it is a safe assumption that the heating systems would have to be modified to incorporate a connection to the BioMax. The one exception is the new health clinic. If a decision is made to purchase a BioMax system before construction is far advanced, the building design could be modified to include an HVAC system capable of utilizing the waste heat from the BioMax. Such a design would require the work of an HVAC engineer.

Another issue that could be addressed through the installation of a BioMax is the frequent power outages experienced on the QIR. In most net metering situations the electricity generator automatically shuts off when grid power is interrupted. This protects line workers who might otherwise be exposed to voltage in the line created by the distributed sources of electricity. In order to use the BioMax for both net metering and as a back-up generator dedicated circuits are required. Under normal operating conditions the electricity produced by the system would be fed into the grid. During a power outage, the system would be switched to the dedicated circuits to provide essential electricity. All of the buildings identified as candidates for a system use more electricity than is produced by the BioMax. The system would not be able to provide enough electricity to power the entire building during an outage, so only essential systems would be on the dedicated circuits. This electricity would not be eligible for net metering.

If the QIN wishes to sell the renewable energy credits associated with the BioMax electricity, a meter dedicated to the system could track its production. The Bonneville Environmental Foundation (BEF) is a potential buyer of green energy credits. They refer to them as Green Tags and sell them to city governments, utilities, and companies who wish to use green energy. It is very important to find a buyer for the renewable energy credits before purchasing the system to ensure that revenue stream.

Fueling the BioMax

Providing the fuel for a small, modular biomass energy conversion system is easily done on the QIR. The potential biomass availability is 11,000 tons annually while the 15 kWe BioMax would use only 217 tons, even if run continuously which is not the usual situation. The wood collected for the system needs to be chipped before being placed in the drier/feeder module. This is likely best done at the location of the biomass, which can then be transported to the BioMax site. The maps attached to this document show the location of woody biomass on the QIR, close to the proposed BioMax sites. These could be useful when considering transportation costs.

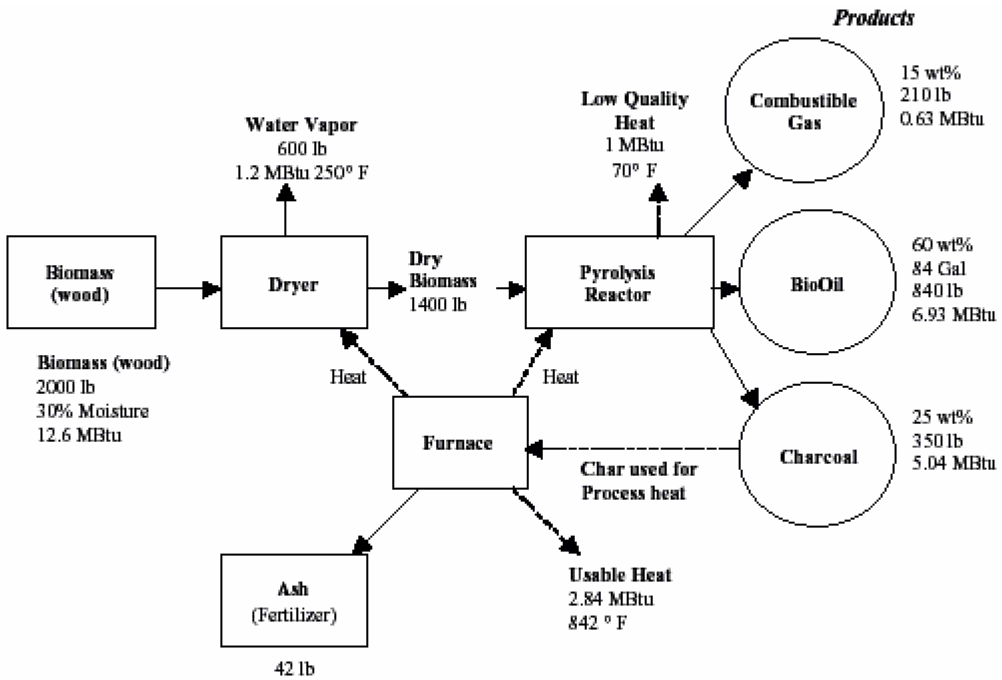
COMMERCIAL-SCALE ENERGY PRODUCTION:

Because the biomass resource on the QIR is so large, particularly when combined with other sources on the Olympic Peninsula, there is the possibility of producing energy on a commercial scale. The challenge in this case is that Grays Harbor PUD would have to agree to buy the electricity, if that is the end product, and transmit it to its final destination. Transmission constraints, and the technology required to monitor such a system, are a problem on the QIR. The line from Moclips to Taholah has a maximum load of 5 MW and is not currently monitored. These issues may make Grays Harbor PUD reluctant to enter into an agreement to purchase this electricity. If the final energy product is not electricity, transportation and marketing becomes an issue, both of which need to be addressed in the initial cash flow and before any purchases are made.

Renewable Oil

Renewable Oil International (ROI) has developed a biorefinery process that converts biomass to a “BioOil” that can be transported and later used instead of natural gas, propane, or other fuels.

In this process biomass is dried and then placed in a pyrolysis reactor that, in the absence of oxygen, produces a gas, an oil, and charcoal. The gas and charcoal are used to fuel the process and the BioOil can then be sold as a product. The figure below diagrams the process.



ROI Material and Energy Balance for Biomass (wood) at 30% Moisture

Although this technology is on a much different scale than the BioMax technology previously discussed, a comparison (Table 2) reveals that the efficiency of the two processes is very similar, if not the same. Any difference lies in the fact that ROI's biorefinery uses the majority of the excess gas and charcoal to run the more energy intensive process.

The Renewable Oil technology would run as a stand-alone system. It would also produce usable waste heat, so a location at which this heat could be used would increase the efficiency. ROI's current plan is to put out a 100 ton/day system commercially. At this level they believe that the system will be cost effective. To run such a system on the QIR would require 36,500 tons of biomass annually. This figure is far above the estimates for a sustainable forestry plan. It is possible that by transporting biomass from the rest of the peninsula such a plant could be feasible. The other possibility is to work with ROI on a smaller plant as a demonstration project. With the increased biomass requirements transportation costs would also become a major factor.

Dynamotive

Dynamotive is a design and manufacturing company producing bio-oil production facilities. It is involved with the use of bio-oil as an electricity-generating fuel as well as value-added product research for bio-oil. Dynamotive is located in Vancouver, BC, but has several projects spanning the world: Quebec, Nova Scotia, Ukraine, and several more opportunities.

The bio-oil facilities and machinery that Dynamotive designs have two basic capacities: 100 tons of biomass per day and 200 tons per day. The company is reluctant to pursue demonstration of other sizes because of financial concerns and the company's mission to manufacture consistent products. In the long term, the company may be interested in pursuing demonstration project development.

Bio-oil is produced from a pyrolysis process which thermally converts cellulosic material to a liquid fuel, char, and usable trace gases. Several companies have significantly different technologies to produce these materials, but Dynamotive is the most established with the track record matching the current needs of the QIN.

CONCLUSION

The technologies discussed here are not yet available commercially. For this reason I have not included cost information. To obtain one of these systems, it would be best to present a proposal for a demonstration project. In this way the scale of the project could be fitted to the needs of the QIN and possibly increased in a modular fashion as the opportunity presents. The biomass resource on the QIR and the QIN's commitment to renewable, independent energy make the installation of one of these systems an excellent goal.

BIOMASS DEFINITIONS, THERMAL CONVERSION PROCESSES, AND BIO-OIL PRODUCTS

KEY DEFINITIONS

Pyrolysis – Fast pyrolysis is a process in which organic materials are rapidly heated to 450 – 600° C in absence of air. Under these conditions, organic vapors, pyrolysis gases and charcoal are produced. The vapors are condensed to bio-oil. Typically, 70-75 wt.% of the feedstock is converted into oil. Pyrolysis offers the possibility of de-coupling (time, place and scale), easy handling of the liquids and a more consistent quality compared to any solid biomass. With fast pyrolysis a *clean* liquid is produced as an intermediate for a wide variety of applications.

Gasification – Generally, biomass gasification is a thermal conversion technology where a solid fuel is converted into a combustible gas. A limited supply of oxygen, air, steam or a combination serves as the oxidizing agent. The product gas mainly consists of carbon monoxide, carbon dioxide, hydrogen, methane, water, nitrogen, but also contaminants like e.g. small char particles, ash and tars. After cleaning the gas makes is suitable for boiler, engine use, and turbine use to produce heat and power (CHP).

Boiler – Feedstock is ground and placed in a boiler where it is combusted to create steam to power a turbine. Boilers can burn wood chips, wood pellets, bio-oils, charcoal, and even other waste materials. The heat off the system would be used for Combined Heat and Power (CHP) for most efficiency.

Bio-Oil – This is the liquid product of pyrolysis. We associate the word *biofuel* with *bio-oil* because both mean a fuel derived from woody biomass. There are many new terms floating around the industry and it is important to understand the differences. Bio-Oil is a heavy fuel derived from woody biomass through pyrolysis. It contains less nitrogen than petroleum products, and almost no metal and sulfur components. This is *not* the same as biogas or bio-diesel.

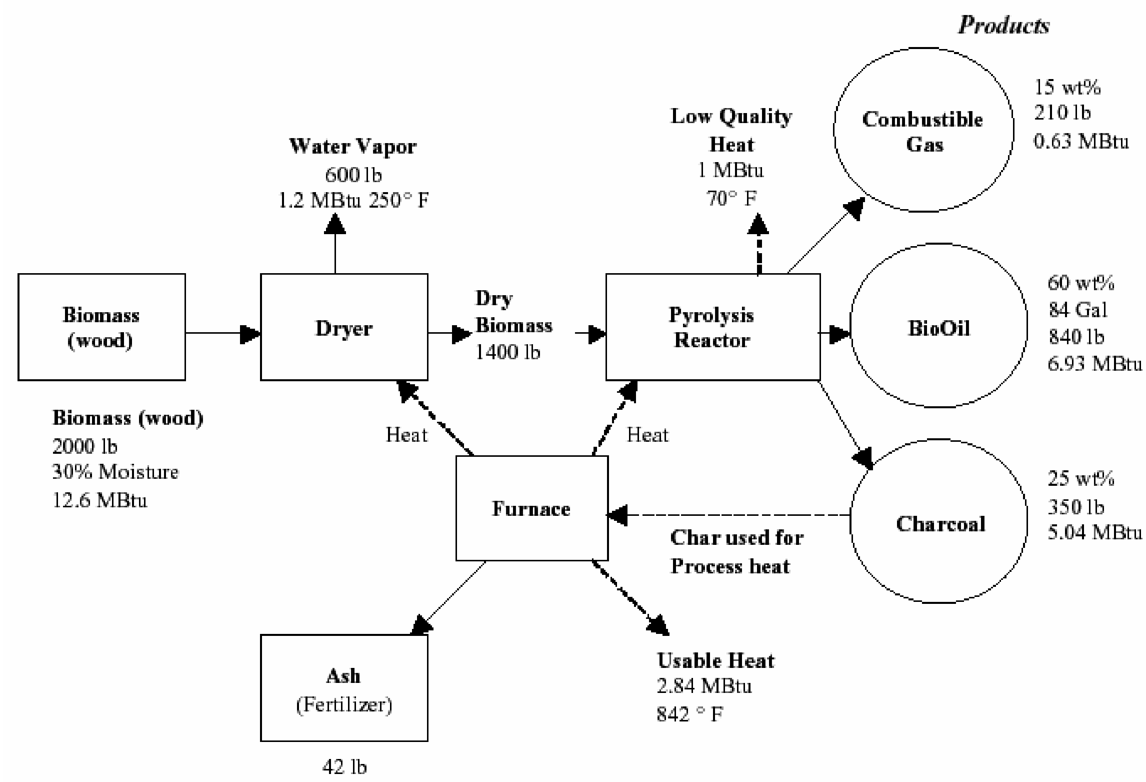
Generator – A generator uses fuel to produce energy through a combustion process. There are many fuel sources and each requires distinct retrofits to the engine itself. There have been significant industry improvements to incorporate the new alternative fuels for energy production.

Turn-Key System – A turn-key system is a complete system that is delivered to the customer with all the necessary components in place and ready to just “turn the key”.

Retail Energy – Retail energy price is what a retail consumer pays for electricity off of the grid. Retail energy prices are important in order to calculate how much money is saved by replacing present energy sources with new energy sources. This applies to on-site power generation

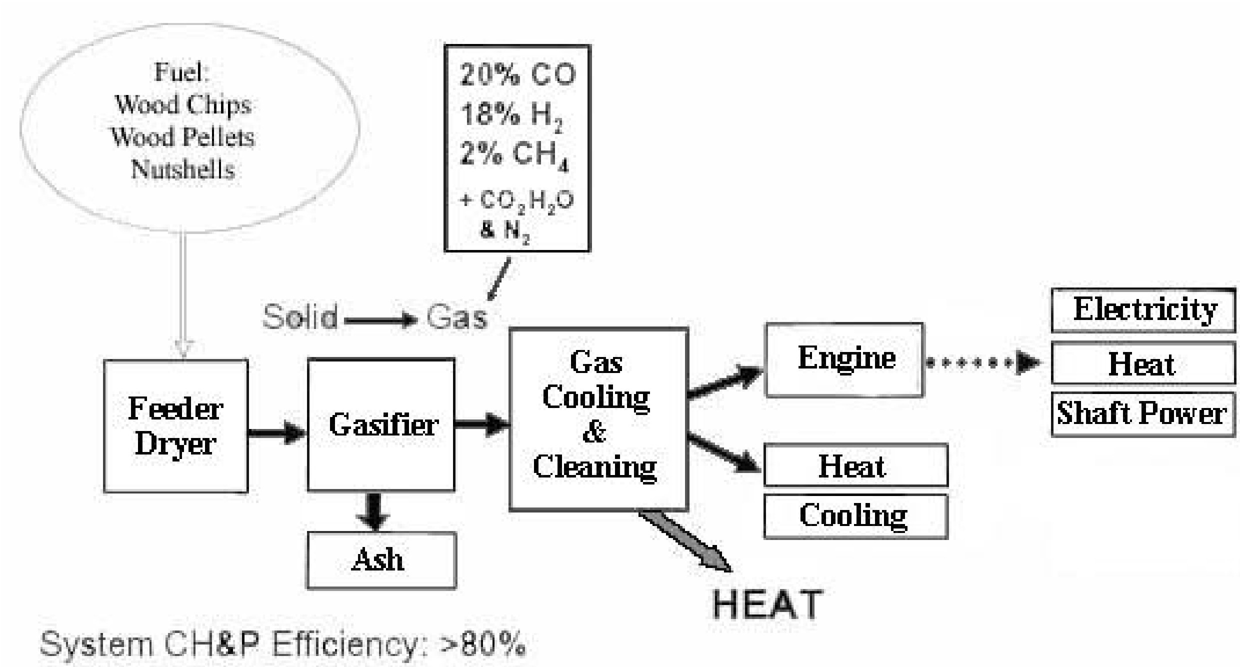
Wholesale Energy – Wholesale energy price is what an independent producer of electricity is able to sell the power back to the utility. The utility will buy the energy for a reduced rate in order to sell it back to consumers at the retail price. This applies to commercial power generation.

PYROLYSIS PROCESS



ROI Material and Energy Balance for Biomass (wood) at 30% Moisture

GASIFICATION



Sources:
Phil Badger, Renewable Oil International
Art Lilley, Community Power Corporation

PRODUCT DEVELOPMENT

http://www.dynamotive.com/biooil/productdevelopment.htm

BioOil-based products that utilize the whole BioOil or fractions include the following:

Acetalization
RTI has patented a method for reacting BioOil with alcohols to form acetals, polyacetals and esters. This process converts acetic and other acids to esters and removes a significant percentage of the water contained in the BioOil. As a result, fuel stability is improved, corrosivity and viscosity are reduced, and heating value is increased by up to 30%. The upgraded product is also more soluble in gasoline, suggesting potential application as an alternative source of octane enhancers.

Acetic Acid, Glyoxal, Acetol and Formic Acid
These chemicals are the most abundant individual compounds found in BioOil. All are widely used commercial chemicals with well-known applications.

Catalytic Reforming
The most preferred method of upgrading BioOil is to convert it to a premium fuel that is fully compatible with existing petroleum fuels. RTI has demonstrated techniques to gasify BioOil and convert it into synthesis gas, which can then be converted into a bio-based synthetic diesel fuel or bio-methanol via commercial processes (i.e., Fischer Tropsch, etc.). Synthesis gases and/or bio-methanol may be applied directly to SO or PEM fuel cells. The US National Renewable Energy Laboratory (NREL) is also developing a steam gasification process to generate hydrogen from BioOil.

Emulsions
BioOil is not miscible in diesel. Two programs, one in Canada (CANMET) the other in Italy (University of Florence), are focused on commercializing BioOil/diesel emulsions using surfactants. Emulsions of 10 - 30% BioOil in diesel would improve fuel stability, corrosivity, and viscosity and provide a cetane value similar to neat diesel. DynaMotive is providing BioOil for both emulsion projects. Patents are issued or pending

Flavour Chemicals, Solvents, Resins
Reaction of BioOil with ethanol via the acetalization process described above also results in a significant increase in the distillable fraction of BioOil. Hence, additional useful products may be more readily recovered by conventional methods. Applications for these products include: flavour chemicals, octane enhancers, solvents, resins and varnishes.

Chemical Refining and Extraction
BioOil contains a number of valuable chemicals, which may be recovered through extraction or refining. The principle candidates for recovery include the following:

- Hydroxyacetaldehyde. This is one of the most abundant single compounds present in BioOil. Potential applications include brightening agents for paper production and as a replacement for glyoxalin in some applications.

- Levoglucosan. Potential applications include pharmaceutical synthesis, pesticide synthesis, specialty polymers and resins, and surfactants.
- Levoglucosenone. This chemical can be produced with pre-treatment of feedstock. Potential applications include synthesis of antibiotics and immuno-suppressive agents, production of phernomes, and "green" chemicals including fuel additives, pesticides and solvents.

Resins

Several organizations including Neste Chemicals, NREL and Louisiana Pacific are investigating the potential to extract pyrolytic lignin from BioOil to produce bio-based resins in which the pyrolysis lignin partially replaces phenol in phenol-formaldehyde novellas and resoles. Bio-based resins may replace oil-based resins used in building products. Preliminary work carried out by RTI suggests that some BioOil fractions may also have the potential for replacement of poliols in polyurethane formulations.

Slow Release Fertilizers

Reaction of BioOil with ammonia, urea and other amino compounds has proven effective as a fertilizer with commercially competitive slow release properties. DynaMotive has collaborated with RTI to develop prototype slow release fertilizers.

Results of Wind Monitoring Effort for Quinault Site #3 (Point Grenville)
26 October 2005

Introduction/Overview

Report Outline
Project Overview/Summary of Results
Location/Instrumentation
Discussion of Wind Resource

Interpretation of wind data charts
Full wind data charts

Project Overview/Summary of Results
As part of the NREL Anemometer Loan Program an anemometer was installed on the Quinault Indian Reservation to determine the reservation's wind energy potential. The monitoring period ran from 25 June 2004 to 7 July 2005.

The annual average wind speed (at 20 meters [66']) measured at the site is 4.1 m/s (9.1 mph). The measured average wind power density is 126 Watts/ m^2. Comparison with a relatively nearby reference site indicates that the monitoring period wind data is below the long-term average wind resource.

Project Location
The monitoring site is at Point Grenville, WA (N 47.3057°, W 124.2783°) at an elevation of 29 meters (96 feet).

Project Instrumentation
The instrumentation consisted of an NRG Wind Explorer system including cup anemometer, wind vane and data logger. The instruments were mounted at a height of 20 meters (66') on a tilt-up tubular tower. The data consists of 10-minute average wind speed, wind speed standard deviation and wind direction.

Summary

Annual Average Wind Speed & Power Density:	4.1 m/s (9.1 mph) / 126 watts/m^2
Month with best wind resource:	March
Average wind speed and power density for best month:	4.2 m/s (9.3 mph) / 206 watts/m^2
Month with worst wind resource:	February
Average wind speed and power density for worst month:	3.1 m/s (6.9 mph) / 77 watts/m^2
Estimated Corrected Average Wind Speed	4.3 m/s (9.6 mph) / 145 watts/m^2
Estimated Resource @ 50 meters:	4.9 m/s (11 mph) / 220 watts/m^2 (Class I or low class II)

The values for the 50-meter wind speed and power density are estimated using a wind shear factor of 0.15, a somewhat conservative value.

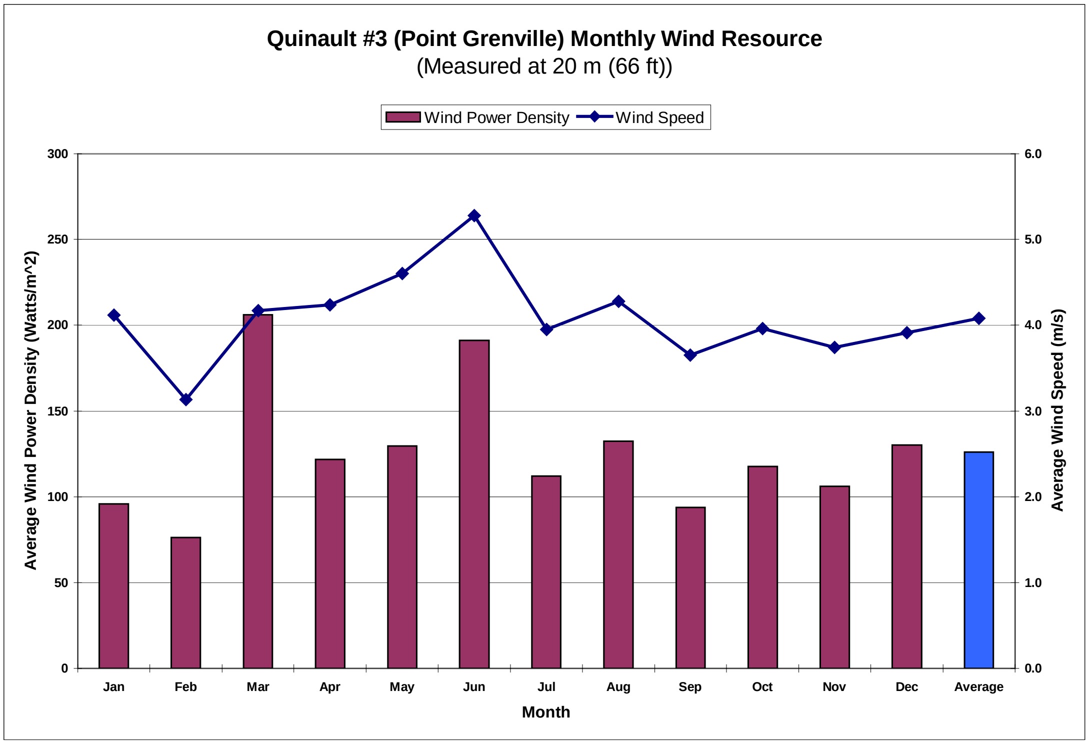


Figure 1: Monthly average and annual average wind power density and wind speed.

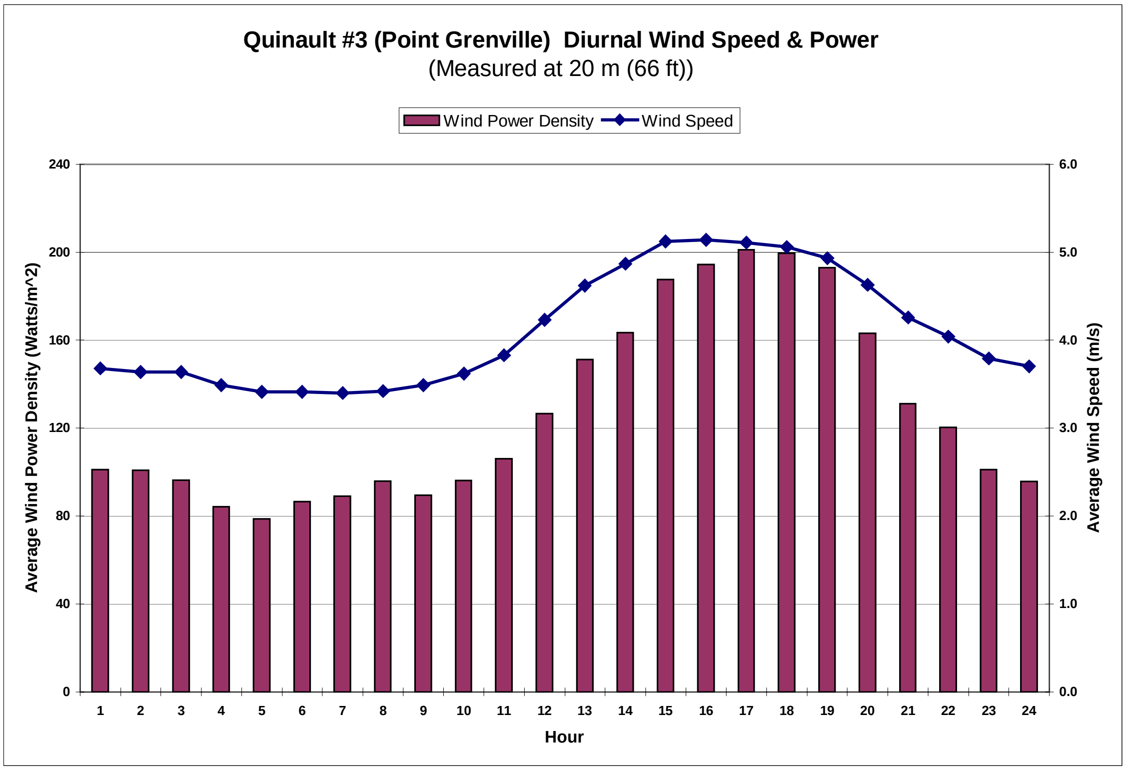


Figure 2: Average annual daily wind profile.

Speed and Power by Month
Figure 1 shows the monthly average and annual average wind power density. The measured annual average power density is 126 watts/m^2. The measured annual average wind speed is 4.1 m/s (9.1 mph).

Speed and Power by Hour
Figure 2 shows the annual average diurnal (daily) profile for the site. This site has a distinct diurnal profile. In general the winds are highest in the early evening and weakest in the early morning. This pattern is most prevalent in the late spring through early autumn. (See Appendix B for monthly profiles) Higher up off the ground the diurnal peak probably occurs at night.

Frequency and Speed by Direction
Figure 3 shows that on an annual basis the most energetic winds come from the west-northwest (WNW). According to the NREL meteorologist, this site should also get significant south winds. It is the absence of these winds that contributed to the below-average wind speeds recorded during the monitoring period. Wind turbines placed at this site should have good exposure to the west and north and south.

The percentage of calms is relatively high, 11.7%.

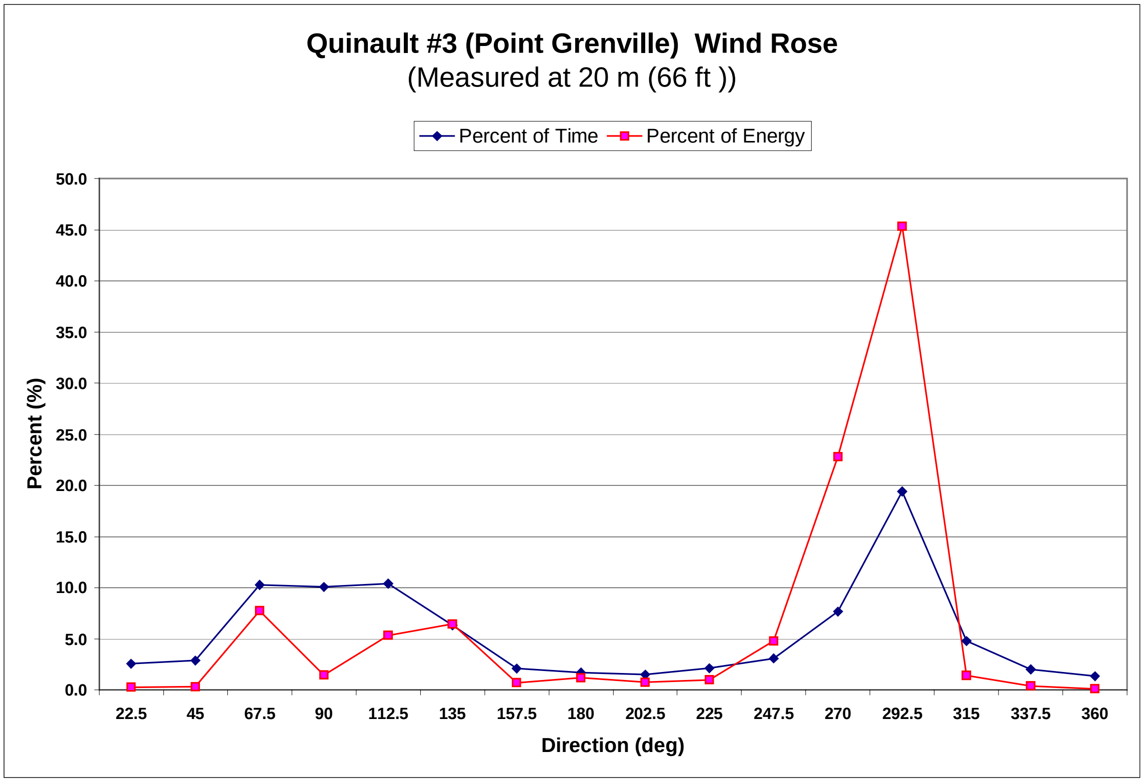


Figure 3: Frequency and Energy by direction.

Frequency of Speed and Percent of Power by Speed
Figure 4 shows the annual frequency distribution of wind speed and power density. The line labeled PCTs shows the fraction of time that the wind falls within the specified bin. The line labeled PCTp shows the fraction of total annual energy contributed by winds in the indicated wind speed bin. On an annual basis, while most of the time the wind speed is below 5 m/s (68%), most of the wind energy is in winds with wind speeds from 6 to 12 m/s, (61%). (See Appendix B).

The weibull K, a measure of the width of the frequency distribution for this site, is 1.54.

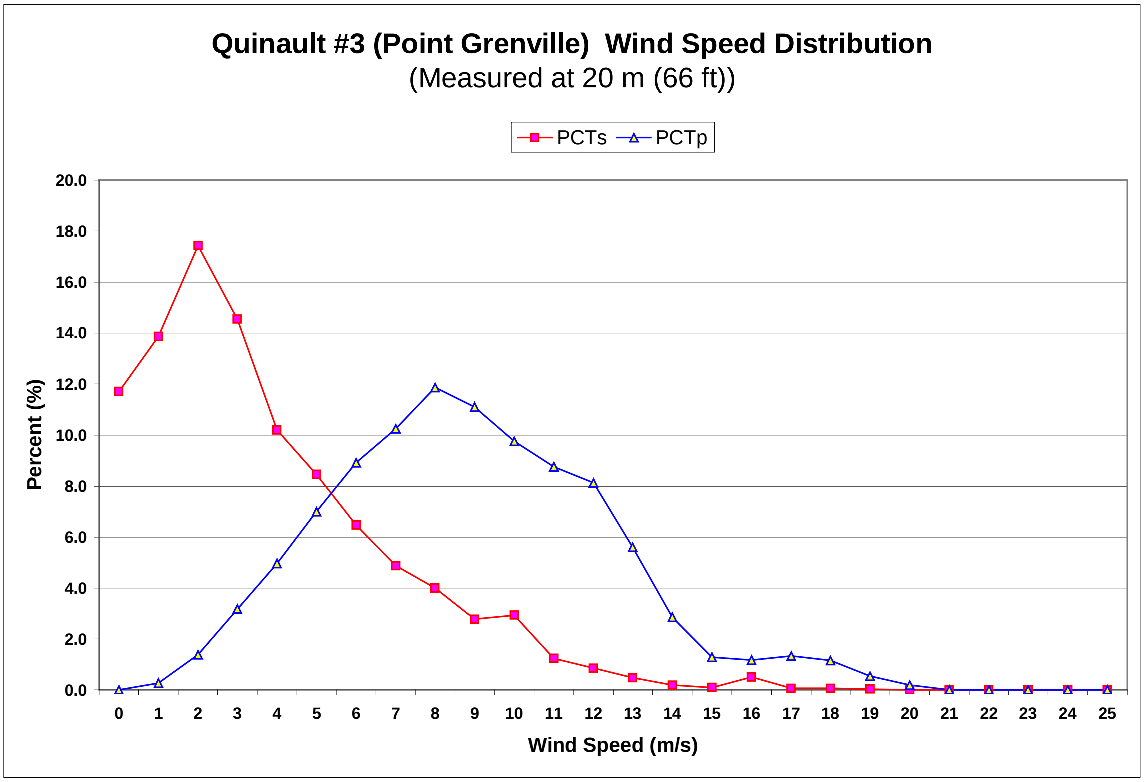


Figure 4: Annual wind and wind energy distribution.

Comparison of this data with long term average data
An important consideration is how well does the monitoring period data reflect the long-term (multi-year) average resource. In other words, does the monitoring period data reflect a good year, a bad year or an average year? To answer this question I examined long term data from two relatively nearby reference sites. For this site the multi year average wind speed was compared to the wind speed during most of the monitoring period. The results are shown in Figure 5 and Figure 6, below.

After reviewing the monitoring site and reference site data, the NREL meteorologist believes that the winter winds during the monitoring period were significantly weaker than normal. He estimates the average wind speed during the period December through February was 0.5 m/s (1.1 mph) below normal for those months. Thus the long term average wind speed (@ 20 meters) is perhaps 4.3 to 4.4 m/s.

	Lat	Long	Monitoring Period	Long Term	Ratio
Hoquiam / Bowerman	46.97	123.93	3.8	4.21	1.11
Quillayute State	47.9	124.53	2.5	2.47	0.99
Monitoring Site	47.31	124.28			1.05

Figure 5: Comparison of long term data with monitoring period data

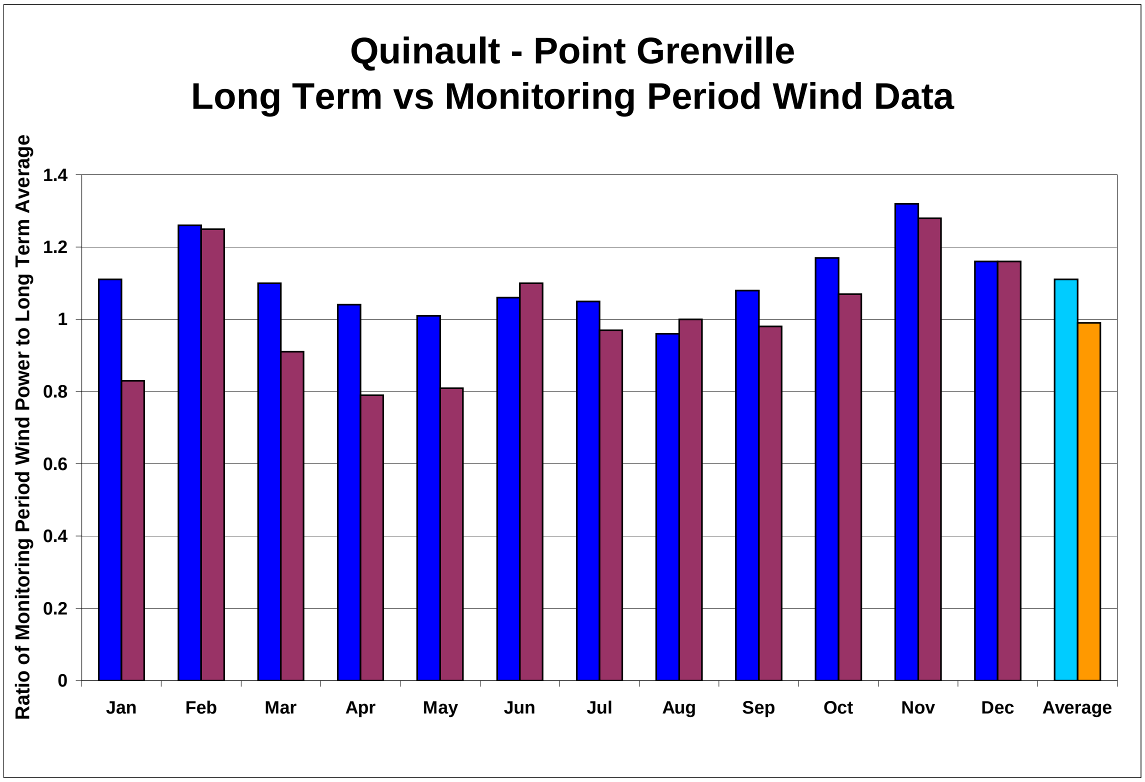


Figure 6: Long term versus monitoring period wind data for nearby sites

Appendix A: Wind Data in Tabular Form

Figure A1: Monthly average and annual average wind power density and wind speed.

Month	Wind Speed (m/s)	Wind Power (W/m^2)
Jan	4.1	96
Feb	3.1	77
Mar	4.2	206
Apr	4.2	122
May	4.6	130
Jun	5.3	191
Jul	4.0	112
Aug	4.3	132
Sep	3.7	94
Oct	4.0	118
Nov	3.7	106
Dec	3.9	130
Average	4.1	126

Figure A2: Average annual daily wind profile.

Hour	Wind Speed (m/s)	Wind Power (W/m^2)
1	3.7	101
2	3.6	101
3	3.6	96
4	3.5	84
5	3.4	79
6	3.4	87
7	3.4	89
8	3.4	96
9	3.5	89
10	3.6	96
11	3.8	106
12	4.2	127
13	4.6	151
14	4.9	164
15	5.1	188
16	5.1	194
17	5.1	201
18	5.1	199
19	4.9	193
20	4.6	163
21	4.3	131
22	4.0	120
23	3.8	101
24	3.7	96

Figure A3: Frequency and Energy by direction.

	F%	%Pwr
Calm	11.7	
22.5	2.6	0.3
45	2.9	0.3
67.5	10.3	7.8
90	10.1	1.5
112.5	10.4	5.3
135	6.3	6.4
157.5	2.1	0.7
180	1.7	1.2
202.5	1.5	0.7
225	2.2	1.0
247.5	3.1	4.8
270	7.7	22.8
292.5	19.4	45.3
315	4.8	1.4
337.5	2.0	0.4
360	1.4	0.1

Figure A4: Annual wind and wind energy distribution.

Wind Speed (m/s)	PCTs	PCTp
0	11.7	0.0
1	13.9	0.3
2	17.4	1.4
3	14.6	3.2
4	10.2	5.0
5	8.5	7.0
6	6.5	8.9
7	4.9	10.3
8	4.0	11.9
9	2.8	11.1
10	2.9	9.8
11	1.2	8.8
12	0.9	8.1
13	0.5	5.6
14	0.2	2.9
15	0.1	1.3
16	0.5	1.2
17	0.1	1.3
18	0.1	1.2
19	0.0	0.5
20	0.0	0.2
21	0.0	0.0
22	0.0	0.0
23	0.0	0.0
24	0.0	0.0
25	0.0	0.0

Appendix B: Interpretation of the Wind Data Charts

Introduction

This appendix is a guide to interpreting the wind data charts included in the report. Included is background information and an explanation of the meaning of the data in each chart.

Note on Differences between the Wind Data Charts and the charts in the main body of the report

The annual results given in the charts in this appendix may differ somewhat from the results given in the charts in the main body of the report. This is due to differences in how the data is processed. This is best described by using an example. Let us assume that 15 months of data was collected from a site, with the monitoring period running from 1 January 2003 to 31 March 2004. The annual average numbers given in the appendix simply provide the average of all the data collected. However this double counts the months of January, February & March. If these months tend to be windier than the rest of the year, than the wind resource will be over estimated.

The proper procedure is to average together the data from the double counted months before averaging the data to create annual averages. This is what has been done for the charts in the man body of the report.

The reason the software does not do this is that it was really designed to process multiyear data. If 9.5 years of data are processed, having say 10 Januarys and 9 Julys creates negligible error. However, with only a little over a year of data, the double counted months can cause noticeable error.

Power Density versus Wind Speed

Wind turbines convert the kinetic energy of moving air into useful mechanical or electrical energy. The power of a column of moving air is given by the equation below.

$$P = 0.5\rho A v^3 \qquad \text{(Equation B - 1)}$$

Where

P	=	power in a column of air (watts)
ρ	=	density of air (kg/m^3) (Roughly ~ 1 kg/m^3)
A	=	cross sectional area of the column of air (m^2)
v	=	velocity of the air (m/s)

Thus the power a wind turbine can extract from the wind is proportional to the cross sectional area of the rotor, the density of the air, and the cube of the wind velocity. At a given location the air density typically doesn't change by more than 10%. Therefore the big variable is the wind speed. Annual average wind turbine production is very sensitive to the annual average wind speed.

A wind turbine cannot extract all the energy from the air stream moving past it. A wind turbine's extraction efficiency typically varies with wind speed. In their range of maximum conversion efficiency most of today's wind turbines extract about 30% - 40 % of the wind's energy.

Power density is simply the power divided by the cross sectional area. Power density is given in units of watts per meter squared. (watts/m^2)

$$\text{Power Density} = 0.5\rho v^3 \qquad \text{(Equation B - 2)}$$

The cubic dependence of wind power density upon velocity underscores the importance of accurately characterizing the wind at a given location. A small uncertainty in wind speed translates to a large uncertainty in wind turbine power production. For example a 5% uncertainty in wind speed leads to a 15% uncertainty in power output. The cubic relationship also makes it more difficult to predict the long term performance of a wind turbine. More information is needed than simply the average wind speed. For example, imagine a location where the wind speed is a constant five meters per second. The average power density of a column of air with a 1m^2 cross section is then $0.5 * 1.0\ kg/m^3 * 1.0\ m^2 * 5\ (m/s)^3 =$ 62.5 watts. Over a year the total energy of that column would be 547.5 kWh. Now imagine a location where half the time the wind speed is 3 m/s and the other half the time the wind speed is 7 m/s. The average wind speed is still 5 m/s but the average power density is now $0.5*1.0*1.0*(3^3 + 7^3)/2 = 92.5$ watts. This leads to an annual energy of 810 kWh.

Power density is listed in many of the graphs below because power density gives a better indication of wind turbine production than does wind speed alone. As can be seen from the graph titled "Speed and Power by Month," power density correlates to wind speed, but doesn't follow wind speed exactly.

Wind Speeds/Wind Directions
These first plots simply show the wind speed and direction for the monitoring period. Good data is shown with a solid line. Bad data is shown with a dotted line.

Speed and Power by Month
This graph gives the average wind speed and average power density for each month. This shows how the wind resource is distributed throughout the year.

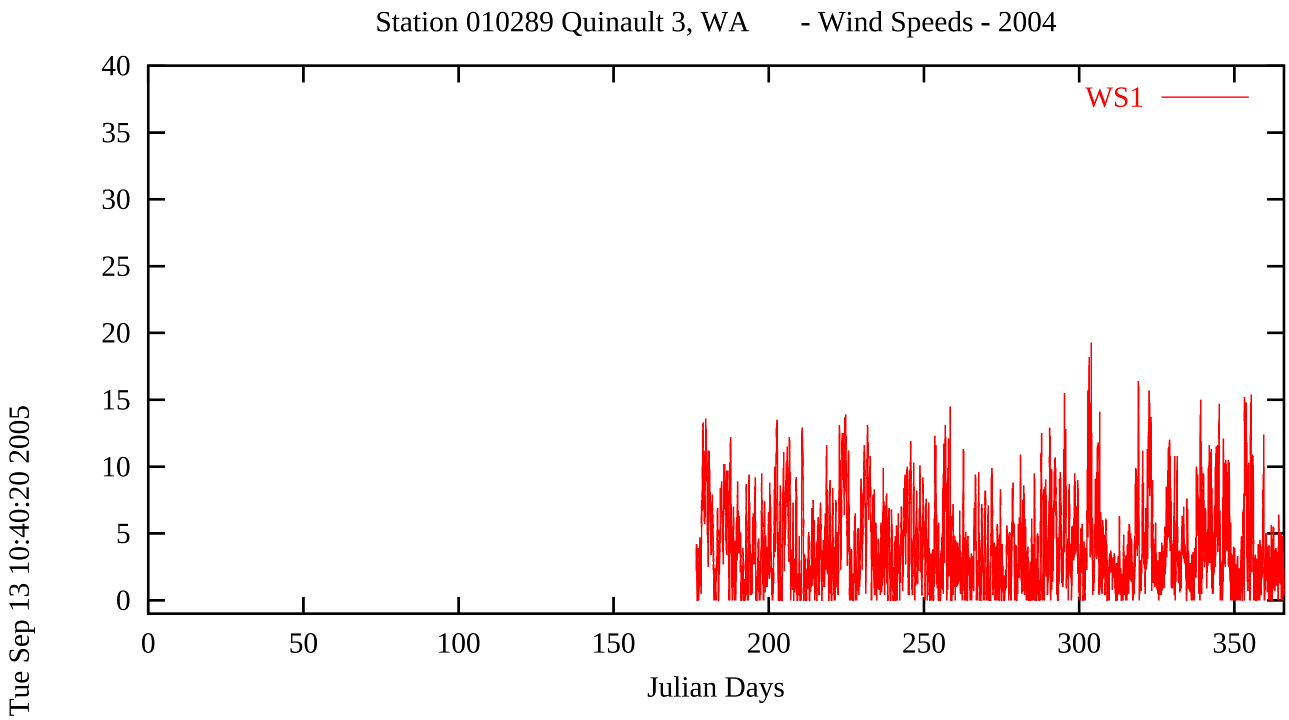
Observations by Month
This graph shows the number of observations for each month. The greater the number of observations, the greater the probability that the data is close to the long-term average resource.

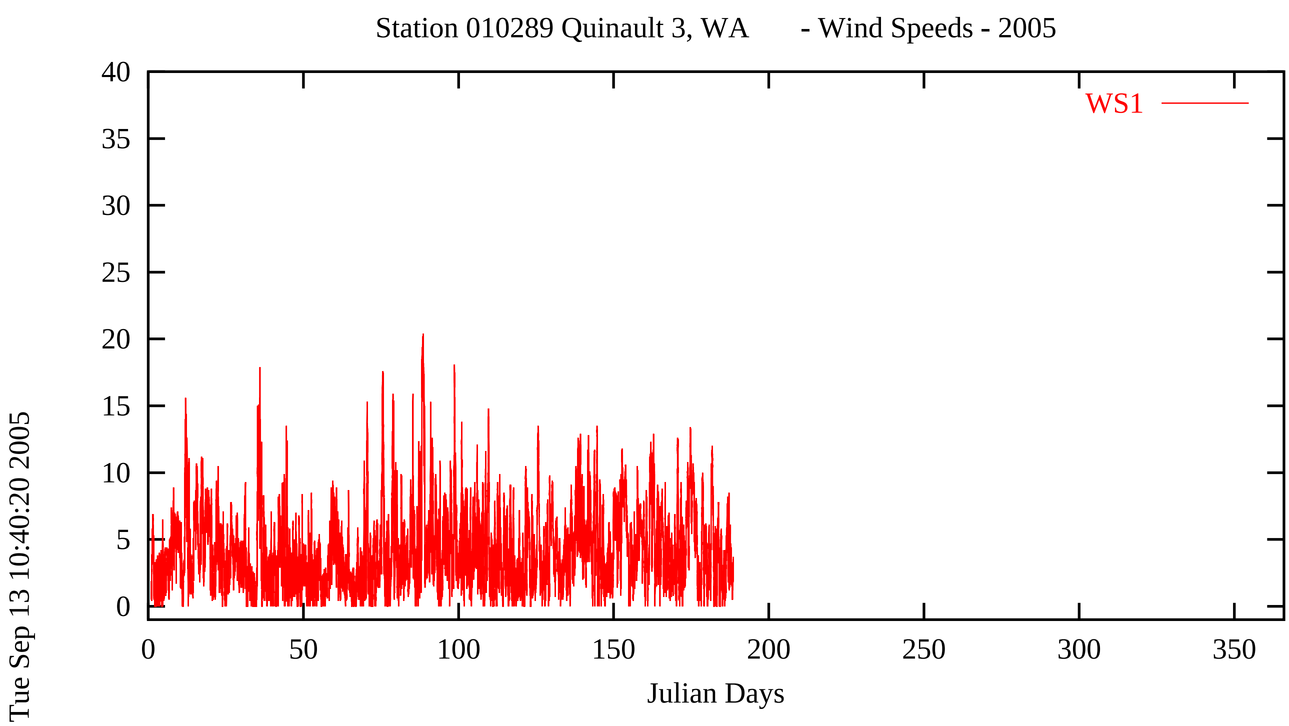
Speed and Power by Hour
The top graph shows how the wind speeds and power densities are distributed by time of day over the whole year. The other 12 graphs show the same thing for each month. On top of each graph is an average wind speed and power density for the period in question.

Frequency and Speed by Direction
These graphs show how the winds are distributed by direction. The solid line shows the fraction of time that the wind comes from a particular direction. The dotted line shows the average wind speed of the winds coming from a particular direction. Above each graph the fraction of time that the wind is calm (below 1.0 m/s) is given. These graphs indicate the directions from which the strongest winds come. Special care should be taken to ensure the wind turbines have good exposure to winds from these directions.

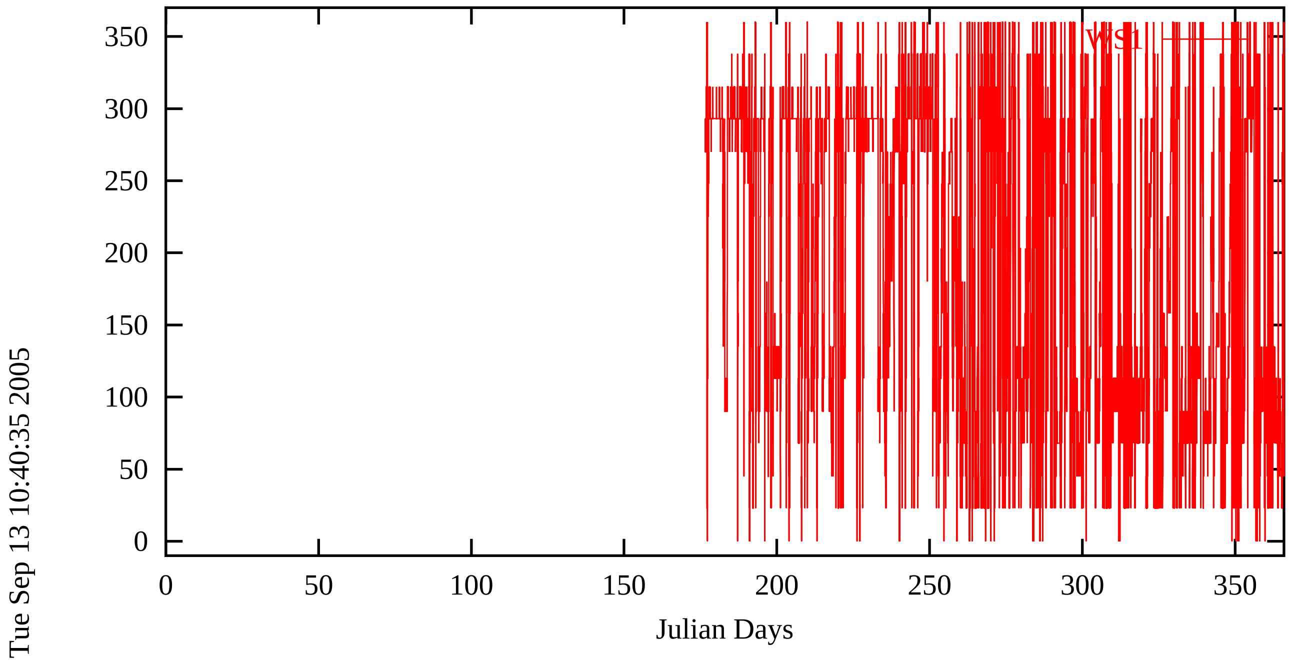
Frequency of Speed and Percent of Power by Speed
These graphs show the distribution of wind speeds and power densities. The solid line indicates the fraction of time that the wind has a particular velocity. The solid line indicates the fraction of the total wind power contributed by winds at each wind speed.

Appendix C: Wind Data Graphs

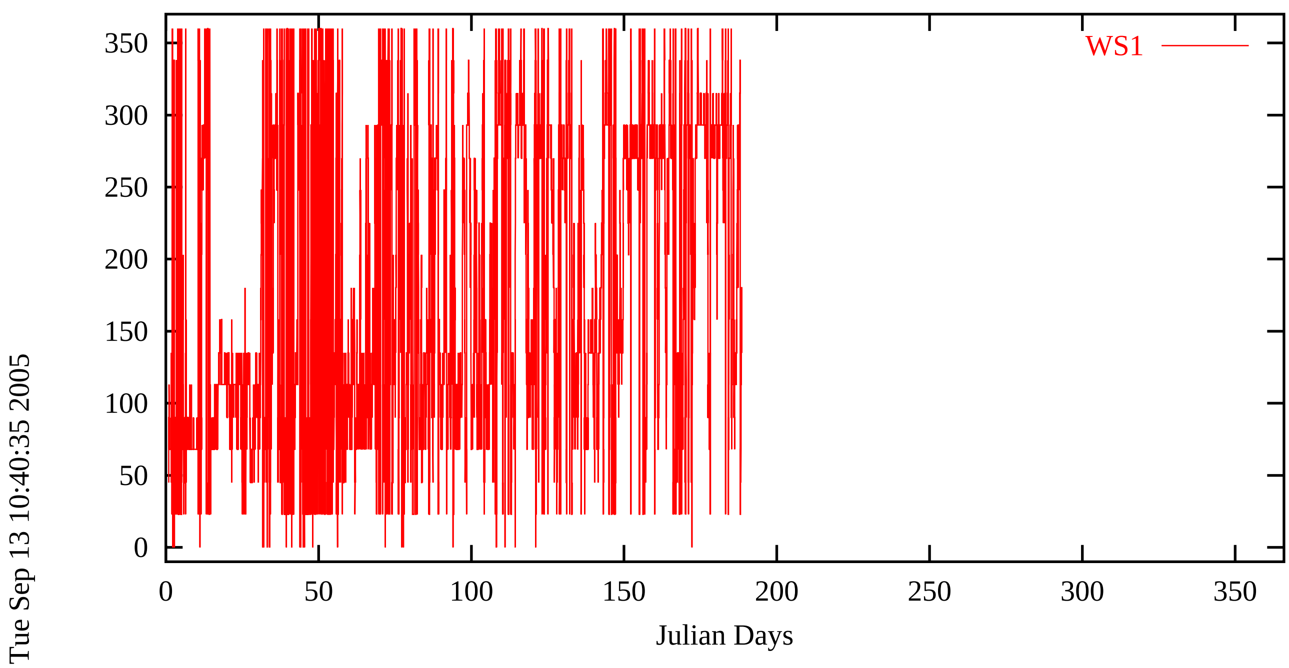

Station 010289 Quinault 3, WA - Wind Speeds - 2004
WS1
Julian Days
Tue Sep 13 10:40:20 2005
0
5
10
15
20
25
30
35
40
0
50
100
150
200
250
300
350


Station 010289 Quinault 3, WA - Wind Speeds - 2005
WS1
Julian Days
Tue Sep 13 10:40:20 2005
0
5
10
15
20
25
30
35
40
0
50
100
150
200
250
300
350

Station 010289 Quinault 3, WA - Wind Directions - 2004



Station 010289 Quinault 3, WA - Wind Directions - 2005

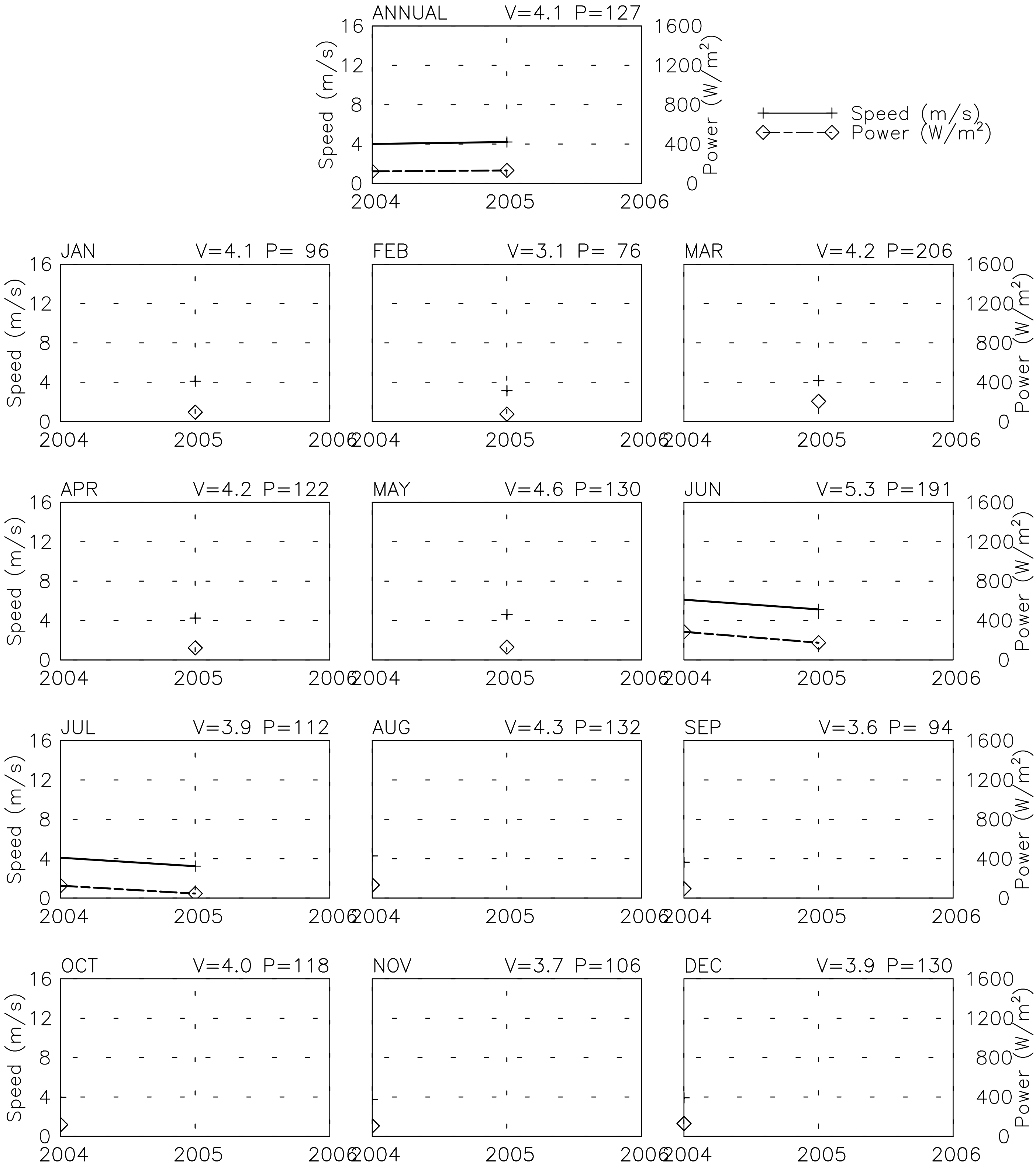


SPEED AND POWER BY YEAR

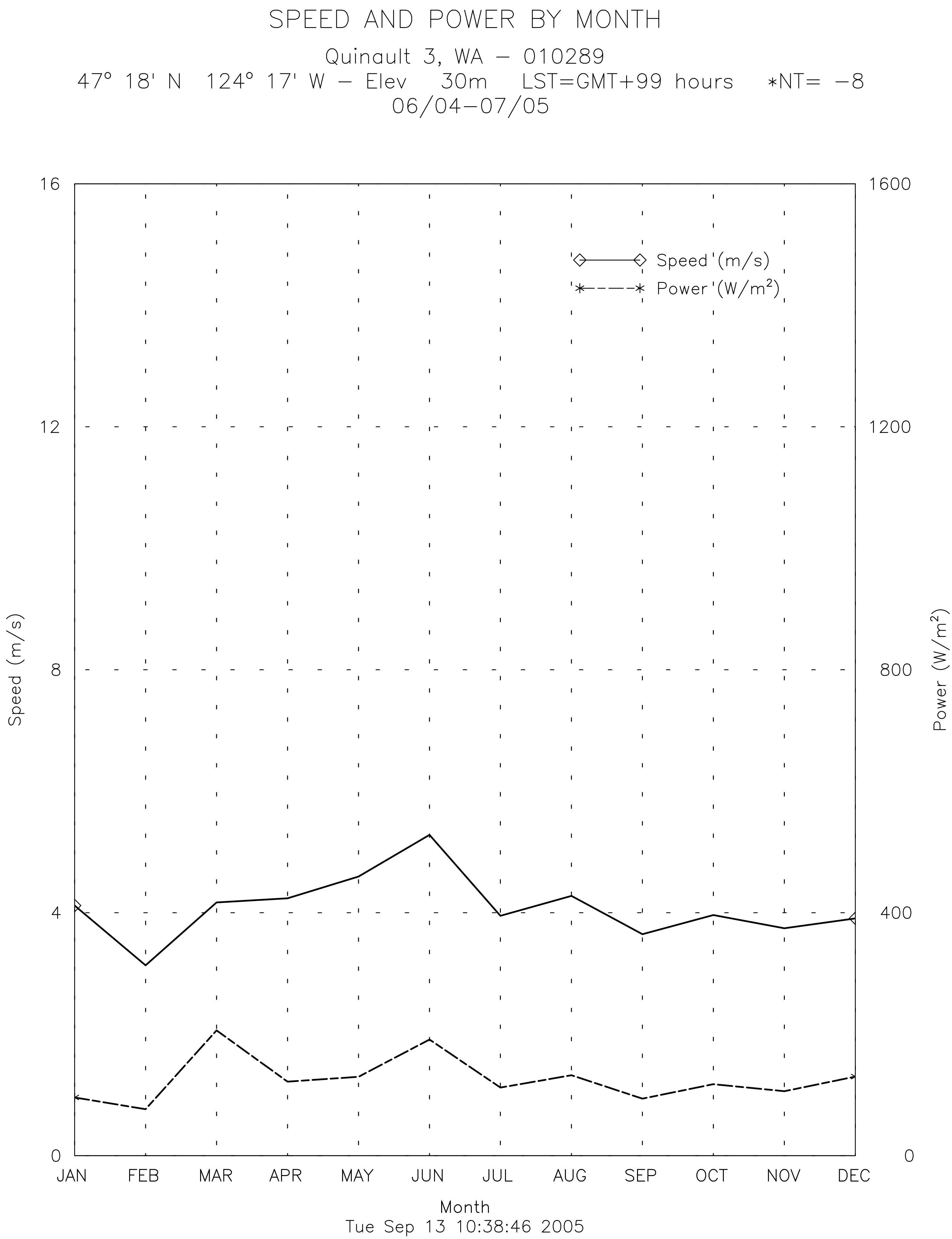
Quinault 3, WA – 010289

47° 18' N 124° 17' W – Elev 30m LST=GMT+99 hours *NT= -8

06/04–07/05



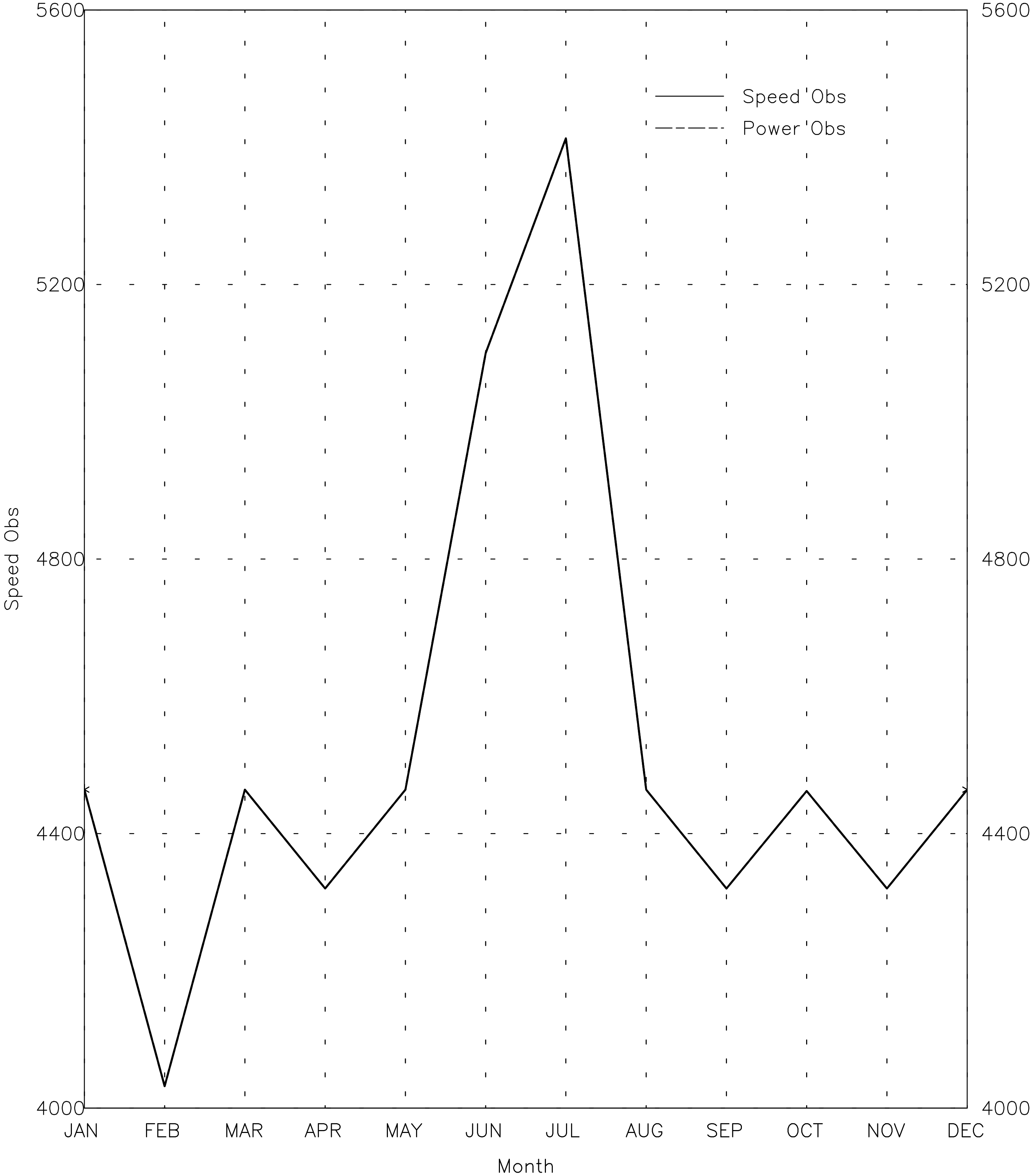
Tue Sep 13 10:38:45 2005



SPEED AND POWER BY MONTH
Quinault 3, WA - 010289
47° 18' N 124° 17' W - Elev 30m LST=GMT+99 hours *NT= -8
06/04-07/05
Speed (m/s)
Power (W/m²)
16
12
8
4
0
1600
1200
800
400
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Tue Sep 13 10:38:46 2005

OBSERVATIONS BY MONTH

Quinault 3, WA – 010289
47° 18' N 124° 17' W – Elev 30m LST=GMT+99 hours *NT= -8
06/04–07/05



Tue Sep 13 10:38:46 2005

SPEED AND POWER BY HOUR

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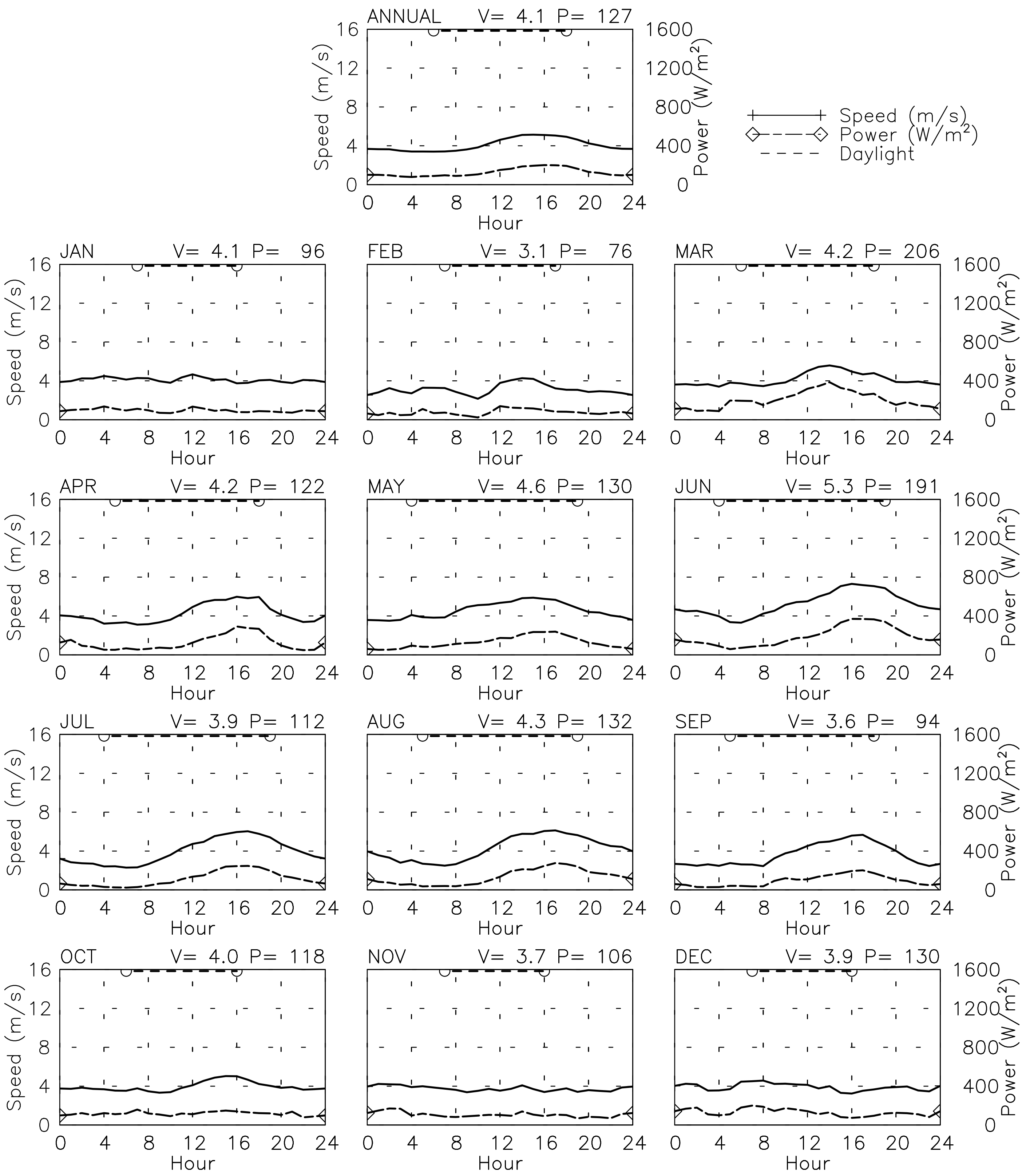
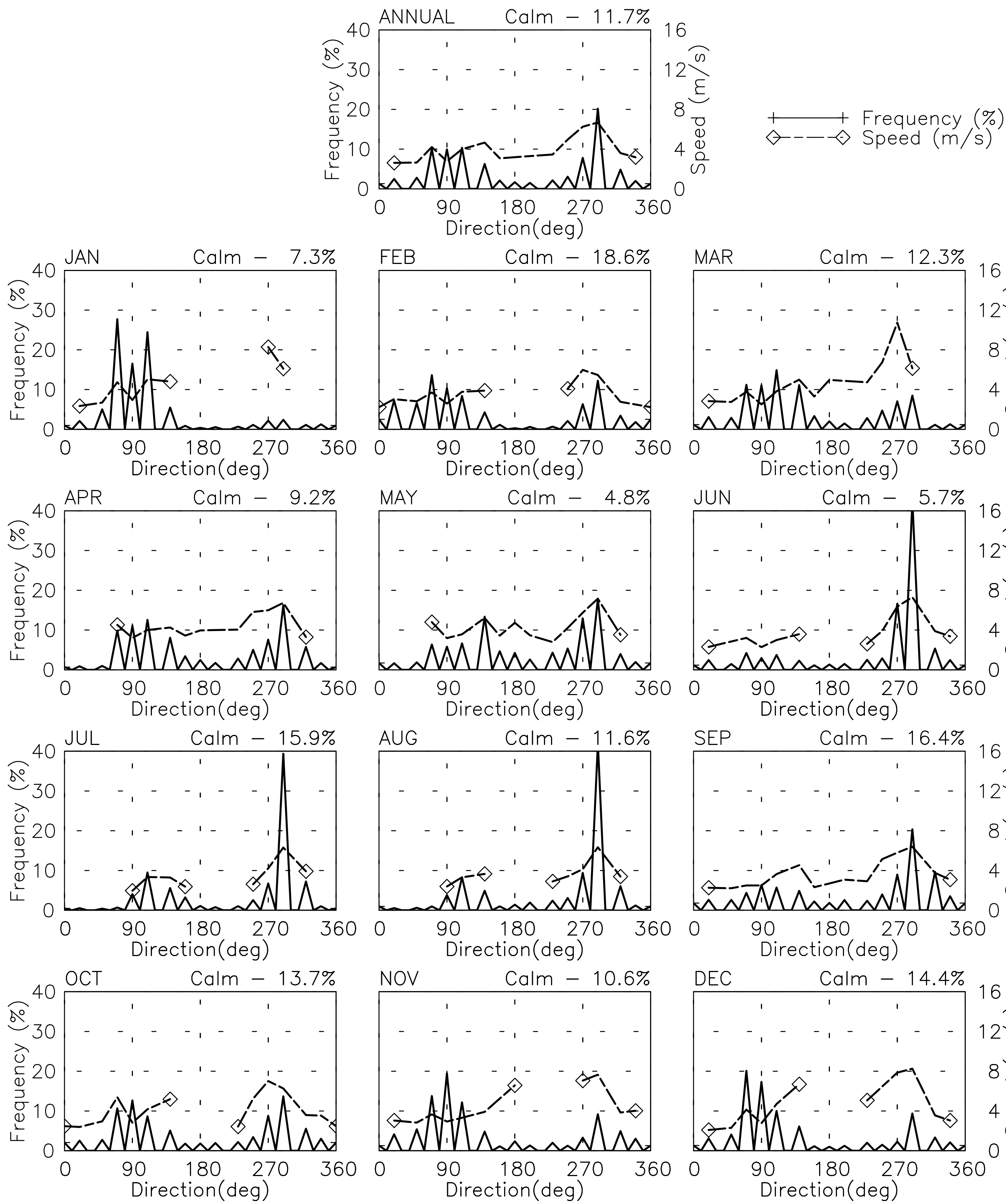
06/04-07/05



Tue Sep 13 10:38:46 2005

FREQUENCY AND SPEED BY DIRECTION

Quinault 3, WA – 010289
47° 18' N 124° 17' W – Elev 30m LST=GMT+99 hours *NT= –8
06/04–07/05



Tue Sep 13 10:38:48 2005

FREQUENCY OF SPEED & PERCENT OF POWER BY SPEED

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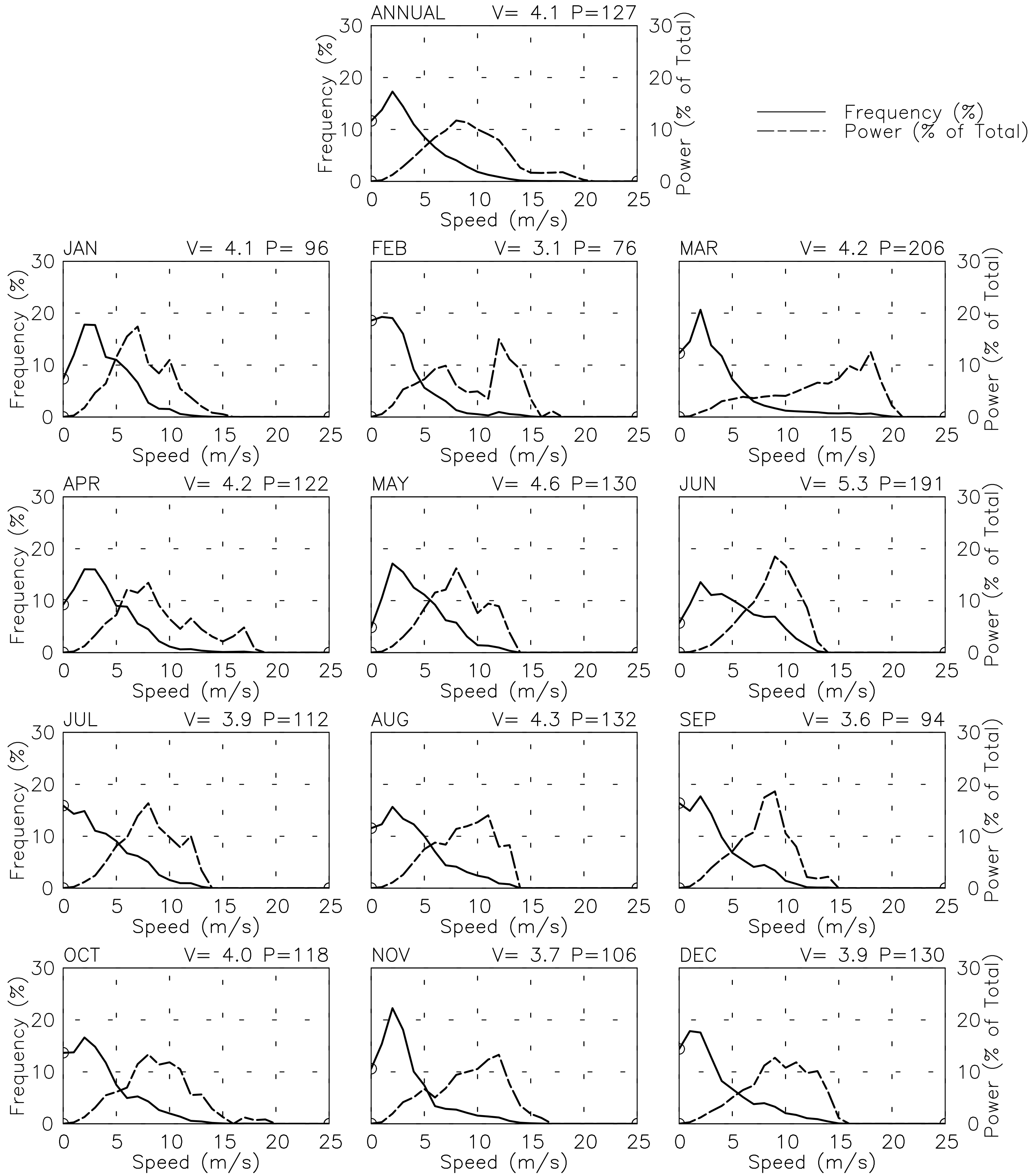
47° 18' N 124° 17' W – Elev 30m LST=GMT+99 hours *NT= -8
06/04–07/05



Tue Sep 13 10:38:49 2005

PREVAILING DIRECTION & SPEED BY HOUR

Quinault 3, WA – 010289

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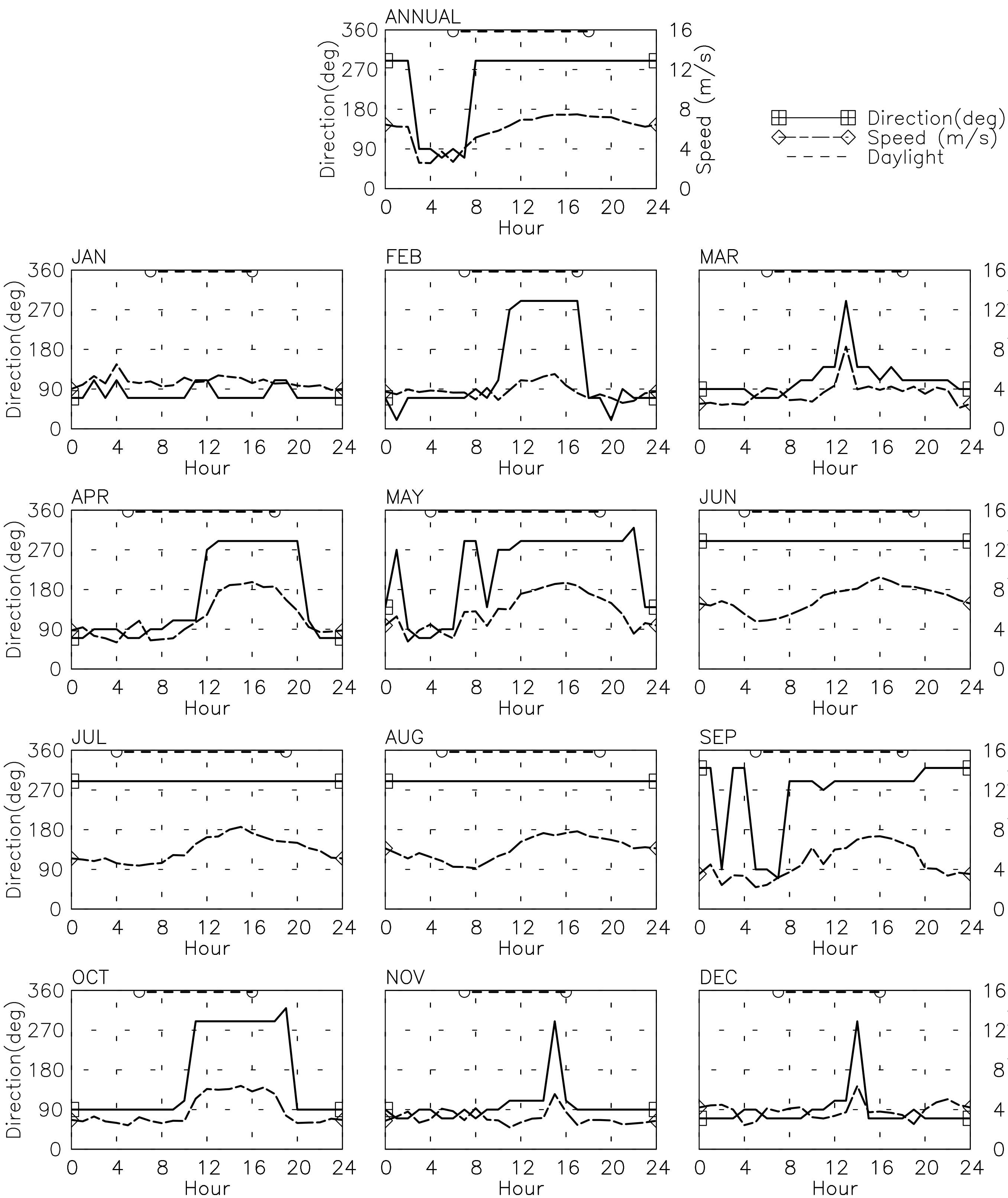
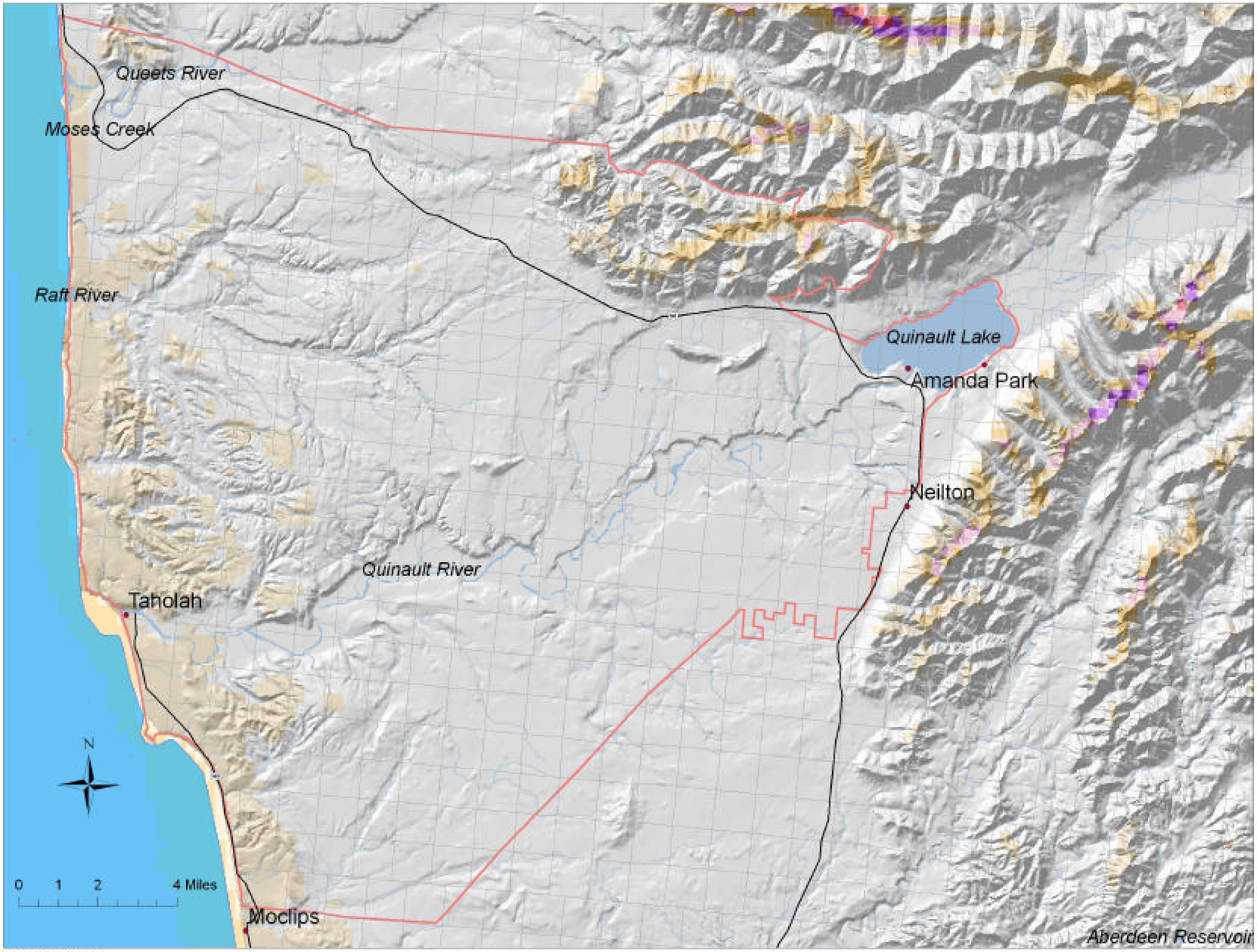
06/04–07/05



Tue Sep 13 10:38:49 2005

QIR Wind Resource



Legend

- Major Roads
- Rivers
- QIR

Wind Class

- Class 1 (Poor)
- Class 2 (Marginal)
- Class 3 (Fair)
- Class 4 (Good)
- Class 5 (Excellent)
- Class 6 (Outstanding)
- Class 7 (Superb)

The wind resource estimates presented on this map were developed by TrueWind Solutions using a MesoMap, a mesoscale atmospheric simulation system, at a spatial grid resolution of 400 meters (one-quarter mile). The estimates have been validated by the National Renewable Energy Laboratory (NREL) and independent meteorologists but should also be confirmed by direct measurement according to wind energy industry standards.

Map by: Jessica Raker 3/4/2005
Data Sources: TrueWind, NREL, ESRI