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FILED
DEC 12 2003
Missouri Public
Service Commission

December 11, 2003

Public Service Commission
Governor Hotel
Jefferson City, MO 65102

RE: Aquila Networks Electric Rate Case, Case No. ER-2004-0034

Dear Sir/Madam:

Enclosed for filing please find an original and 9 copies of Missouri Department of Natural Resources' Motion to File Late Testimony in the above-styled matter. Please stamp "filed" on the extra copy of the first page for my files. Thank you.

Sincerely,

JEREMIAH W. (JAY) NIXON
Attorney General

Shelley A. Woods /pah

SHELLEY A. WOODS
Assistant Attorney General

SAW:pah
Enclosure
c: Counsel of Record

FILED

DEC 12 2003

Missouri Public
Service Commission

STATE OF MISSOURI
PUBLIC SERVICE COMMISSION

In the Matter of Aquila, Inc. d/b/a Aquila Networks L&P and Aquila Networks MPS, and Its Tariff Filing to Implement a General Rate Increase for Electric Service	))))	Case No. ER-2004-0034

FILED

DEC 09 2003

Missouri Public
Service Commission

AFFIDAVIT OF ANITA RANDOLPH

STATE OF MISSOURI)
) ss.
COUNTY OF COLE)

Anita Randolph, being duly sworn on her oath, hereby states that she has participated in the preparation of the foregoing Testimony in question and answer form; that the answers in the foregoing Testimony were given by her; that she has knowledge of the matters set forth in such answers; and that such matters were true and correct to the best of her knowledge, information and belief.

Anita C Randolph
Anita Randolph

Kay A. Johannpeter
Notary Public

KAY A. JOHANNPETER NOTARY PUBLIC SEAL STATE OF MISSOURI

My commission expires:

KAY A. JOHANNPETER
Notary Public - Notary Seal
STATE OF MISSOURI
Moniteau County
My Commission Expires: Aug. 4, 2007

Subscribed and sworn before me this 5th day of December 2003.

Exhibit No.:	
Issues:	Commitment to Provide Low or No Cost Weatherization Assistance to Aquila Electric Low-Income Customers, Energy Efficiency Services to Residential and Commercial Customers and Wind Energy Assessments.
Witness:	Anita C. Randolph
Sponsoring Party:	Missouri Department of Natural Resources' Outreach and Assistance Center, Missouri Energy Center
Type of Exhibit:	Testimony
Case No.:	ER-2004-0034

AQUILA NETWORKS ELECTRIC RATE CASE

DIRECT TESTIMONY

OF

ANITA C. RANDOLPH

MISSOURI DEPARTMENT OF NATURAL RESOURCES

ENERGY CENTER

December 9, 2003

BEFORE THE PUBLIC SERVICE COMMISSION
OF THE STATE OF MISSOURI
TESTIMONY OF
ANITA C. RANDOLPH
DIRECTOR
MISSOURI DEPARTMENT OF NATURAL RESOURCES
ENERGY CENTER

CASE NO. ER-2004-0034

Q. Please state your name and address.

A. My name is Anita C. Randolph. My business address is Missouri Department of Natural Resources, Energy Center, 1659 East Elm Street, P.O. Box 176, Jefferson City, Missouri 65102-0176.

Q. By whom and in what capacity are you employed?

A. I am employed by the Missouri Department of Natural Resources as the director of the Missouri Energy Center, a division of state government with its executive office located in Jefferson City, Missouri.

Q. On whose behalf are you testifying?

A. I am testifying on behalf of the Missouri Department of Natural Resources, an intervenor in these proceedings.

Q. Please describe your educational background and business experience.

A. I attended the University of Missouri and received a Bachelor of Journalism degree in 1974. In addition, I attended the University of Oklahoma and received a Master's in Public Health degree in 1988 with a specialty in environmental management. I have worked as a research analyst in the Missouri House of Representatives' House Research office. In this capacity, I developed legislative approaches for environmental, energy and natural resource issues for the Energy and Environment, State Parks, and Mining legislative committees. Prior to becoming the director of the Missouri Energy Center, I was employed by the Missouri Department of Transportation in its Office of Transportation Planning and Policy Development. In this position I worked directly with Missouri's Congressional Delegation, the Missouri Governor's Office and the Missouri General Assembly on legislative and appropriation issues affecting Missouri's transportation system. On July 13, 1998, I was appointed director of the Energy Center, formerly the Division of Energy, by Mr. Stephen Mahfood, director of the Missouri Department of Natural Resources.

Q. What is the purpose of your direct testimony in these proceedings?

A. The purpose of my testimony is to focus on the proposed $79.6 million annual electric rate increase by Aquila, Inc., d/b/a Aquila Networks – MPS and Aquila Networks – L&P; low-income residential customers served by Aquila Inc.; the need for the company to implement a low-income residential weatherization assistance program consistent with federal weatherization assistance guidelines; the need to promote utility-based energy efficiency services for residential and commercial customers; and the need to conduct assessments of Missouri's wind energy resources in the Aquila Networks – L&P service territory.

The Energy Center is seeking commitment by Aquila Inc. to provide funding for weatherization assistance for its low-income residential customers, utility-based energy efficiency services and programs for residential and commercial customers and wind resource assessments.

Q. Please describe the relationship between Aquila Inc.'s current commitment to low-income weatherization assistance and energy efficiency services for residential and commercial customers and the proposed rate increase.

A. Aquila, Inc. is proposing an electric rate increase for its two divisions that operate in Missouri; Aquila Networks – MPS and Aquila Networks – L&P. Aquila Networks – MPS is seeking a $65 million annual revenue increase while Aquila L&P is seeking a $14.639 million annual revenue increase. In both divisions, the largest portion of the proposed rate increase is directed toward residential and small general use customers, including small commercial customers.

Of the $65 million annual revenue increase proposed for Aquila Networks – MPS, $34.6 million, or 53.2 percent is targeted toward residential customers and $9.6 million or 14.8 percent is targeted toward small general use customers, including small commercial customers. Combined, this represents $44.2 million or nearly 70 percent of the revenue increase.

Of the $14.6 million annual revenue increase proposed for Aquila Networks – L&P, $6.5 million, or 44.5 percent is targeted toward residential customers and $1.2 million or 8.0 percent is targeted toward small general use customers, including small commercial customers. Combined, this represents $7.7 million or nearly 53 percent of the revenue increase.

Aquila, Inc. has filed new electric tariffs with the Missouri Public Service Commission that will increase annual revenues to the company by $79.639 million which reflect "higher costs and investments made by Aquila to provide safe and reliable electricity to Missouri customers", as described by the company's filing. Recognizing, to some extent, the adverse financial impact an $80 million annual rate increase will have on the poorest households within the company's service territories, Aquila, Inc. has offered $115,000 for low-income residential utility billing assistance – for both MPS and L&P electric *and* gas customers.

Aquila, Inc. currently offers a limited number of energy efficiency programs to their electric customers, including a low-income weatherization assistance program. However, these programs appear to have limitations including funding and participation. Aquila, Inc. does not offer any new or expanded energy efficiency service or product by the current rate filing that would assist low-income residential, residential or small commercial customers in reducing their consumption of electricity or their monthly utility bill in light of potentially higher energy bills as a result of this general rate filing.

Q. Please describe the format and content of your direct testimony as it relates to this electric rate case.

A. My direct testimony will first address low-income energy issues and the difficulties low-income customers face in paying their utility bills, the need for weatherization assistance for the company's low-income residential customers and the benefits of weatherization to low-income households as well as other rate-payers and the utility company. Following the low-income issue, I will address residential and commercial energy efficiency and the opportunity to help customers in using energy more efficiently to help reduce the economic impact of rising energy costs ultimately passed on to all customers through higher energy rates. Next, I intend to address the need for the company to examine the potential development of alternative energy generation in Missouri and the subsequent benefits to the company and its customers. And lastly, I will summarize these issues and propose actions and funding amounts to support the proposals offered in my filed direct testimony.

Q. Please describe the relationship between home heating bills and low-income residential utility customers in Missouri.

A. Winter home heating bills in Missouri impose significant burdens on low-income households. In a report prepared by Fisher, Sheehan & Colton, Structuring a Public Purpose "Distribution Fee" For Missouri, July 1997, the authors noted that "According to the U.S. Department of Housing and Urban Development (HUD), a household that faces a shelter burden exceeding 30 percent of income is over-extended. Shelter burdens include rent or mortgage payments and all utility payments other than telephone. A household that is paying

20 to 25 percent of its income simply toward home heating (not taking into account non-heat electric burdens) will not be able to stay below this 30 percent limit." (Structuring a Public Purpose "Distribution Fee" For Missouri, July 1997, page 6)

Q. Please describe the significance of home heating burdens on low-income households.

A. The significance of home heating burdens was also identified by Structuring a Public Purpose "Distribution Fee" For Missouri. "The significance of home heating burdens imposed on low-income households is very apparent when one considers the full range of incomes at which low-income residents of Missouri live. The 1997 study reported that most households that qualify for the Low-Income Home Energy Assistance Program (LIHEAP) in Missouri by living at or below 150 percent of poverty lived below the ceiling rather than at the ceiling. (Current LIHEAP eligibility is 125 percent of federal poverty guidelines) The report sets forth the actual distribution of winter heating burdens for Missouri LIHEAP recipients by income category using an average winter heating (natural gas) bill of $210.94 (Table 4, Winter Gas Bill As Percentage of Income LIHEAP Recipients By Income Range, Source: R. Colton and M. Sheehan, On the Brink of Disaster: A State-by-State Analysis of Natural Gas Winter Home Heating Bills) A household with an annual income of $2,000 or less will have winter heating burdens of nearly 85 percent. Households living with annual incomes of $2,000 to $4,000 will have winter heating burdens of nearly 30 percent; and households living with annual incomes of $4,000 to $6,000 will have winter heating burdens of more than 16 percent." (Structuring a Public Purpose "Distribution Fee" For Missouri, July 1997, page 6 and 7).

"The number of households with these extremely low levels of annual incomes (and thus high heating burdens) is significant." (Source: Structuring a Public Purpose "Distribution Fee" for Missouri", July 1997, page 7)

Q. Is there additional evidence that identifies the need for weatherization assistance?

A. Yes. An April 2003 report titled "On the Brink: The Home Energy Affordability Gap in Missouri" (Fisher Sheehan & Colton, April 2003), it was found that home energy is a crippling financial burden for low-income Missouri households. As noted in the report, "Missouri households with incomes of below 50% of the Federal Poverty Level pay 38% or more of their annual income simply for their home energy bills." And home energy unaffordability was not an exclusive characteristic of the very poor. "Bills for households between 50% and 100% of Poverty take up 13% of income. Even Missouri households with incomes between 150% and 185% of the Federal Poverty Level often have energy bills above the percentage of income generally considered to be affordable."

Existing sources of energy assistance do not adequately address the energy affordability gap in Missouri. "Actual low-income energy bills exceeded affordable energy bills in Missouri by nearly $273 million at 2001/2002 winter heating fuel prices. In contrast, Missouri received a gross allotment of federal energy assistance funds of $38.7 million for Fiscal Year 2003. During the 2002/2003 winter heating season, the unaffordability gap increased to more than $321 million.

"The energy affordability gap in Missouri is not created exclusively, or even primarily, by home heating and cooling bills. At 2001/2002 winter heating prices, while home heating bills were $354 of a $1,273 (annual utility) bill (27.8%), electric bills (other than cooling) were $543 (42.7%). Annual cooling bills represented $117 in expenditures (9.2% of the total bill), while domestic hot water represented $258 in expenditures (20.2%)."

In other words, the largest part of a residential electric bill is for general use throughout the household (baseload). Therefore, as electric utility rates increase in Missouri, the home energy affordability gap grows. As this gap increases, more low-income households are unable to pay either a portion or their entire energy bill.

Utility billing assistance funding has great merit, but does very little to address the need for long-term and sustainable benefits for low-income households. Weatherization improvements help low-income households to use energy more efficiently resulting in long-term benefits to both the customer and to the utility by reducing utility bills and arrearages.

Q. Do a large number of low-income homes in Missouri still need to be weatherized?

A. Yes. A significant number of low-income households in Missouri are in need of energy-efficiency improvements.

Information gathered from the state Weatherization Assistance Program (WAP) which is administered by the Missouri Department of Natural Resources' Energy Center, shows that from 1978 (beginning of the program in Missouri) through June 30, 2003, approximately 143,000 homes were weatherized in Missouri. The Energy Center estimates that approximately 450,000 eligible homes remain (as identified by the U.S. Census Bureau, Table P93. Ratio of Income in 1999 to Poverty Level by Household Type – Missouri). (In Missouri State Fiscal Year 2001, the eligibility was increased from 125% to 150% of the poverty level in response to the 2000 – 2001 heating crisis, resulting in approximately 100,000 additional homes meeting the eligibility criteria.) Clearly, on-going and additional sources of low-income energy-efficiency services are needed.

Q. What is the estimated number of Missourians currently on weatherization waiting lists?

A. Statewide, more than 3,000 families are currently on weatherization waiting lists.

Q. How many new clients are added to that list annually?

A. On average, more than 2,300 households are added to that waiting list annually.

Q. At the current rate, how long would it take the state's weatherization program to meet the needs of eligible clients in the Aquila, Inc. service territory?

A. According to the 2000 U.S. Census Bureau, 458,416 Missouri low-income households are eligible to receive weatherization assistance statewide. Approximately 27 percent or 124,622 households (150 percent of poverty as of 2000 census data, all fuel types including electric and/or natural gas heated homes, including both Aquila and non-Aquila utility customers) are located in counties within the Aquila electric service territory. At current resource levels, and assuming no additional homes are identified as eligible to receive weatherization assistance, it is estimated that it would take approximately 62 years to serve those low-income households located within the electric service territory of Aquila Networks – MPS and Aquila Networks – L&P.

Q. Please describe changes made to the Weatherization Assistance Program that focus on electricity.

A. In addition to electric related energy efficiency measures such as furnaces, water heaters, insulation and replacement windows and doors just to name a few, the U.S. Department of Energy has added electric base-load (or electric plug-load) measures to the federal program regulations effective January 1, 2001. This is an evolution in the federal and state guidelines, allowing the program to move toward whole-house weatherization. Typically, addressing just the heating and/or cooling cost of a dwelling unit accounts for only about half of the unit's energy expenditures. The addition of cost-effective electric base load measures gives local weatherization agencies greater flexibility to help low-income households reduce their energy costs, and to partner with sources of leveraged funds, including electric utilities. These measures include replacement lighting, replacement electric water heaters and other electric appliances such as refrigerators. Missouri is currently evaluating these measures for inclusion in Missouri's federal Weatherization Assistance plan.

Q. What are some of the general benefits of low-income residential weatherization?

A. As noted earlier in my testimony, home heating is a high cost for individuals with low income. Overall, low-income households that qualify for weatherization spend more of their income on energy needs compared to non-low-income households. The decision and ability to pay one's utility bill often compete with other necessities. Many low-income individuals live in older homes equipped with older, less-efficient heating systems and generally lack energy-efficiency items such as insulation.

Weatherization reduces space heating fuel consumption by an average (including all heating fuels) of 18.2 percent. Specifically for homes using electricity for heat, annual space heating fuel consumption is reduced by 35.9 percent. For homes using natural gas for heat, weatherization reduces space heating fuel consumption by 33.5 percent. (Source: "Progress Report of the National Weatherization Assistance Program," Oak Ridge National Laboratory, September 1997.)

Weatherization is a cost-effective means to help low-income individuals or families pay their energy bills year after year for the life of the energy-efficiency product. Weatherization reduces the amount of state and federal assistance needed to pay higher utility bills, keeps money in the local economy, results in a positive impact on the household's promptness in paying utility bills, reduces arrearages and helps to reduce environmental pollution through energy efficiency.

Q. Are there utility benefits from low-income energy efficiency services?

A. Yes. In addition to looking at energy-efficiency from a household perspective, it is beneficial to examine the benefits of a low-income energy-efficiency program from the perspective of energy service providers. Extensive research has found that low-income energy-efficiency programs result in substantial non-energy savings to utilities. These non-energy savings include reductions in working capital expense, uncollectible accounts, credit and collection expenses, and others.

The Pennsylvania Low-Income Usage Reduction Program (LIURP) for all Pennsylvania utilities is an example of benefits derived for low-income households to whom energy efficiency was delivered. A payment of less than 100 percent means the specified low-income household did not completely pay the current month's utility bill. In contrast, a payment exceeding 100 percent means the low-income household not only paid the current bill, but paid off its arrears as well. For every Pennsylvania utility but one, the installation of energy efficiency products substantially improved the payment patterns of the treated low-income households. Indeed, the delivery of energy efficiency generally caused a substantial increase in the payment coverage of the household energy bill. In most cases, the low-income household moved from falling further and further behind by failing to pay the current bill, to paying the entire current bill and beginning to retire the arrears. (Source: "Structuring a Public Purpose 'Distribution Fee' for Missouri", Fisher, Sheehan & Colton, Public Finance and General Economics consultants, July 1997.)

Q. Please describe utility billing arrearage for Aquila, Inc.

A. According to Aquila, Inc., customers receiving electric service from the company have had difficulty in meeting their monthly utility bill.

Aquila, Inc. reports that approximately 64,000 electric accounts were in arrears each month during calendar year 2002 with an outstanding monthly average balance in excess of $5.2 million. (Data Request, MDNR-55, Dawn Hall, Aquila, Inc., November 25, 2003).

Aquila – MPS experienced an average monthly arrearage balance of $4.05 million with over 47,000 customers unable to fully pay their electric utility bill. The number of accounts in arrearage grew dramatically from July 2002 with an average of approximately 42,000 accounts with an outstanding balance of $3.5 million to over 52,000 accounts with an outstanding balance nearing $6 million by October 2002.

Aquila – L&P experienced an average monthly arrearage balance of $1.2 million per month with over 16,000 customers unable to fully pay their electric utility bill. The average number of accounts in arrearage grew dramatically from July 2002 with an average of approximately 15,000 accounts with an outstanding balance of $1.1 million to over 17,000 accounts with an outstanding balance over $1.5 million by October 2002.

Presuming that a low-income annual heating bill in Missouri is estimated at $354 (at 2001/2002 winter heating prices) or 42.7% of an annual total electric household utility bill as noted by the April 2003 report "On the Brink: The Home Energy Affordability Gap in Missouri", a savings of 35.9 percent due to weatherization improvements could help reduce space heating demand. The improved efficiency in electric space heating could result in annual savings of $127 per year ($354 x .359 = $127). Over the life of such improvements, typically 20 years, the accrued savings would be approximately $3,900 for the low-income household ($127 x 20 = $2,542 at 2001/2002 winter heating prices), assuming no further increase in space heating cost . Such savings have been shown to help the low-income household meet its monthly utility bill and help reduce arrearage collections for the utility.

Q. Please describe the relationship between billing arrearage and utility service disconnects.

A. Over 9,000 Aquila electric customers experienced service disconnects due to billing arrearage (Data Request, MDNR-32, Carl Turner, Aquila, Inc., December 1, 2003). During calendar year 2002, Aquila Networks – MPS disconnected nearly 9,000 residential customers due to utility billing arrearage with nearly 3,000 disconnects during the months of September and October – just prior to the 2002/2003 winter heating season. Aquila Networks – L&P disconnected nearly 162 residential customers due to utility billing arrearage with 32 disconnects during the months of September and October.

Q. Please describe Aquila, Inc.'s gross uncollectible revenues from their residential customers.

A. During the 12-month period ending December 31, 2002, Aquila, Inc. reported uncollectible revenue from their electric customers at nearly $3.5 million (Data Request, MDNR-57, Dawn Hall, Aquila, Inc., November 25, 2003). Low-income residential weatherization may have helped to reduce the amount of uncollectible revenues by reducing energy demand and lowering monthly utility bills.

Q. Please describe natural gas expense increases and the impact on both residential electric and natural gas customers.

A. The patterns of natural gas price volatility and its impact on all consumers started several years ago. The volatility of natural gas supply and price has impacted consumers that rely on gas to heat their homes and businesses and energy utilities that generate electricity through natural gas combustion units. This new demand for natural gas places additional pressure on natural gas supplies and prices. Missouri's electric utilities used about 7 billion cubic feet

(Bcf) of natural gas in 1997, 16 Bcf in 1998, 19 Bcf in 1999 and 30 Bcf in 2000 – an average increase of 23 percent per year. (Governor's Energy Policy Council, June 2003 report, pg. 6). Beginning with the summer of 2000, natural gas prices began rising across the country. As we entered the 2000-2001 winter heating period, natural gas spot market prices had increased from approximately $2.00 per Mcf (1,000 cubic feet) to over $10. According to the Missouri Public Service Commission, the effects of the coldest November and December (2000) in Missouri history were still being felt in July 2001 by Missourians struggling to pay high heating bills from the winter of 2000-2001. Information presented in Chairman Simmons' July 2001 letter to Missouri's Congressional delegation indicated many of the investor-owned energy utilities reported higher numbers of residential customers (79,000 natural gas heated households) unable to fully pay for their energy bills. Although Chairman Simmons' concerns were focusing on natural gas heated households, this situation also occurs in electric heated households. Weatherization can help customers to use energy more efficiently and reduce their winter heating bills.

Wholesale natural gas prices spiked 287 percent higher during the winter of 2002-2003 than during the winter of 2001-2002, moving from $2.36 to $9.13 per million Btu (MMBtu) (Missouri Energy Bulletin, March 26, 2003). The natural gas spot price has remained high in historical terms. Throughout most of 2003, the average spot price for natural gas was above $4.00 per MMBtu, reaching a peak of over $9.00 per MMBtu in late February 2003.

Q. Please describe the current weatherization program administered by Aquila, Inc.

A. The weatherization program offered by Aquila, Inc. is limited to eligible residential electric customers and was initiated on July 1, 1999. The program is not offered to residential natural gas customers served by either Aquila Networks – MPS or Aquila Networks – L&P. The program offers a limited number of energy conservation measures including compact fluorescent lamps (light bulbs), electric water heater tank wrap, electric water heater pipe wrap, low flow shower-head, kitchen aerator, floor insulation, attic insulation, wall insulation and duct repair. The program is funded through rates and was provided a budget of $23,840 during calendar year 2002. From July 1, 1999 through October 2002, Aquila, Inc. reports that 28 customers participated in this program with only 2 participating during the 12-month period ending December 31, 2002. Of the $23,840 budgeted, only $1,894 was expended. Clearly, the current "weatherization" program offered by Aquila, Inc. has not had the intended impact nor the potential participation rate given the current number of low-income residential customers served by the company (Data Requests, MDNR-33 through MDNR-38, MDNR-46, MDNR-47, MDNR-61, MDNR-62, MDNR-66, MDNR-74 and MDNR-75, Matthew Daunis, November 25, 2003, Aquila, Inc.).

Q. Please describe the funding level required to support a low-income weatherization assistance program by Aquila, Inc.

Aquila, Inc. currently provides service to approximately 246,042 residential electric customers in 30 Missouri counties (Data Request, No. MDNR-26, Carl Turner, Aquila, Inc., November 25, 2003) and a total of 282,261 electric customers in both Aquila Networks – MPS and Aquila Networks – L&P service territories. According to the community action agencies currently providing weatherization services within Aquila, Inc.'s service territories, approximately 200 Aquila, Inc. low-income households are on waiting lists to receive weatherization services. In order to meet these customers' needs and additional Aquila, Inc. customers that may be added to the weatherization assistance waiting list in future months, we request annual funding of $282,000 for low-income weatherization. This utility-based weatherization assistance fund would supplement federal weatherization program funds and allow approximately 209 Aquila, Inc. low-income households to receive weatherization assistance. This is based on a leveraging amount of $1,350 per household from Aquila, Inc.'s weatherization fund (this represents approximately a 50/50 cost share between Aquila, Inc. and federal weatherization assistance funds that would be provided to an eligible low-income household receiving electric service from Aquila, Inc.). It is requested that funds should be used to exclusively weatherize Aquila, Inc.'s low-income electric heated homes.

Q. How should the program be designed?

A. This program should be designed to be consistent with federal guidelines for the federal Low-Income Weatherization Assistance Program.

Q. Please describe the need for residential energy efficiency.

Investments in residential energy efficiency help to improve the efficient use of energy by consumers. Energy efficiency recognizes the truism that Missouri households do not seek to consume energy. Instead, what they seek is to have light, hot water, refrigeration and heating and cooling. If these end uses can be delivered using less energy, the needs of Missouri consumers will have been satisfied.

U.S. Department of Housing and Urban Development (HUD) 1990 data showed that roughly one of every six Missouri units of housing that are affordable to households living above 80 percent of median income were constructed before 1940. Moreover, of the total of roughly 550,000 units affordable at that income level, nearly 90,000 have some type of "physical problem" under HUD's definitions. Finally, nearly 55,000 households living above 80 percent of median income pay more than 30 percent of their income for shelter costs, and roughly 5,000 pay more than 50 percent (Source: "Structuring a Public Purpose 'Distribution

Fee' for Missouri", Fisher, Sheehan & Colton, Public Finance and General Economics consultants, July 1997.)

In its August 29, 2001, final report, the Missouri Public Service Commission's Natural Gas Commodity Price Task Force recognized the need for energy efficiency programs by its recommendation that "the (Missouri Public Service) Commission should pursue incentive measures for encouraging energy efficiency." The report included this explanation of the need for efficiency programs: "Effective energy efficiency programs can address the barriers that inhibit customers from making investments in energy efficiency improvements – lack of money or competing demand for available funds, the perception that up-front costs are more important than long-term savings and lack of technical expertise."

Q. Briefly describe the benefits of residential and commercial utility-based energy-efficiency services.

A. The Missouri Energy Policy Task Force recommended in its October 16, 2001 final report, that "Missouri pursue incentives funded through various sources to encourage the increased development of energy efficiency and renewable energy to provide for a more secure energy future." The Task Force report cited the following benefits to customers, utilities, the economy and the environment: "Missourians would benefit greatly from investments in energy efficiency and renewable resource programs. Efficiency programs provide assistance to customers by helping to reduce their energy usage and utility bills, which is particularly important when energy prices are high and volatile. System reliability and resilience are improved by reducing vulnerability to disruptions in energy supplies through efficiency and a diversified fuel mix. Long-term costs can be lowered by reducing expenditures by gas and electric utilities to upgrade their infrastructure to meet increasing demand. Investments in energy efficiency and the resulting lower energy costs coupled with the development of domestic renewable energy will improve the ability of businesses to compete, keep energy dollars closer to Missouri, increase customers' discretionary income, preserve natural resources and reduce pollution."

Well-designed energy-efficiency programs have been shown to produce substantial economic benefits for local and state economies. *The Missouri Statewide Energy Study (1992)* prepared by Missouri's Environmental Improvement and Energy Resources Authority concluded that energy efficiency would "sustain more employment opportunities than either the continued current level of energy use or the development of new energy supplies."

In addition to these benefits, state investment in energy-efficiency tends to protect households against "insurable events." In August 1996, Lawrence Berkeley Laboratory released findings showing that energy-efficiency investments in housing often lead to the correction of conditions that place buildings at risk. Such conditions include fire, carbon monoxide poisoning, and the like.

Energy-efficiency investments can also promote the affordability of homeownership in Missouri. A study by Fisher, Sheehan and Colton, Public Finance and General Economics, released in November 1996, documented how energy-efficiency investments affect the affordability of first-time home ownership. The study found that, in the Census Division of which Missouri is a part, a $3,000 energy- efficiency investment made at the time of home purchase, financed at 9 percent interest, would yield an effective reduction in the price of the home of 6 percent and an effective interest-rate discount of 0.48 percent. In other words, in order to generate the same dollar savings as the energy efficiency investment, the interest rate charge on the home mortgage would need to be reduced by 0.48 percent.

A study completed by Lawrence Berkeley Laboratories for the U.S. Department of Energy addressed the economic benefits of commercial efficiency programs. In a comprehensive review of evaluations for 40 large commercial programs that accounted for one-third of 1992 utility demand side management spending, the majority of the programs reviewed, which accounted for 88 percent of utility and consumer spending on programs included in the study, were cost-effective. For all the programs analyzed, the savings weighted average ratio of total resource benefits to total resource costs was 3.2 to 1 (Source: The Cost and Performance of the Largest Commercial Sector DSM Programs, Lawrence Berkeley National Laboratory, December 1995). Lawrence Berkeley Laboratories found that overall, utilities demonstrated a capability to undertake highly cost-effective energy-efficiency programs.

Q. Briefly describe utility-based energy-efficiency services available today.

A. Several utilities throughout the nation continue to offer energy efficiency services and programs to their customers. These energy efficiency measures include residential and commercial energy audits, consumer education, and rebates or low-interest loans for the purchase of new products such as efficient water heaters, lights, showerheads, air conditioners, and heat pumps. Energy savings of approximately 40% can be realized through energy efficiency improvements. (Source: U.S. Department of Energy.)

Missouri energy utilities including Springfield's City Utilities, City of Independence Power & Light Department, Columbia Water and Light, Kansas City Power & Light and Missouri Gas Energy offer energy efficiency services to their customers as described above (Source: Utility Energy Efficiency and Renewable Energy Programs Survey, Missouri Department of Natural Resources, Outreach and Assistance Center, Energy Center, August 2002). Similar programs are offered by other utilities in other states, Wisconsin Public Service Corporation, Portland General Electric, and Northern State Power; and People's Natural Gas (Iowa), a division of Aquila Networks; Northern Minnesota Utilities and Peoples Natural Gas, divisions of Aquila Networks, to name just a few.

Q. What is the cost comparison of energy efficiency to new electric generation?

A. Energy efficiency is appropriately viewed as an energy resource like coal, oil or natural gas. In contrast to supply options for new generation such as drilling for more natural gas or mining coal, energy efficiency helps contain energy prices by curbing demand instead of increasing supply. This means that energy efficiency provides additional economic value by preserving natural resources and reducing emissions. (Source: "Utility Deregulation a Bust for Energy Efficiency Programs", Environmental Working Group, October 1998.) The primary efficiency programs having the most potential for energy savings include efficient residential heating, ventilating and air conditioning equipment (HVAC), tune-ups and repair; proper installation, maintenance and use of commercial HVAC and other building systems; and commercial and industrial sector lighting retrofits. In addition, energy efficient design and construction of new buildings have significant potential for energy savings in Missouri. To achieve these savings, training for building contractors, developers and architects is essential and could be included in a utility-based efficiency program.

It is difficult to accurately compare investments in energy efficiency measures, often referred to as demand-side management (DSM), to investments in building new generation plants or supply-side resources. Economic comparisons of efficiency and supply-side investments require that consideration of the life-cycle cost of the options are addressed on an integrated basis, such as the interaction of the change in usage patterns with the generation function of the utility must be considered over the expected life of the options. (Source: "Electric Utility

Demand Side Management 1998," U.S. Department of Energy, Energy Information Administration.)

While cost calculations will vary by region and individual utility, the U.S. Department of Energy (USDOE) has used the cost of energy in cents per kilowatt hour (kWh) saved as an index for making approximate comparisons between the cost of energy efficiency programs and new generation plants.

USDOE data collected from surveys of 63 percent of reporting utilities in 1994 indicated that the cost of energy efficiency programs was competitive with or below the cost of new generating capacity. The average costs of achieving conserved energy were reported at under 3 cents per kWh while the cost for new generation facilities ranged from 2 to 15 cents per kWh on a significant number of days per year. During capacity shortages, prices could increase to 50 cents per kWh or higher, reflecting the cost of building new generation to serve peak loads or the price signals that might be required to match demand to available supply if power must be purchased on the spot market.

In a more recent report issued by the Rocky Mountain Institute in 2001, it was found that the average cost of implementing energy efficiency has been 2 cents per kWh with the best-designed programs costing less. In contrast, each kWh generated by an existing power plant costs an average of 5 cents or more.

In April 2001, the Missouri Public Service Commission reported that the current long-term wholesale market price for electricity in the Midwest was 4 cents per kWh, or $40 per megawatt, not including transmission costs. Using these cost estimates, energy efficiency investments ranging from 2 to 3 cents per kWh are more cost-effective than building new generation at 4 to 5 cents per kWh without factoring in the additional environmental and system benefits due to less stress on the transmission and distribution systems.

Q. What are some of the statistics related to energy efficiency investments and potential in Missouri?

The Alliance to Save Energy, a nationally recognized coalition of prominent business, government, environmental, and consumer leaders who promote the efficient and clean use of energy worldwide to benefit consumers, the environment, economy and national security, issued a report in 1998 addressing energy-efficiency improvements to homes. It was found that residential energy-efficiency improvements could reduce energy consumption in Missouri by an estimated 567 billion Btu's, or the equivalent of approximately 100,000 barrels of crude oil each year. The Alliance reported that, of the 34 states studied that had not adopted the 1993 Model Energy Code, Missouri ranked 5th highest in terms of potential total energy savings and 5th highest in potential energy savings per home.

In a report to the Missouri Legislature pursuant to House Concurrent Resolution 16 titled "Economic Opportunities Through Energy Efficiency and the Energy Policy Act of 1992", Missouri specific opportunities and benefits of commercial energy efficiency programs were addressed. The report found that if Missouri had met its mandatory obligation set forth in the Energy Policy Act of 1992 (to adopt a state-wide commercial building efficiency standard by 1995), the result would have been a reduction in the cumulative consumption of energy by new commercial buildings built between 1995 and 2000 by 4 trillion BTUs, the equivalent of nearly 700,000 barrels of oil per year. The cumulative operating cost savings for Missouri commercial building owners would have been nearly $68 million by the year 2000. The report goes on to say that this potential is "dwarfed by the energy consumption of the pre-

1995 standing commercial building stock." This existing commercial building stock would benefit from energy efficiency programs.

Q. What are some of the statistics related to energy efficiency investments and potential nationally?

A. In its March 1990 report "Efficient Electricity Use: Estimates of Maximum Energy Savings," the Electric Power Research Institute, funded by utility companies, estimates that 22 to 44 percent of total U.S. electricity consumption could be saved by using the most efficient technology available in 1990. Nationwide, spending on state energy efficiency programs fell from $1.65 billion in 1993 to nearly half -- $912.5 million in 1998 – at a cost of nearly 15,000 megawatts in power savings. The Environmental Working Group reported in 1998 that through the mid-1990's, programs gradually shrunk as utilities sought to cut cost in preparation for restructuring. As programs shrunk, so did savings, contributing to high demand growth and current reliability problems. As a result, Americans forfeited $1 billion in savings on electric bills as of 1997. These savings would have continued every year for the subsequent 10 years, a total of at least $10 billion in consumer savings lost due to cuts in energy efficiency programs by utilities, inspired largely by utility deregulation.

Utility commitment to energy efficiency programs varies largely by company and region. For example, the City of Eugene, Oregon, whose utility serves some 73,000 customers, invested more in energy efficiency than the combined outlay of Southern Company, Entergy, Commonwealth Edison, and American Electric Power, which serves more than 12 million customers.

Energy efficiency measures are proven to cut energy usage and pollution. For example, compact fluorescent bulbs use one-quarter the electricity for incandescent bulbs. Replacing just one incandescent light bulb will save a consumer $50 and reduce carbon monoxide emissions by 1,000 pounds over the life of the bulb.

Q. Does Aquila, Inc. offer residential and commercial energy efficiency services or products to their residential or commercial natural gas customers?

A. Yes. According to Aquila, Inc., the company provides a limited number of energy efficiency services or products for their residential or commercial electric customers (Data Requests, MDNR-33, MDNR-34, MDNR-46, MDNR-47, MDNR-61, MDNR-62 and MDNR-74, Matthew Daunis, Aquila, Inc., November 25, 2003). Aquila offers the following energy efficiency programs: Residential Financing, Residential Mail In Energy Audits, Small Commercial and Industrial Energy Audits, Large Commercial and Industrial Energy Audits, Residential Lighting Program. Aquila also reports that they have joined a utility coalition to promote energy efficiency in the Greater Kansas City marketplace through energy education, resources and actions.

Q. Do you request any changes to these programs?

A. Yes. I commend Aquila for their involvement in offering energy efficiency services. I do have suggestions for ways to improve participation levels in these programs however, to make them more effective in achieving energy savings benefits for their customers.

I request that Aquila replace its Residential Mail-In Energy Audit Program with a web-based residential energy audit program. The web-based energy audit program should be available to both MPS and SJLP residential customers. Aquila began implementation of the mail-in energy audit program on April 1, 1999. From inception through May 2003, Aquila reports there have been 10,840 requests for audit services and only 4,447 audits, 41 percent, have been completed and returned to customers. Upon receipt of the audit form, MPS combines the survey results with the customer's billing data to generate an audit report to send to the customer. The report provides an estimate of energy usage by appliance and end-use and a list and description of energy efficiency measures that are relevant to the customer's home. To be able to meet their residential customers' requests for energy audits and to provide this service to both MPS and SJLP residential customers, I request that Aquila develop and implement a web-based residential energy audit that links to a customer's billing data to quickly and accurately provide energy-saving recommendations and information. This would reduce the staff time to manually complete the energy audits that are now done by Aquila for its MPS customers (Data Request, No. MDNR-33, Attachment: Demand Side Analysis Report dated November 26, 2002, Matthew E. Daunis, November 30, 2003). A similar program is under development by AmerenUE as part of the Residential and Commercial Energy Efficiency Collaborative established in the Stipulation and Agreement in Case No. EC-2002-1. Based on the projected cost to implement this online residential energy audit program, I request that $250,000 in one-time costs and $125,000 in annual costs be allocated to develop and implement this program. This online audit program can serve both MPS and L&P *electric and gas* customers because energy efficiency measures identified in the audit will relate to both electric and gas measures. As a result, the cost to establish this program could be allocated among Aquila-MPS and Aquila-L&P *electric and gas* customers. The cost allocation could be based on the number of customers in each service territory. The Energy Center will include a similar proposal in the Aquila, Inc. natural gas rate case GR-2004-0072.

Q. Do you request other changes to Aquila's energy efficiency programs?

A. Yes. In addition to implementing an online residential energy audit program and offering this service to both MPS and SJLP customers, I request that the Small Commercial and Industrial Energy Audit Program also be offered to L&P customers. This audit program is currently offered to MPS customers only. (Data Request, MDNR-46, Mathew Daunis, Aquila, Inc., November 25, 2003). The program should be structured to provide incentives for commercial customers to implement the energy efficiency measures identified in the energy audit. A similar program is being implemented by AmerenUE as part of the Residential and Commercial Energy Efficiency Collaborative established in the Stipulation and Agreement in Case No. EC-2002-1. We request $50,000 annually to make this program available to both MPS and SJLP commercial customers and to include incentives to encourage implementation of energy efficiency measures identified in the energy audit.

Based on the number of customers served by Aquila, Inc., participation rates are low for many of these programs. I also request that the current programs be marketed more extensively to increase customer participation.

Recently, Aquila, Inc. became a utility partner with the ENERGY STAR program, a program sponsored by the U.S. Department of Energy and the U.S. Environmental Protection Agency helping businesses and individuals protect the environment through superior energy efficiency.

Last year alone, Americans, with the help of ENERGY STAR, saved enough energy to power 15 million homes and avoid greenhouse gas emissions equivalent to those from 14 million cars - all while saving $7 billion.

Energy efficient choices can save families about a third on their energy bill with similar savings of greenhouse gas emissions, without sacrificing features, style or comfort. ENERGY STAR helps consumers to make informed energy efficient choices. ENERGY STAR products include new high energy efficiency household products and appliances, energy-efficient ratings for new homes and tools and resources to help utility customers to plan and undertake projects to reduce energy bills and improve home comfort. For businesses, ENERGY STAR can provide a strategic approach to energy management that can produce twice the savings - for the bottom line and the environment. ENERGY STAR partnership offers a proven energy management strategy that helps in measuring current energy performance, setting goals, tracking savings, and rewarding improvements. ENERGY STAR provides an innovative energy performance rating system which businesses have already used for more than 10,000 buildings across the country. ENERGY STAR also recognizes top energy and environmental performing buildings.

I request that Aquila, Inc. provide annual funding in the amount of $35,000 to promote the Change A Light, Change the World program in the company's service territory. The Change A Light, Change the World program is a national lighting campaign facilitated by the ENERGY STAR program and centered on light fixtures and light bulbs that have earned the ENERGY STAR label. The program would provide a unique opportunity for Aquila, Inc. to work with area retailers, manufacturers and regional partners to tailor a program to promote the use of high efficiency lighting systems, improve energy use and help promote environmental benefits.

The three primary goals of the program are to 1) stimulate demand for increased availability and variety of ENERGY STAR qualified lighting products in the marketplace; 2) influence market share of ENERGY STAR qualified lighting products; and, 3) strengthen consistent ENERGY STAR identity in the marketplace.

By choosing ENERGY STAR products, individuals have the power to make a difference for the environment. Products that earn the ENERGY STAR label meet strict guidelines set by the Environmental Protection Agency and the Department of Energy.

Q. What are the benefits to consumers from renewable energy sources?

A. The Governor's Energy Policy Council cited economic and environmental benefits of renewable resources and recommended that Missouri aggressively pursue their production and use. The Council's June 1, 2003 report stated:

"Renewable energy sources in the Midwest are playing an increasing role in providing energy needs. Diversifying energy sources in Missouri will provide numerous benefits by:

- reducing our vulnerability to volatile oil markets,
- improving grid reliability through on-site generation,
- increasing the competitiveness and reliability of businesses and energy systems,
- offering economic benefits from the development of renewable energy industries and keeping more of our energy dollars in the local economy, and
- improving the environment from reduced emissions that harm public health.

Clean domestic energy choices for power generation, including solar, wind and biomass, can improve efficiencies and reduce expenditures on transmission and distribution equipment by siting these technologies close to the point of consumption, where possible.

Other Midwest states have begun to realize the economic benefits from the development of renewable energy industries. Many of these economic benefits accrue, in particular, to the rural economy. In Iowa for example, wind-farm developers pay 115 farmers about $2,000 per year for each wind turbine placed on the farmer's property, for a statewide total of approximately $640,000 per year. The Iowa wind projects also generate $2 million per year in tax revenue to counties and have created 40 new jobs. An economic study by the Regional Economics Applications Laboratory estimates that the state of Illinois can add 13,500 new jobs and $1.5 billion in annual economic output by 2020 by investing in renewable energy technologies. (Source: "Job Jolt: The Economic Impacts of Repowering the Midwest: The Clean Energy Development Plan for the Heartland, An Economic Study by the Regional Economics Applications Laboratory for the Environmental Law and Policy Center," November 2002)

The study includes estimates for nine other states in the Midwest.

The Union of Concerned Scientists (UCS) studied the impact of a national policy called a renewable portfolio standard (RPS) to increase the United States' use of renewable energy to 20 percent by 2020 (Source: "Renewing Where We Live," Union of Concerned Scientists, 2002). The UCS analysis found that under a 20 percent RPS, Missouri could produce the equivalent of 3 percent of its electricity use from renewable energy (not including hydropower) in 2010 and 23 percent in 2020 from bioenergy resources (88%), wind (7%) and landfill gas (5%). If a RPS were in place, the study estimates that between 2002 and 2020 renewable energy development could generate $1.6 billion in new capital investment in Missouri; $62 million in new property tax revenues for local communities; and $4 million in lease payments to farmers, ranchers and rural landowners from wind power (1999 dollars)."

Q. Does Missouri have renewable energy resources?

A. Yes. As an agriculturally productive state, Missouri has substantial land area available for energy crops and crop waste that can be used for bioenergy production. If one-half of the energy content of these available biomass resources were used in technology that is as efficient as the average American electric generation plant, the Energy Center estimates that the net energy produced would be 15.2 million megawatt hours (MWh). This assumes that biomass fuel can be economically transported to plants capable of burning such fuel. This compares to 76.6 million MWh generated in Missouri in 2000, or 20% of our current generation. (Source: Governor's Energy Policy Council, June 2003 report).

Missouri also has an average daily summer solar radiation comparable to the vast majority of the United States including the state of Florida, making solar energy in Missouri an untapped opportunity. As the cost of traditional fossil fuels increases and the cost of solar energy declines, solar energy for electrical power generation and water heating continue to become more cost-effective as a means to help meet peak electrical demand (Source: Governor's Energy Policy Council, June 2003 report).

Q. Does Missouri have wind energy resources?

A. Yes. To help assess Missouri's wind energy potential, the Energy Center contracted with the firm TrueWind Solutions, Inc. for the development of new high-resolution wind energy maps of Missouri. At a resolution of 25 kilometers, the 1987 national wind maps provided only a gross indication of general areas with potentially productive wind sites. Advances in weather forecasting have resulted in substantial improvement in computerized models of the atmosphere. Not only has this affected weather forecasting, it has also resulted in new ways to predict wind energy patterns that result in a new generation of maps that are much more detailed.

The maps that are currently available are interim-final work products of TrueWind Solutions and are subject to independent validation by the National Renewable Energy Laboratory

(NREL) and consulting meteorologists. We expect this validation to be completed in the next few months. According to NREL staff, historically their validation has resulted in only minor changes.

The high-resolution maps offer new insights into Missouri's wind energy resources. Previous maps of wind energy patterns prepared in the 1980s indicated that Missouri's best wind energy resources were likely to be found on well-exposed ridges in southern Missouri. The new maps predict that the largest areas with the highest average wind speeds are to be found in northwest Missouri, much of which is in the service area of Aquila Networks – L&P. While in general, similarly exposed locations to the south and east have progressively lower average wind speeds, the map indicates there are smaller areas with wind speeds similar to those found in northwest Missouri at various locations throughout the state. Missouri's wind power also substantially increases as the distance from the ground increases. For example, the wind power density measured at 100 meters is much better than at 50 meters.

While Missouri's wind resources are not as abundant as some of our neighboring states to the north and west, we do have the potential for development at some locations in the state, particularly in northwest Missouri and as wind generation technology continues to provide taller wind turbines. The interim-final wind maps can be viewed on the Department of Natural Resources' web page at http://www.dnr.mo.gov/energy/renewables/wind-energy.htm#maps.

Q. How are these maps used?

A. These new high-resolution wind maps can be used by Missouri utilities and property owners to guide site-specific assessments to determine the viability of installing wind turbines at these sites. For utility-scale wind development, assessments are conducted on tall towers at heights of 70 to 100 meters. The Energy Center proposes to work with Aquila, Inc., to use the maps to identify potential sites in their service territory to conduct site-specific wind resource assessments.

The Energy Center requests that Aquila Inc. spend $100,000 in funding over the next three years to contract with a consulting wind energy meteorologist to conduct wind energy assessments at seven to ten sites in the SJLP service territory. Wind energy assessments should be consistent with the American Wind Energy Association's Standard Procedures for Meteorological Measurements at a Potential Wind Turbine Site (AWEA Standard 8.1 – 1986 or successor standards). Selection of the sites should be consistent with the best wind energy resources identified in the Department of Natural Resources' recently published wind map of the state of Missouri. To determine the feasibility of utility scale wind development, a minimum of one-half of the assessments should be conducted at a height of 100 meters with the remaining sites to be at heights of at least 70 meters. The cost for each site assessment is estimated to be approximately $10,000. Costs would include the wind measuring equipment, installation costs, lease payments for the use of existing tall towers (such as communication towers when located on or near sites predicted to have a strong wind resource) and consultant analysis of the data.

Q. Is wind energy economically viable?

A. Yes. Because of the improved efficiency of wind turbines and government policies encouraging wind energy investments, wind-driven electrical generation is the fastest growing source of new electrical generation capacity in the United States. Recent technological improvements have made it possible to generate energy from wind levels previously considered insufficient.

When installed on sites with a strong wind resource, the cost of wind energy is now in a competitive range with power technologies that use fossil fuels, ranging from 4.0 to 6.0 cents per kilowatt hour, not including the U.S. federal production tax credit (Source: U.S. Department of Energy National Renewable Energy Laboratory National Wind Technology Center). The federal production tax credit for renewable energy is 1.9 cents/kWh (1.5 cents/kWh adjusted for inflation). The federal energy bill under consideration at the time of this filed direct testimony, extends the production tax credit until January 1, 2007. Unlike some other electric generation technologies, wind energy contracts are often for 10 to 20 years, resulting in a known price for energy that can serve as a hedge against price volatility, utility companies are deciding to build wind-powered generation because it is economical to do so.

Q. Does Aquila invest in wind energy?

A. Yes. I commend Aquila for their leadership in diversifying their resource mix by including wind energy. Aquila has a 16 percent ownership share (0.12 MW) of the Jeffrey Energy Center wind turbines and purchases power on long term contract from the Gray County Wind Farm. Both sources are located in Kansas. Aquila provides the wind energy that Springfield City Utilities and Boone County Electric Cooperative make available to their customers.

Q. What funding level would be required to adequately support energy efficiency programs for Aquila, Inc.'s residential and commercial electric customers and the renewable energy program presented by your testimony?

A. As noted earlier in my testimony, Aquila, Inc. is targeting the largest proportion of this rate increase to its residential and small commercial electric customers. In order to help Aquila, Inc.'s residential and commercial electric customers face these rising energy costs, they should be offered the opportunity to improve the way they use energy and help to reduce their energy expense.

Aquila, Inc. currently provides electric service to approximately 218,300 customers in Aquila Networks – MPS; approximately 189,000 are residential customers and 25,000 are general service customers that include small commercial. Approximately 64,000 electric customers are served by Aquila Networks – L&P; approximately 56,000 are residential customers and 5,500 are general service customers that include small commercial. In total, Aquila Networks serves approximately 282,200 electric customers which includes 245,000 residential customers and about 30,000 small commercial customers.

The Energy Center requests that Aquila, Inc. implement the proposed residential and commercial energy efficiency programs and renewable energy programs annually as follows:

Low-Income Residential Weatherization Assistance

Annually fund through rates, $218,000 for Aquila Networks – MPS and $64,000 for Aquila Networks – L&P, for a total annual budget of $282,000 to implement low-income residential weatherization assistance consistent with federal weatherization guidelines through local community action agencies operating within Aquila, Inc.'s electric service territory. Presuming an average savings to investment ration of 1:2.5, low-income households could realize a net benefit of $705,000 per year or $14.1 million dollars over the life of this investment ($282,000 x 2.50 x 20 years = $14,100,000).

Residential Energy Efficiency

Fund through rates $250,000 in one-time costs and $125,000 in annual costs for an online residential energy audit.

Change A Light, Change the World

Annually fund through rates $35,000 to participate in the Change a Light, Change the World program within the Aquila, Inc. service territory.

Commercial Energy Efficiency

Fund through rates $50,000 in annual costs for a commercial energy audit program with incentives for implementation of energy efficiency measures.

Renewable Energy

One-time funding in the amount of $100,000 divided over a three-year period to complete the wind energy assessment project.

Q. Please explain the estimated cost per customer to implement these energy efficiency and renewable energy programs.

A. First year costs related to the proposed energy efficiency and renewable energy programs total $775,333:

• Weatherization Assistance	$282,000 annual
• Residential Efficiency	$250,000 one-time
	$125,000 annual
• Change A Light	$ 35,000 annual
• Commercial Efficiency	$ 50,000 annual
• Renewable Assessment	$ 33,333 annual for three years
Total	$775,333

If costs were allocated to all electric customers served by Aquila Networks – MPS and Aquila Networks – L&P, the estimated cost per customer would be approximately $2.75 for the first year or approximately $0.23 per month.

Over the next two years, the cost to all electric customer served by Aquila, Inc. is estimated at $525,333 per year, with an estimated cost per customer at $1.86 per year or $0.16 per month:

- Weatherization Assistance $282,000 annual
- Residential Efficiency $125,000 annual
- Change A Light $ 35,000 annual
- Commercial Efficiency $ 50,000 annual
- Renewable Assessment $ 33,333 annual

Total $525,333

In order to prevent any further contribution to increased electric rates for customers served by Aquila Inc., the Energy Center requests a reduction in Aquila, Inc.'s rate filing of no less than $1,825,999 equal to the funding amounts to support the proposed energy efficiency and renewable energy programs for a period of no less than three years.

Following this 3-year period, the Energy Center requests annual funding in the amount of $492,000 to support Weatherization Assistance ($282,000), Residential Efficiency ($125,000), Change A Light ($35,000) and Commercial Efficiency ($50,000) until the company's next rate filing.

Q. Does this conclude your testimony?

A. Yes. Thank you.

Missouri Weatherization Assistance Program, 2003

<u>Eligible Energy Efficiency Measures</u>

Air leakage reduction
Attic insulation
Foundation insulation
- sillbox insulation
- foundation insulation
- floor insulation

Wall insulation
Duct insulation
Storm windows
Window replacement
Door replacement
Heating System
- repairs
- clean and tune
- venting repairs
- replacement*: these will be limited to natural gas, propane, and oil-fired systems.

Water heater tank insulation
Water heater pipe insulation
Low flow showerheads
Water heater replacement
Repair measures
- minor drywall
- minor roof
- minor electrical
- minor moisture

Moisture barrier

* Electric heating systems are normally not eligible for replacement. Program guidance from DOE discourages this practice. Repairs to these systems can be made under incidental repairs and replacement can be made on site-specific situations.

December 2, 2003

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STANDARD PROCEDURES FOR METEOROLOGICAL MEASUREMENTS AT A POTENTIAL WIND TURBINE SITE

Prepared by:

Siting Subcommittee
Standards Program
American Wind Energy Association
122 C Street, NW, Fourth Floor
Washington, DC 20001 USA
Cooperative Agreement DE-FC01-80CH10302

AMERICAN WIND ENERGY ASSOCIATION STANDARDS

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FOREWORD

This foreword is included for informational purposes and is not part of *Standard Procedures for Meteorological Measurements at a Potential Wind Turbine Site, AWEA 8.1 - 1986.*

This standard is one in a series of standard documents being prepared by the American Wind Energy Association (AWEA) to facilitate uniform practices and communication in the technology of wind energy conversion. To continue to be of service to those organizations and individuals who use it, this document should not be static -- especially in view of the rapid evolution of wind energy technology. Suggestions for improvement will be welcomed by the Association. Address all correspondence to AWEA Standards Program, 122 C Street, NW, Fourth Floor, Washington, DC, 20001, USA.

AWEA 8.1 - 1986 was developed by the Siting Subcommittee of the AWEA Standards Program. The purpose of this subcommittee has been, and continues to be, to develop criteria for the design of wind energy conversion systems (WECS).

This document was prepared for submittal to the AWEA membership under the overall guidance of the AWEA Standards Coordinating Committee which was constituted as follows at the time of this submittal:

Robert W. Baker	US Windpower
Don Bain	Oregon Dept. of Energy
Paul Bergman	Massachusetts Energy Office
Dr. Edwin X. Berry	Atmospheric Research & Technology Institute
Val Bertoia	Bertoia Studio
David Blittersdorf	NRG Systems
F.J. Bourbeau	Enerpro
Remy Ceci	Pan Pacific Energy Development Corp.
Carel Dewinkel	Wisconsin Power & Light
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Dr. B.K. Gupta	Institute for Development of Energy & Society
Kurt Hohenemser	Washington University
William T. Hopwood	Springhouse Energy Systems
Gary Johnson	Johnson Energy Corp.
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Jack Kline	Howden Wind Parks
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Robert C. Pooser	Pooser Lumber
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Robert N. Swanson	PG & E
Alex Theodorou	
Jon Traudt	Applied Energy
William A. Turner	Harriman Associates
John E. Wade	Oregon State University
Bob Zickerfoose	Alternative Energy Corp.

1.0 Scope

This document provides procedures and methods for obtaining meteorological measurements at a site that has been proposed for wind energy use. Standards are provided for meteorological measurement systems and installation, operation, and calibration of equipment. Guidelines for sampling strategies, data processing and site evaluation practices are given in the appendices.

General wind turbine siting guidelines are not included here. References presenting this topic are given in "Applicable Documents".

This document does not cover standards for interpolating nearby data to the site, or for extrapolating short-term data into a long-term climatology. Numerical schemes for vertical extrapolation of data are also excluded. However, guidelines for obtaining the most representative measurements for the site and for recording these measurements during selected periods of the year to obtain annual estimates are given in Appendix C.

For the purposes of this document, wind energy utilization is defined as the use of single units or arrays of multiple units of wind turbines of any size greater than 1 kW for purposes of generating electricity. Although many of the guidelines in this document are applicable for all types of wind energy utilization, this document emphasizes procedures for commercial wind energy projects.

2.0 Applicable Documents

2.1 AWEA Terminology Standard AWEA 5.1 - 1985

2.2 Hiester, T. R. and W. T. Pennell, 1981. The Meteorological Aspects of Siting Large Wind Turbines. PNL-2522, Pacific Northwest Laboratory, Richland, Washington.

2.3 Wegley, H. L., et al. 1980. A Siting Handbook for Small Wind Energy Conversion Systems. PNL-2521 Rev. 1, Pacific Northwest Laboratory, Richland, Washington.

2.4 Pennell, W. T. 1983. Siting Guidelines for Utility Application of Wind Turbines. AP-2795, Research Project 1520-1. Electric Power Research Institute, Palo Alto, California.

3.0 Significance and Use

This document provides standard procedures for obtaining reliable, calibrated, and representative meteorological data from a site proposed for wind energy use. Adherence to this program will provide comparability of measurements among different sites and ensure that the data values are real and traceable to standards established by the National Bureau of Standards. The data base developed from this measurement program will enable the user to:

- Estimate energy production of wind systems over diurnal and monthly cycles from the installed equipment.
- Identify potential turbulence and/or site-specific wind characteristics wind turbines might encounter.
- Estimate on-peak, mid-peak, and off-peak energy production from the wind turbine site.

4.0 Description of Components of Wind Measurement Systems

4.1 Wind Sensors

Wind sensors measure the wind speed and direction. The most common type of sensors for measuring the horizontal wind speed component are cup or propeller anemometers. A wind vane is used to measure wind direction. Propeller anemometers also are used to measure the wind components in three orthogonal directions. These "uvw" anemometers can provide a measure of the vertical component of the wind.

4.1.1 Anemometer

A cup anemometer and wind vane could be independent sensors separated by a few feet, or the cup and vane could be mounted on the same vertical axis. When propellers and vanes are used, the propeller is attached to the vane. Because in this case the two sensors are not totally independent, structural or mechanical failure of the vane can cause erroneous wind speed data. Also, there may be errors introduced by the vane's response to wind direction, as opposed to cups that are essentially non-directional.

The rotation of anemometers is used to generate a signal that is proportional to wind speed. In most cases, the signal is electrical, although some anemometers produce mechanical signals. These signals may be continuous or intermittent. Continuous signals permit the wind speed to be determined at any instant. Intermittent signals can only be used to determine the average wind speed during a specific interval, depending on sampling rate.

Note: An example of a continuous signal would be the output of a small DC generator. If an anemometer is connected to a DC generator, the output of the generator can be displayed using a voltmeter or ammeter. The needle of the voltmeter will rise and fall with each wind gust, and the average wind speed is reflected by the average position of the needle. An example of an intermittent signal would be a flashing light. An anemometer can be connected to the light switch so that the number of light flashes over a predetermined time period equals the average wind speed. No information would be available on the speed during gusts during that period. Other methods of obtaining intermittent signals include use of reed switches or photocell light-choppers.

4.1.2 Wind Vanes

Wind vanes produce continuous signals; however, there are two types of signals. One type relates the signals to discrete direction sectors (i. e., north, northwest, etc.). As long as the wind continues within the sector, the signal remains constant even though there may be small direction fluctuations. The other type relates the signal to the instantaneous wind direction.

4.2 Signal Conditioners

Signal conditioners can supply power to sensors when required, and receive the signal from the sensor and convert it to a form that can be used by a recorder or display. Signal conditioning equipment is often included in the recorder or display equipment.

4.3 Displays

4.3.1 Dials

The information is read directly by needles or pointers.

4.3.2 Digital Displays

Information is presented directly by numerals and letters.

4.4 Recorders

4.4.1 Electromechanical Counters

Electromechanical counters record only the total amount of wind passing the sensor over a specified time interval. To estimate wind speed for electromechanical counters, it is necessary to determine elapsed time and divide the total amount of wind passing the sensor by the elapsed time. For example:

Average wind speed (mph) = miles of wind passage/elapsed time (hours)

4.4.2 Electronic Storage Data Loggers

In their simplest form, electronic data loggers can combine a number of accumulated signals, each with certain wind data. At the end of the observation period, the contents of the accumulators can provide a variety of statistics on wind, such as wind speed frequency distributions or sequential wind speed averages representative of predetermined time intervals. More complex data loggers may be used to record wind speed by direction and/or time of day. Data loggers that perform electronic calculations using the input signals and then record the results of the calculations are called "smart" data loggers.

4.4.3 Chart Recorders

In a chart recorder, the signal from the sensor moves a pen or other marking device back and forth across a piece of paper, which is typically moving at speeds between 2 and 15 centimeters (1 and 6 inches) per hour. The trace is a continuous wind record in which time of occurrence is determined by position along the chart.

4.4.4 Magnetic Tape or Solid State Recorders

Recorders can be used to record time sequential raw data or to record data that have been processed by the data logger. In the second case, a large part of the data analysis may be completed before recording. This preprocessing reduces the amount of data stored on the tapes, but may limit the flexibility of further data analysis, because the raw "time sequential" data have been lost. On the other hand, if the system only records the raw data, the sampling frequency must be high enough to ensure that sufficient samples are recorded for statistical analysis.

4.5 Wind Measurement Data Systems

Wind measurement data systems are defined on the basis of data storage capability as shown in Table 1.

Class I Systems: These systems do not have any data storage capability. If data are to be collected, an observer must monitor the system and manually record the data.

Class II Systems: These systems characterize the wind with a single number. Wind-run odometers are examples of these systems. Other instruments in this class record available energy in the wind (proportional to the sum of the cubes of instantaneous wind speed samples) or extractable energy (assuming a wind turbine's cut-in, rated, and cutout wind speeds are known). The time between readings of these instruments must be known to use the results.

Class III Systems: These systems store data in a sequential or accumulated form that retains information about the individual wind observations, including date and time. As a result, Class III systems record, store, and accumulate more data than the other systems. The data from these systems can be summarized in more than one form for analysis. As long as the recorded data are not lost, flexibility in analysis is retained, even after data collection is completed. Data collected by these systems can be used even if the details of data analysis were not determined before the data collection.

These systems are suitable for many wind turbine siting applications and provide more information on wind characteristics than Class II systems. Class III systems are particularly useful if diurnal load matching is important, because the data can be organized by time of day. Many of these systems are designed for unattended operation in remote locations and contain their own power sources.

The summary and analysis of data from Class III systems require the handling of large quantities of data. These systems generally require more attention to maintain the same levels of data recovery as Class I and II systems. However, because of the continuous nature of the data record obtained from these systems, software programs can be designed to obtain summaries of wind statistics over any time period desired. Many Class III systems have internal programs that summarize the data in various ways before recording them.

TABLE 1

DESCRIPTION OF THREE MAJOR CLASSES OF WIND MEASUREMENT SYSTEMS

Class	Storage Capability	Recording Medium	Primary Application	Comments
I	None	Manual records by observer	Real time, instantaneous data	Lowest cost,but human factor could introduce bias error
II	Single register	Counter or Electronic	Weekly, monthly averages	Minimum system for average speed or annual energy output
III	Multiple register, processed and sequential	Magnetic tape/ solid state/ strip chart	Summarized bin data, detailed statistical data analysis	Raw data retained for further processing;some internal processing;data storage dependent on sophistication of processing and logging systems.

5.0 Minimum Requirements for Standard Site Measurement Procedures

5.1 Data Use

Illustrations of different measurement strategies that can be used for various machine evaluations are shown in Appendix A.

5.2 Minimum Data Requirements

Data shall cover the wind speed range from 0 to 45 m/s (0 to 100 mph). In the wind speed range of 4.5 to 20 m/s (10 to 45 mph), resolution of the data shall be at a minimum of 0.5 m/s (1 mph). Data shall be recorded on a continuous basis for at least one year, even if wind turbines are installed before that period. During that year, a valid data recovery goal of at least 90% shall be established.

For the purposes of this document, "valid data" are measured data that are representative of the unknown quantities within the calibration tolerances of the instrumentation used and that would be confirmed by redundant measurements.

5.3 Maximum Wind Measurement System Inaccuracy

The wind measurement system consists of two primary subsystems: The physical subsystem (anemometer and wind vane sensors) and the electronic subsystem (signal conditioning, recording devices, and all cabling and connectors). The overall maximum wind speed system inaccuracy shall be +-2% of the true wind speed. The maximum wind direction system inaccuracy shall be +-5 degrees. These system inaccuracies shall apply over the temperature range specified by the manufacturer.

5.3.1 Physical Subsystem Measurement Inaccuracy

Under steady airflow conditions in a wind tunnel the physical subsystem contribution to the maximum wind speed inaccuracy shall be +-2% of the true wind speed for the range of 4.5 to 27 m/s (10 to 60 mph).

Note: Under normal use in the atmosphere, the inaccuracy of cup and propeller anemometers has not been documented, but may be greater than wind tunnel inaccuracies due to unsteady wind effects.

The physical subsystem contribution to the maximum wind direction inaccuracy shall be +-5 degrees of the true wind direction for the range of 4.5 to 27 m/s (10 to 60 mph) over the active part of the sensor. The sensors shall have a "dead band" (in which no measurement is possible) of less than 10 degrees.

5.3.2 Electronic Subsystem Measurement Uncertainty

The electronic subsystem contribution to the inaccuracy of wind speed and wind direction measurements shall be negligible for the range of 4.5 to 27 m/s (10 to 60 mph).

Note: Should the electronic subsystem measurement inaccuracy be significant, the total system measurement inaccuracy shall still be less than +-2% for wind speed and +-5 degrees for wind direction.

5.4 System Reliability

In assessing system reliability, data losses can result from malfunctions of sensors, processors, and data recorders. As a result, the data collection program shall incorporate the quality assurance procedures specified in Section 7 of this document.

Missing data records shall be clearly marked. Data processing procedures shall be established that ensure that missing data are not factored into statistical averages.

Note: In some cases, missing data gaps need to be filled so that a complete data set is available. Procedures for filling missing data are beyond the scope of this document.

6.0 Installation of Measurement Systems

6.1 Wind Energy Site Characteristics

Before selecting a site for wind energy measurements, and ultimately for wind energy use, consideration shall be given to local topography and obstructions, and preferred locations that may experience wind enhancement. References are given in the Applicable Documents section that provide detailed guidance on the siting of wind turbines incorporating these considerations.

6.2 Representativeness of Measurement System Locations

Measurements shall be taken as close to the intended turbine location as possible and at the anticipated hub height (or, for a vertical-axis machine, the equator height) of the rotor. At a minimum, the anemometer shall be at a height of at least 33 feet (10 meters).

To ensure representativeness of the planned wind turbine site, anemometers installed for site evaluation purposes shall be in exposures similar to the turbines. For example, if turbines are to be sited along a ridge crest, the anemometer shall be installed on the same crest. Use of isolated hills for anemometers, when the turbines are subsequently installed in lower terrain, often leads to unrepresentative measurements. Measurements shall be taken in an open area, free of heavy vegetation and structures. If sensors must be located near an obstruction, the location shall be a horizontal distance at least ten times the height of the obstruction.

Rooftop locations shall not be used for wind measurement systems unless the generator will also be on top of the roof at nearly the same height as the anemometer.

For large machine installations, or for multiple installations, or for complex terrain areas, more than one measurement location and/or level may be necessary. Due to the change of wind speed with height that normally occurs in the atmosphere, and the fluctuation of the magnitude of this change with time, anemometer heights must be at the turbine hub or equator height to avoid the introduction of uncertainties in the representativeness of the measurements due to this phenomenon. Multiple levels of measurements are beneficial when the exact hub height of the turbine is not known, or if the turbine height must be optimized.

6.3 Installation and Calibration of Wind Measuring Systems

6.3.1 Inspecting the Equipment

Before they are installed, measurement systems shall be given a functional check and calibration.

Signal conditioning and recording/display equipment shall be checked by putting simulated signals corresponding to sensor outputs for known wind speeds or directions into the signal conditioning equipment and comparing the recording/display equipment's outputs to the known speeds or directions. The check shall be performed for signals representing zero, as well as three or four additional wind speeds (e. g., 10, 20, and 30 mph), and four wind directions (0, 90, 180, and 270 degrees).

Note: When appropriate, torque watch values can be used to measure the starting speed of a sensor for comparison with manufacturers' specifications, if available. A torque watch is a device that is used to measure the amount of drag of the rotating shaft of the anemometer.

The chart speed of strip chart recorders shall be verified to be within manufacturer's specifications by running the recorder a minimum of one hour, and then measuring the amount of chart travel.

6.3.2 Installation

To avoid the effect of towers and cross-arms on sensors, the sensors shall be mounted on a mast above their support. Wind sensors shall be placed at a distance at least three structure diameters from lattice-type towers and at least six structure diameters from solid towers. Sensors shall be oriented into the prevailing wind direction.

The supporting structure shall be designed to withstand the wind loading expected for the site (structural standards for this loading are available from tower manufacturers). The structure shall be free of vibration and motion induced by the wind. The structure shall include lightning protection equipment to protect the sensors and data logging equipment. The structure shall be adequately secured against vandalism, unauthorized tower climbing, and other hazards. All necessary warning signs and ownership tags shall be clearly visible. If the supporting structure is 60 meters (200 feet) or higher, or is near an airport, proper FAA permits shall be obtained, and the tower shall be lighted according to regulations.

The anemometer and wind vane shall be aligned to assure that the appropriate axes are vertical (cup anemometers) and/or horizontal (propeller anemometers and wind vanes).

The wind vane shall be aligned by one of the following methods: 1) Drive a surveyor-type stake into the ground about 60 meters (200 feet) from the sensor toward true north and visibly align the "north" mark on the sensor to the stake; 2) Identify an existing landmark at the true north or other known direction position from the sensor and align according to 1); or 3) Use a compass to align the "north" mark to magnetic north then adjust the sensor's alignment for magnetic deviation. Before installation, sensor north shall be aligned with the supporting cross arm, since the cross arm is easier to line up with the reference point.

6.4 Operating the Equipment for Site Evaluation

A sampling strategy for site evaluation for a wind turbine or wind turbine array shall be designed to incorporate information on the turbulence characteristics of the site, fluctuations in winds that affect turbine operating strategies, the diurnal and seasonal variability, and the interannual variability of the winds. Examples of data analysis and reporting procedures may be found in Appendix A.

7.0 Standard Operating Procedures

The successful completion of a field monitoring program depends on the adherence to a set of Standard Operating Procedures. These procedures define all necessary steps to perform system calibrations, document site visits, identify and correct system problems, and provide for proper record keeping of all the steps involved from collecting data to summarizing the results with the assurance that the results are accurate and traceable to known standards. The Standard Operating Procedures shall include, at a minimum, procedures for the following activities.

7.1 Site Visits

At a minimum, the following steps shall be taken during each routine site visit:

- Record the date and time.
- Visually inspect the sensors, and document (and correct, if possible) any irregularities.
- Visually inspect the sensor support, including guy wire tensions, trueness of the support in the vertical, and condition of grounding system. Correct as needed.
- Check the power source or batteries. Replace batteries on a scheduled or as needed basis and document changes.
- Check the recorder or data logger operation according to manufacturer's specifications.
- Where appropriate, check "0" and "full scale" spans on signal conditioning equipment, and adjust where necessary. Document "as arrived" and "as left" conditions.
- Annotate the recording medium to identify the in formation recorded, the date and time that data recording started, and the time that it was completed.
- Document any actions taken during emergency or routine visits. The person performing the site visit shall be identified in the log each time.

7.2 Record Keeping Procedures

A record shall be kept for descriptions of the status of the instrument system. This record shall include the manufacturer and model number, and serial numbers of all pieces of equipment. References to the equipment shall always include the serial number.

7.2.1 Site Inspections

Each site inspection shall be documented in the record. This documentation shall include the pertinent features of the inspection procedures listed in Section 7.1. Where corrective action was required, this shall be noted in the record, and the date of the action shall be documented if different from the date of the inspection.

7.2.2 Instrument Inspection

The record shall contain a complete history of the instruments used in a measurement program from the time the instruments are received until the program is completed. Initial entries shall describe the instruments, the pre- installation inspection and calibration, the measurement site, the installation, and any recalibrations. Sufficient information shall be contained so that the measurement program could be reconstructed at a later date.

All records shall be initialed by the person making the entry. The initials shall be correlated to individuals.

7.3 Sensor Calibrations

Sensor calibrations shall be done with equipment traceable to National Bureau of Standards. Calibration reports shall be factored into any post-processing of data.

7.3.1 Field Calibrations

Instruments and recorders that can be field calibrated shall be calibrated to manufacturers' specifications at least twice a year. This calibration shall consist of an electronics check of the signal conditioning and recording equipment.

Note: Adequate steps shall be taken to assure that the bearings and DC generators have not deteriorated to the point of affecting the sensor calibration. Consequently, the Standard Operating Procedures shall include provisions for checking and replacing the sensors at appropriate intervals..

7.3.2 Laboratory Calibrations

Sensors shall be removed and tested in the laboratory on a regularly scheduled interval. Sensors shall be refurbished with new bearings and/or other parts as needed. Sensors shall be recalibrated by appropriate measures to ensure that the equipment is operating within the manufacturer's specifications.

Appendix A

EXAMPLES OF DATA ANALYSIS AND REPORTING PROCEDURES

A.1 Data Analysis

A wide range of sampling strategies and data processing procedures is available depending on the kind of recording equipment used in the collection program. Data logger sampling frequencies and averaging times are partially determined by the wind turbine application and utility purchase rate structure. As a result, advance planning should be done to determine the most appropriate and useful strategy.

For Class III systems, data should be sampled approximately once every one to three seconds, averaged over a period not to exceed one hour, and then stored in bins to obtain a variety of information. Also included in this sampling strategy should be a calculation of turbulence over the averaging period, as defined in AWEA's Terminology Standard. A Class III system should record the following information:

- The mean wind speed and direction.
- Turbulence data.

Software may be required to produce the type of information listed for Class III systems. For most Class III systems currently available, this type of sampling strategy should allow for approximately one month of data collection before the recording medium needs to be refreshed or replaced from the system. From this basic sampling and recording strategy, summarized output of Class III systems should be as follows:

- Mean wind speed for each recording period not to exceed one hour.
- A wind speed frequency histogram in 1 m/s (2 mph) speed intervals.
- A joint distribution of wind speed and direction in 2 m/s (5 mph) speed intervals and 22.5-degree direction intervals.
- A joint distribution of wind speed versus time of day in 2 m/s (5 mph) speed intervals and time intervals not to exceed 3 hours.
- A joint distribution of wind direction versus time of day in 22.5-degree intervals and 3-hour time intervals.
- Information about turbulence.
- Maximum peak gust and sustained (based on averaging interval) wind speeds.

A.2 Data Reporting Formats

Table A-1 summarizes information that should be reported on a routine (preferably monthly) basis for the various classes of data measurement systems.

TABLE A-1

ROUTINE (PREFERABLY MONTHLY) REPORTING RECOMMENDATIONS FOR VARIOUS CLASSES OF INSTRUMENTATION SYSTEMS

	Class I	Class II	Class III
Monthly/annual mean wind speed		X	X
Wind speed frequency distribution and cumulative frequency distribution			X
Wind direction frequency distribution			X
Mean speed/direction by time of day			X (not more than 1/4 day increments)
Vertical shear of speed by direction and time of day*			X
Turbulence			X
Maximum gusts		X	X

* Requires at least two levels of instrumentation on tower

Appendix B

EXAMPLE PROCEDURES FOR ENHANCING DATA REPRESENTATIVENESS AT A SITE

B.1 Extrapolating On-Site Data to Long-Term Statistics

It is obviously impractical to sample at a proposed wind turbine site long enough to obtain information on interannual variability, and perhaps even seasonal variability. Wind measurement strategies, based on the known statistical characteristics of high-wind sites, have been developed, and are recommended here to obtain information on the likely long-term variability of a site.

For a single season or year of measurements at the wind turbine site, the long-term wind speed for the corresponding season, or the long-term annual wind speed for a single year of measurements, will be within +-10% of the single season or year observation with about 90% confidence (References 1, 2, and 3).

When a nearby long-term reference station is available, and the diurnal and seasonal wind patterns at the reference station and measurement station are similar, the short-term site data can be adjusted to the climatological station using the following relationship:

If a number of different sites in a wind turbine array are to be monitored, an intermittent measurement strategy can be used at each site to maximize instrument usage (Reference 3).. Based on results quoted in (3) it is recommended that at least two to three months of intermittent measurements be made at each location for a period of at least three years. This will provide a data set that will give at least the same, if not higher, confidence of the long-term estimate at all sites than one year of continuous measurements at each site.

B.2 Special Measurements for Site Evaluation

B.2.1 Turbulence Measurements

For site evaluation for large wind turbines or wind turbine arrays, special turbulence measurements may be desirable to determine more precisely the types of loads wind machines might experience at the site. It is recommended that a special measurement program using high quality, sensitive wind sensors and sophisticated data loggers be undertaken for short periods of time. Detailed descriptions of these programs is beyond the scope of this document.

B.2.2 Kite Anemometer Measurements

Kite anemometers can be used in the site evaluation process to obtain information on the spatial representativeness of the measurement station(s) installed at the site. For these studies, it is recommended that kite anemometer studies be made at different times on each of 2 to 3 days per month, three to four times per year. The studies should involve at least two kites, which are first flown together to obtain a relative comparison on the readout of each. Then one kite is flown continuously, close to the measurement station and at the same height as the anemometer of the measurement station, while the other is flown at the same height at several pre-determined locations around the site. These locations should be representative of the locations where wind turbines would be installed. At each location, at least three 10-minute measurement periods are recommended, with a 3- to 5-minute break between each period. During each measurement period, readings approximately every 15 seconds should be taken. At the conclusion of the measurements, all values within each 10-minute measurement period should be averaged and compared with the "control" kite anemometer.

A kite anemometer can also be used to estimate the vertical variation of the wind speed at the measurement station, and at any location within the site. These measurements should also be done for several hours on 2 to 3 days per month, 3 to 4 months per year, using the same sampling strategy as before. A "control" kite at the measurement station is recommended for this practice as well.

References for Appendix B

1. Corotis, R. B., et al., 1977: "Variance Analysis of Wind Characteristics for Energy Conversion." Journal of Applied Meteorology 16:1149-1157.

2. Justus, C. G., et. al., 1979: "Interannual and Month-to-Month Variations of Wind Speed." Journal of Applied Meteorology 18:913-920.

3. Ramsdell, J. V., et. al., 1980. Measurement Strategies for Estimating Long-Term Average Wind Speeds. PNL-3448, Pacific Northwest Laboratory, Richland, Washington.