360
2-19-80

DR-788

DOE/SEA-1109-20401/79/2

WIND ENERGY APPLICATIONS IN AGRICULTURE

Final Report

Executive Summary

By

Milton L. David

Robert J. Buzenberg

Earl F. Glynn

Gary L. Johnson

J. Kenneth Shultis

John P. Wagner

August 1979

Work Performed Under Contract No. EX-76-A-29-1026

MASTER

Development Planning and Research Associates, Inc.
Manhattan, Kansas

U.S. Department of Energy

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

Solar Energy

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Department of Energy, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

This report has been reproduced directly from the best available copy.

Available from the National Technical Information Service, U. S. Department of Commerce, Springfield, Virginia 22161.

Price: Paper Copy \$9.25
Microfiche \$3.00

DISCLAIMER

This book was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

WIND ENERGY APPLICATIONS IN AGRICULTURE

Final Report
Executive Summary

Milton L. David
Robert J. Buzenberg
Earl F. Glynn

Gary L. Johnson
J. Kenneth Shultis
John P. Wagner

DEVELOPMENT PLANNING AND RESEARCH ASSOCIATES, INC.
Post Office Box 727, Manhattan, Kansas 66502

August 1979

Prepared For
Science and Education Administration
US Department of Agriculture
Beltsville, Maryland 20705

Contract No. 12-14-1001-839

As a Part of The
US DEPARTMENT OF ENERGY
DIVISION OF DISTRIBUTED SOLAR TECHNOLOGY
WIND SYSTEMS BRANCH

Interagency Agreement EX-76-A-29-1026

WIND ENERGY APPLICATIONS IN AGRICULTURE

ABSTRACT

This report presents an assessment of the potential use of wind turbine generator systems (WTGS) in U.S. agriculture. In particular, this report presents the number of WTGS's economically feasible for use in U.S. agriculture and the conditions which yielded economic feasibility of WTGS's for certain agricultural applications.

In addition, for each case, i.e., set of assumed conditions, under which WTGS's were found to be economically feasible, this report identifies (1) the agricultural WTGS applications in terms of location, type and size (complete farm and dedicated-use applications); (2) the number of WTGS's by wind machine and generator size category; (3) aggregate energy conversion potential; and (4) other technical and economic WTGS performance data for particular applications.

This report also describes the methodology, data and assumptions used for the analysis. A major part of the study was the development and use of a rigorous analytical system to assess an application's wind power generation and use potential. The basis of this analytical system is the study's unique Wind Turbine General System Performance Model, a computer code, which was used to simulate each potential wind application. This model simulates the technical and economic performance of various WTGS sizes and determines the WTGS size parameters which are optimum for each case and application.

The WTGS Performance Model uses four basic types of data for each application: (1) application energy use data (half-hourly, daily, and seasonal), (2) wind speed frequency distributions (diurnal, seasonal and location specific), (3) energy cost data (conventional sources), and (4) WTGS model data (capital cost functions, power response functions, engineering and economic coefficients, etc.). Given these data, the WTGS model determines the optimum wind turbine system (rated power and rated speed) based on the greatest expected net annual dollar savings.

After the applications are evaluated, the number of economically feasible applications are identified and enumerated, wind system size characteristics are summarized, and various technical and economic performance data are tabulated and analyzed.

Key words: wind power, wind systems, agriculture, market potential, economics, model.

CONTENTS

	<u>Page</u>
EXECUTIVE SUMMARY	ix
ACKNOWLEDGEMENTS	xxii
 <u>Chapter</u>	
I. INTRODUCTION	I-1
A. Background	I-1
B. Purpose	I-2
C. Scope	I-2
D. Organization of the Report	I-2
II. METHODOLOGY	II-1
A. Overview	II-1
B. Wind Turbine Generator System (WTGS) Performance Model	II-3
1. Description of the Model	II-3
2. Response Function for the Wind Generator System	II-4
3. Matching of Load to Available Wind Power	II-9
III. DATA AND ASSUMPTIONS	III-1
A. Number and Type of Potential WTGS Application on U.S. Farms	III-2
1. Complete Farm Applications	III-2
2. Dedicated use (Irrigation) Application	III-6
B. Energy use Profiles	III-6
1. Farmhouse Appliance Load	III-8
2. Farmhouse Heating and Cooling Load	III-8
3. Farm Operations Loads	III-10
C. Wind Data	III-11
D. Conventional Energy Cost Data	III-13
E. WTGS Costs and Response Characteristics	III-15
IV. PRELIMINARY SCREENING AND ANALYSIS	IV-1
A. Preliminary Screening	IV-1
B. Preliminary Analysis	IV-4
1. Load Demands	IV-4
2. Optimum WTGS Size	IV-8
3. Optimum WTGS Performance Model	IV-9
C. Ranking a Selected Farm Enterprises	IV-13

CONTENTS (Continued)

	<u>Page</u>
V. MARKET POTENTIAL ASSESSMENT	V-1
A. Scenarios Studies	V-1
B. General Results	V-1
1. Scenario 5: Low WTGS Capital Costs, Price of Alternative Energy Equivalent to 6¢/kWh	V-2
2. Scenario 6: Low WTGS Capital Costs, Price of Alternative Energy Equivalent to 8¢/kWh	V-10
C. Sensitivity of Results to Differing Heating and Cooling Load	V-14
1. WTGS Size	V-14
2. Number and Location of Feasible "Residence Only" WTGS Applications	V-18
D. Sensitivity of Results to Differing Duration of Irrigation Loads	V-18
E. Conclusion	V-20
1. The Wind	V-20
2. The Load	V-21
3. Alternative Fuel Costs	V-21
4. WTGS Costs	V-22
 BIBLIOGRAPHY	 VI-1
 APPENDICES	
Technical Appendix A: Seasonal and Diurnal Wind Velocity Frequency Statistics	A-1
Technical Appendix B: Energy Load Profiles	B-1
Technical Appendix C: Technical and Economic WTGS Performance Data	C-1
Technical Appendix D: Sample Optimum WTGS Diurnal and Seasonal Performance Data	D-1

LIST OF TABLES

<u>Table No.</u>	<u>Title</u>	<u>Page</u>
1	Estimated number, capital cost, energy generated and used and annual net savings of economically feasible WTGS's in U.S. agriculture	iii
2	Summary for electricity cost of 6¢/kWh and low cost WTGS model by state	v
3	Number in thousands of feasible wind turbine systems by generator rating and rated speed based on displacement of 6¢/kWh electricity and lowest cost WTGS estimate	vii
4	Summary for electricity cost of 8¢/kWh and low cost WTGS model by states	viii
5	Number in thousands, of feasible wind turbine systems by generator rating and rated speed: (based on displacements of 8¢/kWh electricity and low cost WTGS estimates)	x
II-1	Usual control keywords	II-8
II-2	WTGS capital cost (\$000)	II-20
III-1	Potential WTGS applications by type and total number of farms per state, 1974	III-3
III-2	Number of potential complete farm applications by type-size category and state	III-5
III-3	Number of irrigation units by type and total number of dedicated use (irrigation) application by state	III-7
IV-1	Description of preliminary farm enterprises with potential wind energy applications, ranked as to available wind power	IV-2
IV-2	Summary analysis of optimized wind energy applications in agriculture assuming 4¢ per kWh purchased electricity price - 1977	IV-5
IV-3	Summary analysis of optimized wind energy applications in agriculture assuming 6¢ per kWh purchased electricity price - 1977	IV-6
IV-4	Summary analysis of optimized wind energy applications in agriculture assuming 8¢ per kWh purchased electricity price - 1977	IV-7
IV-5	Summary of wind energy in agriculture assuming 4¢ per kWh purchased electricity price	IV-10
IV-6	Summary of wind energy in agriculture assuming 6¢ per kWh purchased electricity price	IV-11
IV-7	Summary of wind energy in agriculture assuming 8¢ per kWh purchased electricity price	IV-12
IV-8	Wind energy applications in agriculture ranked by breakeven electrical costs of specific farm enterprises.	IV-14

LIST OF TABLES (Continued)

<u>Table No.</u>	<u>Title</u>	<u>Page</u>
V-1	Estimated number, capital cost, and energy generated and used and annual net savings of economically viable WTGS's in U.S. agriculture	V-3
V-2	Summary for electricity cost of 6¢/kWh and low WTGS cost by states	V-5
V-3	Aggregate energy (billion kWh) generated and used by farm application category in the wind states (electricity cost is 6¢/kWh and low WTGS cost)	V-6
V-4	Aggregate annual net savings (\$ million) by farm application category in the wind states (electricity cost is 6¢/kWh and low WTGS cost)	V-7
V-5	Number in thousand of optimum wind turbine systems by generator rating and rated speed (Scenario 5 conditions: low WTGS cost, electricity cost 6¢/kWh)	V-8
V-6	Rated power (kW) and speed (m/s) of optimal discretized WTGS by farm application category in the wind states (electricity cost is 6¢/kWh low WTGS cost)	V-9
V-7	Summary for electricity cost of 8¢/kWh and low WTGS cost by states	V-11
V-8	Aggregate energy (billion kWh) generated and used by farm application category in the wind states (electricity cost is 8¢/kWh and low WTGS cost)	V-12
V-9	Aggregate annual net savings (\$ million) by farm application category in the wind states (electricity cost is 8¢/kWh and low cost)	V-13
V-10	Number in thousands of wind turbine systems by generator rating and rated speed: (electricity cost is 8¢/kWh and low WTGS cost)	V-14
V-11	Rated power (kW) and speed (m/s) of optimal discretized WTGS by farm application category in the wind states (electricity cost is 8¢/kWh and low WTGS cost)	V-16
V-12	Optimum "residence only" WTGS size at 100 and 150 percent heating and cooling load and 6, and 8 cents per kWh by state, low WTGS costs	V-17
V-13	Optimum WTGS size and minimum number of irrigation days required for economic feasibility of selected irrigation system types and locations (4, 6 and 8 cents per kWh low WTGS capital cost)	V-19

LIST OF FIGURES

<u>Figure No.</u>		<u>Page</u>
1	Geographical distribution of economic wind generators if 6¢/kWh energy is displaced	vi
2	Size distribution of economic farm wind generators, if 6¢/kWh energy is displaced	vi
3	Geographical distribution of economic farm wind generators, if 8¢/kWh energy is displaced	ix
4	Size distribution of economic farm wind generators, if 8¢/kWh energy is displaced	ix
5	Methodology to evaluate the market potential for WTGS to U.S. agriculture	xii
II-1	Methodological components and flows to evaluate the market potential for WTGS to U.S. agriculture	II-2
II-2	The variation of the WTGS output for different wind speeds	II-4
II-3	Flowchart for the program Blowhard II	II-5
II-4	Flowchart for the economic analysis program ECAN	II-7
II-5	Sample of load profile and results from the WTGS Performance Model	II-10
II-6	Illustration of the cost used for the WTGS	II-18
III-1	Breakdown of diurnal power demand for a representative farm (60-cow dairy in New York in spring)	III-9
III-2	Wind regions, states and stations	III-12
III-3	Comparison of paraneutic costs used in this study, prices paid by farmers (1976) FPC predictions of 1980 costs of production from existing facilities	III-14
IV-1	Locations of representative farm enterprises, wind energy applications in agriculture (preliminary screening)	IV-3

**THIS PAGE
WAS INTENTIONALLY
LEFT BLANK**

EXECUTIVE SUMMARY

WIND ENERGY APPLICATIONS IN AGRICULTURE

A. Background

The economics and the market potentials for wind turbine generator systems (WTGS) applications in United States agriculture are analyzed in this report. The analysis was done by simulating the performance, by half-hour increments for an entire year, of 32 different sizes of wind turbine generators on 17 types and sizes of farms in each of 23 different states (those having annual average wind power of 100 W/m² or more at 10-meter height). The value of wind energy generated and used was calculated assuming it was displacing the equivalent use of electric energy costing 4¢, 6¢, and 8¢/kWh. This value was compared to the cost of ownership of the same 32 different wind turbines, for two different expected levels of cost for wind turbine generators (representing the lowest and highest probable costs). Assuming farmers are most likely to buy the wind turbine generator which produces the greatest net return, these estimates for each representative application were then aggregated to produce estimates of the expected national market for WTGS's in U.S. agriculture and the breakdown of this market by size of WTGS and by state. The number of farms represented by each application analyzed was estimated using U.S. Census of Agriculture data.

No value was assumed for wind energy occasionally generated in excess of the farm needs. No device or system was assumed for mechanical or electrical energy storage or for load management (switching off some deferrable loads until the WTGS was developing enough power to supply most of the load). Also, only those farm loads that were electrical or those that could readily be converted to electrical power, for example space heating, crop drying and water heating were supplied by the WTGS. Energy for mobile equipment--tractors, combines, trucks were not included. Further, no anemometer height correction was made on the wind speed data.

B. Conclusions

A general summary of study results is shown in Table 1. Wind turbine generator systems were found to be economically feasible in agriculture only when capital costs for such systems were equal to the lowest expected levels. Even then, they were economically feasible only when displacing 6¢ and 8¢/kWh electric energy. Displacement of 4¢/kWh energy with a wind turbine generator was not economical for the representative agricultural applications analyzed in this study.

Table 1. Estimated number, capital cost, energy generated and used and annual net savings of economically feasible WTGS's in U.S. agriculture.

Case	Case	Description	Number of feasible WTGS application in U.S. agriculture (number)	Capital cost (million)	Energy generated and used		Annual net savings (million)
	WTGS capital cost	Alternate energy cost			Amount (billion kWh)	Value (million)	
1	high	\$.04/kWh	none	none	none	none	none
2	high	\$.06/kWh	none	none	none	none	none
3	high	\$.08/kWh	none	none	none	none	none
4	low	\$.04/kWh	none	none	none	none	none
5	low	\$.06/kWh	445,500	\$ 3,600	9.4	\$ 564.0	\$ 68.7
6	low	\$.08/kWh	991,700	\$10,000	21.1	\$1,688.0	\$335.2

When the energy to be displaced was priced at 6¢/kWh, 445,500 economically feasible applications for low-cost WTGS's were identified. Thus the cost of electric utility power against which low-cost WTGS will breakeven displacing that power lies between 4¢ and 6¢/kWh for approximately 445,500 applications. The total cost of the 445,500 WTGS's to the purchasers was estimated at \$3.6 billion, for an average cost of \$8,140 each. The annual total quantity of utilized wind energy generated by these WTGS's would be expected to be 9.4 billion kWh at \$564 million (6¢/kWh). Aggregate net annual savings to users was estimated to be \$68.7 million.

The greatest number of feasible applications were located in Iowa (137,300 applications), Kansas (77,700), Nebraska (61,600), Missouri (45,700), South Dakota (42,700), and North Dakota (41,200) as shown in Table 2 and Figure 1.

The size characteristics of the 445,500 WTGS's found to be economically feasible when low WTGS capital costs and 6¢/kWh alternative fuel costs were assumed are shown in Figure 2 and Table 3. Here the 10-kW generator with a rated speed of 9 or 10 m/s (swept area equal to 85 to 62 m²) accounts for 63 percent of the total. The medium size systems predominate, with just 12 percent of the total number of systems rated at 35 kW or larger. Wind systems of 1, 5, and 100 kW were not found to be optimum size for any type of farm. It must be borne in mind that Table 3 represents the sizes of WTGS which yield the maximum economic return. Somewhat smaller or larger WTGS units may still be economically feasible, but in the interest of brevity and simplicity of the report, the distribution of "second-best" sizes was not computed.

If the price of the energy displaced is 8¢/kWh, 991,700 low-cost WTGS's, located in 21 states, were found to be economically feasible. The total capital cost of the 991,700 WTGS's to purchasers was \$10 billion, for an average cost of \$10,084 each. The annual total amount of utilized wind energy generated by these WTGS's was 21.1 billion kWh, valued at \$1.7 billion (8¢/kWh). Aggregate net annual earnings to users was estimated to be \$335.2 million. These results are shown above in Table 1.

When 8¢/kWh electricity is displaced the greatest number of feasible applications were located in Texas (187,700), Missouri (138,800), Iowa (137,300), Oklahoma (82,800), Kansas (77,700) and Nebraska (61,600) as shown in Table 4 and Figure 3.

The size characteristics of the 991,700 WTGS's found to be economically feasible when low capital costs and high alternative energy costs were assumed is shown in Figure 4 and Table 5. The 10-kW generator with a rated speed of 9 to 8 m/s still accounts for nearly two-thirds of the total. The medium size systems clearly predominate, with less than 5 percent of the systems having a rated power of 35 kW or greater. Wind systems of 1 and 5 kW were never the optimum size for any farm.

Table 2. Summary for electricity cost of \$.06/kWh and low cost WTGS model by states.

State	Number of potential applications (000)	Number of feasible WTGS's (000)	Potential electrical load (billion kWh)	Aggregate wind energy generated and used (billion kWh)	Aggregate annual net savings (\$ million)
Colorado	34.5	26.5	2.67	0.53	3.58
Idaho	35.7		3.72		
Illinois	125.9		9.49		
Indiana	106.1	2.8	6.85	0.08	0.35
Iowa	137.9	137.3	9.62	2.97	17.87
Kansas	94.2	77.7	6.34	1.14	5.71
Maine	7.6	1.0	.51	0.03	0.06
Maryland	17.8		1.05		
Michigan	80.0	1.4	5.19	0.05	0.29
Minnesota	118.1		7.74		
Missouri	139.0	45.7	7.76	0.91	4.97
Montana	24.7		1.69		
Nebraska	75.5	61.6	5.62	1.31	14.62
New Jersey	8.0	1.0	.52	0.03	0.04
New York	57.5		3.32		
North Dakota	41.6	41.2	3.81	1.15	10.05
Ohio	116.9		7.28		
Oklahoma	89.0		4.90		
Pennsylvania	71.0	3.4	4.36	0.10	0.20
South Dakota	43.4	42.7	3.10	0.97	9.11
Texas	234.8	3.2	16.58	0.16	1.92
Wisconsin	106.1		6.56		
Wyoming	9.9		.74		
TOTAL	1,775.1	445.5	119.42	9.40	68.7

Total cost of the 445,500 WTGS's to purchasers is estimated at \$3.6 billion for an average cost of \$8,140 each.

Figure 1. Geographical distribution of economic wind generators, if 6¢/kWh energy is displaced. Number for each state, in thousands.

Figure 2. Size distribution of economic farm wind generators, if 6¢/kWh energy is displaced.

Table 3. Number in thousands of feasible wind turbine systems by generator rating and rated speed (based on displacement of 6¢/kWh electricity and lowest cost WTGS estimate).

Generator rating (kW)	←-----Rated speed (m/s)----->				Total
	<u>7</u>	<u>8</u>	<u>9</u>	<u>10</u>	
1					
5					
10			154.5	126.3	280.8
15	1.4	16.1	90.6	3.4	111.5
25		3.2		35.6	38.8
35				3.0	3.0
50				11.4	11.4
100					
TOTAL	<u>1.4</u>	<u>19.3</u>	<u>245.1</u>	<u>179.7</u>	<u>445.5</u>

Source: DPRA estimates

Table 4. Summary for electricity cost of 8¢/kWh and low cost WTGS model by states.

State	Number of potential applications (000)	Number of feasible WTGS's (000)	Potential electrical load (billion kWh)	Aggregate wind energy generated and used (billion kWh)	Aggregate annual net savings (\$ million)
Colorado	34.5	26.5	2.67	0.62	15.71
Idaho	35.7		3.72		
Illinois	125.9	58.2	9.49	1.18	2.60
Indiana	106.1	37.3	6.85	0.75	3.83
Iowa	137.9	137.3	9.62	3.99	90.91
Kansas	94.2	77.7	6.34	1.52	32.68
Maine	7.6	1.0	.51	0.05	0.88
Maryland	17.8	1.5	1.05	0.05	0.84
Michigan	80.0	17.8	5.19	0.40	2.73
Minnesota	118.1	12.8	7.74	0.29	0.12
Missouri	139.0	138.8	7.76	2.92	53.04
Montana	24.7	12.6	1.69	0.29	2.63
Nebraska	75.5	61.6	5.62	1.64	44.22
New Jersey	8.0	2.4	.52	0.08	0.97
New York	57.5		3.32		
North Dakota	41.6	41.2	4.81	1.44	36.63
Ohio	116.9	41.8	7.28	0.73	1.42
Oklahoma	89.0	82.8	4.90	1.07	1.87
Pennsylvania	71.0	4.2	4.36	0.18	3.01
South Dakota	43.4	42.7	3.10	1.26	31.46
Texas	234.8	187.7	16.58	2.55	9.04
Wisconsin	106.1	3.6	6.56	0.06	0.01
Wyoming	9.9	2.2	.74	0.07	0.62
TOTAL	1,775.1	991.7	119.42	21.1	335.2

Total cost of the 991,700 WTGS's to purchasers is estimated at \$10.0 billion for an average cost of \$10,084 each.

Figure 3 . Geographical distribution of economic farm wind generators, if 8¢/kWh energy is displaced. Number for each state, in thousands.

Figure 4 . Size distribution of economic farm wind generators, if 8¢/kWh energy is displaced.

Table 5. Number in thousands, of feasible wind turbine systems
by generator rating and rated speed: (based on dis-
placements of 8¢/kWh electricity and low cost
WTGS estimates.

Generator rating (kW)	<-----Rated speed (m/s) ----->				Total
	<u>7</u>	<u>8</u>	<u>9</u>	<u>10</u>	
5					
10	1.4	275.6	363.4		640.4
15	15.1	151.6	19.0		185.7
25	10.0		106.4		116.4
35			35.5		35.5
50		0.8	11.9		12.7
100				1.0	1.0
TOTAL	26.5	428.0	536.2	1.0	991.7

Table 2 and Table 4 also reveal that use of the optimum size of wind turbine generator produced only a small proportion of the electric energy needs of the farm simulated, about 8 percent and 18 percent when displacing 6¢ and 8¢/kWh energy, respectively. This is a serious limitation on the economics of the WTGS. This result is largely due to the fact that (a) the power demand of the farm, as a function of time, is poorly correlated with the availability of power from the wind, and (b) the study assumes that no attempt was made to "manage" the power demand on the farm to improve this correlation and no value was received for energy generated by the wind turbine in excess of instantaneous use on the farm. Introduction of some load management to improve this correlation, and obtaining some credit for excess power generated might substantially change the economic value of the WTGS on a farm. Analysis of the economics of wind energy applications under such circumstances would be a valuable sequel to this study.

Although alternative energy cost equivalent to 6¢/kWh is naturally expected before 8¢/kWh, both of these costs are higher than current (1977) average costs paid by farmers in the United States. However, a small proportion of farmers do pay more than 6¢/kWh. These farmers are located predominantly in the Northeast. This does not coincide with the geographical location of the most feasible WTGS's predicted by this analysis. Although energy costs are expected to rise in the future, the price of the lowest cost WTGS's may also rise. Thus, WTGS's will not become feasible extensively in agriculture unless the cost of energy rises substantially more than the expected cost of WTGS's. Estimating the likelihood of this happening is beyond the scope of this study.

Sensitivity analyses were also performed in which assumptions concerning application of certain major loads were varied. The sensitivity results show that an increase in load magnitude, load duration or combination of loads improves the economic feasibility of WTGS's.

C. Methodology

The methodology used in this study to assess the market potential for wind turbine generator systems (WTGS) in U.S. agriculture is described schematically in Figure 5. This methodology evolved from preliminary computer models and analyses of selected agricultural applications.

The main component of the analytical system is the Wind Turbine Generator System (WTGS) Performance Model. This computer model calculates the "optimum" WTGS rated power and rated speed needed for users to realize the greatest financial saving from substituting wind energy for traditional energy sources. The "optimum" WTGS for a given application depends on several factors:

Figure 5. Methodology to evaluate the market potential for WTGS to U.S. agriculture

- diurnal and seasonal electrical energy requirements of the application, i.e. the application load profile over time,
- diurnal and seasonal wind resources, i.e. wind speed distributions,
- the cost of alternate (traditional) energy sources, and
- the cost and response characteristics of the WTGS.

Using data and assumptions about these factors as input, the WTGS performance model also computes expected technical and economic performance for various WTGS sizes and identifies the optimum size WTGS for each application evaluated.

In this study the market potential for WTGS's in U.S. agriculture was assessed by first collecting the needed input data, then applying the WTGS Performance Model to each representative application and finally aggregating the results to produce estimates of the expected national agricultural market for WTGS's and the breakdown of this market by size of WTGS and by state.

The number of farms represented by each application analysed was estimated by using U.S. Census of Agriculture data. Wind data were based on studies by Reed (1975) and wind speed distributions for selected stations provided by the National Climatic Center, Asheville, North Carolina. The cost of alternate energy sources was assumed to be 4¢, 6¢ and 8¢/kWh based on retail prices paid by farmers for electricity reported by USDA and expected future costs for electricity. High and low WTGS costs estimates were developed based on information contained in Rosen (1975) and Obermeir (1976). The high and low WTGS costs represent the extreme upper and lower limits of expected costs. Power output of the WTGS was assumed to vary with the cube of wind speed between a cut-in and rated wind speed, equal to zero when wind speed was below the cut-in speed and equal to rated power when wind speed exceeded rated wind speed.

The following key assumptions were made regarding the data used and the operation of the WTGS on each farm:

- (a) Only continental states with an average annual wind power density greater than or equal to 100W/m^2 at 10 meter height, according to Reed (1975), were included in this study.
- (b) No adjustments for wind speed data were made for either recorded anemometer height or WTGS tower height.
- (c) No storage of wind generated electricity.
- (d) No load management such as rescheduling energy use to periods of expected high winds.
- (e) No credit for excess wind energy generated.
- (f) Purchased electricity from utilities would provide back-up to wind generated electricity as needed without penalty for power company revenue losses.

- (g) All stationary energy needs that could readily be electrical were electrical e.g. all water heaters, grain dryers, space heaters, and residences were assumed to be total electric but farm tractors, vehicles and non-stationary items were not assumed electrical.

Naturally these key assumptions influenced the results of this study and alternate assumptions could have been chosen. As indicated previously, analysis of the economics of wind energy under different but logical key assumptions would be a valuable sequel to this study.

Sensitivity analysis with respect to WTGS costs and price of displaced electricity were performed for all representative farm and dedicated use applications considered. Special sensitivity analyses were performed against length of irrigation season and magnitude of residence heating and cooling load for "irrigation" and "farmhouse only" applications, respectively.

ACKNOWLEDGEMENTS

This study of wind energy applications in agriculture was conducted for the Science and Education Administration (formerly the Agricultural Research Service), U.S. Department of Agriculture in cooperation with the Department of Energy (formerly Energy Research and Development Administration) by Development Planning and Research Associates, Inc. (DPRA), Manhattan, Kansas (Contract No. 12-14-1001-839). DPRA especially acknowledges the leadership of Dr. L.A. Liljedahl of SEA, USDA, Beltsville, Maryland who was Project Manager for this study.

Many DPRA staff members and associates participated in this study. In particular, acknowledgement is given to Dr. J. Kenneth Shultis, who was principally responsible for the design and development of the study's unique Wind Turbine General System (WTGS) Performance Model. Major contributions were also made by staff members: Dr. Samuel G. Unger, Milton L. David, John P. Wager and Earl F. Glynn, plus research assistants and secretaries. In addition, DPRA acknowledges the contributions of the following associate staff: Dr. Gary L. Johnson, Dr. N. Dean Eckhoff, Dr. Stanley J. Clark, and Ralph I. Lipper, who each contributed to the formulation and development of the overall study.

Robert J. Buzenberg
Principal Investigator

WIND ENERGY APPLICATIONS IN AGRICULTURE

I. INTRODUCTION

Petroleum and natural gas now supply over 75 percent of the nation's energy. Readily available supplies of these fuels are declining in the United States and other parts of the world. In the future, energy shortages can be expected unless current consumption trends change and supplemental and substitute energy sources are developed and used.

A. Background

With constantly escalating prices for energy and in some cases restricted distribution of conventional fuels, the economics and market potential for wind systems to generate power for certain applications needs to be assessed. Information and data are needed to describe how wind energy systems might be utilized, what generator and wind machine sizes are best suited to certain applications, where wind energy systems are most likely to succeed, the number of wind systems that can be expected to be economically feasible, and the conditions necessary for their feasibility.

Wind power could be used in many ways to meet stationary energy needs on a farm. For example, the wind machine might be used to operate only one, or a few, special loads. Devices might be installed to store energy for use when the wind does not blow. A single control system might also be installed to discontinue one or two major loads unless wind power were available at certain minimum power levels. These systems have not been fully tested and demonstrated, however, and estimation of their economic feasibility would require knowledge of their real operational characteristics, which have not yet been measured. The simplest method of using wind power on farms would be to generate 120/240 v. 60 Hz A.C. power in synchronization with utility power and place it in parallel with the utility sources. In this study, this scheme is the one assumed to be used, with no credit given for excess power that would flow into the utility line and no rate penalty for the exacerbated demand the system would place on the utility.

B. Purpose

The purpose of this study is to estimate the total number of such wind electric energy applications in U.S. agriculture which are technologically and economically feasible and to specify the conditions under which they would be feasible. A second purpose is to describe the results of the analysis performed, including the identification of specific feasible applications, associated WTGS size characteristics, and expected technical and economic performance characteristics.

C. Scope

The scope of this study is limited and considers only applications of wind energy in the U.S. farm sector. This includes approximately 2.8 million commercial and noncommercial farms in the fifty states.

Also a screening criterion was used in which only farms in continental states having an annual average wind power of 100 W/m^2 or more at 10-meter height were considered. After this screening criterion was applied 1.8 million farms in 23 high wind states remained for detailed evaluation.

D. Organization of the Report

This report is organized as follows:

Chapter I, INTRODUCTION, briefly explains the background, purpose, scope and organization of this report.

Chapter II, METHODOLOGY, describes the analytical approach used to organize and analyze the data for the market potential assessment. Fundamental concepts incorporated in the Wind Turbine General System (WTGS) Performance Model are described. Data requirements for the computer model are identified.

Chapter III, DATA AND ASSUMPTIONS, describes the data sets needed for the market potential assessment including:

- wind data
- type and number of potential WTGS applications
- energy use profile
- energy cost data and
- WTGS cost and response characteristics

Chapter IV, PRELIMINARY SCREENING AND ANALYSIS, summarizes initial study results based on preliminary wind data and analysis techniques applied to selected types of locations of typical U.S. farms.

Chapter V, MARKET POTENTIAL ASSESSMENT, presents the findings of this study considering six scenarios including high and low WTGS capital costs and alternate energy prices of 4¢, 6¢ and 8¢/kWh. The number, location and size characteristics of economically feasible WTGS in U.S. agriculture are presented for the aggregate national market. Further these estimates are broken down by state and type of farm. Results of special sensitivity analyses are also shown in Chapter V.

Finally, a BIBLIOGRAPHY and TECHNICAL APPENDICES are included containing references used, wind data, energy use profiles, and expected technical and economic performance results of optimal WTGS's for economically feasible applications.

II. METHODOLOGY

A. Overview

The methodology used in this study to assess the market potential for wind turbine generator systems (WTGS) in U.S. agriculture is described schematically in Figure II-1. This methodology evolved from preliminary computer models and analyses of selected agricultural applications.

The main component of the analytical system is the Wind Turbine Generator System (WTGS) Performance Model. This model computes the "optimum" WTGS rated power and rated speed needed for users to realize the greatest financial savings from substituting wind energy for traditional energy sources. The "optimum" WTGS depends on several factors:

- diurnal and seasonal electrical energy requirements of the application over time, i.e. the application load profile,
- diurnal and seasonal wind speed distributions,
- the cost of alternate energy sources and
- the cost and response characteristics of the WTGS.

Using these factors as input, the model computes expected technical and economic performance data for various WTGS sizes and selects the optimum size WTGS for each application and set of assumed conditions. Then expected technical and economic performance estimates of the optimum WTGS are summarized by the model for each application evaluated.

The market potentials assessment was done by simulating the expected quantity of wind energy generated and used by half-hour increments for an entire year, of 32 different sizes of synchronous wind turbine generators on 17 types and sizes of representative agricultural applications in each of 23 different states (those having annual average wind power of 100 W/m² at 10-meter elevation). The value of wind energy generated and used was calculated assuming it was displacing the use of electric energy costing 4¢, 6¢, and 8¢/kWh. This value was compared to the cost of ownership of the same 32 different wind turbines, for two different expected levels of cost for wind turbine generators (representing the lowest and highest probable costs). Assuming farmers are most likely to buy the wind turbine generator which produces the greatest net return, these estimates for each representative application were then aggregated to produce estimates of the expected national market for WTGS's and the breakdown of this market by size of WTGS, by state and by farm type. The number of farms represented by each application analyzed was estimated using U.S. Census of Agriculture data. It was assumed that no value could be received for energy occasionally generated in excess of the

Figure II-1. Methodological components and flows to evaluate the market potential for WTGS to U.S. agriculture

farm needs, and that no device or system was used for mechanical or electrical energy storage or to manage the power demand by switching off some deferrable loads until the WTGS was developing enough power to supply most of the load. All farm energy needs that could be electrical, were assumed to be electrical, except farm vehicles and other non-stationary items not readily converted to electricity. Further no anemometer height correction was made on the wind speed data.

A mathematical description of the Wind Turbine Generator System Performance Model and its relation to the total analytical system is presented in this chapter.

B. Wind Turbine Generator System (WTGS) Performance Model

1. Description of the Model

The principal purpose of the computational model developed in this study was to determine the optimum sized wind turbine generator system (WTGS) that will result in maximum financial savings for an agricultural application. The annual net savings is calculated from

$$\text{Annual Net Savings} = (E_g)(C_b) + (E_s)(C_s) - AC_{WTGS} - AOM, \quad (1)$$

where

E_g $\equiv$ total electrical energy, in kWh, generated in a year by the WTGS, which is used by the application,

E_s $\equiv$ total surplus electrical energy, in kWh, generated in a year by the WTGS, which is sold to another user, (e.g., utility or neighboring enterprise) or waste ,

C_b $\equiv$ cost of purchasing electrical energy from the utility, in \$/kWh,

C_s $\equiv$ price for which excess WTGS electrical energy can be sold, in \$/kWh, if wasted $C_s = 0$

AC_{WTGS} $\equiv$ effective annual capital cost, in dollars, of the WTGS

AOM $\equiv$ effective annual cost in dollars, for operating and maintenance.

Since the electrical power requirements (load) for any given application usually varies widely throughout the day as well as from season to season, it is necessary to calculate accurately the available power from a WTGS throughout each day of every season to obtain a reliable estimate of E_g and E_s . Hence, the "average" WTGS output values (used in many wind energy evaluations) were not used in this study. The procedure used in this methodology allows for the variation of both the application load and wind speed throughout each day and from season to season. By using the methodology described in this chapter realistic estimates can be obtained for E_g and E_s for any given load conditions, wind conditions, and WTGS characteristics.

To describe fully each agricultural application for the purpose of the model, it is necessary to specify: (1) the electrical power requirements for each specified time interval throughout each day of every season, (2) the wind speed frequency distribution for each time interval at the enterprise's location, and (3) the purchase and selling prices (if any) of electricity. Since no allowance is made for the storage of excess energy from the WTGS (other than the possibility of selling excess power to the utility), the above data are sufficient to permit the calculation of the probable wind power at all times throughout the year and the extent to which a given WTGS can meet the electrical power demands of the application.

By considering all possible combinations of discrete WTGS parameters used in this study (i.e., rated powers and rated speeds), one can determine the optimum-sized WTGS for a given application to achieve the maximum economic savings from the use of wind energy. Such an optimized WTGS is essential if the potential for wind energy at various sites and in different applications are to be compared. A WTGS that is too large for a particular application (and hence too expensive) would make wind energy appear relatively unattractive, whereas one that is too small would not fully utilize the wind system potential. The overall structure of the programs developed in this study to perform the analysis described above is shown in Figure II-3 and II-4. In the following sections of this Chapter, some of the key elements in these programs are described.

2. Response Function for the Wind Generator System

In any computation of the energy available from the wind, it is necessary to use a "response function" which describes how much output power a WTGS can produce for given wind conditions. For the present study the response function of the WTGS, $P(s)$, is taken as the electrical power output of the WTGS in a steady wind of speed s . The function $P(s)$ can vary widely with the type of generator, particularly at high or low speeds.

Figure II-2 shows an idealized response function that is characteristic of many propeller WTGS which change blade pitch to prevent the system from exceeding the rated power of the generator.

Figure II-2. The variation of the WTGS output for different wind speeds.

Figure II-3. Flow chart for the program Blowhard II

1/ See Figure II-4.

..... continued

Figure II-3. (continued)

Figure II-4. Flow chart for the economic analysis program ECAN

Figure II-1. Usual control keywords

<u>Name</u>	<u>Parameters</u>	<u>Purpose</u>
*APPLIANCES	---	Retrieve appliance load from disk file
*FACTORS	1 - 10 factors	Specify factors to apply to enterprise load assignment
*FARM	enterprise index	Retrieve specified enterprise load assignment from disk file
*HEATCOOL	heating/cooling index	Retrieve specified heating/cooling load
*INTEGRALS	---	Evaluate integrals for all specified amplitude factors, rated speeds and power ratings
*OPTIONS	various flags and options	Request various functions (such as printed summaries)
*PRATED	1 - 5 WTGS power ratings	Specify power ratings
*SRATED	1 - 5 WTGS rated speeds	Specify rated speeds
*WIND	wind region or station indices	Retrieve raw wind data for specified wind region and evaluate wind speed distribution parameters

At low wind speeds, the low energy content of the wind, plus the poor efficiency of the generator at low power output, severely curtails power production. In effect there is a cut-in wind speed, s_c , below which the WTGS produces zero power. As the wind speed increases above s_c , the WTGS output will increase with the cube of the wind speed (assuming constant system efficiency and negligible wind gust response). At the rated speed, s_r , the WTGS achieves its rated power, P_r . For wind speeds above s_r , a control system varies the blade pitch to maintain the rated power so that the generator capacity is not exceeded.

In this study v_c was chosen such that $P(v_c) = 0.1 P_r$, i.e., $v_c = \sqrt[3]{0.1} v_r$. The idealized response function can be written as

$$P(s) = \begin{cases} 0, & s < s_c = 0.4642 s_r \\ P_r \left(\frac{s}{s_r} \right)^3, & s_c \leq s < s_r \\ P_r, & s \geq s_r \end{cases} \quad (2)$$

In most realistic systems there is also a "furling speed" above which the WTGS is feathered or shutdown to prevent damage from high winds. However in this study, measured "wind frequency" data were used to describe wind conditions, and high wind conditions were suppressed. By the suppression of storm level winds from wind frequency data (as is commonly done in reported data), the existence of a furling speed can be ignored.

3. Matching of Load to Available Wind Power

Figure II-5 shows a computer summary of the load profile by 30 minute intervals for a specific farm enterprise, i.e., a broiler operation in Maryland. Further, two graphs have been superimposed on the load profile (where the load data form a half-hourly bar graph for a typical day in the spring, corresponding to the load data reported in Columns 2-5). First, the heavy solid line represents the total wind power generated throughout an average day at the enterprise location in the spring. Second, the light solid line represents the amount of wind power generated and used (with the optimum WTGS at an estimated energy cost of 6¢/kWh). The difference between the two lines represents power generated but not used. When the load far exceeds the WTGS output, little power is wasted and the two curves coalesce.

Also, the difference between the light solid line (wind electricity generated and used) and the bar graph (load) reflects the remaining purchased electricity requirements, taking into account the expected performance of the WTGS. Each of these components of the energy profile is also summarized in tabular form in the computer results as illustrated in Figure II-5.

The capability of WTGS to produce a given power need that varies throughout the day and from season to season can be calculated provided that the following information is known.

Figure II-5.

Sample of load profile and results from
the WTGS Performance Model.

- (1) P_d^{ij} = the electrical power requirement (load) in kW, for the i -th time period of a day in season j .
- (2) $f^{ij}(s)$ = the wind speed distribution function for the i -th period of a day in season j . The quantity $f^{ij}(s)ds$ is the probability that the wind speed is in ds about s during the i -th daily time interval in season j .
- (3) $P(s)$ = the WTGS electrical power response function, i.e., the power produced when the wind speed is s (Eq.(2)).

a. Purchased Electrical Energy

If the WTGS is too small, the demand too large, or the wind speed too low, it is necessary to purchase supplemental electrical energy. If the wind speed is s for the i -th daily time interval in the j -th season, the amount of power which must be purchased is

$$(P_d^{ij} - P(s))H[P_d^{ij} - P(s)]$$

where $H[x]$ is the unit step function, which is unity for $x > 0$, and =zero for $x < 0$. The unit step function is needed when the demand is less than the WTGS power level; thus, no purchased power is needed.

For the i -th daily time interval of the j -th season, the wind speed distribution is given by $f^{ij}(s)$. Hence the average power that must be purchased is

$$\overline{P_b^{ij}} = \int_0^{\infty} [P_d^{ij} - P(s)] f^{ij}(s) H[P_d^{ij} - P(s)] ds \quad (3)$$

where the purchased power has been averaged over the wind speed distribution for the ij -th time period. The properties of $f^{ij}(s)$ and the specific response function, $P(s)$, described in the pervious section, can be used to simplify Eq. (3) for numerical evaluation. Physically, $f^{ij}(s) = 0$ for $s > s_{\max}$, since there is a maximum wind speed ($s_{\max}$) experienced at any particular site (unusually high storm speeds are usually omitted in the calculation of $f^{ij}(s)$). The above result can be written as

$$\overline{P_b^{ij}} = \begin{cases} P_d^{ij} - \int_{s_c}^{s_{\max}} P(s) f^{ij}(s) ds, & P_r \leq P_d^{ij} \\ P_d^{ij} \int_0^{s_d} f^{ij}(s) ds - \int_{s_c}^{\min[s_d, s_{\max}]} P(s) f^{ij}(s) ds, & P_r > P_d^{ij} \end{cases} \quad (4a)$$

$$(4b)$$

where $s_d = s_r (P_d^{ij}/P_r)^{1/3}$, as derived from Equation 2, is the maximum speed below which the WTGS produces less than the demand power. Should $P(s_c) = P_d^{ij}$, then $s_d = s_c$. With the explicit form of $P(s)$ given by Equation 2, this result becomes *

$$\overline{P_b^{ij}} = \begin{cases} P_d^{ij} - \frac{P_r}{3s_r} \int_{\min[s_c, s_{\max}]}^{\min[s_r, s_{\max}]} s^3 f^{ij}(s) ds - P_r \int_{s_r}^{s_{\max}} f^{ij}(s) ds, & P_r \leq P_d^{ij} \quad (5a) \\ P_d^{ij} \int_0^{\min[s_d, s_{\max}]} f^{ij}(s) ds - \frac{P_r}{3s_r} \int_{\min[s_c, s_{\max}]}^{\min[s_d, s_{\max}]} s^3 f^{ij}(s) ds, & P_r > P_d^{ij} \quad (5b) \end{cases}$$

*To simplify the notation it is implied that any integral in which the upper limit is less than the lower limit is set to zero, e.g., this condition may occur for the second integral in Eq. (5a). This convention is used throughout this section.

The average WTGS power output is

$$\overline{p^{ij}} = \int_{s_c}^{s_{\max}} P(s) f^{ij}(s) ds. \quad (5c)$$

Thus from Eq. (4a)

$$\overline{p_b^{ij}} = p_d^{ij} - \overline{p^{ij}} \text{ for } P_r < p_d^{ij}, \quad (5d)$$

i.e., when $P_r < p_d^{ij}$ we could equally well use the average WTGS output to calculate the average purchased power requirements. However, when $P_r > p_d^{ij}$ then from Eq. (4b),

$$\begin{aligned} \overline{p_b^{ij}} &= p_d^{ij} - \overline{p^{ij}} + \int_{\min[s_d, s_{\max}]}^{\max[s_d, s_{\max}]} [P(s) - p_d^{ij}] f^{ij}(s) ds \\ &> p_d^{ij} - \overline{p^{ij}}, \text{ if } s_{\max} > s_d \end{aligned} \quad (5e)$$

Hence if the rated WTGS speed is less than the maximum wind speed and if the rated WTGS power is greater than the demand speed, the purchased power would be underestimated by using the average power output of the WTGS. In other words, if the rated power of the WTGS is p_d^{ij} we get the correct value for $\overline{p_b^{ij}}$ by using the average power, $\overline{p^{ij}}$, since (for this case) all power that is generated can be used no matter what the wind speed. However, if $P_r > p_d^{ij}$, some generated power must be wasted (or sold) during high wind speed conditions and hence more power must be bought than would be expected from using an average WTGS power.

Finally, to obtain the purchased electrical energy required for the i -th daily time interval (Δt_i) of the j -th season (containing d_j days) multiply $\overline{p_b^{ij}}$ by Δt_i . The total annual purchased electrical energy, E_b , is given by

$$E_b = \sum_{j=1}^{NSEASON} d_j \sum_{i=1}^{NINT} p_b^{ij} \Delta t_i \quad (6)$$

where NSEASON is the number seasons in the year and NINT is the number of daily time intervals.

b. Surplus Electrical Energy

Whenever the WTGS produces power greater than the demand, the excess must be stored, wasted, or sold to some other consuming sector. Storage has not been considered in this study. For the i -th daily time interval the j -th season the amount of surplus power is

$$(P(s) - p_d^{ij}) H[P(s) - p_d^{ij}].$$

The average of this quantity with the wind speed distribution, is used to obtain an expression for the excess power for this time period

$$p_s^{ij} = \int_0^{\infty} (P(s) - p_d^{ij}) f^{ij}(s) H[P(s) - p_d^{ij}] ds. \quad (7)$$

The explicit WTGS response function of Eq. (2) is used to obtain a result which can be written as

$$p_s^{ij} = \begin{cases} \int_{\min[s_r, s_{\max}]}^{\min[s_r, s_{\max}]} f^{ij}(s) [P_r \left(\frac{s}{s_r}\right)^3 - p_d^{ij}] ds + (P_r - p_d^{ij}) \int_{s_r}^{s_{\max}} f^{ij}(s) ds, & P_r > p_d^{ij} \\ 0, & P_r < p_d^{ij} \end{cases} \quad (8a)$$

$$(8b)$$

As stated by Eq. (8b) there is no excess power if the maximum power of the WTGS is less than the demand since all generated power is consumed. For $P_r > p_d^{ij}$, i.e., where there is excess power it can be shown that the excess power is greater than $\bar{p}^{ij} - p_d^{ij}$, i.e., more excess power is generated than would be expected from using the average WTGS output for the i, j time interval. Again the average WTGS power output is misleading!

The total annual excess WTGS energy, E_s , is obtained from

$$E_s = \sum_{j=1}^{N\text{SEASON}} d_j \sum_{i=1}^{N\text{INT}} P_b^{ij} \Delta t_i \quad (9)$$

where NSEASON is the number of seasons in the year and NINT is the number of daily time intervals.

c. Electrical Energy Generated and Used

Once the annual amounts of purchased and excess electrical energy have been calculated, the amount of WTGS electrical energy used to meet an enterprise's load, E_g , is calculated as the difference between total demand and total purchased electrical energy, i.e.,

$$E_g = \sum_{j=1}^{N\text{SEASONS}} d_j \sum_{i=1}^{N\text{INT}} P_d^{ij} \Delta t_i - E_b \quad (10)$$

d. Numerical Evaluation of P_b and P_s

Gauss-Legendre quadrature was used to evaluate the integrals in Eqs. (5) and (8). For the function form of $f^{ij}(s)$ used in this study (see next section), a low order quadrature usually was sufficient. However, certain integrals with relatively large a or b coefficients sometimes needed a higher order quadrature scheme or they would lead to misleading results. To minimize the required computational effort and maintain accuracy of integral evaluation, a varying order quadrature scheme was developed: For integer a and b values the $f^{ij}(s)$ function is a polynomial of degree $a+b-2$. A polynomial of degree $2n+1$ or less can be integrated "exactly" by $n+1$ point Gauss-Legendre quadrature. Therefore, the integrals of the form

$$\int_{s_1}^{s_2} f^{ij}(s) ds \quad (11a)$$

can be evaluated "exactly" with the $\max[2, (a+b-1)]$ point quadrature and integrals of the form

$$\int_{s_1}^{s_2} \left(\frac{s}{s_r} \right)^3 f^{ij}(s) ds \quad (11b)$$

can be evaluated "exactly" with $(a+b+2)$ point quadrature. Note the above expressions are evaluated using integer a and b values ($a \geq 1$ and $b \geq 1$). For noninteger values of a and b , an appropriate quadrature scheme is selected by truncating the results.

e. Construction of Diurnal and Seasonal Wind Frequency Distributions

To calculate the purchased and generated electrical energy by the method described in the previous section, the wind distribution function $f_{ij}(s)$ must be obtained first. This distribution, which is the probability the wind speed is in unit speed about s during the i -th daily interval in the j -th season, contains the total information (save directional dependence which is not needed in this study) about the diurnal and seasonal wind variations.

Since all observed wind frequency distributions are zero beyond some maximum wind speed, $s_{\max}$, it is reasonable to fit the observed data to a distribution which has support over only a finite interval. Ideally such a distribution should have few parameters and be able to reasonably describe observed wind speed frequencies. Such a distribution is the Beta distribution

$$f(s) = \frac{1}{s_{\max} B(a,b)} \left(\frac{s}{s_{\max}}\right)^{a-1} \left(1 - \frac{s}{s_{\max}}\right)^{b-1}, \quad 0 \leq s \leq s_{\max}, \quad (12)$$

with parameters a and b and where $B(a,b)$ is the ratio of gamma functions, Γ , i.e.,

$$B(a,b) = \frac{\Gamma(a)\Gamma(b)}{\Gamma(a+b)} \quad (13)$$

The Beta distribution can assume any value for the mean and variance over its range. The mean and variance of the Beta distribution are

$$\mu = \frac{a}{(a+b)} s_{\max} \quad (14)$$

and

$$\sigma^2 = \frac{ab}{(a+b)^2 (a+b+1)} s_{\max}^2 \quad (15)$$

From the observed wind speed frequency distribution for each 3-hour interval for each season $F_j(s)$, the mean, $\bar{s}$, and variance, v^2 , are easily evaluated. Upon setting $\bar{s}$ equal to μ [Eq. (14)] and v^2 equal to σ^2 [Eq. (15)], we can solve the resulting equations for the Beta parameters a and b . The result is

$$a = \frac{\bar{s}}{s_{\max}} \left[\frac{\bar{s}(s_{\max} - s)}{s^2} - 1 \right] \quad (16)$$

and

$$b = \frac{s_{\max} - \bar{s}}{\bar{s}} a \quad (17)$$

Of course the approximating distribution need not have been the Beta distribution and alternate approximating distributions could have been chosen which reasonably fit the reported wind speed frequency distributions. The Beta distribution was used because it was found to fit the reported wind speed frequency distributions and parameter evaluation was performed easily and economically for a large number of locations, seasons and daily time intervals using the method described above.

One novel aspect of the use of diurnal and seasonal wind speed probability distributions is that the effect of stagnation days or abnormally windy days on the economics of wind power application can be considered in the model. In fact, since the power output of a WTGS varies with the cube of the wind speed and since in practice there is a cut-in speed and a rated speed above which the power output is kept constant, the use of average wind speeds would be often quite misleading. Consequently, the average wind speed method of representing potential wind power output was not used in this study. The use of average wind speeds effectively assumes that a built-in storage system (without cost) is available and operates such that energy available in high wind speeds is stored to compensate for periods when the wind speeds are lower than the cut-in speed. Since this study was constrained to preclude any storage devices, the computer algorithm developed for the analysis of the optimum WTGS for a particular application more effectively evaluates actual wind power potential by utilizing all of the information about wind speeds, not simply the average wind speed as has been done in many previous studies.

f. Wind Turbine Generator System Cost Models

Few modern wind turbine generator systems (WTGS) have been produced; hence, costs cannot be accurately estimated. The costs will vary with the rated power, P_r , rated speed, s_r , size and type of wind rotor, gear mechanism, inverter, and tower as well as the type of feathering device used to prevent WTGS damage of high wind speeds. Figure II-6 is an illustration of cost per kilowatt (kW) as a function of rated power in kW based on Obermeier (1976), Eldridge (1975), Rosen et al (1975), Coty et al (1977) and Justus (1976).

To obtain a function for use in the optimization program, the four high values from Justus (1976) and the NASA experimental value (the Plumbrook unit) were fit to a quadratic polynomial:

$$\ln(\$/\text{kW}) = 9.33160 - 0.45094 \ln(P_r) + 0.06010[\ln(P_r)]^2, P_r > 1\text{kW} \quad (18)$$

This function was used for a high value estimated for WTGS with rated power equal to or greater than 1.0 kW. We used the slope of Eq. (18) at $\text{kW} = 1.0$ to find a cost function to be used for WTGS rated less than 1.0 kW:

$$\$/\text{kW} = 11290 (P_r)^{-0.45904}, P_r < 1\text{kW}. \quad (19)$$

Figure II-6. Illustration of the costs used for the WTGS.

For a low value estimation of WTGS costs, the data from Rosen, et al (1975) were fit to a polynomial:

$$\ln(\$/\text{kW}) = 7.73971 - 0.46578 \ln(P_r) + 0.02573[\ln(P_r)]^2, P_r \geq 1\text{kW} \quad (20)$$

For WTGS rated below 1kW, the slope of Eq. (20) at $P_r=1.0$ kW was used to obtain the following fit:

$$\$/\text{kW} = 2297.8 (P_r)^{-0.46578}, P_r < 1\text{kW}. \quad (21)$$

The cost function, Eqs. (18-21), form bounds on the costs reported in published literature or in literature distributed by manufacturing companies. The upper bounds functions, Eqs. (18) and (19), are for WTGS rated at a wind speed of 18 mph (8.05 m/s). The lower bounds functions, Eqs. (20) and (21), are for WTGS, generally rated at a wind speed of 25 mph (11.18 m/s). Eldridge (1975) and Purner et al (1976) report that costs can be corrected for different rated speeds by multiplying the costs (\$/kW) by $(s_{\text{ref}}/s)^2$, where s is the rated wind speed for a particular WTGS and s_{ref} is the wind speed for which the cost function was developed.

The region labeled "Lockheed Results" in Figure II-7 are those calculations reported for a very complex optimization analysis in which the rated wind speed was not held constant but was used as an optimization variable. Therefore, these results could not be fit directly and the fit results were modified by the $(s_{\text{ref}}/s)^2$ adjustment factor. However, the "Lockheed Results" are generally within the upper and lower bounds functions, Eqs. (18-21).

Thus, the total cost of WTGS was determined by multiplying the \$/kW found from the appropriate relation, Eqs. (18-21), by the power (kW) and correcting the result for rated wind speed by multiplying by $(s_{\text{ref}}/s)^2$. Table II-2 shows these capital costs for various generator and wind machine size parameters (rated power and rated speeds) for the high and low cost models.

g. Method of Optimization

The WTGS Performance Model computes expected technical and economic performance data for each economic scenario, application, and pair of WTGS size parameters, i.e., rated power and rated speed. In this study, rated power and rated speed were optimized as continuous variables for the preliminary screening and analysis whereas for the market potential assessment discrete WTGS sizes based on rated powers of 1, 5, 10, 15, 25, 35, 50 and 100 kW and rated speeds of 6, 7, 8, 9, and 10 m/s were compared for each application. The WTGS, defined by its rated power and rated speed, that resulted in the greatest annual net savings was defined as the optimal WTGS for that application. The discrete WTGS sizes used for the market potential assessment of preliminary study results of various selected potential agricultural applications.

Table II-2. WTGS capital cost (\$000) ^{1/}

Rated Power of Generator (kW)	Rated Wind Speeds (meters/sec.)				
	6	7	8	9	10
High Cost Estimate					
1	39.2	28.8	22.0	17.4	14.1
5	110.7	81.4	62.3	49.2	39.9
10	190.7	140.3	107.3	84.8	68.7
15	269.2	197.8	151.4	119.7	96.9
25	427.5	314.1	240.5	190.0	153.9
35	589.7	433.3	331.7	262.1	212.3
50	841.8	618.5	437.5	374.1	303.1
100	1756.2	1290.3	987.9	780.5	632.2
Low Cost Estimate					
1	4.1	3.0	2.3	1.8	1.5
5	10.4	7.7	5.9	4.6	3.8
10	16.2	11.9	9.2	7.2	5.8
15	21.2	15.6	11.9	9.4	7.6
25	30.1	22.1	16.5	14.0	10.8
35	38.2	28.1	21.5	17.0	13.8
50	49.5	36.4	27.9	22.0	17.8
100	83.5	61.4	47.0	37.1	30.1

^{1/} Includes wind turbine, controls, generator, tower and installation.

III. DATA AND ASSUMPTIONS

This chapter discusses the basic data and key assumptions used in this study to assess the market potential for wind energy systems in U.S. Agriculture.

Basic data requirements for the market potential assessment and the Wind Turbine Generator System (WTGS) Performance Model include the following:

- number and type of WTGS applications
- energy use profiles
- wind data
- conventional energy cost data
- WTGS costs and response characteristics.

The number and type of WTGS applications was estimated using U.S. Census of Agriculture data primarily as well as other data sources described below. Energy use profiles were constructed using engineering synthesis techniques and were based on contacts with county extension agents, agricultural engineers and other knowledgeable sources. Wind data were taken from Reed (1975) and wind speed distributions for selected stations were obtained from the National Climatic Center, Asheville, North Carolina. The cost of alternate energy sources was assumed to be 4 cents, 6 cents and 8 cents/kWh based on retail prices paid by farmers for electricity reported by USDA and expected future costs for electricity. WTGS costs were developed from information contained in Justus (1976), Rosen (1975) and Obermeier (1976). High and low cost models were used to represent the extreme upper and lower limits of expected costs. Power output of the WTGS was assumed to vary with the cube of the wind speed between a cut-in and a rated wind speed, equal zero when wind speed was less than cut-in speed and equal to rated power when wind speed exceeded rated speed.

Key assumptions were made regarding the data used and the operation of the WTGS on each farm as follows:

- (a) Only continental states with an average annual wind power density of 100 w/m^2 at 10 meter height, according to Reed (1975), were included in this analysis.
- (b) No height adjustments for wind speed data or WTGS tower height were made.
- (c) No storage of wind generated electricity was assumed.
- (d) No load management such as rescheduling energy use to periods of expected high winds was assumed.

- (e) No credit for excess wind energy generated was assumed.
- (f) Purchased electricity from utilities would provide back-up to wind generated electricity as needed without penalty for power company revenue losses.
- (g) All stationary energy needs that could readily be electrical were electrical, e.g. all farm residences were assumed to be total electric; but farm tractors, vehicles and non-stationary items were not assumed electrical.

These data and assumptions are discussed in detail below.

A. Number and Type of Potential WTGS Application on U.S. Farms

The number of potential WTGS applications considered in this study was 1,775,100. This number represents 1,662,100 complete farm applications and 113,000 dedicated use (irrigation) applications in the 23 continental states with an average annual wind power density equal to 100 w/m² or more. This compares with 1,712,900 farms in these same 23 states reported in 1976 Agricultural Statistics. These numbers are shown in Table III-1. Complete farm applications are defined as those in which the electrical needs of the farm include:

- residence appliance load;
- residence heating and cooling load; and,
- farm operations load.

Dedicated use applications are defined as single function applications. In this study irrigation was the only dedicated use or single function application considered because irrigation energy requirements often are continuous over extended time periods and remote with respect to other farm electrical energy needs. Nearly all other single energy-consuming functions on farms require power for only short times throughout the day or year and can usually be incorporated with other electrical power requirements of the farm.

1. Complete Farm Applications

The total number of potential complete farm applications by state and the number within each complete farm type-size category is shown in Table III-2. These numbers were estimated on the basis of USDA-SRS estimates of the total number of farms by state in 1974 as reported in Agricultural Statistics, 1976. The number of farms by type size category are DPRA estimates based on 1976, 1969 and the 1974 preliminary Census of Agriculture.

Table III-1. Potential WTGS applications by type and total number of farms per state, 1974

State	Number of complete farm applications ^{1/}	Number of dedicated use (irrigation) applications ^{2/}	Total number of potential applications	Total number of farms ^{3/}
	------(000)-----			
Colorado	26.5	8.0	34.5	29.5
Idaho	21.8	13.9	35.7	27.2
Illinois	125.7	0.2	125.9	126.0
Indiana	105.6	0.5	106.1	106.0
Iowa	137.3	0.6	137.9	138.0
Kansas	77.7	16.5	94.2	83.0
Maine	7.6	---	7.6	7.6
Maryland	17.6	0.2	17.8	17.8
Michigan	80.0	---	80.0	80.0
Minnesota	117.2	0.9	118.1	118.0
Missouri	138.8	0.2	139.0	139.0
Montana	24.5	0.2	24.7	24.6
Nebraska	61.6	13.9	75.5	69.0
New Jersey	8.0	---	8.0	8.0
New York	57.0	0.4	57.4	57.0
North Dakota	41.2	0.4	41.6	41.5
Ohio	116.6	0.3	116.9	117.0
Oklahoma	82.8	6.2	89.0	87.0
Pennsylvania	71.0	---	71.0	71.0
South Dakota	42.7	0.7	43.4	43.5
Texas	187.7	47.1	234.8	209.0
Wisconsin	105.0	1.1	106.1	105.0
Wyoming	8.2	1.7	9.9	8.2
TOTAL	1662.1	113.0	1775.1	1712.9

1/ Excludes farms classified as primarily irrigation farms.

2/ Considers each irrigation unit a potential WTGS application.

3/ Based on USDA-SRS estimates. 1976 Agricultural Statistics.

Numbers of farms were developed for the following categories:

- Cash grain
- Fruit, nut and vegetable
- Poultry and eggs
- Dairy
- Livestock other than poultry and dairy
- Farmhouse (residence) only

a. Cash Grain

The cash grain category was slightly modified and expanded to include cotton farms in Texas and potato farms in Idaho and Maine, then further broken down into nonirrigated and irrigated and by acreage into three sizes: small (less than 180 acres); medium (180 to 500 acres); and, large (over 500 acres). This farm type category thus became two categories, "non-irrigated crops" and "irrigated crops." The number of farms classified as "non-irrigated crops" by state and size category is shown in Table III-2. The number of "irrigated crops" application is discussed below under dedicated use applications.

b. Fruit, Nut and Vegetable

Fruit, nut and vegetable farms were present in sufficient numbers to warrant separate classification in only Michigan and New Jersey. These farm types in other states were included in the "residence only" category.

c. Poultry

Poultry farms also were present in sufficient numbers in only seven states and are included in the "residence only" category in the other 16 states where they were found to operate according to the census data.

d. Dairy and Livestock

Both dairy and livestock farms were sized by number of head rather than by acreage. This criterion was not only more clearly shown by census data but was more relevant for the purposes of this study. Dairies were sized into a small, medium and large category on the basis of herd size 1-19, 20-49, and 50 and over.

Primary livestock numbers were based on hog only, cattle only, and hog and cattle operations. These head counts were then converted into animal units and allocated into the small, medium, and large classes on the basis of fewer than 75, 75 to 325, and more than 325 units.

Table III-2. Number of potential complete farm applications by type-size category and state

State	Nonirrigated crops			Fruit, nut, vegetable (all)	Poultry and eggs (all)	Dairy			Livestock			Farmhouse only	Total
	S	M	L			S	M	L	S	M	L		
	<180	180- 500	>500			<20	20- 50	>50	<75	75- 325	>325		
----- (000) -----													
Colorado	1.0	0.2	0.2			0.2	0.6	0.5	2.5	3.0	1.0	17.3	26.5
Idaho	0.6					2.0	1.6	0.3	2.0	1.4	0.5	13.4	21.8
Illinois	22.4	28.4	1.0			2.0	4.9	0.8	15.0	11.0	2.0	38.2	125.7
Indiana	16.4	10.8	0.6		2.8	3.9	3.8	0.7	17.0	5.0	0.4	44.2	105.6
Iowa	12.9	17.6	0.3			3.8	6.1	0.6	27.5	30.2	4.0	34.3	137.3
Kansas	7.6	13.1	3.5			1.8	2.4	0.6	11.9	9.9	2.9	24.0	77.7
Maine	0.5	0.6			1.0	0.3	0.6	0.2				4.4	7.6
Maryland	1.0	0.3	0.1		1.4	0.5	1.7	0.9	0.3	0.3	0.1	10.5	17.6
Michigan	7.7	4.7	0.1	4.1	1.4	7.0	7.5	1.1	5.0	1.2	0.2	40.0	80.0
Minnesota	7.9	11.1	0.7			14.6	17.6	1.0	10.4	7.0	0.6	46.3	117.2
Missouri	6.9	8.9	0.5			7.1	4.6	0.7	25.5	13.9	0.9	69.7	138.8
Montana	1.1	2.2	4.1						1.3	2.5	0.9	11.9	24.5
Nebraska	3.2	7.7	1.6			1.2	1.6	0.3	13.5	14.0	3.0	15.5	61.6
New Jersey				1.4	1.0	0.1	0.7	0.4				4.4	8.0
New York						4.0	12.8	3.7				36.5	57.0
North Dakota	2.1	12.0	8.6			0.9	1.0	0.1	3.9	3.0	0.8	8.8	41.2
Ohio	12.3	7.3	0.4			7.4	7.4	1.1	13.1	4.7	0.4	62.5	116.6
Oklahoma	3.0	3.8	0.4			0.8	1.5	0.7	7.5	4.7	0.8	59.6	82.8
Pennsylvania					3.4	6.6	11.9	0.2	4.0	0.7	0.1	44.1	71.0
South Dakota	1.3	3.2	1.8			1.2	1.8	0.2	8.0	12.2	2.4	10.6	42.7
Texas	4.9	12.7	3.0		3.2	0.3	1.6	2.4	12.9	5.5	0.8	140.4	187.7
Wisconsin						16.6	37.2	3.4	4.6	2.0	0.2	41.0	105.0
Wyoming									0.9	0.7	0.6	6.0	8.2
												TOTAL	1662.1

Note: All categories with small or insignificant totals are included in miscellaneous.

Size distributions for grain farms are in acres. Dairy and livestock sizes are in head of animals and animal equivalents.

Source: 1964 Agriculture Census updated by 1969 Census, 1974 preliminary Census and -DPRA- estimates.

e. Farmhouse (Residence) Only

The "farmhouse only" category is broadly named to include all minor farm numbers from previously mentioned categories as well as all farm numbers that are not classified elsewhere. Certain farms that operate as ranches with only range cattle, i.e., no farmstead energy load, are also included. The "farmhouse only" classification is used to identify those farms that for load qualification will be considered as a residence with appliance and heating and cooling loads only and no additional farm operations load.

2. Dedicated Use (Irrigation) Application

Irrigation was identified in this study as the highest potential dedicated use application in agriculture for a WTGS and was thus singled out for individual consideration. Generally, single energy-consuming functions on farms require power only intermittently throughout the day or year, and wind energy systems are not well suited for such "flashy" loads.

Because many farms had multiple irrigation systems and because irrigation loads were extremely high compared to other farm loads, it was decided to treat each irrigation system as a dedicated use application. Thus irrigation systems rather than farms were counted. The number of irrigated farms, however, was subtracted from total crop farms in order to derive the number of nonirrigated farms for each state and size category as mentioned above.

The number of dedicated use (irrigation) applications thus considered in this study was 113,000. The number of irrigation applications by state and by type of system is shown in Table III-3. These numbers represent estimates based on the reported acres irrigated by system type and by state reported in the November/December 1976 Irrigation Journal.

B. Energy Use Profiles

Potential diurnal and seasonal electric energy load profiles were developed for various types and sizes of complete farm and dedicated use applications. It was assumed that all stationary energy needs that could readily be electrical were electrical. Thus the potential electrical load profiles included typical time-of-day requirements for loads that are traditionally supplied by electricity, such as lights, air conditioning, water pumps, refrigeration, ventilation-aeration, water heaters, and tractor heaters. They also included loads that may be supplied by fossil fuels but could be converted to electricity such as residence or farm space heating, hot water heater, clothes dryer, oven/range, conveyors, water pumps (including irrigation engines), silo unloader, grain drying, bunk feeders, and feed grinders. Consequently, the load profiles used in this study represent potential rather than actual useage of electricity on farms.

Table III-3. Number of irrigation units by type and total number of dedicated use (irrigation) application by state

State	Number of Irrigation Systems ^{1/}					Total Dedicated Use (Irrigation) Appl.
	(1) Center Pivot	(2) Hand Move	(3) Tow Line	(4) Gated Pipe (Ground water)	(5) Gated Pipe (Surface Water)	
	------(000)-----					
Colorado	3.8	0.2	0.2	1.7	2.1	8.0
Idaho	1.6	10.0	2.2		0.1	13.9
Illinois	0.2					0.2
Indiana	0.2	0.2		0.1		0.5
Iowa	0.4			0.2		0.6
Kansas	5.6	0.4	0.2	10.3		16.5
Maine						
Maryland	0.1	0.1				0.2
Michigan						
Minnesota	0.8	0.1				0.9
Missouri	0.2					0.2
Montana	0.2					0.2
Nebraska	13.6	0.1	0.2			13.9
New Jersey						
New York		0.4				0.4
North Dakota	0.4					0.4
Ohio		0.3				0.3
Oklahoma	1.1	1.1	1.2	2.3	0.5	6.2
Pennsylvania						
South Dakota	0.1		0.4		0.2	0.7
Texas	4.0	6.4	5.3	27.6	3.8	47.1
Wisconsin	0.4	0.5	0.2			1.1
Wyoming	0.6	0.3	0.3		0.5	1.7
						113.0

1/ Blanks indicate 50 or fewer systems

Source: DPRA estimates derived from data in Irrigation Journal, Nov./Dec. 1976.

Required load profile data included the quantities of electrical energy needed for all appliance, heating and cooling and farm operations of the enterprise for each 30-minute period of the day and for each of the four calendar seasons. Average days in April, July, October, and December were used in this study to represent all days in the spring, summer, fall and winter seasons, respectively. This is illustrated in Figure III-1.

The load profiles were developed on a half-hourly, daily and seasonal basis so that each application's power requirements could be evaluated relative to the distribution of power available from the wind. This technique allowed more accurate and detailed simulation of expected load and wind power matching that would have been possible had diurnal and seasonal load profiles and wind distributions not been used. Neither the load nor wind speeds were smoothed or averaged.

Generally complete application load profiles were obtained by summing (1) residence appliance load, (2) a residence heating and cooling load (one of three location-dependent options) and (3) a farm operation load (dependent on farm type and location). "Farmhouse only" and "dedicated use" loads were exceptions. "Farmhouse only" loads consisted of the residence appliance and a heating and cooling load only, farm operation load was not included. "Dedicated use" loads consisted of irrigation loads only; residential load was not included.

1. Farmhouse Appliance Load

The farmhouse was assumed to be occupied by a family of four on a normal living pattern. The house is assumed to be total electric with water heater (4.5 kW), clothes dryer (3.5 kW), range, dishwasher, refrigerator, freezer, television, etc. Lighting and appliance use varies throughout the day to simulate typical time and occupancy patterns. The daily appliance load was assumed the same regardless of farm type, location or season.

2. Farmhouse Heating and Cooling Load

The farmhouse is assumed to be a three bedroom, ranch style, 1½ bath with a first floor heated area of 1,270 sq. ft. and a basement area of 990 sq. ft. There is a 3 3/8 in. of insulation in the walls and 6 in. in the ceiling. The windows are weather stripped with storm windows. A two-car garage is attached. The furnace has three 5-kW coils and uses a ½-hp blower motor. The air conditioner unit draws 4.7 kW. Three heating and cooling options were developed to represent different climates.

- Option A -- Moderating Heating/Cooling Load
- Option B -- Low Heating/Cooling Load
- Option C -- High Heating/Cooling Load

These options are described in detail in Appendix A. While these three options do not reflect perfectly all home heating and cooling situations in the U.S., we believed they are adequately representative of rural residential heating and cooling loads for the purposes of this study.

Figure III-1 . Breakdown of diurnal power demand for a representative farm (60-cow dairy in New York in Spring).

3. Farm Operation Loads

Farm operation loads were developed for representative types of farms in the 23 states with annual average wind power density greater than 100 w/m². These include time-of-day operation loads for the following types of farms:

Nonirrigated crops

Soybeans and corn
Winter wheat and Sorghum
Potatoes

Dairy

NE Grade A. Dairy
Central Grade A Dairy

Irrigated crops

Fruit, nut and vegetable

Fruit
Truck

Livestock

Hog-beef farm
Hog-beef fattening
Beef-winter wheat
Beef-other crops
Feeder cattle farm

Poultry and eggs

Broilers
Eggs

Farm operation load profiles for each of the above farm types are described in detail in Appendix A and include potential electrical use patterns estimated to be representative of the type of farm operations indicated.

Farm operations loads include energy consumption patterns for specific potential electricity-consuming activities. These activities were mainly as follows:

Lights - all nonresidential lighting, e.g., buildings, yard areas.

Irrigation - Type I, center pivot; Type II, hand move; Type III, two line; Type IV, gated pipe (ground water); Type V, gated pipe (surface water).

Store - crop or feed storage, including aeration, and unloading crops and feeds for processing or shipping.

House - energy required for livestock housing - heating and ventilation.

Feeding - all energy used to prepare feeds, including grinding, mixing, as well as distribution of feed whether home grown or purchased.

Processing - the energy for processing the animals or animal products such as grain drying, milking, egg gathering and grading, hatching, etc.

Storage - product storage between point of processing and shipment.

Waste - disposal energy including collection, storage and final disposal.

Again it is assumed that all stationary energy needs that could readily be electrical were electrical. Thus the load profiles represent potential rather than actual electrical energy use patterns.

An attempt was made to represent regional load variations within complete farm and dedicated use categories. As examples, nonirrigated crops in Iowa were representative of a soybean and corn farm and those in Kansas were representative of a winter wheat and sorghum farm.

The amplitude of the energy use profiles was adjusted to reflect farm and irrigation system size variation. Load amplitude factors (percent) by type and size of farm in the U.S. are also shown in Appendix B.

C. Wind Data

Wind data and information for the selected locations used in the preliminary screening and analyses of this study (reported in Chapter IV) are contained in Reed (1975). Wind data and information used for the market potential assessment of this study (reported in Chapter V) are contained in Reed (1975) and the Revised Uniform Summary of Surface Weather Observations: Part C, Surface Winds, National Climatic Center (NCC), Asheville, North Carolina.

Reed's (1975) data and information were used (1) to screen states with an average annual wind power density of 100 W/m^2 or more at 10. meter height, (2) to describe wind speed frequency distributions for selected locations for the preliminary analyses and (3) to group the high wind states (average annual wind power density of 100 W/m^2 or more) into eight separate regions with similar winds.

Surface wind summaries containing diurnal and seasonal wind speed distributions (by 3-hour intervals for January, April, July and October) were obtained from the National Climatic Center for selected reporting stations within each of the eight high wind regions. Figure III-2 shows where the eight high wind regions were defined and lists the fifteen reporting stations which were used to represent the winds in each region. As shown in Figure III-2, several regions of the country, basically the southeast, southwest and west, were eliminated on the basis of the screening criterion that the state average annual wind power density be at least 100 W/m^2 at 10 m height. Within the eight high wind regions, comprised of 23 states which met the screening criterion, wind characteristics were assumed to be those of the reporting stations chosen for each region. Ideally, smaller geographic areas would be desirable for characterizing wind regimes, however small area wind resource assessments have not yet been completed and the quality of the available wind and agricultural data did not justify a finer geographic resolution of the wind regions for this national market potential assessment.

Figure III-2. Wind regions, states, and stations

* Wind Data Reporting Station

Region	States	Station	Region	States	Station
I	Idaho	Mountain Home, Idaho	VI	Iowa Missouri	Des Moines, Iowa
II	Montana Wyoming	Glasgow, Montana	VII	Illinois Indiana Michigan Minnesota Ohio Wisconsin	Rantoul, Illinois Columbus, Indiana Mount Clemens, Mich. Madison, Wisconsin
III	North Dakota South Dakota	Fargo, North Dakota Sioux Falls, South Dakota	VIII	Maine Maryland New Jersey New York Pennsylvania	Brunswick, Maine Patuxent River, Md. Syracuse, New York
IV	Colorado Kansas Nebraska	Wichita, Kansas			
V	Oklahoma Texas	Dallas, Texas Lubbock, Texas			

Wind data from one or more interior reporting stations, as indicated in Figure III-2 were used directly or combined (if more than one station per region) for input into the Wind Turbine Generator System Performance Model. A Beta probability distribution was used to approximate reported wind speed frequency distributions. The Beta distribution adequately fit the reported wind speed data and was easily and economically employed considering the large number of locations, seasons and daily time intervals evaluated in this study.

Also, the wind data were not adjusted for anemometer height or exposure. Consequently, this study may underestimate the number of feasible WTGS applications in U.S. Agriculture because most wind data are collected near airports in relatively sheltered locations at about 7 to 10 m elevation. Most wind turbines would be located at better sites and at greater heights.

Appendix A contains actual probability distribution parameters and surface wind speed frequency summaries by time of day, season and wind region used in this study.

D. Conventional Energy Cost Data

The marketing potential for a WTGS depends largely on the cost of alternative sources of energy to the user. In this study we assumed that wind energy generated and used on the farm would be valued at 4¢, 6¢, and 8¢ per kWh. Electricity generated beyond the instantaneous farm load would be wasted or supplied to the utility at no cost. That is, the energy meter at the farm could be slowed, or even stopped, but it could not be reversed. The farmer would never receive credit from the utility for wind energy generated in excess of instantaneous farm load.

The assumed prices of 4¢, 6¢ and 8¢ per kWh are compared to recent prices paid by farmers and FPC projections of electricity costs of production in 1980 in Figure III-3. The assumed prices are approximately equal to or higher than retail prices presently being paid for electricity by farmers across the U.S.A. Electricity costs will likely increase relative to WTGS costs in the future. The alternate price levels of 4¢, 6¢ and 8¢ represent different relative price levels.

Alternate assumptions could have been made in this study concerning excess wind generated electricity buy-back prices, hook-up charges and WTGS-utility interfacing. However, because these policies are not uniform among utilities and alternate policies are not universally available, no credit for excess wind energy generated, no hook-up charge to the utility grid and utility back-up were assumed. Comparison of alternate assumptions would be a valuable sequel to this study.

Figure III-3. Comparison of parametric costs used in this study, prices paid by farmers (1976) and FPC predictions of 1980 costs of production from existing facilities

E. WTGS Costs and Response Characteristics

1. WTGS Cost

Not many modern wind turbine generator systems (WTGS) have been produced, hence, system costs cannot be accurately estimated. The costs will vary with the rated power and rated speed, the size and type of wind rotor, gearing, synchronizer, and tower. Larger WTGS's can usually be built at lower per unit costs than smaller ones. In given situations, this trend could be reversed when some critical size exceeds locally available erection capability, of course.

The high and low cost models for the WTGS were developed from cost studies made by Obermier (1976) and Rosen, et al (1975), according to procedures explained in Chapter II, METHODOLOGY. These models were used to determine the total capital cost of WTGS with rated powers of 1, 5, 10, 15, 25, 35, 50, and 100 kW and rated wind speeds of 6, 7, 8, 9, and 10 m/s. These costs were shown in Table II-2. Discrete sizes were selected on the basis of a preliminary screening and assessment and were used to illustrate the probable situation of future commercial availability. The low and high costs probably represent the extreme upper and lower limits of expected costs, while present costs and even expected future cost lie somewhat between these two extremes.

Annualized capital cost were based on a 20 year amortization period and 10 percent interest rate. Annual operating and maintenance costs were assumed equal to 2 percent of the WTGS capital cost. No salvage value was assumed.

2. WTGS Reponse Characteristics

In this study, the Wind Turbine Generating System (WTGS) is used to describe the equipment and systems of the wind that generate electricity. The common terminology Wind Energy Conversion System (WECS) implies that the conversion of wind energy by all means including electrical generation, is a broader concept, and is therefore not used in this study.

To compute the power output from the WTGS from the wind speed distributions, one must use a "response function", which gives the electrical power output from a WTGS for a given wind speed. In practice, different WTGS often exhibit different responses to the wind. However, their power output increases roughly proportional to the cube of the wind speed up to some "rated speed" beyond which a governor, or the inherent dynamics of the system, maintain the WTGS output at roughly a constant value (the so-called "rated power"). In this study, a idealized WTGS response function, was used to obtain the WTGS power output probability distributions from the wind speed distributions. The general form of the response function used in this study is shown in Figure II-2 and described in detail in Chapter II, METHODOLOGY.

IV. PRELIMINARY SCREENING AND ANALYSIS ^{1/}

A broad array of representative farm enterprises and locations was screened to identify those locations and applications most likely to be economically feasible for WTGS's. A preliminary analysis also provided useful information regarding expected optimal WTGS rated power and rated speed and the sensitivity of these size variables to wind characteristics, load characteristics and economic parameters such as the cost of alternative sources of energy. The preliminary screening and analysis provided valuable insight and experience with the Wind Turbine Generator System Performance Model that was useful in guiding the planning for the market potential assessment.

A. Preliminary Screening

Forty-one farm enterprises were initially identified representing principal types of commercial farming operations in 25 major farming areas in the United States. (The primary source of information in this selection was: "Farm Costs and Returns, Commercial Farms by Type, Size and Location," USDA, ERS, Ag. Info. Bull. No. 230, October, 1967). The 41 representative farm enterprises are listed in Table IV-1.

After the initial selection of farm enterprises, it was essential, within the scope of study, to screen the list to only those which were deemed, a priori, to have the highest economic potential for wind energy applications. Based on the contractor's judgement, the average annual wind power density at each enterprise location was chosen as the screening factor. As also shown in Table IV-1, the estimated annual average wind power density for each enterprise location ranged from a high of 296 W/m² to a low of 27 W/m². Based on the distribution shown, a screening cut-off value of 100 W/m² was chosen, and subsequent preliminary analysis was made of only the 23 enterprises that met the wind power density criterion.

The locations of the 41 initial farm enterprises are depicted on a map as shown in Figure IV-1. Distinct regional wind energy patterns are apparent, especially for those enterprises and locations not selected for further assessment. One should recognize, however, that wind energy applications may be feasible in these locations; this study was simply limited in the number that could be assessed within the time and scope allowed.

^{1/} The discussion and results presented in this chapter are based on preliminary wind data and analysis of specific but representative farm applications. The reader interested in the market potential assessment may wish to go directly to Chapter V.

Table IV-1. Description of preliminary farm enterprises with potential wind energy applications, ranked as to available wind power.

Region	Enterprise Type	Wind Data Recorded	Wind Power W/m ²
High Plains	Irrigated corn, sugarbeets - Kans.-Col.-Neb.	Garden City, KS	295.9
North Central	Potato-sugarbeet N.D.-Minn.	Fargo, ND	263.8
High Plains	Winter wheat-sorghum - Kansas.-Okla.	Dodge City, KS	253.4
Corn Belt	Hog-beef farm	Fort Dodge, IA	199.0
Northeast	Broiler production - Maine	Portland, ME	187.0
Northeast	Potato farm - Maine	Portland, ME	187.0
High Plains	Irrigated cotton - Texas-Okla.	Lubbock, TX	163.6
North Central	Cattle - Neb.-Wy.-S.D.-Mont.	Sioux Falls, SD	161.5
Southern	Rice - La.-Texas	Houston, TX	156.3
High Plains	Winter wheat - beef - Kans.-Okla.	Salina, KS	155.9
Corn Belt	Hog-beef fattening farm	Indianapolis, IN	143.3
Southern	Cotton farm - Texas	Dallas, TX	137.8
Northwest	Cattle - Mont.-Idaho	Burley, ID	133.3
North Central	Spring wheat - fallow - N.D.-Mont.	Glasgow, MT	133.0
North Central	Grade A Dairy - Wisc.-Minn.	Madison, WI	130.2
North Central	Fruit - Mich.	Muskegon, MI	129.9
Corn Belt	Cash grain farm	Rantoul, IL	121.8
Mid Atlantic	Broiler farm - Del.-Md.	Patuxent River, MD	119.9
Northeast	Grace A. dairy - Central, N.Y.	Syracuse, NY	115.7
North Central	Truck farming - Mich.	Mt. Clemens, MI	115.2
Northwest	Potato - Idaho	Mountain Home, ID	110.2
Northeast	Egg Production - N.J.	Newark, NJ	109.0
Northwest	Wheat fallow - Wash.	Spokane, WA	100.9
Border Interior	Tobacco-livestock - Kentucky	Ft. Knox, KY	76.3
Border Interior	Tobacco-dairy farm - Kentucky	Ft. Knox, KY	76.3
Border Interior	Tobacco-beef farm - Kentucky	Ft. Knox, KY	76.3
Border Interior	Tobacco-dairy farms - Ky.-Tenn.	Ft. Knox, KY	76.3
Southern	Cotton farms - Miss.-Tenn.-Ark.	Memphis, TN	57.8
Southwestern	Sheep - Utah-Nev.	St. George, UT	49.5
Southern	Vegetable-truck - Fla.	Orlando, FL	49.0
Southern	Citrus	Orlando, FL	49.0
Atlantic Coast	Tobacco farms - coastal plain	Ft. Bragg, NC	46.9
Mid & Atlantic	Cotton-peanuts & corn - Ga.-N.C.-S.C.	Warner Robins, GA	41.9
Mid & Atlantic	Broiler farms - Ga.	Albany, GA	41.3
California	Irrigated cotton	Fresno, CA	35.8
California	Fruit	Fresno, CA	35.8
California	Vegetable	Fresno, CA	35.8
Southern	Sugar cane - Tex.-La.-Fla.	Alexandria, LA	34.4
Southwest	Citrus - Ariz.	Phoenix, AZ	34.1
California	Rice	Los Alinitos, CA	34.1
Southwest	Sheep & Cattle - Southern N.M. & Ariz.	Chandler, AZ	26.8

Figure IV-1. Locations of Representative Farm Enterprises, Wind Energy Applications in Agriculture (preliminary screening)

B. Preliminary Analysis

Following the initial screening, substantial amounts of detailed wind ^{1/} and energy use data were developed for each of the 23 selected representative farm enterprises, and the Wind Turbine Generator System (WTGS) Performance Model, as described above, was executed on the computer.

The WTGS Performance Model determined the optimal WTGS for each wind energy application. If, however, no feasible WTGS solution was found, i.e., net annual savings was not positive, the algorithm was terminated and, therefore, no results are shown.

A series of electrical energy values of 4¢, 6¢ and 8¢ per kWh were sequentially run. This procedure provided the basis for extrapolating (or interpolating) to estimate breakeven prices for each enterprise as presented subsequently. (Note: The computer algorithm could be amended to derive breakeven prices, but the time constraints prohibited developing the software.)

With the understanding that technical (and economic) results are available only for "feasible" solutions, then the key preliminary results are as summarized in Tables IV-2, IV-3, and IV-4 for the three electricity values, i.e., 4¢, 6¢ and 8¢, respectively. Specific notice should be given to: (1) the estimated load demands, (2) the optimum WTGS sizes, and (3) the optimum WTGS performance results.

1. Load Demands

Load demands (average and peak), as reported in the designated tables, are a function of the energy-use characteristics of each enterprise; however, they do indirectly affect the optimal selection of a WTGS via aggregate power needs and, especially, energy loads over time. For example, average loads for the 23 enterprises studies ranged from 5.2 kW to 193kW. Peak loads ranged from 18.3 kW to over 546 kW.

For this study, representative diurnal and seasonal load requirements were estimated. These data are most critical, and they are reported in detail for each representative farm enterprise in Appendix B.

^{1/} Improvements in the wind data were made after the preliminary analysis and before the market potential assessment described in Chapter V, thus some slight technical, economic and feasibility differences exist between results reported in Chapters IV and V. The appendices support Chapter V results.

Table IV-2. Summary analysis of optimized wind energy applications in agriculture assuming
4¢ per kWh purchased electricity price-1977

No.	Enterprise Name	Location	Wind Average Wind Power W/M ²	Load Demand		Optimum WTGS Size				Optimum WTGS Performance		
				Average	Peak	Rated Power KW	Cut-in Speed M/S	Rated Speed M/S	Maximum Speed	Useful Energy Generated 000 KWH/Yr	Energy Purchased	Excess Energy Generated
1	Dairy	NY	115.7	8.6	35.1	NA	NA	NA	NA	NA	NA	NA
2	Egg	NJ	109.0	16.3	30.3	NA	NA	NA	NA	NA	NA	NA
3	Broiler	ME	187.0	14.4	33.2	NA	NA	NA	NA	NA	NA	NA
4	Potato	ME	187.0	6.6	23.2	NA	NA	NA	NA	NA	NA	NA
5	Broiler	MD	119.9	13.8	28.9	NA	NA	NA	NA	NA	NA	NA
6	Cotton	TX	137.8	NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Rice	TX	156.8	NA	NA	NA	NA	NA	NA	NA	NA	NA
8	Hog-Beef	IA	199.0	8.9	24.6	NA	NA	NA	NA	NA	NA	NA
9	Hog-Beef	IN	143.3	7.9	26.4	NA	NA	NA	NA	NA	NA	NA
10	Cash Grain	IL	121.8	17.2	68.2	NA	NA	NA	NA	NA	NA	NA
11	Winter Wheat- Sorghum	KS	253.4	6.0	19.8	14.8	5.7	12.3	20.8	22	30	13
12	Irr. Corn-Beets	KS	295.9	139.0	546.5	546.2	4.5	9.7	NA	562	656	1290
13	Winter Wheat-Beef	KS	155.9	6.0	18.3	NA	NA	NA	NA	NA	NA	NA
14	Irrigated Cotton	TX	163.6	52.7	NA	106.1	3.9	8.4	14.2	189	273	132
15	Potato-Beets	MN-ND	263.8	NA	NA	NA	NA	NA	NA	NA	NA	NA
16	Spring Wheat Fallow	MT	133.0	NA	NA	NA	NA	NA	NA	NA	NA	NA
17	Cattle Crop	SD	161.5	9.4	36.1	NA	NA	NA	NA	NA	NA	NA
18	Dairy	WI	130.2	8.3	31.9	NA	NA	NA	NA	NA	NA	NA
19	Fruit	MI	129.9	10.2	26.5	NA	NA	NA	NA	NA	NA	NA
20	Truck Farm	MI	115.2	9.0	21.3	NA	NA	NA	NA	NA	NA	NA
21	Feeder Cattle	ID	133.3	20.8	86.1	NA	NA	NA	NA	NA	NA	NA
22	Potato	ID	110.2	NA	NA	76.1	3.5	7.5	14.2	173	101	29
23	Wheat Fallow	WA	100.9	NA	NA	NA	NA	NA	NA	NA	NA	NA

NA -- None Applicable

Table IV-3. Summary analysis of optimized wind energy applications in agriculture assuming
6¢ per kWh purchased electricity price-1977

No.	Enterprise Name	Location	Average Wind Power W/M ²	Load Demand		Optimum WTGS Size				Optimum WTGS Performance		
				Average	Peak	Rated Power	Cut-in Speed	Rated Speed	Maximum Speed	Useful Energy Generated	Energy Purchased	Excess Energy Generated
				-----KW-----		KW	-----M/S-----			-----000 KWH/Yr-----		
1	Dairy	NY	115.7	8.6	35.1	NA	NA	NA	NA	NA	NA	NA
2	Egg	NJ	109.0	16.3	30.3	19.1	3.2	6.8	14.8	55	88	7
3	Broiler	ME	187.0	14.4	33.2	15.4	3.3	7.2	14.1	42	84	5
4	Potato	ME	187.0	6.6	23.2	NA	NA	NA	NA	NA	NA	NA
5	Broiler	MD	119.9	13.8	28.8	17.4	3.5	7.6	14.2	39	82	8
6	Cotton	TX	137.8	NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Rice	TX	156.8	NA	NA	NA	NA	NA	NA	NA	NA	NA
8	Hog-Beef	IA	199.0	8.9	24.6	13.2	3.9	8.4	14.1	30	47	11
9	Hog-Beef	IN	143.3	7.9	26.4	12.4	3.9	8.4	14.1	24	45	8
10	Cash Grain	IL	121.8	17.2	68.2	NA	NA	NA	NA	NA	NA	NA
11	Winter Wheat-Sorghum	KS	253.4	6.0	19.8	14.8	5.0	10.7	20.8	27	25	20
12	Irr. Corn-Beets	KS	295.9	139.0	546.5	548.0	3.8	8.3	14.1	702	515	1,700
13	Winter Wheat-Beef	KS	155.9	6.0	18.3	NA	NA	NA	NA	NA	NA	NA
14	Irrigated Cotton	TX	163.6	52.7	107.4	103.7	3.2	7.0	14.2	242	219	188
15	Potato-Beets	MN-ND	263.8	NA	NA	NA	NA	NA	NA	NA	NA	NA
16	Spring Wheat Fallow	MT	133.0	NA	NA	NA	NA	NA	NA	NA	NA	NA
17	Cattle Crop	SD	161.5	9.4	36.1	16.7	4.5	9.6	14.1	23	59	15
18	Dairy	WI	130.2	8.3	31.9	NA	NA	NA	NA	NA	NA	NA
19	Fruit	MI	129.9	10.2	26.5	NA	NA	NA	NA	NA	NA	NA
20	Truck Farm	MI	115.2	9.0	21.3	NA	NA	NA	NA	NA	NA	NA
21	Feeder Cattle	ID	133.3	20.8	86.1	NA	NA	NA	NA	NA	NA	NA
22	Potato	ID	110.2	134.8	368.2	303.9	3.7	7.9	14.2	368	813	364
23	Wheat Fallow	WA	100.9	NA	NA	NA	NA	NA	NA	NA	NA	NA

NA -- None Applicable

Table IV-4. Summary analysis of optimized wind energy applications in agriculture assuming
8¢ per kWh purchased electricity price-1977

No.	Enterprise Name	Location	Average Wind Power W/M ²	Load Demand		Optimum WTGS Size				Optimum WTGS Performance		
				Average	Peak	Rated Power	Cut-in Speed	Rated Speed	Maximum Speed	Useful Energy Generated	Energy Purchased	Excess Energy Generated
				-----KW-----		KW	-----M/S-----			-----000 KWH/Yr-----		
1	Dairy	NY	115.7	8.6	35.1	12.1	3.7	7.7	14.2	21	51	9
2	Egg	NJ	109.0	16.3	30.3	24.1	3.0	6.4	14.1	67	75	19
3	Broiler	ME	187.0	14.4	33.2	18.6	3.0	6.4	14.1	54	72	13
4	Potato	ME	187.0	6.6	23.2	10.4	3.6	7.9	14.1	19	38	7
5	Broiler	MD	119.9	13.8	28.8	19.3	3.1	6.7	14.2	50	70	15
6	Cotton	TX	137.8	5.9	23.2	10.4	3.8	8.3	14.2	19	33	10
7	Rice	TX	156.8	5.2	18.3	11.0	3.9	8.4	14.1	20	26	14
8	Hog-Beef	IA	199.0	8.9	24.6	16.1	3.6	7.9	14.1	36	42	19
9	Hog-Beef	IN	143.3	7.9	26.4	15.3	3.6	7.8	14.1	30	39	15
10	Cash Grain	IL	121.8	17.2	68.2	54.9	3.8	8.2	14.2	59	92	80
11	Winter Wheat-Sorghum	KS	253.4	6.0	19.8	14.1	4.4	9.2	20.8	32	20	31
12	Irr. Corn-Beets	KS	295.9	193.0	546.5	548.5	3.4	7.4	14.1	784	433	1950
13	Winter Wheat-Beef	KS	155.9	6.0	18.3	10.3	3.8	8.3	14.2	19	33	11
14	Irrigated Cotton	TX	163.6	52.7	107.4	104.0	2.9	6.2	14.2	274	187	224
15	Potato-Beets	MN-ND	263.8	5.9	23.2	11.0	3.9	8.5	14.2	25	27	16
16	Spring Wheat Fallow	MT	133.0	5.9	23.2	10.4	3.9	8.5	14.2	17	35	9
17	Cattle Crop	SD	161.5	9.4	36.1	19.1	4.1	8.8	14.1	28	54	24
18	Dairy	WI	130.2	8.3	31.9	12.6	3.5	7.7	14.2	25	48	13
19	Fruit	MI	129.9	10.2	26.5	18.7	3.4	7.7	14.1	33	56	24
20	Truck Farm	MI	115.2	9.0	21.3	12.7	3.3	7.1	14.2	31	47	9
21	Feeder Cattle	ID	133.3	20.8	86.1	19.3	4.5	9.6	14.1	18	164	11
22	Potato	ID	110.2	134.8	368.2	349.5	3.2	6.9	14.2	478	703	578
23	Wheat Fallow	WA	100.9	5.2	18.2	NA	NA	NA	NA	NA	NA	NA

NA -- None Applicable

2. Optimum WTGS Size

An assessment of the optimum sizes of generators in the three tables shows essentially two size groupings. The major size category is from 10 to 20 kW, representing about 75 percent of the applications studied. Three enterprises (15 percent) have requirements over 100 kW. Thus, in terms of potential marketability, most farm enterprises could better utilize generators in the 10-20 kW range. Rated power was treated as a continuous optimized variable in these preliminary analyses.

Cut-in speed is strictly a function of the rated speed of the wind turbine. It is about 50% of rated speed but provides only 10% of the power at rated speed due to the cube relationship of wind power to wind speed.

Maximum speed is more a function of the available wind data rather than optimum design. The wind data show the same velocity ranges for all reporting stations even though some stations report in knots and some in miles per hour. Thus, the maximum wind speed that a WTGS will have to withstand in normal operation is likely greater than the maximum wind speed that occurs frequently enough to show in the frequency distribution statistics.

Rated speed is the primary design criterion. The rated speed determines the cost and the critical design parts of the wind turbine. Costs of complete WTGS are very sensitive to rated speeds but rather insensitive to rated power sizes. Rated speed, like rated power, was also treated as a continuous optimized variable in these preliminary analyses.

An analysis of individual enterprises across the three price levels reveals an important relationship between the continuous optimum WTGS rated power and rated speed. For example, representative farm enterprise number 11 has the following "optimum" WTGS characteristics:

	<u>4¢/kWh</u>	<u>6¢/kWh</u>	<u>8¢/kWh</u>
Rated power (kW)	14.8	14.8	14.1
Rated speed (m/s)	12.3	10.7	9.2

As the price of purchased electricity doubles from 4 to 8 cents, the optimum rated generator changes only from 14.8 to 14.1 kilowatt. Note that this same price change triggers a 33 percent change in rated speed from 12.3 to 9.2 m/w. The higher cost of alternative energy makes feasible a more complete and expensive wind turbine. Its design will convert more of the wind into usable electrical energy by virtue of its lower rated speed. According to Coty et al (1977) about 90 percent of the WTGS costs are a function of wind speed (rated speed) and only 10 percent are a function of rated power.

3. Optimum WTGS Performance Results

A final set of technical results, which are used in the economic analysis, are the energy results of the optimal WTGS for each enterprise. These results include: (1) the estimated amount of energy generated and used, (2) the amount of back-up electricity purchased from the utility, and (3) excess wind energy generated and wasted. The latter category reflects a potential for storage, but in this study neither storage costs nor benefits were analyzed.

Each optimal and feasible solution of the WTGS model also had an associated economic performance result. For the three prices, i.e., 4¢, 6¢ and 8¢ kWh, the corresponding economic results are shown in Tables IV-5, IV-6 and IV-7 as the following estimates:

Annual wind cost -- the annualized cost of the WTGS based on the original investment depreciated over 20 years, the interest cost at 10%, and an annual operating and maintenance cost of 2% of the investment cost.

Estimated investment cost -- the capital cost of the WTGS as determined by the cost curve for the rated power size, corrected for the applicable wind speed. For these results shown, the lower capital cost option was used (see Chapter II, METHODOLOGY).

Value of useful power generated -- the number of kWh generated and used times the kWh price level of purchased power replaced. The applicable kWh value is stated on each table.

Net present value (NPV) of the WTGS savings -- the present value of the enterprise with its local wind distribution using the optimum WTGS.

When 4¢ per kWh cost was assumed (Table IV-5), only four of the 23 farm enterprises were estimated to have a positive net annual savings. As the assumed rate was increased to 6¢ and 8¢ per kWh, the corresponding number of economically feasible enterprises increased to 10 (Table IV-6); and 22 out of the 23 investigated (Table IV-7). At the lower price of 4¢ per kWh, only those enterprises that were large energy users could afford the investment in wind power. At the highest rate of 8¢ per kWh, the small users, which included some with residential use of electricity only, as well as the large users, showed a net annual savings.

The one enterprise (#23) that did not show a net annual savings at 8¢ per kWh was the enterprise with the lowest wind power density of the 23 analysed. This finding supports the preliminary screening criteria of 100 W/m² average annual wind power density.

Table IV-5. Summary of wind energy in agriculture assuming 4¢ per kWh purchased electricity price

No.	Enterprise Name	Location	Annual Wind Cost	Economics of Optimum WTGS			
				Estimated Investment Cost	Value of Useful Power Generated Per Yr.	NPV of WTGS Savings	Net Annual Savings
					-----\$000-----		
1	Dairy	NY	NA	NA	NA	NA	NA
2	Egg	NJ	NA	NA	NA	NA	NA
3	Broiler	ME	NA	NA	NA	NA	NA
4	Potato	ME	NA	NA	NA	NA	NA
5	Broiler	MD	NA	NA	NA	NA	NA
6	Cotton	TX	NA	NA	NA	NA	NA
7	Rice	TX	NA	NA	NA	NA	NA
8	Hog-Beef	IA	NA	NA	NA	NA	NA
9	Hog-Beef	IN	NA	NA	NA	NA	NA
10	Cash Grain	IL	NA	NA	NA	NA	NA
11	Winter Wheat-Sorghum	KS	.5	4.7	.9	1.9	0.2
12	Irr. Corn-Beets	KS	13.6	127.4	22.5	46.4	5.1
13	Winter Wheat-Beef	KS	NA	NA	NA	NA	NA
14	Irrigated Cotton	TX	4.7	44.0	7.6	13.9	1.5
15	Potato-Beets	ND	NA	NA	NA	NA	NA
16	Spring Wheat Fallow	MT	NA	NA	NA	NA	NA
17	Cattle Crop	SD	NA	NA	NA	NA	NA
18	Dairy	WI	NA	NA	NA	NA	NA
19	Fruit	MI	NA	NA	NA	NA	NA
20	Truck Farm	MI	NA	NA	NA	NA	NA
21	Feeder Cattle	ID	NA	NA	NA	NA	NA
22	Potato	ID	4.7	44.0	6.9	8.8	0.9
23	Wheat Fallow	WA	NA	NA	NA	NA	NA

Table IV-6 Summary of wind energy in agriculture assuming 6¢ per kWh purchased electricity price

No.	Enterprise Name	Location	Annual Wind Cost	Economics of Optimum WTGS			
				Estimated Investment Cost	Value of Useful Power Generated Per Yr.	NPV of WTGS Savings	Net Annual Savings
					\$000-		
1	Dairy	NY	NA	NA	NA	NA	NA
2	Egg	NJ	2.0	18.7	3.3	6.1	0.6
3	Broiler	ME	1.7	15.9	2.5	4.3	0.5
4	Potato	ME	NA	NA	NA	NA	NA
5	Broiler	MD	1.6	15.0	2.3	3.3	0.4
6	Cotton	TX	NA	NA	NA	NA	NA
7	Rice	TX	NA	NA	NA	NA	NA
8	Hog-Beef	IA	1.1	10.3	1.8	4.2	0.5
9	Hog-Beef	IN	1.0	9.4	1.4	1.3	0.1
10	Cash Grain	IL	NA	NA	NA	NA	NA
11	Winter Wheat-Sorghum	KS	.8	7.5	1.6	6.5	0.7
12	Irr. Corn-Beets	KS	18.8	176.1	42.1	100.0+	18.0
13	Winter Wheat-Beef	KS	NA	NA	NA	NA	NA
14	Irrigated Cotton	TX	6.8	63.7	14.5	54.5	5.8
15	Potato-Beets	ND	NA	NA	NA	NA	NA
16	Spring Wheat Fallow	MT	NA	NA	NA	NA	NA
17	Cattle Crop	SD	.9	8.4	1.4	1.5	0.2
18	Dairy	WI	NA	NA	NA	NA	NA
19	Fruit	MI	NA	NA	NA	NA	NA
20	Truck Farm	MI	NA	NA	NA	NA	NA
21	Feeder Cattle	ID	NA	NA	NA	NA	NA
22	Potato	ID	12.6	118.0	22.1	55.3	5.9
23	Wheat Fallow	WA	NA	NA	NA	NA	NA

Table IV-7. Summary of wind energy in agriculture assuming 8¢ per kWh purchased electricity price

No.	Enterprise Name	Location	Annual Wind Cost	Economics of Optimum WTGS			
				Estimated Investment Cost	Value of Useful Power Generated Per Yr.	NPV of WTGS Savings	Net Annual Savings
-----\$000-----							
1	Dairy	NY	1.2	11.2	1.7	1.9	0.2
2	Egg	NJ	2.7	25.3	5.4	17.5	1.9
3	Broiler	ME	2.3	21.5	4.3	13.3	1.4
4	Potato	ME	1.0	9.4	1.5	2.1	0.2
5	Broiler	MD	2.2	20.6	4.0	11.7	1.2
6	Cotton	TX	.9	8.4	1.5	2.9	0.3
7	Rice	TX	.9	8.4	1.6	3.8	0.4
8	Hog-Beef	IA	1.4	13.1	2.9	10.5	1.1
9	Hog-Beef	IN	1.3	12.2	2.4	6.4	0.7
10	Cash Grain	IL	3.0	28.1	4.7	7.7	0.8
11	Winter Wheat-Sorghum	KS	1.0	9.4	2.6	12.2	1.3
12	Irr. Corn-Beets	KS	23.3	218.2	62.7	100.0+	37.8
13	Winter Wheat-Beef	KS	.9	8.4	1.5	3.0	0.3
14	Irrigated Cottor.	TX	8.5	79.6	21.9	100.0+	11.0
15	Potato-Beets	ND	.9	8.4	2.0	7.4	0.8
16	Spring Wheat Fallow	MT	.9	8.4	1.4	1.9	0.2
17	Cattle Crop	SD	1.2	11.2	2.3	6.2	0.6
18	Dairy	WI	1.2	11.2	2.0	3.9	0.4
19	Fruit	MI	1.6	15.0	2.6	5.6	0.6
20	Truck Farm	MI	1.4	13.1	2.5	5.9	0.6
21	Feeder Cattle	ID	1.0	9.4	1.4	.9	0.1
22	Potato	ID	18.4	172.3	38.2	100.0+	14.6
23	Wheat Fallow	WA	NA	NA	NA	NA	NA

C. Ranking of Selected Farm Enterprises

The 23 farm enterprises evaluated were ranked according to their estimated breakeven cost of electricity within the groups shown in Table IV-8. Classification by group is largely determined by the coincidence of the diurnally and seasonally variable electrical energy requirements of the farm enterprise with diurnally and seasonally variable wind speed distributions. Group I farms are generally characterized as being in good wind regimes and or as having extended periods of substantial power requirements. Group II and III farms generally have good wind regimes but power requirements are less or not as well matched to diurnal and seasonal periods of expected high winds. The Group IV farm is located in a less powerful wind regime and its load is small consisting of farmhouse heating and cooling and appliance loads only with no additional farm enterprise loads.

The preliminary screening and WTGS feasibility analysis for selected farm enterprises provided useful analytical techniques, background data, and understanding of data requirements and sensitivities which guided the planning of the market potential assessment which follows in Chapter V.

Table IV-8. Wind energy applications in agriculture ranked by breakeven electrical costs of specific farm enterprises.

Rank	No.	Enterprise Name
Group I 3-4¢/kWh	11	Winter Wheat, Sorghum KS
	12	Sugar Beets KS
	14	Irrigated Cotton TX
	22	Potato Farm ID
Group II 4-6¢/kWh	8	Hog-Beef Farm IA
	2	Egg Production NJ
	3	Broiler Production ME
	5	Broiler Farm MD
	17	Cattle SD
	9	Hog-Beef Fattening Farm IN
Group III 6-8¢/kWh	10	Cash Grain IL
	15	Potato - Beet ND
	19	Fruit Farm MI
	20	Truck Farm MI
	18	Dairy WI
	7	Rice Farm TX
	13	Winter Wheat - Beef KS
	6	Cotton Farm TX
	4	Potato Farm ME
	16	Spring Wheat Fallow MT
	1	Dairy NY
	21	Cattle ID
Group IV > 8¢/kWh	23	Wheat Fallow WA

V. MARKET POTENTIAL ASSESSMENT

This chapter presents an enumeration and analysis of feasible wind turbine generator systems applications in U.S. Agriculture that might be expected under specific assumptions about WTGS costs, alternate energy costs and other important data estimates and assumptions as explained in Chapter III, DATA AND ASSUMPTIONS. The results presented in Chapter V MARKET POTENTIAL ASSESSMENT are based on the approach described in Chapter II, METHODOLOGY.

A. Scenarios Studied

The economic feasibility of representative potential WTGS applications was examined under six scenarios considering combinations of high and low WTGS capital costs and alternative energy cost equivalents of 4, 6 and 8¢ per kWh. These six scenarios are defined as follows:

<u>Scenario</u>	<u>Description</u>	
	<u>WTGS Capital Cost 1/</u>	<u>Alternative Energy Cost</u>
1	High	4¢/kWh
2	High	6¢/kWh
3	High	8¢/kWh
4	Low	4¢/kWh
5	Low	6¢/kWh
6	Low	8¢/kWh

1/ See Table II-2, WTGS Capital Cost.

Economic feasibility for a given representative application was based on a nonnegative net annual dollar savings of the WTGS in that application. A negative total net annual dollar savings of the WTGS in that application meant that for that scenario, the WTGS was not economically feasible.

B. General Results

When the high WTGS capital costs were assumed, none of the representative applications--neither complete farms nor dedicated uses--resulted in a net annual savings. Even when alternative energy costs were assumed equivalent to 8¢ per kWh, none of the applications considered were feasible.

When low WTGS capital costs were assumed, applications were economically feasible only when alternative energy costs of 6¢ per kWh or greater were assumed. At 4¢ per kWh, none of the applications were economically feasible.

Assuming low WTGS capital cost and alternative energy cost equivalents of 6¢ and 8¢ per kWh, the numbers of economically feasible WTGS applications were 445,500 and 991,700, respectively. The aggregate annual amount of wind energy generated and used for all economically feasible WTGS's in agriculture was 9.4 billion kWh at 6¢/kWh and 21.1 billion kWh at 8¢/kWh. Total capital costs for the 445,500 WTGS feasible at 6¢/kWh was \$3.6 billion. Total capital costs for the 991,700 WTGS feasible at 8¢/kWh was \$10.0 billion. Total net annual savings was \$68.7 million at 6¢/kWh and \$335.2 million at 8¢/kWh. These results are shown in Table V-1.

It is evident based on the figures shown in Table V-1 that potential WTGS applications in U.S. agriculture will not become economically feasible until WTGS capital costs are reduced to levels more consistent with the low capital cost model and the cost of non-wind energy sources increases dramatically above 1977 levels. It should be emphasized, however, that this conclusion is strongly dependent on the economic and technical assumptions made. The WTGS low cost figures used will probably remain optimistic unless some unforeseen technical breakthrough is made. Further the load profiles assume extensive conversion from direct use of fossil fuels; natural gas, LP, diesel, fuel oil, and gasoline to electricity for stationary load readily converted to electricity. Most of the other assumptions have been conservative, however. A discount rate of 10% was assumed, which does not consider the possibility of low interest government loans. Such loans made the rural electrification economically feasible 40 years ago and would make a big difference in the economics of wind power today. It was further assumed that any surplus electricity generated would be wasted, when actually it might have some value if fed back into the utility grid.

1. Scenario 5: Low WTGS Capital Costs, Price of Alternative Energy Equivalent to 6¢/kWh

This scenario characterizes the expected earliest market entry for agricultural use of WTGS's. Characteristics of potential applications that are economically feasible under the low WTGS capital cost and 6¢/kWh assumptions show a certain distribution by size and rated power and use by type of farm.

a. Number of Economically Feasible Wind Turbine Applications

As stated previously, when low WTGS capital costs and 6¢/kWh alternate energy costs were assumed 445,500 potential applications were economically feasible. This is 25 percent of the total 1,781,000 potential applications considered. The number of feasible applications by state are tabulated in Table V-2. Iowa with 137,300 feasible applications in the leading state, followed by Kansas with 77,700 and Nebraska with 61,600. The leading

Table V-1. Estimated number, capital cost, and energy generated and used and annual net savings of economically viable WTGS's in U.S. agriculture.

Scenario	Description		Number of feasible WTGS applications in U.S. Agriculture (number)	Capital Cost (million)	Energy Generated and Used		Annual Net Savings (million)
	WTGS Capital Cost	Alternate Energy Cost			Amount (billion kWh)	Value (million)	
1	high	\$.04/kWh	none	none	none	none	none
2	high	\$.06/kWh	none	none	none	none	none
3	high	\$.08/kWh	none	none	none	none	none
4	low	\$.04/kWh	none	none	none	none	none
5	low	\$.06/kWh	445,500	\$ 3,600	9.4	\$ 564.0	\$ 68.7
6	low	\$.08/kWh	991,700	\$10,000	21.1	\$1,688.0	\$335.2

Source: DPRA estimate

feasible applications in these states were for nonirrigated crops, livestock and miscellaneous farms and farmhouse (residence) only. These details are found in Appendix C - Technical and Economic WTGS Performance Data.

b. Aggregate Energy Conversion Potential

Iowa, Nebraska, North Dakota and Kansas led in the aggregate wind energy generated and used with 2.97, 1.31, 1.15 and 1.14 billion kWh, respectively. Aggregate wind energy generated and used on all farms for all feasible applications totaled 9.4 billion kWh. This is depicted by Table V-2, which shows the aggregate energy generated and used by state. Table V-3 indicates which categories were feasible by indicating a quantity of energy generated and used by farm application category and by state.

These results are based on the assumption that all farm energy needs that could be electrical were electrical, except farm vehicle and other nonstationary items not readily converted to electricity. In practice this would involve extensive conversion of space heating, crop drying, and similar stationary items commonly powered directly by fossil fuels to convert to electricity.

Aggregate annual net savings of all feasible WTGS was computed as the value of the energy generated less annual WTGS costs summed over all feasible applications. This totaled \$68.7 million for all applications. The category totals by state are shown in Table V-4. State totals were shown in Table V-2.

c. Generator and Wind Machine Size Characteristics

The optimum WTGS rated power and rated speed were determined for each representative feasible application. The total number of economically feasible WTGS applications by optimum system size (rated power and rated speed) are shown in Table V-5.

The analysis showed that when low WTGS capital costs and \$.06/kWh alternative fuel costs were assumed, 280,800 applications were optimized with a 10 kW generator with a rated wind speed of 9 or 10 meters per second. With a 15 kW generator rated at 9 meters per second, 90,600 applications were optimized. None of the applications were optimized with generators rated at 1, 5 or 100 kW.

Estimated aggregate cost of the 445,500 WTGS's to purchasers is \$3.6 billion, for an average cost of \$8140 each (low cost model).

Also, all of the feasible applications were for complete farm applications with combined potential electrical loads for residential and farm functions. None of the dedicated use (irrigation) applications were economically feasible. Table V-6 shows the optimum rated power (P) and rated wind speeds (S) for each feasible application category. Detailed technical and economic performance characteristics of these WTGS's for individual applications are tabulated in Appendix D.

Table V-2. Summary for electricity cost of 6¢/kWh and low WTGS cost by states

No.	State	Number of potential applications (000)	Number of feasible WTGS's (000)	Potential electrical load (billion kWh)	Aggregate wind energy generated and used (billion kWh)	Aggregate annual net savings (\$ million)
1	Colorado	34.5	26.5	2.67	0.53	3.58
2	Idaho	35.7		3.72		
3	Illinois	125.9		9.49		
4	Indiana	106.1	2.8	6.85	0.08	0.35
5	Iowa	137.9	137.3	9.62	2.97	17.87
6	Kansas	94.2	77.7	6.34	1.14	5.71
7	Maine	7.6	1.0	.51	0.03	0.06
8	Maryland	17.8		1.05		
9	Michigan	80.0	1.4	5.19	0.05	0.29
10	Minnesota	118.1		7.74		
11	Missouri	139.0	45.7	7.76	0.91	4.97
12	Montana	24.7		1.69		
13	Nebraska	75.5	61.6	5.62	1.31	14.62
14	New Jersey	8.0	1.0	.52	0.03	0.04
15	New York	57.5		3.32		
16	North Dakota	41.6	41.2	3.81	1.15	10.05
17	Ohio	116.9		7.28		
18	Oklahoma	89.0		4.90		
19	Pennsylvania	71.0	3.4	4.36	0.10	0.20
20	South Dakota	43.4	42.7	3.10	0.97	9.11
21	Texas	234.8	3.2	16.58	0.16	1.92
22	Wisconsin	106.1		6.56		
23	Wyoming	9.9		.74		
TOTAL		1,775.1	445.5	119.42	9.40	68.7

Total cost of the 445,500 WTGS's to purchasers is estimated at \$3.6 billion for an average cost of \$8,140 each.

Source: DPRA estimates.

Table V-3 Aggregate energy (billion kWh) generated and used by farm application category in the wind states (electricity cost is 6¢/kWh and low WTGS cost)

#	STATE	NONIRRIGATED CROPS			IRRIGATED CROPS					FRUIT, NUT, VEGETABLE (ALL)	POULTRY AND EGGS (ALL)	DAIRY			LIVESTOCK			RESIDENCE ONLY
		S	M	L	UNIT TYPE							S	M	L	S	M	L	
		<180	190- 200	>200	1	2	3	4	5			<20	20- 250	>250	<75	75- 225	>225	
1	COLORADO	0.02	0.00	0.00								0.00	0.01	0.01	0.07	0.11	0.05	0.24
2	IDAHO																	
3	ILLINOIS																	
4	INDIANA										0.08							
5	ICHA	0.30	0.46	0.01								0.07	0.11	0.01	0.52	0.79	0.14	0.58
6	KANSAS	0.11	0.20	0.05								0.03	0.05	0.01	0.18	0.15	0.04	0.34
7	MAINE										0.03							
8	MARYLAND																	
9	MICHIGAN										0.05							
10	MINNESOTA																	
11	MISSOURI											0.07	0.01		0.46	0.35	0.03	
12	MONTANA																	
13	NEBRASKA	0.06	0.15	0.03								0.02	0.03	0.01	0.27	0.39	0.11	0.23
14	NEW JERSEY										0.03							
15	NEW YORK																	
16	NORTH DAKOTA	0.04	0.35	0.40								0.02	0.02	0.00	0.08	0.08	0.02	0.13
17	OHIO																	
18	OKLAHOMA																	
19	PENNSYLVANIA										0.10							
20	SOUTH DAKOTA	0.03	0.09	0.08								0.02	0.04	0.00	0.16	0.32	0.06	0.16
21	TEXAS										0.16							
22	WISCONSIN																	
23	WYOMING																	

TOTAL ENERGY GENERATED AND USED ON ALL FARMS = 9.4 BILLION KWH.
VALUE AT \$0.06/KWH = \$ 0.57 BILLION.

Table V-4 Aggregate annual net savings (\$ million) by farm application category in the wind states. (electricity cost is 6¢/kWh and low WTGS cost)

#	STATE	NONIRRIGATED CROPS			IRRIGATED CROPS					FRUIT, NUT, VEGETABLE (ALL)	POULTRY AND EGGS (ALL)	DAIRY			LIVESTOCK			RESIDENCE ONLY
		S	M	L	UNIT TYPE							S	M	L	S	M	L	
		<180	180- 500	>500	1	2	3	4	5			<20	20- 50	>50	<75	75- 325	>325	
1	COLORADO	0.1	0.0	0.0								0.0	0.1	0.1	0.8	1.2	0.4	0.8
2	IDAHO																	
3	ILLINOIS										0.3							
4	INDIANA																	
5	IOWA	0.9	1.5	0.0								0.3	0.5	0.1	3.8	8.5	1.8	0.4
6	KANSAS	0.6	1.2	0.4								0.2	0.3	0.1	1.0	0.9	0.3	0.7
7	MAINE										0.1							
8	MARYLAND																	
9	MICHIGAN										0.3							
10	MINNESOTA																	
11	MISSOURI											0.0	0.0		1.9	2.7	0.3	
12	MONTANA																	
13	NEBRASKA	0.5	1.3	0.3								0.2	0.3	0.1	3.3	5.3	1.7	1.7
14	NEW JERSEY										0.0							
15	NEW YORK																	
16	NORTH DAKOTA	0.5	3.4	3.0								0.2	0.2	0.0	0.8	0.7	0.2	1.0
17	OHIO																	
18	OKLAHOMA																	
19	PENNSYLVANIA										0.2							
20	SOUTH DAKOTA	0.3	0.9	0.6								0.3	0.4	0.0	1.6	3.0	0.7	1.2
21	TEXAS										1.9							
22	WISCONSIN																	
23	WYOMING																	

TOTAL ANNUAL NET SAVINGS ON ALL FARMS = \$ 68.7 MILLION.

Table V-5. Number in thousand of optimum wind turbine systems
by generator rating and rated speed (Scenario 5 conditions:
low WTGS cost, electricity cost 6¢/kWh)

Generator rating (kW)	<-----Rated speed (m/s)----->				Total
	<u>7</u>	<u>8</u>	<u>9</u>	<u>10</u>	
1					
5					
10			154.5	126.3	280.8
15	1.4	16.1	90.6	3.4	111.5
25		3.2		35.6	38.8
35				3.0	3.0
50				11.4	11.4
100					
TOTAL	<u>1.4</u>	<u>19.3</u>	<u>245.1</u>	<u>179.7</u>	<u>445.5</u>

Source: DPRA estimates.

Table V-6. Rated power (kW) and speed (m/s) of optimal discretized WTGS by farm application category in the wind states. (electricity cost is 6¢/kWh, low WTGS cost)

STATE		NONIRRIGATED CROPS			IRRIGATED CROPS			UNIT TYPE	FRUIT, NUT, VEGETABLE	POULTRY AND EGGS	DAIRY			LIVESTOCK			RESIDENCE ONLY
		S	M	L	S	M	L				S	M	L	S	M	L	
1 COLORADO	P	10	10	10							10	10	10	25	35	50	10
	S	10	10	9							9	9	9	10	10	10	10
2 CALIF	P																
	S																
3 ILLINOIS	P																
	S																
4 INDIANA	P									15							
	S									8							
5 IOWA	P	15	25	25							10	10	15	10	15	15	10
	S	9	10	10							9	9	9	9	9	8	9
6 KANSAS	P	10	10	10							10	10	10	10	10	10	10
	S	10	10	10							9	9	9	10	10	10	10
7 MAINE	P									15							
	S									8							
8 MARYLAND	P																
	S																
9 MICHIGAN	P									15							
	S									7							
10 MINNESOTA	P																
	S																
11 MISSOURI	P										10	10		10	15	15	
	S										9	9		9	9	8	
12 MONTANA	P																
	S																
13 NEBRASKA	P	10	10	10							10	10	15	10	15	15	10
	S	9	9	9							9	9	9	9	9	8	10
14 NEW JERSEY	P									15							
	S									8							
15 NEW YORK	P																
	S																
16 NORTH DAKOTA	P	15	25	30							10	10	15	10	15	15	10
	S	10	10	10							9	9	9	9	9	9	10
17 OHIO	P																
	S																
18 OKLAHOMA	P																
	S																
19 PENNSYLVANIA	P									15							
	S									8							
20 SOUTH DAKOTA	P	15	25	30							10	10	15	10	15	15	10
	S	10	10	10							9	9	9	9	9	9	10
21 TEXAS	P									25							
	S									8							
22 WISCONSIN	P																
	S																
23 WYCHING	P																
	S																

P - rated power

S - rated speed

Source: DPRA estimates

2. Scenario 6: Low WTGS Capital Costs, Price of Alternative Energy Equivalent to 8¢/kWh

This scenario illustrates the number and characteristics of WTGS's and their application that might be expected given the low WTGS capital cost and \$.08/kWh assumptions.

a. Number of Economical Wind Turbine Applications

When low WTGS capital costs and 8¢/kWh alternative energy costs were assumed, 991,700 potential applications were economically feasible. This represents 55 percent of the total 1,781,600 potential agricultural applications considered. Under these conditions the states with the most feasible applications were Texas with 187,700, Missouri with 138,800 and Iowa with 137,300. The higher assumed alternative energy cost (8¢/kWh from 6¢/kWh) allowed a larger number of feasible applications and created some interesting market dynamics. For example in most states the number of feasible applications increased with the high alternative energy cost assumption. The most dramatic increases were in Texas, Missouri, Illinois, Indiana, Michigan, Minnesota, Montana, Ohio, and Oklahoma. The combination of wind and load characteristics brings feasibility to these states after the higher wind states such as Iowa, Kansas, Nebraska, Colorado, North and South Dakota. These market dynamics trends can be seen by comparing Table V-2 with Table V-7.

b. Aggregate Wind Energy Conversion Potential

Given alternative energy costs equivalent to 8¢ per kWh, aggregate wind energy generated and used by feasible applications totals 21.1 billion kWh. State totals for aggregate wind energy generated and used are shown in Table V-7. At 8¢/kWh the leading states are Iowa, Missouri, Texas, Nebraska, Kansas, North Dakota, South Dakota, Illinois, and Oklahoma. Aggregate totals by farm type-size categories are shown in Table V-8.

These results are based on the assumption that all farm energy needs that could be electrical were electrical except farm vehicles and other non-stationary items not readily converted to electricity. In practice this would involve extensive conversion of space heating, crop drying, and similar stationary items commonly powered directly by fossil fuels to convert to electricity.

Aggregate annual net savings by state is shown in Table IV-7 and by farm-type-size category in Table V-9. The leading states in terms of annual net savings were Iowa, Missouri, Nebraska, North Dakota, Kansas and South Dakota.

c. Generator and Wind Machine Size Characteristics

The number of economically feasible WTGS's assuming 8¢ per kWh alternative energy, is shown in Table V-10 by optimum system size, i.e., rated power and rated wind speed.

Table V-7. Summary for electricity cost of 8¢/kWh and low WTGS cost by states.

#	State	Number of potential applications (000)	Number of feasible WTGS's (000)	Potential Electrical Load (billion kWh)	Aggregate wind energy generated and used (billion kWh)	Aggregate annual net savings (\$ million)
V-17	1 Colorado	34.5	26.5	2.67	0.62	15.71
	2 Idaho	35.7		3.72		
	3 Illinois	125.9	58.2	9.49	1.18	2.60
	4 Indiana	106.1	37.3	6.85	0.75	3.83
	5 Iowa	137.9	137.3	9.62	3.99	90.91
	6 Kansas	94.2	77.7	6.34	1.52	32.68
	7 Maine	7.6	1.0	.51	0.05	0.88
	8 Maryland	17.8	1.5	1.05	0.05	0.84
	9 Michigan	80.0	17.8	5.19	0.40	2.73
	10 Minnesota	118.1	12.8	7.74	0.29	0.12
	11 Missouri	139.0	138.8	7.76	2.92	53.04
	12 Montana	24.7	12.6	1.69	0.29	2.63
	13 Nebraska	75.5	61.6	5.62	1.64	44.22
	14 New Jersey	8.0	2.4	.52	0.08	0.97
	15 New York	57.5		3.32		
	16 North Dakota	41.6	41.2	3.81	1.44	36.63
	17 Ohio	116.9	41.8	7.28	0.73	1.42
	18 Oklahoma	89.0	82.8	4.90	1.07	1.87
	19 Pennsylvania	71.0	4.2	4.36	0.18	3.01
	20 South Dakota	43.4	42.7	3.10	1.26	31.46
	21 Texas	234.8	187.7	16.58	2.55	9.04
	22 Wisconsin	106.1	3.6	6.56	0.06	0.01
	23 Wyoming	9.9	2.2	.74	0.07	0.62
	TOTAL	1,775.1	991.7	119.42	21.1	335.2

Total cost of the 991,700 WTGS's to purchasers is estimated at \$10.0 billion for an average cost of \$10,084 each.

Source: DPRA estimates.

Table V-8 Aggregate energy (billion kWh) generated and used by farm application category in the wind states (electricity cost is 8¢/kWh and low WTGS cost)

#	STATE	NONIRRIGATED CROPS			IRRIGATED CROPS					FRUIT, NUT, VEGETABLE (ALL)	POULTRY AND EGGS (ALL)	DAIRY			LIVESTOCK			RESIDENCE ONLY
		S	M	L	1	2	3	4	5			S	M	L	S	M	L	
		<180	180-	>2500								<20	20-	>50	<75	75-	>225	
1	COLORADO	0.02	0.00	0.00								0.00	0.01	0.01	0.09	0.13	0.05	0.29
2	IDAHO																	
3	ILLINOIS		0.65	0.03										0.01	0.24	0.19	0.06	
4	INDIANA		0.25	0.02							0.10			0.01	0.27	0.08	0.01	
5	IOWA	0.40	0.69	0.02								0.10	0.17	0.02	0.77	0.97	0.17	0.69
6	KANSAS	0.14	0.28	0.08								0.04	0.06	0.02	0.25	0.21	0.06	0.41
7	MAINE										0.05							
8	MARYLAND										0.05						0.00	
9	MICHIGAN		0.11	0.00						0.09	0.07			0.02	0.08	0.02	0.01	
10	MINNESOTA		0.26	0.02										0.02				
11	MISSOURI	0.20	0.33	0.03								0.18	0.11	0.02	0.56	0.42	0.04	1.05
12	MONTANA	0.02	0.04	0.07											0.04	0.09	0.04	
13	NEBRASKA	0.07	0.18	0.04								0.03	0.05	0.01	0.34	0.46	0.13	0.34
14	NEW JERSEY									0.03	0.05							
15	NEW YORK																	
16	NORTH DAKOTA	0.07	0.42	0.47								0.03	0.03	0.00	0.11	0.09	0.03	0.19
17	OHIO		0.17	0.01								0.12	0.12	0.02	0.21	0.08	0.01	
18	OKLAHOMA	0.04	0.05	0.01								0.01	0.03	0.01	0.10	0.08	0.01	0.72
19	PENNSYLVANIA										0.17				0.01	0.00		
20	SOUTH DAKOTA	0.04	0.11	0.10								0.03	0.05	0.01	0.23	0.37	0.08	0.23
21	TEXAS	0.06	0.17	0.05							0.19	0.01	0.03	0.04	0.17	0.09	0.01	1.68
22	WISCONSIN													0.05			0.00	
23	WYOMING														0.02	0.02	0.03	

TOTAL ENERGY GENERATED AND USED ON ALL FARMS = 21.1 BILLION KWH.
VALUE AT \$0.08/KWH = \$ 1.69 BILLION.

Source: DPRA estimates.

Source:

Table V-9 Aggregate annual net savings (\$ million) by farm application category in the wind states. (electricity cost is 8¢/kWh and low WTGS cost)

#	STATE	NONIRRIGATED CROPS			IRRIGATED CROPS					FRUIT, NUT, VEGETABLE (ALL)	POULTRY AND EGGS (ALL)	DAIRY			LIVESTOCK			RESIDENCE ONLY
		S	M	L	UNIT TYPE							S	M	L	S	M	L	
		<180	180- 500	>500	1	2	3	4	5			<20	20- 50	>50	<75	75- 225	>225	
1	COLORADO	0.4	0.1	0.1								0.1	0.3	0.3	2.5	3.8	1.8	6.3
2	IDAHO																	
3	ILLINOIS		0.3	0.0										0.0	0.7	1.0	0.6	
4	INDIANA		0.1	0.0							2.4			0.0	0.7	0.5	0.1	
5	ICWA	8.7	14.2	0.3								2.1	3.5	0.4	17.4	26.9	4.8	12.7
6	KANSAS	3.2	5.9	1.7								0.9	1.3	0.4	5.2	4.5	1.3	8.2
7	MAINE										0.9							
8	MARYLAND										0.8						0.0	
9	MICHIGAN		0.0	0.0						0.7	1.6			0.0	0.2	0.1	0.1	
10	MINNESOTA		0.1	0.0										0.0				
11	MISSOURI	3.4	5.4	0.4								2.7	1.9	0.3	12.2	10.4	0.9	15.6
12	MONTANA	0.1	0.1	0.3											0.6	1.1	0.4	
13	NEBRASKA	1.8	4.5	1.0								0.8	1.1	0.2	9.6	13.9	3.9	7.4
14	NEW JERSEY									0.2	0.8							
15	NEW YORK																	
16	NORTH DAKOTA	1.7	11.4	11.9								0.6	0.7	0.1	2.7	2.4	0.7	4.4
17	OHIO		0.1	0.0								0.0	0.1	0.0	0.6	0.4	0.1	
18	OKLAHOMA	0.2	0.2	0.0								0.1	0.2	0.1	0.5	0.4	0.1	0.1
19	PENNSYLVANIA										3.0					0.0	0.0	
20	SOUTH DAKOTA	1.0	3.0	2.5								0.8	1.3	0.2	5.5	9.6	2.1	5.3
21	TEXAS	0.3	0.8	0.2							5.6	0.0	0.2	0.4	0.9	0.4	0.1	0.1
22	WISCONSIN													0.0			0.0	
23	WYOMING														0.2	0.2	0.2	

TOTAL ANNUAL NET SAVINGS OF ALL FARMS = \$ 335.2 MILLION.

Source: DPRA estimates.

Table V-10. Number in thousands, of wind turbine systems by generator rating and rated speed: (electricity cost is 8¢/kWh and low WTGS cost)

Generator Rating (kW)	<-----Rated Speed (m/s) ----->				Total
	<u>7</u>	<u>8</u>	<u>9</u>	<u>10</u>	
10	1.4	275.6	363.4		640.4
15	15.1	151.6	19.0		185.7
25	10.0		106.4		116.4
35			35.5		35.5
50		0.8	11.9		12.7
100				<u>1.0</u>	<u>1.0</u>
TOTAL	26.5	428.0	536.2	1.0	991.7

Source: DPRA estimates.

The 10 kW generator according to the assumptions made in Scenario 6 represents 65% (640,400 units) of the total generator sizes and this size is further divided into three wind speeds of 7, 8, and 9 meters per sec.. The smaller sizes of 1 kW and 5 kW were also analyzed but neither were economically optimum sizes.

A total of 185,700 units, 19% of the total, were identified as the 15 kW size. These 15 kW generators also were divided into 3 wind speeds as were the 10 kW generators.

The remaining WTGS's were divided into 25, 35, 50, and 100 kW sizes with 12% (116,400), 4% (35,500), 1% (12,700) and 0.1% (1,000) units, respectively. Only the 100 kW size required a turbine with a rated speed of 10 meters per second wind speed.

These 991,700 WTGS's represent a total investment cost of \$10.0 billion using the low cost WTGS option.

The details as to which discrete sized generators and wind speed turbines were optimally feasible for category farms are shown in Table V-11. None of the dedicated applications, i.e., irrigation, were feasible at the assumed purchase power rate of 8¢ per kWh.

C. Sensitivity of Results to Differing Heating and Cooling Load

The number, location, and optimum size of WTGS's depended on the magnitude of the farmhouse (residence) heating and cooling load. To assess this sensitivity, "residence only" applications in each of the 23 wind states were simulated with residence heating and cooling loads at 100 and 150% of the levels reported in Appendix B.

Study constraints required that the heating and cooling load sensitivity analysis be limited to the "residence only" category for which heating and cooling was the principal load component (along with appliances but no farm load). WTGS feasibility for other farm type categories, which include a relatively small and seasonal farm load relative to the residential heating and cooling load such as "winter wheat and sorghum" and "potatoes," would also likely be sensitive to the residential heating and cooling variation, but these were not analyzed. Results of this sensitivity analysis are presented in Table V-12.

1. WTGS Size

At the 100 percent heating and cooling load, all feasible "residence only" applications are optimized with a WTGS rated power of 10 kW and rated speed of 8, 9 or 10 m/s. When the heating and cooling load was increased to 150 percent, the optimum (discretized) WTGS rated power increased in most cases from 10 to 15 kW. Rated speeds decreased in most cases from either 9 to 8 or 10 to 9 m/s.

Table V-11. Rated power (kW) and speed (m/s) of optimal discretized WTGS by farm application category in the wind states. (electricity cost is 8¢/kWh and low WTGS cost)

STATE	NONIRRIGATED CROPS			IRRIGATED CROPS			UNIT TYPE	FRUIT, NUT, VEGETABLE (ACRE)	POULTRY AND EGGS (ALL)	DAIRY			LIVESTOCK			RESIDENCE ONLY
	S	M	L	S	M	L				S	M	L	S	M	L	
1 COLORADO	P 10 S 8	10 8	10 8							15 9	15 9	15 9	25 9	35 9	100 10	10 9
2 ILLINOIS	P S															
3 ILLINOIS	P S	25 9	35 9								10 8	10 8	10 8	15 7		
4 INDIANA	P S	25 9	35 9					15 7		10 8	10 8	10 8	15 7			
5 IOWA	P 25 S 9	35 9	50 8							15 8	15 8	15 8	15 8	15 8	15 7	10 8
6 KANSAS	P 10 S 9	10 8	10 8							15 9	15 9	15 8	10 8	10 8	10 8	10 9
7 MAINE	P S							25 7								
8 MARYLAND	P S							15 7							10 8	
9 MICHIGAN	P S	25 9	35 9					15 8	25 7		10 8	10 8	10 8	15 7		
10 MINNESOTA	P S	25 9	35 9								10 8					
11 MISSOURI	P 25 S 9	35 9	50 8							15 8	15 8	15 8	10 8	15 8	15 7	10 9
12 MONTANA	P 15 S 8	10 8	15 8										15 8	35 9	50 9	
13 NEBRASKA	P 10 S 8	10 8	10 8							15 8	15 8	15 8	15 9	15 8	15 7	10 8
14 NEW JERSEY	P S							10 7	25 7							
15 NEW YORK	P S															
16 NORTH DAKOTA	P 25 S 9	25 9	50 9							15 8	15 8	15 8	15 8	15 8	25 9	10 8
17 OHIO	P S	25 9	35 9							10 8	10 8	10 8	10 8	15 8	15 7	
18 OKLAHOMA	P 10 S 9	10 9	10 8							10 8	10 8	10 8	10 9	10 8	10 8	10 9
19 PENNSYLVANIA	P S							25 7					10 8	15 8		
20 SOUTH DAKOTA	P 25 S 9	25 9	50 9							15 8	15 8	15 8	15 8	15 8	25 9	10 8
21 TEXAS	P 10 S 9	10 9	10 8					25 7		10 8	10 8	10 8	10 9	10 8	10 8	10 9
22 WISCONSIN	P S										10 8				15 9	
23 WYOMING	P S												15 8	35 9	50 9	

P = Rated power

S = Rated speed

Source: DPRA estimates

Table V-12. Optimum "residence only" WTGS size at 100 and 150 percent heating and cooling load and 6, and 8 cents per kWh by state, low WTGS costs

Cost of purchased electricity: Heating load:		6¢/kWh				8¢/kWh			
State	Number of "residence only" farms <u>1/</u> (000)	100%		150%		100%		150%	
		Rated power (kW)	Rated speed (m/s)	Rated power (kW)	Rated speed (m/s)	Rated power (kW)	Rated speed (m/s)	Rated power (kW)	Rated speed (m/s)
Colorado ^{2/}	17.3	10	10	10	9	10	9	15	9
Idaho	13.4								
Illinois	38.2							10	8
Indiana	44.2							10	8
Iowa	34.3	10	9	10	8	10	8	15	8
Kansas	24.0	10	10	10	9	10	9	15	9
Maine	4.4								
Maryland	10.5								
Michigan	40.0							10	8
Minnesota	46.3							10	8
Missouri	69.7					10	9	15	9
Montana	11.9							15	9
Nebraska	15.5	10	10	15	9	10	8	15	8
New Jersey	4.4								
New York	36.5								
North Dakota	8.8	10	10	15	9	10	8	15	8
Ohio	62.5							10	8
Oklahoma	59.6					10	9	10	8
Pennsylvania	44.1								
South Dakota	10.6	10	10	15	9	10	8	15	8
Texas	140.4					10	9	10	8
Wisconsin	41.0							10	8
Wyoming	6.0							10	8

1/ From Table III-7.

2/ WTGS were found feasible at 4 cents per kWh only for Colorado "residence only" applications and then only when heating and cooling load was 150 percent.

Source: DPRA estimates.

2. Number and Location of Feasible "Residence Only" WTGS Applications

At 4 cents per kWh no "residence only" applications were economically feasible at 100 percent heating and cooling load. At 150 percent heating and cooling load the Colorado "residence only" application became feasible. This represents 17,300 farms.

At 6 cents per kWh "residence only" applications were economically feasible for Colorado, Iowa, Kansas, Nebraska, North Dakota and South Dakota at both 100 and 150 percent heating and cooling loads. These states collectively represent 110,500 "residence only" farms. Increasing the heating and cooling load from 100 to 150 percent at 6 cents per kWh did not affect the number or location of feasible "residence only" WTGS applications.

At 8 cents per kWh and 100 percent heating and cooling load, model "residence only" applications were economically feasible for Colorado, Iowa, Kansas, Missouri, Nebraska, North Dakota, Oklahoma, South Dakota and Texas. Collectively these states represent 380,200 "residence only" farms. When the heating and cooling load was increased from 100 to 150 percent at 8 cents per kWh, "residence only" applications also became feasible in Illinois, Indiana, Michigan, Minnesota, Montana, Ohio, Wisconsin and Wyoming. These states add 290,100 feasible applications for a total of 670,300 economically feasible "residence only" applications.

D. Sensitivity of Results to Differing Duration of Irrigation Loads

Wind turbine generator systems dedicated to continuous irrigations loads during three summer months (91.25 days) were not economically competitive with 4, 6, or 8 cents per kWh purchased electricity, but WTGS's can become competitive against purchased electricity as the dedicated load duration increases.

The minimum number of irrigation days required for economic feasibility of optimally sized WTGS's for selected irrigation applications are shown in Table V-13. The selected irrigation applications represent approximately 85,000 or 75 percent of the estimated 113,000 potential irrigation applications in the 23 high wind states. The selected applications include high wind regions I, IV, and V covering Idaho, Kansas, Colorado, Nebraska, Oklahoma, and Texas. The selected loads range from 60 to 90 kW.

The 60 to 90 kW loads represent the irrigation applications selected, but they could represent any operation requiring 60 to 90 kW during spring and summer. It is also assumed that the load occurs during 91.25 summer days and a variable number of spring days.

Table V-13. Optimum WTGS size and minimum number of irrigation days required for economic feasibility of selected irrigation system types and locations (4, 6 and 8 cents per kwh, low WTGS capital costs)

System type- location	Wind region	Load	Approximate number of irrigation systems	4¢			6¢			8¢		
				Rated power	Rated speed	Minimum load duration ^{1/}	Rated power	Rated speed	Minimum load duration	Rated power	Rated speed	Minimum load duration ^{1/}
		(kW)	(000)	(kW)	(m/s)	(days)	(kW)	(m/s)	(days)	(kW)	(m/s)	(days)
Center pivot:												
Texas	6	90	4.0	--	--	>182	100	8	152	100	7	126
Nebraska	5	80	13.6	100	10	176	100	8	134	100	7	114
Colo-Kans.	5	60	9.4	--	--	>182	100	9	145	100	8	122
Hand move:												
Idaho	1	70	10.0	--	--	>182	--	--	>182	100	9	159
Texas	6	70	6.4	--	--	>182	100	9	165	100	7	140
Grated pipe:												
Tex-Okla.	6	70	29.9	--	--	>182	100	9	165	100	7	140
Colo-Kans.	5	60	12.0	--	--	>182	100	9	145	100	8	122
			85.3									

^{1/} Includes 91.25 summer days plus a variable number of spring days. Number of spring days = minimum feasible season length - 91.25.
Source: DPRA estimates.

For each application the minimum load duration decreases as the cost of purchased electricity increases. For example, a WTGS for Nebraska center pivot irrigation (wind region IV, 80 kW continuous load while operating) requires a minimum irrigating season of 176 days at 4 cents per kWh, 134 days at 6 cents per kWh and 114 days at 8 cents per kWh. Less use is required to recover the capital costs for the WTGS when alternative energy costs are higher; hence, the shorter minimum load duration per irrigation season. These results indicate that 100 kW WTGS's would likely be economically feasible for 80 kW loads in wind region IV if the application load duration were equal to or greater than 176, 134, or 114 summer and spring days at 4, 6 and 8 cents per kWh or equivalent alternate energy costs, respectively.

Similar results are shown for the other selected applications. At 60 kW load in wind region IV requires a minimum load duration of 145 days at 6 cents per kWh and 122 days at 8 cents per kWh. At 4 cents per kWh, the minimum load duration exceeds 182 days. Continuous seasonal loads of 70 to 90 kW in wind regions I and V show comparable results.

E. Conclusion

The data presented shows that a market for wind turbine generator systems in the United States exists only under very specific conditions. A major constraint on that market is the low cost of alternative energy sources as compared to the annualized cost of owning and operating a wind turbine generating system with free wind.

Adequate wind exists for WTGS's in many agricultural areas. The electrical loads on a large number of farms in these wind regions are certainly adaptable to wind-generated electricity but the attractive economic opportunity for use of WTGS's begins to show up only when alternative electrical energy or its equivalent is priced at 6 to 8 cents per kilowatt hour.

Following are some of the factors that influence the market size for WTGS as they relate to the wind, the load, the alternative energy cost and the WTGS investment and operating costs.

1. The Wind

In the beginning this study was limited to states whose annual wind power density averaged greater than 100 watts per square meter. However, many of the states with winds that exceed this figure still do not have adequate wind for economical generation of electricity so that, as a general conclusion, only North and South Dakota, Kansas, Nebraska, Colorado, Iowa, Missouri, Texas, Minnesota and Oklahoma show any significant potential for wide application of wind turbine generating systems.

These ten states represent 97 percent of the market for 445,500 units that are feasible when purchased electricity is priced at 6 cents per kilowatt hour. At 8 cents per kilowatt hour, the ten states represent 80 percent of the market estimated to be 991,700 units. Thus from a marketing standpoint the potential wind turbine generating system market lies in the High Plains area from Texas to North Dakota.

Local high wind regions such as those in south-central Wyoming, southwest Kansas, and the Texas and Oklahoma panhandles probably deserve additional detailed analysis on a crop reporting district or county basis with local wind speed profiles. A follow-up study of the wind potential in these areas should probably include nonagricultural as well as agricultural wind energy application potentials.

2. The Load

In analyzing the market figures from the standpoint of the load or the type of the farm that has this characteristic load, we find that the livestock farms produce the highest aggregate net annual savings, for those farms located in the best wind states. Nonirrigated crop farms that have drying and aeration loads also generally return better aggregate net annual savings than dairy or poultry farms.

Irrigated crop farms on which the irrigation load was figured as dedicated load were not economically feasible. The type of load essentially was based on a 90-day summer load, assuming a 24-hour day irrigation load operation. With this concentrated high kilowatt requirement, the net annual savings potential was not great enough to overcome the annualized costs of WTGS's. When irrigation systems were combined with a residential load on a year-around basis, then economic feasibility did exist. However, the optimum wind generator and turbine size were such that the amount of electricity generated essentially satisfied the residential load and only incidentally contributed to the load for irrigation.

3. Alternative Fuel Costs

The cost of alternative energy is probably the most dominant factor in determining the size of the market. As the data have shown, no cases were considered where wind turbine generating systems replaced other power sources that could be valued at the equivalent of 4 cents per kilowatt hour. Only when alternative energy cost 6 or 8 cents per kilowatt hour equivalent, did there appear to be an economic basis and justification for purchase and operation of wind turbine generating systems and then only when the low WTGS capital costs were assumed. The fact that alternate energy sources (purchased electricity and fossil fuels) at the time of this report, cost less than the 6 and 8 cents per kilowatt hour on which this work is predicated indicates that fuel pricing, availability, or some other factors would have to change drastically before wind turbine generating systems would be used to produce a substantial amount of the agricultural energy requirements.

4. WTGS Costs

Two levels of investment costs for wind generators and related equipment were evaluated. None of the high cost equipment was economically feasible under the various conditions tested. Only the lower capital costs showed some potential. The lower costs for various size WTGS's represent an optimistic blend of current prices for units now on the market, and estimated production costs for larger wind turbine systems that may be available within the next 2 to 5 years. If, however, these low and optimistic cost projections are, high and manufacturers can offer this equipment at prices below those used in the analysis, the market potential of wind turbine generating systems is greatly enhanced.

BIBLIOGRAPHY

- Carpenter, B.H., and H.C. Sweeny, "Process Improvement with Simplex Self-Directing Evolutionary Operation," Chemical Engineering, July 5, 1965.
- Coty, Ugo and Lou Vaugher, Effects of Initial Production Quantity and Incentives on the Cost of Wind Energy, Lockheed California Company, January 3, 1977.
- Eldridge, Frank R., Wind Machines, The Mitre Corp., U.S. Government Printing Office: 1976 O-204-143, October 1975.
- "Farm Costs and Returns, Commercial Farms by Type, Size and Location," U.S.D.A., ERS, Ag Info Bull No. 230, October, 1967.
- Justus, C.G., W.R. Hargraves, and Ali Yalcin, "Nationwide Assessment of Potential Output from Wind-powered Generators," Journal of Applied Meteorology, Vol. 15, No. 7, July 1976.
- Nelder, J.A. and R. Mead, "A Simplex Method for Function Minimization," Computer Journal, Vol. 7, 1964.
- Obermeier, John Lee, Wind Electric Power Generation in Montana, M.S. Thesis, Montana State University, Bozeman, March, 1976.
- Purner, S.S., and L. Icerman, Energy Vol. II - Non-Nuclear Technologies, Pergamon, 1976.
- Reed, Jack W., Wind Power Climatology of the United States, Sandia Laboratories, Albuquerque, New Mexico, 1975.
- Revised Uniform Summary of Surface Weather Observations: Part C, Surface Winds, National Climatic Center, Asheville, North Carolina, various selected stations.
- Rosen, George, Harry E. Deabler, and Donald G. Hall, "Economic Viability of Large Wind Generator Rotors," Proceedings of 10th Intersociety Energy Conversion Engineering Conference, University of Delaware, Newark, August 17-22, 1975.
- Spendley, W., G.R. Hext, and F.R. Himsforth, "Sequential Applications of Simplex Design in Optimization and Evolutionary Operations," Technometrics, Vol. 4, 1964.

TECHNICAL APPENDIX A

SEASON AND DIURNAL WIND VELOCITY FREQUENCY STATISTICS

<u>Region</u>	<u>States</u>	<u>Station</u>	<u>Page</u>
I	Idaho	Mountain Home, Idaho	A-2
II	Montana Wyoming	Glasgow, Montana	A-3
III	North Dakota South Dakota	Fargo, North Dakota Sioux Falls, South Dakota	A-4
IV	Colorado Kansas Nebraska	Wichita, Kansas	A-5
V	Oklahoma Texas	Dallas, Texas Lubbock, Texas	A-6
VI	Iowa Missouri	Des Moines, Iowa	A-7
VII	Illinois Indiana Michigan Minnesota Ohio Wisconsin	Rantoul, Illinois Columbus, Indiana Mount Clemens, Michigan Madison, Wisconsin	A-8
VIII	Maine Maryland New Jersey New York Pennsylvania	Brunswick, Maine Patuxent River, Maryland Syracuse, New York	A-9

Beta Distribution Parameters and Surface Wind Frequency Summary by Time of Day and Season for No. 1 Wind Category

22 Mountain Home, Idaho

SEASON	HOUR	ALPHA	BETA	V-MAX 1951	PERCENTAGE FREQUENCY OF WIND BY SPEED GROUP (KNOTS)									
					<-----	0.50	2.00	5.00	8.50	12.50	17.00	22.50	30.00	37.00
FALL														
	0	0.818	4.160	17.36	24.0	17.4	24.9	20.1	10.3	2.4	0.8	0.4		
	3	0.985	4.262	17.36	17.6	17.6	28.1	21.9	11.1	2.0	1.0	0.4		
	6	1.262	4.423	17.36	17.1	16.5	25.6	24.2	11.3	2.2	0.7	0.4		
	9	1.335	5.018	20.83	10.2	12.6	20.4	24.3	22.6	7.0	2.2	0.6	0.1	
	12	1.115	4.296	20.83	11.3	15.0	20.5	22.2	19.7	7.3	3.1	0.7	0.2	
	15	1.075	3.377	17.36	10.4	14.4	21.0	25.1	18.8	6.9	2.3	1.2		
	18	1.029	4.807	17.36	15.9	18.0	21.2	24.2	8.5	3.1	0.8	0.5		
	21	0.673	3.901	17.36	27.6	21.7	25.0	17.3	6.1	1.9	1.0	0.4		
WINTER														
	0	0.859	2.889	14.15	20.8	16.2	22.2	20.9	15.1	4.1	0.7			
	3	0.813	2.729	14.15	21.3	16.9	20.7	20.6	15.7	3.6	1.2			
	6	0.859	2.665	14.15	20.6	17.5	21.0	19.1	16.1	4.4	1.0			
	9	0.931	2.439	14.15	15.5	15.2	18.6	22.1	20.7	5.9	2.0			
	12	1.152	3.459	17.36	11.4	13.2	16.2	24.6	22.5	9.1	2.8	0.4		
	15	1.197	5.828	17.36	11.1	15.3	20.2	23.1	21.3	7.1	1.7	0.2		
	18	0.960	4.096	17.36	18.9	17.9	22.2	20.0	16.1	4.0	0.8	0.1		
	21	0.902	2.958	17.36	22.4	16.3	20.1	21.3	15.0	4.0	0.8	0.1		
SPRING														
	0	0.750	3.088	17.36	19.8	15.9	21.0	19.8	15.3	4.2	2.2	0.9		
	3	1.070	4.801	20.83	15.1	13.6	24.7	22.5	16.0	5.2	2.5	0.3	0.1	
	6	1.112	4.315	20.83	14.3	12.1	15.7	23.0	19.9	7.1	3.1	0.7	0.1	
	9	1.456	3.844	20.83	6.8	8.5	15.1	19.4	28.3	12.5	6.8	1.7	0.3	
	12	1.420	4.324	20.83	6.9	9.8	17.1	24.4	22.2	12.5	6.6	1.2	0.1	
	15	1.557	2.853	17.36	6.1	7.0	15.5	25.4	24.1	12.4	6.9	1.4		
	18	1.557	5.165	20.83	6.9	8.4	22.9	29.3	22.2	7.8	3.6	0.8	0.1	
	21	1.029	4.914	20.83	14.5	15.3	25.4	21.9	13.1	5.0	2.1	0.4	0.1	
SUMMER														
	0	0.925	4.910	17.36	21.3	18.6	27.0	19.9	10.5	2.0	0.6	0.1		
	3	0.955	3.939	14.15	18.9	18.5	28.5	22.1	9.7	1.7	0.6			
	6	0.942	3.185	14.15	18.4	16.0	25.1	22.3	13.5	3.3	0.9			
	9	1.309	4.590	17.36	13.3	13.5	19.5	28.9	19.7	3.8	1.3	0.1		
	12	1.286	5.116	17.36	12.2	16.0	25.1	27.9	14.0	3.1	0.8	0.2		
	15	1.633	6.058	20.83	8.4	10.0	21.5	28.7	23.0	5.8	1.6	0.3	0.1	
	18	2.057	5.324	17.36	5.7	6.7	16.4	32.6	30.4	6.2	1.5	0.2		
	21	1.256	5.436	17.36	13.1	13.0	34.7	25.4	9.7	2.7	0.9	0.3		

Beta Distribution Parameters and Surface Wind Frequency Summary by Time of Day and Season for No. 2 Wind Category

16 Glasgow, Montana

SEASON	HOUR	ALPHA	BETA	V-MAX 19751	PERCENTAGE FREQUENCY OF WIND BY SPEED GROUP (KNOTS)									
					0.50	2.00	5.00	8.50	13.50	19.00	24.50	30.00	37.00	44.00
FALL														
	0	1.277	2.786	14.15	13.2	5.8	31.1	29.2	13.4	3.2	1.1			
	3	1.346	4.019	14.15	13.4	9.8	21.9	35.0	14.9	1.9	1.1			
	6	1.570	7.134	20.83	12.8	9.0	21.2	24.2	16.2	2.3	1.0	0.2	0.1	
	9	1.974	4.825	17.36	4.5	4.9	20.3	31.9	20.4	6.2	3.1	0.5		
	12	2.423	6.066	20.83	2.5	1.8	11.7	33.7	31.7	10.2	5.4	1.4	0.1	
	15	2.005	5.848	20.83	3.2	5.6	11.5	32.1	28.1	6.5	5.1	0.9	0.1	
	18	1.786	6.536	17.36	8.0	8.7	3.5	30.5	10.7	3.1	0.4	0.1		
	21	1.759	8.497	20.83	10.9	8.2	3.1	32.5	12.2	2.0	1.0	0.0	0.1	
WINTER														
	0	1.572	5.747	20.83	8.1	7.6	2.4	29.4	22.5	5.5	1.4	0.7	0.4	
	3	1.658	4.755	17.36	7.8	7.4	2.4	28.9	23.3	5.5	2.0	0.2		
	6	1.534	4.614	17.36	9.5	7.0	2.3	30.0	22.4	3.7	2.0	0.6		
	9	1.534	6.544	24.56	8.4	6.0	2.5	35.1	23.1	4.7	2.0	0.4	0.0	0.1
	12	1.859	4.735	17.36	5.1	5.5	2.9	32.5	23.7	8.2	3.0	0.1		
	15	2.082	7.636	20.83	6.8	6.2	2.4	33.9	23.1	5.3	1.0	0.2	0.1	
	18	1.891	5.455	17.36	6.9	6.7	2.3	31.8	23.1	5.7	1.2	0.1		
	21	1.608	5.747	20.83	7.2	7.4	2.3	29.2	24.5	4.5	1.8	0.5	0.6	
SPRING														
	0	1.621	3.712	14.15	6.2	6.7	20.1	33.0	19.4	4.6	2.0			
	3	1.525	4.896	17.36	8.5	9.0	20.4	28.1	19.3	5.2	1.1	0.4		
	6	1.697	4.592	17.36	5.1	8.4	23.3	29.6	24.2	6.7	2.2	0.5		
	9	2.251	5.710	20.03	3.5	4.1	17.8	29.6	35.3	12.8	3.8	1.0	0.4	
	12	2.670	7.727	24.56	2.6	1.9	11.2	25.3	34.7	15.0	5.4	1.1	0.1	0.2
	15	2.327	5.432	20.83	1.6	2.1	11.7	25.8	36.3	13.0	5.9	1.4	0.5	
	18	1.863	4.841	17.36	3.5	5.4	20.1	28.0	24.4	6.9	3.0	0.7		
	21	1.775	5.259	17.36	6.0	6.2	21.8	28.6	21.7	6.3	1.1	0.2		
SUMMER														
	0	1.636	6.662	17.36	10.6	10.0	34.5	32.0	10.3	2.1	0.5	0.3		
	3	1.324	4.254	14.15	13.1	12.1	33.2	27.9	11.9	2.6	0.5			
	6	1.674	4.256	14.15	8.0	9.3	25.9	35.3	17.1	3.6	0.8			
	9	2.149	4.201	14.15	4.5	5.4	17.8	38.7	26.9	5.8	1.3			
	12	2.290	5.745	17.36	3.4	5.4	17.6	37.0	27.4	5.4	2.7	0.1		
	15	2.391	7.559	20.83	3.8	6.6	17.4	34.3	28.7	7.2	1.7	0.2	0.1	
	18	1.324	8.445	24.56	7.3	7.9	24.1	31.9	22.5	4.5	1.1	0.4	0.1	0.2
	21	1.862	9.080	20.83	7.7	10.4	34.8	32.0	12.7	1.7	0.2	0.4	0.1	

Beta Distribution Parameters and Surface Wind Frequency Summary by Time of Day and Season for No. 3 Wind Category

**15 Fargo, North Dakota
17 Sioux Falls, South Dakota**

SEASON	HOUR	ALPHA	BETA	V-MAX MPH	PERCENTAGE FREQUENCY OF WIND BY SPEED GROUP (KNOTS)									
					1.50	2.00	5.00	8.50	13.50	19.00	24.50	30.50	37.00	43.00
FALL	0	1.815	6.119	20.83	4.4	9.7	20.6	31.6	23.5	7.1	2.4	0.6	0.1	
	3	1.607	4.344	17.36	6.4	9.3	20.5	29.2	23.9	8.0	2.0	0.4		
	6	1.800	5.905	20.83	5.7	8.4	20.1	29.0	25.2	8.1	2.8	0.3	0.1	
	9	2.148	5.138	20.83	2.1	5.1	14.1	24.5	31.9	14.0	6.0	1.6	0.1	
	12	2.464	5.066	20.83	1.7	2.7	5.2	23.8	34.6	17.2	8.0	2.2	0.3	
	15	2.565	5.869	20.83	0.9	2.9	11.5	29.4	33.6	14.1	5.5	1.7	0.2	
	18	2.005	4.931	17.36	2.2	6.6	21.5	33.3	25.5	7.5	2.5	0.6		
	21	1.597	6.324	20.83	3.7	8.2	16.7	32.4	25.3	8.2	2.3	0.4	0.1	
WINTER	0	1.735	5.207	20.83	3.3	9.4	15.9	26.6	25.9	9.8	4.0	0.5	0.1	
	3	1.692	5.200	20.83	4.3	8.6	20.6	26.7	25.9	9.5	3.2	0.9	0.2	
	6	1.674	5.120	20.83	3.8	10.0	15.0	28.0	24.9	9.5	3.4	1.2	0.1	
	9	1.932	5.263	20.83	2.6	6.4	18.0	27.4	28.6	11.0	4.6	1.1	0.2	
	12	2.280	5.271	20.83	1.1	4.6	12.0	26.1	33.0	13.3	7.1	1.4	0.2	
	15	2.119	3.569	17.36	1.3	4.1	12.9	29.5	31.1	12.6	6.1	1.1		
	18	1.806	4.079	17.36	2.4	6.4	20.3	29.8	26.1	10.0	4.0	0.8		
	21	1.828	5.354	20.83	3.4	7.2	19.6	29.4	25.6	5.3	4.1	1.0	0.1	
SPRING	0	2.062	5.610	20.83	3.8	5.4	15.6	28.5	30.6	10.6	4.2	1.1	0.1	
	3	1.550	5.370	20.83	4.1	6.1	15.7	29.1	28.1	11.0	4.8	0.9	0.1	
	6	2.007	4.926	20.83	3.4	5.4	12.5	25.9	33.3	13.6	6.4	1.3	0.1	
	9	2.395	4.366	20.83	0.6	2.4	6.3	21.0	33.1	18.9	10.8	3.4	0.8	
	12	2.487	4.111	20.83	0.6	1.9	7.0	18.6	32.6	21.6	12.6	4.5	1.0	
	15	2.552	4.436	20.83	0.8	2.0	7.4	19.4	34.0	20.0	11.7	4.0	0.6	
	18	2.365	5.574	20.83	0.8	3.5	14.3	28.3	32.0	13.4	6.1	1.1	0.4	
	21	2.074	5.644	20.83	3.0	5.5	16.6	29.0	29.6	10.6	4.6	0.8	0.2	
SUMMER	0	1.645	4.346	14.15	7.2	12.1	26.1	32.6	18.5	2.6	0.8			
	3	1.775	6.510	17.36	8.0	12.5	20.5	30.9	17.3	2.0	0.5	0.1		
	6	1.952	6.146	17.36	5.7	11.0	23.5	33.2	22.0	3.8	0.6	0.1		
	9	2.503	6.181	17.36	2.0	5.0	17.9	32.9	32.7	7.0	1.3	0.2		
	12	2.719	5.804	17.36	1.5	4.7	14.1	29.2	38.1	9.7	2.3	0.2		
	15	2.663	6.147	17.36	1.1	4.3	14.5	33.0	35.9	8.4	2.4	0.2		
	18	2.576	7.138	17.36	1.5	6.7	24.9	36.3	24.9	4.3	1.0	0.1		
	21	1.799	4.444	14.15	4.5	11.5	26.6	33.6	19.3	3.6	0.7			

Beta Distribution Parameters and Surface Wind Frequency Summary by Time of Day and Season for No. 4 Wind Category

13 Wichita, Kansas

SEASON	HOUR	ALPHA	BETA	V-MAX (MPS)	PERCENTAGE FREQUENCY OF WIND BY SPEED GROUP (KNOTS)								
					<1.50	1.50-2.00	2.00-2.50	2.50-3.00	3.00-3.50	3.50-4.00	4.00-4.50	4.50-5.00	5.00-5.50
FALL													
	0	1.544	4.252	17.36	9.6	8.2	11.4	30.5	24.7	7.3	1.8	0.5	
	3	1.540	4.432	17.36	10.5	8.1	18.5	30.3	24.0	6.4	1.9	0.2	
	6	1.653	4.308	17.36	7.4	8.2	16.3	29.9	25.6	7.6	2.1	0.4	
	9	2.124	4.169	17.36	2.7	5.5	13.2	26.6	33.7	13.2	4.4	0.7	
	12	2.256	5.175	20.83	2.3	4.0	11.1	25.6	32.4	15.7	6.4	1.5	0.2
	15	1.999	3.755	17.36	2.8	4.6	13.7	26.7	30.5	14.8	6.2	0.7	
	18	1.383	2.907	14.15	9.9	8.9	18.1	27.7	26.1	7.9	1.5		
	21	1.513	4.162	17.36	10.9	7.5	17.3	28.3	26.2	7.0	2.2	0.3	
WINTER													
	0	1.575	3.746	17.36	6.3	7.5	17.5	28.7	24.9	11.0	3.4	0.7	
	3	1.526	3.773	17.36	7.1	7.7	19.4	26.4	25.9	9.3	3.8	0.4	
	6	1.544	3.730	17.36	6.9	8.2	17.3	26.1	26.6	10.6	3.2	0.5	
	9	1.837	3.668	17.36	3.7	6.2	14.5	25.6	29.8	14.7	4.6	0.9	
	12	1.993	3.539	17.36	2.2	5.3	12.4	24.4	31.4	16.4	6.9	1.3	
	15	2.080	3.576	17.36	2.3	4.8	14.2	27.0	31.3	14.2	5.6	0.6	
	18	1.557	3.857	17.36	6.3	8.3	20.0	27.8	23.3	10.7	3.4	0.2	
	21	1.588	3.766	17.36	6.4	7.4	17.5	29.0	23.6	12.0	3.8	0.3	
SPRING													
	0	1.600	3.364	17.36	5.9	6.2	15.1	26.9	26.8	13.1	5.7	0.7	
	3	1.975	5.395	20.83	5.2	5.4	15.5	26.5	30.2	12.0	4.3	0.3	0.1
	6	2.342	3.922	17.36	4.3	4.4	12.3	24.1	35.1	13.9	4.5	0.2	
	9	2.671	5.050	20.83	1.2	2.5	7.9	20.3	35.1	19.4	4.9	2.3	0.4
	12	2.806	6.381	24.56	3.4	2.3	7.9	19.8	33.3	20.4	11.5	3.4	0.5
	15	2.441	4.437	20.83	1.0	2.4	8.5	20.4	33.1	19.0	11.8	3.3	0.5
	18	2.055	5.168	20.83	3.2	4.8	14.7	27.5	29.0	13.9	5.6	1.1	0.2
	21	1.545	3.345	17.36	5.6	6.3	16.5	27.8	25.8	11.7	5.1	1.2	
SUMMER													
	0	1.844	4.078	14.15	5.5	8.5	21.3	36.5	22.1	5.1	1.0		
	3	1.706	4.383	14.15	8.3	10.8	23.1	34.9	19.7	4.1	0.1		
	6	1.866	4.066	14.15	5.2	7.7	22.3	36.2	22.0	5.6	1.0		
	9	2.401	5.524	17.36	3.0	4.7	16.3	34.5	30.3	8.7	2.3	0.2	
	12	2.350	5.124	17.36	2.6	4.1	16.1	33.7	29.0	11.5	2.8	0.2	
	15	2.497	5.239	17.36	1.8	4.4	14.7	32.4	31.9	11.6	3.0	0.2	
	18	2.851	8.535	20.83	2.4	4.6	16.4	36.1	30.0	9.0	1.3	0.1	0.1
	21	2.146	5.991	17.36	4.6	7.6	20.7	36.6	23.3	6.2	0.8	0.2	

Beta Distribution Parameters and Surface Wind Frequency Summary by Time of Day and Season for No. 5 Wind Category

06 Dallas, Texas
14 Lubbock, Texas

SEASON	HOUR	ALPHA	BETA	V-MAX (MPS)	<----- PERCENTAGE FREQUENCY OF WIND BY SPEED GROUP (KNOTS) ----->									
					0-50	2-00	5-00	8-50	12-50	19-00	24-50	32-50	37-00	44-00
FALL														
	0	1.433	5.419	17.36	14.2	10.7	23.9	32.0	15.8	3.1	0.7	0.1		
	3	1.208	3.974	14.15	16.4	13.6	24.7	29.6	12.8	2.9	0.2			
	6	1.223	4.001	14.15	15.6	14.0	25.4	29.0	13.1	2.5	0.4			
	9	1.860	3.745	14.15	5.0	7.5	15.0	34.8	25.7	6.4	1.4			
	12	2.112	3.960	14.15	3.6	5.8	18.1	35.5	28.7	6.6	1.5			
	15	2.365	6.150	17.36	4.0	6.5	18.3	36.3	27.4	5.8	1.1	0.2		
	18	1.757	5.007	14.15	8.7	10.4	28.5	33.6	13.8	2.5	0.3			
	21	1.498	4.089	14.15	11.7	8.9	25.8	32.9	16.5	3.7	0.4			
WINTER														
	0	1.604	6.333	20.83	11.3	8.5	20.8	32.4	19.1	6.1	1.4	0.0	0.1	
	3	1.450	4.722	17.36	11.9	9.0	22.1	31.4	18.7	5.3	1.2	0.2		
	6	1.396	4.637	17.36	11.9	10.5	22.1	30.4	19.4	5.1	1.4	0.1		
	9	1.741	4.162	17.36	6.2	5.8	16.4	30.1	27.1	9.7	3.1	0.4		
	12	2.065	5.283	20.83	4.4	4.6	13.5	27.2	29.7	14.4	4.7	1.0	0.1	
	15	2.095	5.701	20.83	4.6	5.3	14.7	28.2	30.0	12.6	3.6	0.7	0.1	
	18	1.634	5.177	17.36	9.3	9.3	23.2	32.6	19.2	5.3	1.1	0.1		
	21	1.546	4.810	17.36	10.8	8.5	21.0	32.5	19.7	6.0	1.3	0.1		
SPRING														
	0	1.937	5.976	20.83	6.7	6.0	16.5	30.7	27.3	9.6	2.5	0.4	0.1	
	3	1.909	6.601	20.83	8.3	6.8	18.3	31.6	25.4	7.1	1.8	0.0	0.1	
	6	1.823	4.658	17.36	6.4	7.0	18.1	32.1	25.7	8.4	1.8	0.3		
	9	2.666	6.031	20.83	2.3	3.0	5.3	27.5	34.6	16.6	5.3	1.1	0.2	
	12	2.736	7.656	24.55	1.9	2.3	10.5	25.4	35.5	18.2	6.0	1.5	0.3	0.1
	15	2.483	5.322	20.33	2.2	2.3	4.3	25.7	34.1	16.5	7.4	1.3	0.5	
	18	2.240	6.160	20.33	3.8	4.5	14.7	31.7	30.0	11.1	3.2	0.7	0.2	
	21	1.914	5.886	20.33	6.4	5.6	16.9	31.8	26.7	8.7	3.0	0.6	0.1	
SUMMER														
	0	1.845	4.518	14.15	9.1	6.2	24.0	36.2	20.2	3.8	0.3			
	3	1.576	4.627	14.15	12.1	10.2	26.0	34.3	14.5	2.6	0.1			
	6	1.655	4.503	14.15	9.8	9.8	26.0	33.9	16.9	3.3	0.2			
	9	2.446	5.126	14.15	3.7	6.4	19.9	39.4	26.2	3.9	0.4			
	12	2.581	5.611	14.15	3.3	5.3	22.4	40.9	24.0	3.1	0.4			
	15	2.874	5.812	14.15	2.7	4.4	19.5	42.5	27.0	3.4	0.4			
	18	2.763	5.904	14.15	3.4	4.3	21.6	44.1	22.8	3.6	0.3			
	21	1.999	4.804	14.15	7.0	5.9	25.9	37.5	19.5	3.6	0.5			

Beta Distribution Parameters and Surface Wind Frequency Summary by Time of Day and Season for No. 6 Wind Category

08 Des Moines, Iowa

SEASON	HOUR	ALPHA	BETA	V-MAX (MPS)	PERCENTAGE FREQUENCY OF WIND BY SPEED GROUP (KNOTS)									
					2.5-5	5.0-9	9.0-13	13.0-17	17.0-21	21.0-25	25.0-30	30.0-35	35.0-40	40.0-45
FALL														
	0	2.614	7.892	17.36	3.8	5.3	23.1	45.8	17.0	2.7	1.1	0.2		
	3	2.355	8.037	17.36	3.5	5.7	23.5	46.0	17.0	3.3	0.9	0.1		
	6	2.785	5.845	20.83	2.9	5.1	21.4	43.7	21.4	4.1	1.2	0.1	0.1	
	9	2.810	7.519	20.83	2.1	4.4	12.3	31.6	35.8	9.6	3.3	0.3	0.1	
	12	3.024	8.734	24.56	1.9	3.1	10.6	25.6	37.6	15.4	4.8	0.8	0.1	0.1
	15	2.435	5.108	17.36	2.6	4.6	14.3	31.1	34.0	10.2	2.9	0.3		
	18	2.490	7.545	17.36	3.2	6.4	24.1	45.0	17.0	3.0	1.0	0.3		
	21	3.009	10.900	20.83	2.8	4.0	22.3	46.0	20.2	3.0	0.9	0.2	0.1	
WINTER														
	0	2.404	7.743	20.83	2.5	4.9	19.4	37.0	26.2	7.4	2.2	0.3	0.1	
	3	2.357	7.582	20.83	2.5	5.6	19.2	38.0	24.7	7.4	2.1	0.4	0.1	
	6	2.315	7.257	20.83	2.3	5.3	20.9	26.2	24.8	7.7	2.1	0.5	0.1	
	9	2.110	4.535	17.36	1.9	5.5	16.2	32.7	28.9	10.0	4.3	0.5		
	12	2.617	6.456	20.83	1.7	3.4	13.1	28.1	35.1	13.0	4.1	1.0	0.1	
	15	2.266	4.711	17.36	2.2	4.7	14.3	32.0	31.6	11.1	3.4	0.7		
	18	2.410	7.316	20.83	2.1	5.0	18.0	38.0	26.5	7.0	2.6	0.7	0.1	
	21	2.442	7.403	20.83	2.5	5.1	17.2	37.4	25.5	7.9	2.4	0.5	0.1	
SPRING														
	0	2.366	8.531	24.56	2.6	4.6	19.2	32.3	23.5	9.1	2.6	0.7	0.2	0.1
	3	2.433	8.825	24.56	3.1	4.5	17.2	34.2	29.3	8.5	2.1	0.8	0.2	0.1
	6	2.409	6.014	20.83	2.3	3.9	12.3	30.0	34.2	11.7	4.0	1.3	0.3	
	9	2.746	5.341	20.83	1.1	2.3	8.3	21.2	36.9	19.7	7.9	2.1	0.5	
	12	2.735	6.171	24.56	1.1	2.2	8.0	17.8	35.0	21.8	9.1	3.5	1.0	0.1
	15	2.530	6.773	24.56	0.7	2.3	6.3	21.5	35.4	20.6	9.4	2.8	0.9	0.1
	18	2.412	6.140	20.83	1.2	3.9	14.4	32.0	31.4	11.5	4.3	0.9	0.4	
	21	2.403	8.472	24.56	2.2	4.9	16.3	34.2	23.5	5.3	3.0	0.8	0.2	0.1
SUMMER														
	0	2.087	6.340	14.15	6.4	12.2	31.1	38.3	10.3	1.5	0.2			
	3	2.006	8.254	17.36	7.7	13.4	31.2	36.5	9.7	1.1	0.2	0.2		
	6	2.092	5.516	14.15	6.5	11.3	27.6	38.4	14.7	1.3	0.2			
	9	2.810	9.913	20.83	2.6	9.3	18.8	38.3	27.8	3.3	0.5	0.1	0.1	
	12	2.536	7.290	17.36	1.8	5.8	15.3	38.0	32.9	5.3	0.6	0.3		
	15	3.122	7.770	17.36	1.5	5.8	15.8	39.6	31.9	4.4	0.9	0.1		
	18	2.711	5.522	17.36	2.0	12.1	28.4	41.2	14.8	1.2	0.2	0.1		
	21	2.427	11.999	20.83	5.5	12.0	32.1	39.5	9.6	0.9	0.2	0.1	0.1	

Beta Distribution Parameters and Surface Wind Frequency Summary by Time of Day and Season for No. 7 Wind Category

09 Columbus, Indiana
10 Rantoul, Illinois
18 Madison, Wisconsin
20 Mount Clemens, Michigan

SEASON	HOUR	ALPHA	BETA	V-MAX MPH	PERCENTAGE FREQUENCY OF WIND BY SPEED GROUP (KNOTS)									
					0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	
FALL														
	0	1.161	4.151	14.15	18.3	14.2	27.7	27.7	17.7	1.9	0.3			
	3	1.109	4.146	14.15	9.3	14.6	27.2	26.5	18.3	1.5	0.5			
	6	1.330	5.528	17.36	16.1	13.3	24.9	28.8	14.1	2.2	0.3	0.1		
	9	2.154	5.503	17.36	5.3	7.7	18.9	34.5	27.1	5.3	1.1	0.1		
	12	2.503	5.530	17.36	3.2	5.1	18.2	34.7	31.2	7.8	1.6	0.1		
	15	2.385	6.783	17.36	4.1	7.0	21.9	37.2	24.4	4.4	0.8	0.1		
	18	1.461	6.579	14.15	11.8	12.7	25.8	31.4	11.5	2.1	0.4			
	21	1.211	4.187	14.15	16.9	13.7	27.2	27.5	12.4	1.9	0.3			
WINTER														
	0	1.686	6.270	20.83	9.3	8.9	15.6	31.9	22.5	5.7	1.7	0.3	0.1	
	3	1.552	4.685	17.36	9.8	8.9	15.9	32.6	21.3	5.5	1.5	0.3		
	6	1.668	5.036	17.36	8.6	9.3	20.6	32.4	22.4	4.9	1.4	0.2		
	9	2.251	7.133	20.83	5.1	6.3	17.0	32.6	29.4	7.2	1.9	0.3	0.1	
	12	2.381	5.200	17.36	3.1	4.7	14.7	32.7	33.0	8.9	2.3	0.5		
	15	2.398	7.641	20.83	3.6	5.8	18.3	35.7	27.8	6.6	1.7	0.3	0.1	
	18	1.755	6.575	20.83	7.5	8.9	22.4	32.0	21.4	5.8	1.5	0.3	0.1	
	21	1.653	6.286	20.83	9.0	9.7	21.2	30.7	21.5	5.9	1.5	0.3	0.1	
SPRING														
	0	1.530	4.956	17.36	11.0	9.6	20.5	33.7	19.0	4.6	1.3	0.2		
	3	1.454	4.756	17.36	12.3	5.7	20.9	31.7	19.2	5.0	1.1	0.2		
	6	1.801	4.749	17.36	7.7	6.9	17.3	31.9	26.7	7.4	1.6	0.3		
	9	2.406	4.821	17.36	2.2	3.3	12.3	30.4	34.5	12.9	3.9	0.5		
	12	2.894	6.445	20.83	1.6	2.9	9.4	28.2	37.1	14.5	5.0	1.0	0.1	
	15	3.012	7.291	20.83	1.6	2.7	10.3	31.0	37.0	12.8	3.7	0.8	0.1	
	18	2.151	5.738	17.36	4.6	5.9	20.0	37.0	24.7	5.7	1.7	0.2		
	21	1.610	5.108	17.36	9.4	9.0	22.4	33.5	19.7	4.2	1.4	0.2		
SUMMER														
	0	1.054	3.692	11.19	24.0	18.5	30.9	21.8	4.1	0.5				
	3	0.970	3.859	11.19	26.3	19.9	28.8	20.5	4.1	0.4				
	6	1.462	5.456	14.15	15.6	15.0	28.6	31.2	8.7	0.8	0.1			
	9	2.059	5.417	14.15	7.1	9.0	25.3	38.8	17.4	2.0	0.2			
	12	2.399	5.342	14.15	4.1	6.5	22.0	41.0	22.6	3.2	0.5			
	15	2.580	5.333	14.15	3.7	6.3	22.5	42.5	21.8	2.9	0.2			
	18	1.773	6.159	14.15	11.1	13.9	31.8	33.4	9.0	0.7	0.1			
	21	1.280	6.048	14.15	21.0	18.2	31.6	24.5	4.3	0.3	0.1			

Beta Distribution Parameters and Surface Wind Frequency Summary by Time of Day and Season for No. 8 Wind Category

01 Syracuse, New York
03 Brunswick, Maine
05 Patuxent River, Maryland

SEASON	HOUR	ALPHA	BETA	V-MAX (MPS)	PERCENTAGE FREQUENCY OF WIND BY SPEED GROUP (KNOTS)									
					5.50	7.00	8.50	10.00	11.50	13.00	14.50	16.00	17.50	19.00
FALL														
	0	1.184	5.079	17.36	16.1	15.2	20.4	25.5	13.5	2.4	0.8	0.1		
	3	1.187	5.122	17.36	16.1	15.3	21.2	24.2	13.9	2.7	0.5	0.1		
	6	1.219	5.025	17.36	13.6	16.8	21.4	24.7	14.8	2.8	0.7	0.1		
	9	1.751	5.312	17.36	5.4	11.9	20.0	30.6	22.8	4.6	1.5	0.1		
	12	2.336	7.945	20.83	2.7	8.1	21.8	34.0	25.8	6.1	1.3	0.2	0.1	
	15	2.013	6.269	17.36	3.7	10.1	21.5	33.4	20.2	4.1	0.9	0.2		
	18	1.331	5.543	17.36	10.9	17.1	21.8	25.8	12.8	2.8	0.6	0.2		
	21	1.234	5.193	17.36	14.9	15.1	21.3	25.0	14.3	2.7	0.6	0.1		
WINTER														
	0	1.209	3.810	17.36	11.9	12.1	21.7	24.5	19.8	6.0	2.3	0.5		
	3	1.218	4.925	20.83	11.2	12.3	21.1	24.5	17.9	6.5	2.2	0.6	0.1	
	6	1.244	5.105	20.83	11.7	13.0	21.9	23.4	19.0	6.4	2.1	0.4	0.1	
	9	1.446	5.136	20.83	7.8	10.7	21.1	24.3	23.8	8.8	2.9	0.5	0.1	
	12	1.821	5.582	20.83	4.7	8.0	11.5	27.6	27.0	9.2	3.5	0.6	0.1	
	15	1.616	5.720	20.83	5.9	10.4	21.5	26.2	22.6	7.5	2.4	0.4	0.1	
	18	1.284	5.318	20.83	11.7	12.7	24.2	23.9	19.2	6.1	1.8	0.4	0.1	
	21	1.225	3.857	17.36	10.9	12.3	21.4	24.1	19.9	7.0	2.2	0.2		
SPRING														
	0	1.374	4.954	17.36	10.7	13.6	21.5	28.0	17.2	3.9	0.9	0.3		
	3	1.329	4.916	17.36	12.1	13.4	21.4	25.8	17.5	3.9	0.8	0.2		
	6	1.515	4.729	17.36	8.2	11.2	24.2	27.5	21.6	5.6	1.4	0.2		
	9	2.225	6.531	20.93	2.6	6.5	11.9	30.5	29.2	9.8	2.9	0.5	0.1	
	12	2.776	7.159	20.93	1.2	4.0	14.1	30.4	34.3	11.8	3.6	0.6	0.1	
	15	2.891	7.685	20.85	1.4	4.0	14.4	31.2	35.0	10.5	3.1	0.3	0.1	
	18	1.967	7.040	20.93	4.6	10.4	21.9	30.8	21.3	5.1	1.6	0.3	0.1	
	21	1.367	4.715	17.36	9.5	13.4	26.0	26.9	19.1	4.4	1.5	0.2		
SUMMER														
	0	1.181	3.775	11.19	15.3	19.7	33.3	22.6	7.3	0.7				
	3	1.082	3.666	11.19	18.8	20.4	32.3	21.1	6.8	0.7				
	6	1.481	5.388	14.15	11.3	18.4	31.6	27.5	10.0	1.1	0.1			
	9	2.081	5.534	14.15	4.1	11.7	29.5	34.6	17.8	2.0	0.2			
	12	2.769	5.707	14.15	1.8	5.4	22.4	40.0	26.5	3.5	0.5			
	15	3.022	8.374	17.36	2.0	5.7	21.3	41.4	25.7	3.3	0.5	0.1		
	18	2.029	8.325	17.36	5.7	14.3	35.6	31.7	11.1	1.2	0.3	0.1		
	21	1.500	6.015	14.15	11.9	20.0	34.8	25.1	7.3	0.8	0.1			

TECHNICAL APPENDIX B

--ENERGY LOAD PROFILES--

	<u>Page</u>
1. Residential Appliance Load	B-3
2. Residential Heating and Cooling Load	B-6
2.1 Heating Option A	B-7
2.2 Heating Option B	B-8
2.3 Heating Option C	B-9
2. Farm Operations	
3.1 Nonirrigated Crops	
3.11 Soybeans and Corn	B-10
3.12 Winter Wheat and Sorghum	B-12
3.13 Potatoes	B-14
3.2 Irrigated Crops	B-16
3.3 Fruit, Nut, Vegetable	
3.31 Fruit	B-19
3.32 Truck	B-21
3.4 Poultry and Eggs	
3.41 Broilers	B-23
3.42 Eggs	B-25
3.5 Dairy	
3.51 NE Grade A Dairy	B-27
3.52 Central Grade A Dairy	B-29
3.6 Livestock	
3.61 Hog-beef farm	B-31
3.62 Hog-beef fattening	B-33
3.63 Beef-winter wheat	B-35
3.64 Beef-other crops	B-37
3.65 Feeder Cattle Farm	B-39
4. Load Amplitude Factors by Type and Size of Farm in the U.S.	B-41

TECHNICAL APPENDIX B

ENERGY LOAD PROFILES

Each energy load profile shown herein describes estimated potential electrical use patterns for the various model agricultural wind system applications. Load profiles for residential appliances, heating and cooling, and farm operations are presented.

A narrative explanation of background information precedes each corresponding energy load profile. Basic descriptions and assumptions are stated to define each load profile in terms of its energy use determinants. Data and information sources are listed.

The quantitative portion of each model load profile shows the amount and distribution of potential electrical load by time of day (half-hour intervals) for each electricity-consuming item. The digit under each time of day interval shows the number of load units consumed in each half hour interval for each consuming item. Thus the rated load of the item times the number of units used (sum of the digits over 48 half hour intervals divided by 2) equals the total energy (kWh) for each consuming item for that day. The total energy used for a given day is the total for all items for that day. Seasonal and annual total energy statistics are estimated by appropriate aggregation of daily totals.

The footnote at the bottom of the quantitative portion of the load profile descriptions identifies the particular state where each load profile was applied.

The final table in this appendix "Load Amplitude Factors by Type and Size of Farm in the U.S." shows the scale factor (percent) to adjust the model load profiles for various size categories within each state-farm type category. With the exception of irrigation, as explained herein, for which load variation data by system type and state were available, energy load profile adjustments for scale are not available in the literature. Consequently, these were estimated judgementally based on contractor's industry knowledge and experience.

Residence Appliance Load

Description: Three bedroom, ranch style (single level), 1½ bath with a first floor heated area of 1,270 sq. ft. and a basement area of 990 sq. ft. There are 3 3/8 in. of insulation in the walls and 6 in. in the ceiling. The windows are weather stripped and have storm windows. A two-car garage is attached. The house is occupied by a family of four on a normal daily living pattern.

Assumptions: The house is total electric, with water heater (4.5 kW), dryer (5.6 kW), range and dishwasher. Lighting use varies throughout the day with time and occupancy. Other loads include refrigerator, freezer, television, etc.

Sources:

"Residential Energy Consumption", Dept. of H.U.D., March, 1973.

"Evaluation of Heating Loads in Old Residential Structures", Dept. of H.U.D., January, 1974.

Institute of Gas Technology Study, "Wind Powered Hydrogen Electric Systems for Farm and Rural Use", April, 1976.

"Cost of Operation of Electrical Equipment", Cooperative Extension, Kansas State University, December, 1968.

Table 1. Residential Appliance Load

SEASON	ITEM	LOAD (KW)	TIME OF DAY <----->																												TOTAL ENERGY (KWH)
			0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3					
FALL	HOT WATER HEATER	4.50		1				1	1													1	1		1	1				20.25	
	OVEN/RANGE	1.60						1					1									1								2.40	
	OVEN/RANGE	2.60					1																							1.30	
	OVEN/RANGE	2.00								1																				1.00	
	OVEN/RANGE	0.10										5	5	6								8								1.20	
	DRYER	3.50							1	1																				3.50	
	WASHER	0.75							1																					0.38	
	REFRIGERATOR	0.40	1	1	1	1	1	1			1	1	1							1	1	1			1					2.40	
	FREEZER	0.40		1	1	1	1	1		1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			2.60	
	LIGHTS	0.03	1	1	1	1	1	1	2	4				4	4	4	4										1	1		0.98	
	LIGHTS	0.35							1	1																	1	1		0.71	
	LIGHTS	0.28							1	1											1	1								0.57	
	LIGHTS	0.21								1	1			1	1															0.64	
	LIGHTS	0.43																			1	1								0.43	
	LIGHTS	0.57																				1	1	1	1					1.14	
	LIGHTS	0.53																								1	1	1	1	1.06	
	TELEVISION	0.40																							1	1	1	1	1	1.40	
	DISHWASHER	0.25																							1					0.13	
	DISHWASHER	1.60																							1					0.80	
	MISCELLANEOUS	0.01	9	9	9	9		6	6	4	1	2	2	1	1	4	4	9	9	9	1			3	3	7	7	9	9	0.87	
	MISCELLANEOUS	0.10		1	1	1	1	1	2	2	1	1	1	2	2	1			1	1	1	1	2	2	2	2	2	2	1	1	2.45
																															46.20
WINTER	HOT WATER HEATER	4.50		1				1	1													1	1		1	1				20.25	
	OVEN/RANGE	1.60						1														1								2.40	
	OVEN/RANGE	2.60					1																							1.30	
	OVEN/RANGE	2.00								1																				1.00	
	OVEN/RANGE	0.10										5	5	6								8								1.20	
	DRYER	3.50							1	1																				3.50	
	WASHER	0.75							1																					0.38	
	REFRIGERATOR	0.40	1	1	1	1	1	1			1	1	1							1	1	1			1					2.40	
	FREEZER	0.40		1	1	1	1	1		1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			2.60	
	LIGHTS	0.03	1	1	1	1	1	1	2	4				4	4	4	4										1	1		0.98	
	LIGHTS	0.35							1	1																	1	1		0.71	
	LIGHTS	0.28							1	1											1	1								0.57	
	LIGHTS	0.21								1	1			1	1															0.64	
	LIGHTS	0.43																				1	1							0.43	
	LIGHTS	0.57																					1	1	1	1				1.14	
	LIGHTS	0.53																								1	1	1	1	1.06	
	TELEVISION	0.40																							1	1	1	1	1	1.40	
	DISHWASHER	0.25																							1					0.13	
	DISHWASHER	1.60																							1					0.80	
	MISCELLANEOUS	0.01	9	9	9	9		6	6	4	1	2	2	1	1	4	4	9	9	9	1			3	3	7	7	9	9	0.87	
	MISCELLANEOUS	0.10		1	1	1	1	1	2	2	1	1	1	2	2	1			1	1	1	1	2	2	2	2	2	2	1	1	2.45
																															46.20

This appliance load profile used in all states.

Table 1 (Con'd). Residential Appliance Load

SEASON	ITEM	LOAD (KW)	TIME OF DAY 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 2 2 2 2 2																								TOTAL ENERGY (KWH)
			0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	
SPRING	HOT WATER HEATER	4.50		1				1	1	1			1							1	1		1	1		20.25	
	OVEN/RANGE	1.60											1							1						2.40	
	OVEN/RANGE	2.60							1																	1.30	
	OVEN/RANGE	2.00											1													1.00	
	OVEN/RANGE	0.10											5	5	6						8					1.20	
	DRYER	3.50							1	1																3.50	
	WASHER	0.75							1																	0.38	
	REFRIGERATOR	0.40	1	1	1	1	1	1				1	1	1	1				1	1	1		1			2.40	
	FREEZER	0.40		1	1	1	1	1				1	1	1	1	1			1	1	1		1	1		2.60	
	LIGHTS	0.03	1	1	1	1	1	2	2	4			4	4	4	4	4						1	1		0.98	
	LIGHTS	0.35							1	1													1	1		0.71	
	LIGHTS	0.28								1	1									1	1					0.57	
	LIGHTS	0.21									1	1			1	1			1	1						0.64	
	LIGHTS	0.43																		1	1					0.43	
	LIGHTS	0.57																		1	1	1	1			1.14	
	LIGHTS	0.53																				1	1	1	1	1.06	
	TELEVISION	0.40																				1	1	1	1	1.40	
	DISHWASHER	0.25																				1				0.13	
	DISHWASHER	1.60																				1				0.80	
	MISCELLANEOUS	0.01	9	9	9	9	9	9	6	6	4	1	1	2	2	1	1	4	4	9	9	9	1	1	3	3	0.87
	MISCELLANEOUS	0.10		1	1	1	1	1	2	2	1	1	1	1	2	2	1	1	1	1	1	2	2	2	2	2	2.45
																										46.20	
SUMMER	HOT WATER HEATER	4.50		1				1	1	1			1							1	1		1	1		20.25	
	OVEN/RANGE	1.60											1							1						2.40	
	OVEN/RANGE	2.60																								1.30	
	OVEN/RANGE	2.00											1													1.00	
	OVEN/RANGE	0.10											5	5	6						8					1.20	
	DRYER	3.50								1	1															3.50	
	WASHER	0.75								1																0.38	
	REFRIGERATOR	0.40	1	1	1	1	1	1				1	1	1	1				1	1	1		1			2.40	
	FREEZER	0.40		1	1	1	1	1				1	1	1	1	1			1	1	1		1	1		2.60	
	LIGHTS	0.03	1	1	1	1	1	2	2	4			4	4	4	4	4						1	1		0.98	
	LIGHTS	0.35								1	1												1	1		0.71	
	LIGHTS	0.28									1	1								1	1					0.57	
	LIGHTS	0.21										1	1			1	1									0.64	
	LIGHTS	0.43																		1	1					0.43	
	LIGHTS	0.57																			1	1	1	1		1.14	
	LIGHTS	0.53																				1	1	1	1	1.06	
	TELEVISION	0.40																				1	1	1	1	1.40	
	DISHWASHER	0.25																				1				0.13	
	DISHWASHER	1.60																				1				0.80	
	MISCELLANEOUS	0.01	9	9	9	9	9	9	6	6	4	1	1	2	2	1	1	4	4	9	9	9	1	1	3	3	0.87
	MISCELLANEOUS	0.10		1	1	1	1	1	2	2	1	1	1	1	2	2	1	1	1	1	1	2	2	2	2	2	2.45
																										46.20	

This appliance load profile used in all states.

Residential Heating and Cooling Load

Description: Three bedroom, ranch style (single level), 1½ bath with first floor heated area of 1,270 sq. ft. and a basement area of 990 sq. ft. There are 3 3/8 inches of insulation in the walls and 6 inches in the ceiling. The windows are weather stripped and have storm windows. A two-car garage is attached. The house is occupied by a family of four on a normal daily living pattern.

Assumptions: Heating and cooling are done electrically. The furnace has three 5 kW coils and uses a ½ hp blower motor. The air conditioning unit draws 4.7 kW. The house is assumed to lose 14,000 Btu per degree day. The cooling load is determined as a ratio of the normal temperature at a given location to a know normal temperature and cooling load, i.e., Baltimore 72.2°F @ 69.7 kWh/day.

	<u>Spring</u> <u>Degree Days/day</u>	<u>Summer</u> <u>Normal Temp. °F</u>	<u>Fall</u> <u>Degree days/day</u>	<u>Winter</u> <u>Degree days/day</u>
Option A	12.7	78.6	9.7	37.9
Option B	14.2	64.4	13.0	30.0
Option C	17.7	73.8	13.8	41.8

Option A

Kansas
Maryland
Missouri
Oklahoma
Texas

Option B

Colorado
Idaho
New Jersey
Wyoming

Option C

Illinois
Indiana
Iowa
Maine
Maine
Michigan
Minnesota
Montana
Nebraska
New York
North Dakota
Ohio
Pennsylvania
South Dakota
Wisconsin

B-7

Option A heating and cooling load profile used for residences in Kansas, Maryland, Missouri, Oklahoma, Texas.

8-

Option B heating and cooling load profile used for residences in Colorado, Idaho, New Jersey, Wyoming.

B-9

Option C heating and cooling load profile used for residences in Illinois, Indiana, Iowa, Maine, Michigan, Minnesota, Montana, Nebraska, New York, North Dakota, Ohio, Pennsylvania, South Dakota, Wisconsin.

Soybeans and Corn

Description: A 500-acre cash grain farm with 250 acres in soybeans and 250 acres in corn. No livestock.

Assumptions: 40,000 bushel storage, with low-temperature electrical grain drying use for corn. All other electricity use would be included in the residence.

Source:

Institute of Gas Technology study, "Wind-Powered Hydrogen Electric Systems for Farm and Rural Use", April 1976.

Ralph Lipper, Agricultural Engineer, Kansas State University.

B-77

[illegible]

Winter Wheat - Sorghum

Description: This winter wheat and sorghum operation has 500 to 800 acres with the amounts of wheat and sorghum varying greatly. Most farms have three 5,000-bushel bins for sorghum storage.

Assumptions: $\frac{1}{2}$ hp aeration fans are used on each bin to prevent spoilage. All other electrical loads come under the residence load.

Sources:

Ralph Lipper, Ag. Engineering, Kansas State University

Telephone interviews with various county agents and farm operators.

B-13

This load profile used for non-irrigated crop farms in Colorado, Idaho, Kansas, Montana, Nebraska, Oklahoma, and Texas.

Potatoes

Description: 150-acre farm with 100 acres each year in potatoes and 50 left fallow. Harvest in September-October.

Assumptions: Yield is 23,500 lb/acre and ventilation requirement is 0.75 cfm per cwt. Grading is done February through April. Conveyors unload trucks in October.

Sources:

Ken Chapman, Potato specialist, Houlton, ME 207-532-6848

B-15

This load profile used for non-irrigated crop farms in Maine only.

Irrigation Crops

Description: This load profile is a basis for the following irrigation systems: center pivot, hand move, tow line, side roll, gated pipe from ground water, gated pipe from surface water. Individual system loads are calculated as a percentage of a standard 100 kW load based on the assumptions below.

Assumptions: The basic irrigation load assumes continuous day and night irrigation for a 90-day period in the summer. Further, each state was classified according to its number and types of systems, the water source, acres per system and pumping head so that Table 3.21 that follows gives the energy rating (kW per system) based on the data for irrigation systems for that state. This kW load then becomes the percent of load of a standard #24 enterprise at 100 kW. Furthermore it is assumed that each system is a dedicated load - not combined with other farm loads or with a residence load.

Sources:

Irrigation Journal, November-December 1976.

Table 3.2 Irrigation systems and loads by type and state - 1976.

	Total irrigation 000 acres	Center Pivot 130 acre/unit no of kW units per unit	Hand Move Sprinkler 80 acres/unit no of kW units per unit	Tow Line Side Roll 160 acres/unit no of kW units per unit	Gated Pipe from grd water 160 acres/unit no of kW units per unit	Gated Pipe from surface water 160 acres/unit no of kW units per unit
Colorado	3,100	3,850 80	150 60	190 120	1,740 60	2,130 15
Idaho	4,081	1,620 90	10,000 70	2,210 130	NA 70	140 15
Illinois	53	210 60	40 40	50 90	NA NA	NA NA
Indiana	48	150 60	150 40	10 100	60 40	NA NA
Iowa	132	450 60	NA NA	30 90	220 40	NA NA
Kansas	3,032	5,590 80	60 60	210 120	10,270 60	NA NA
Maine	6	NA NA	NA NA	NA NA	NA NA	NA NA
Maryland	24	80 60	90 40	20 80	NA NA	NA NA
Michigan	113	NA NA	NA NA	NA NA	NA NA	NA NA
Minnesota	188	760 60	60 40	40 90	NA NA	10 15
Missouri	242	190 60	40 40	NA NA	NA NA	NA NA
Montana	3,100	250 80	NA NA	NA NA	NA NA	NA NA
Nebraska	6,301	13,560 60	450 40	2,970 100	NA NA	NA NA
New Jersey	174	NA NA	NA NA	NA NA	NA NA	NA NA
New York	54	NA NA	410 40	60 90	NA NA	NA NA
North Dakota	103	430 70	10 50	10 100	NA NA	NA NA
Ohio	43	50 70	260 50	NA NA	NA NA	NA NA
Oklahoma	941	1,080 80	1,120 60	1,170 130	2,270 70	500 15
Pennsylvania	19	NA NA	NA NA	NA NA	NA NA	NA NA
South Dakota	296	110 60	10 40	410 90	NA NA	240 15
Texas	8,200	4,000 90	6,440 70	5,310 130	27,640 70	3,770 15
Wisconsin	181	450 70	510 50	240 100	NA NA	20 15
Wyoming	1,830	600 70	310 50	320 100	NA NA	530 15

Source: Irrigation Journal - November/December 1976.

Table 3.22 Irrigated Crops

[illegible]

This load profile used for irrigated farms in all states.

Fruit

Description: This fruit farm consists of 45 acres of cherries, 40 of apples, 30 of pears, and 30 of plums.

Assumptions: 2-15 hp motors pump irrigation and cooling water for the cherries in July and run continuously. One of these pumps is used off and on for pumping spray water in the spring and fall. No on farm processing or storage.

Sources:

Telephone interviews with several county agency and farm operators.

B-20

This load profile used for fruit, nut, and vegetable farms in Michigan only.

Truck farm

Description: This truck farm has about 70 acres of mushrooms, roses, various vegetables and tomatoes. A fairly large greenhouse is used in the winter.

Assumptions: A 5-hp pump is used continuously for irrigation in the spring and summer. A 2-hp pump provides water for the greenhouse in winter and a 1-hp pump is used for greenhouse blowers. Heat is supplied by natural gas.

Sources:

Telephone interviews with county agents in the area.

Table 3.32. Truck

		<----- TIME OF DAY ----->																								TOTAL	
SEASON	ITEM	LOAD (KW)	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	ENERGY (KWH)
FALL	WATER PUMPING	2.00	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	48.00
																											48.00
WINTER	WATER PUMPING	2.00	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	48.00
	BLOWERS-GRNHOUSE	1.00	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	24.00
																											72.00
SPRING	WATER PUMPING	5.00	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	120.00
																											120.00
SUMMER	WATER PUMPING	5.00	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	120.00
																											120.00

This load profile used for fruit, nut, and vegetable farms in New Jersey only.

Broilers

Description: 50,000 bird broiler farm with a change of birds every 7 to 9 weeks. Three story building with 30,000 sq. ft. of floor space. All feed is purchased.

Assumptions: Light is provided by either daylight or artificial light at 40 w per 200 sq. ft. Automatic feeders. Gas hot water heater. Ventilation provides $\frac{1}{4}$ cfm per bird in December and 1 cfm per bird anytime the temperature is over 70°F.

Sources:

Harry Wheldon, Poultry Specialist, University of Maine, "Energy Use and Conservation in the Poultry and Egg Industry".

Midwest Plains Service, "Structure and Environment Handbook", September 1975, 7th edition, MWPS-1.

B-24

This load profile used for poultry and egg farms in Indiana and Maryland.

Eggs

Description: Fully automated, 30,000 bird cage house. All feed is purchased.

Assumptions: Birds have 24-hr. light; ventilation is from 24, $\frac{1}{2}$ hp fans; the only heat supplied by electricity is to egg room. Average egg collection is 21,000 per day.

Sources:

Gary M. Shortt of Diamond Int. Corporation, Farmington, Minn. (313-476-7100)

Poultry Tribune, April 1969.

Institute of Gas Technology study, "Wind-Powered Hydrogen Electric Systems for Farm and Rural Use", April 1976.

Midwest Plains Service, "Structures and Environment Handbook", September 1975, Seventh Edition, MWPS-1.

Table 3.42. Eggs

SEASON	ITEM	LCAD (KWH)	TIME OF DAY 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 2 2 2 2 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3																						TOTAL ENERGY (KWH)	
FALL	LIGHTS	3.50	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	84.00		
	FEEDERS	1.25	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	30.00		
	WATER	0.75	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	7.13		
	EGG COLLECTION	1.60	1			1					1					1					1			4.00		
	MANURE REMOVAL	3.60								1	1								1	1				7.20		
	VENTILATION	1.00	1	1	1	1	1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4	3	54.00		
	EGG COOLER	0.75	1							1						1	1			1	1			3.00		
	MISC.	0.50	1	1	1	1	1	1	1	1	3	3	3	3	3	3	3	3	3	3	1	1	1	20.00		
																										209.32
WINTER	LIGHTS	3.50	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	84.00		
	FEEDERS	1.25	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	30.00		
	WATER	0.75	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	7.13		
	EGG COLLECTION	1.60	1			1					1					1					1			4.00		
	MANURE REMOVAL	3.60								1	1								1	1				7.20		
	VENTILATION	1.00														1	1	1	1					2.00		
	VENTILATION	2.00	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	48.00		
	EGG COOLER	0.75	1							1						1	1			1	1			3.00		
	MISC.	0.50	2	2	2	2	2	2	2	2	4	4	4	4	4	4	4	4	4	2	2	2	2	31.50		
																										216.82
SPRING	LIGHTS	3.50	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	84.00		
	FEEDERS	1.25	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	30.00		
	WATER	0.75	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	7.13		
	EGG COLLECTION	1.60	1			1				1						1					1			4.00		
	MANURE REMOVAL	3.60								1	1								1	1				7.20		
	VENTILATION	1.00	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	13.00		
	VENTILATION	2.00	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	59.00		
	EGG COOLER	0.75	1							1						1	1			1	1			3.00		
	MISC.	0.50	1	1	1	1	1	1	1	1	3	3	3	3	3	3	3	3	3	1	1	1	1	20.00		
																										227.32
SUMMER	LIGHTS	3.50	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	84.00		
	FEEDERS	1.25	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	30.00		
	WATER	0.75	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	7.13		
	EGG COLLECTION	1.60	1			1					1					1					1			4.00		
	MANURE REMOVAL	3.60								1	1								1	1				7.20		
	VENTILATION	1.00	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	8.00		
	VENTILATION	2.00	3	3	3	3	3	3	3	3	4	4	4	4	5	5	5	5	5	5	4	4	4	204.00		
	EGG COOLER	0.75	1							1						1	1			1	1			3.00		
	MISC.	0.50									3	3	3	3	3	3	3	3	3					12.75		
																										360.07
This load profile used for poultry and egg farms in Maine, Michigan, New Jersey,																										360.07

This load profile used for poultry and egg farms in Maine, Michigan, New Jersey,
 Pennsylvania and Texas.

NE Grade A Dairy

Description: 160-acre farm grows silage and roughage. Has large free stall barn with cleaner and upright silos. Milks 60 cows twice a day and has 26 other cows in the herd.

Assumptions: Cows daily diet consists of 35 lbs. silage and 12 lbs. purchased grain. Production, 40 lbs. per cow per day. Has 800-gallon bulk tank, 100-gallon kW water heater, 1-hp water pump, and 3-hp barn cleaner.

Sources:

Price, D.R., "Electricity Use and Costs on Four New York Farms", Agricultural Engineer, Extension Bulletin #369, Cornell University.

Telephone interviews with various county agents and farm operators.

Table 3.51 NE Grade A Dairy

SEASON	ITEM	LOAD (KWH)	TIME OF DAY																												TOTAL ENERGY (KWH)
			0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3					
FALL	LIGHTS	2.10																											10.50		
	WATER PUMP	0.05																											0.25		
	VACUUM PUMP	1.80																											7.20		
	SPACE HEATER	3.10																											9.30		
	WATER HEATER	2.50																											12.50		
	MILK COOLING	3.00																											24.00		
	CLEANING	2.00																											1.00		
	SILD	1.75																											1.75		
																													66.50		
WINTER	LIGHTS	2.10																											10.50		
	WATER PUMP	0.05																											0.25		
	VACUUM PUMP	1.80																											7.20		
	SPACE HEATER	3.10																											9.30		
	WATER HEATER	2.50																											12.50		
	MILK COOLING	3.00																											24.00		
	CLEANING	2.00																											1.00		
	SILD	1.75																											1.75		
																													66.50		
SPRING	LIGHTS	2.10																											10.50		
	WATER PUMP	0.05																											0.25		
	VACUUM PUMP	1.80																											7.20		
	WATER HEATER	2.50																											12.50		
	MILK COOLING	3.00																											24.00		
	CLEANING	2.00																											1.00		
	SILD	1.75																											1.75		
																													57.20		
SUMMER	LIGHTS	2.10																											10.50		
	WATER PUMP	0.05																											0.25		
	VACUUM PUMP	1.80																											7.20		
	WATER HEATER	2.50																											12.50		
	MILK COOLING	3.00																											24.00		
	CLEANING	2.00																											1.00		
	SILD	1.75																											1.75		
																													57.20		

This load profile used for dairy farms in Maine, Maryland, New Jersey, New York, Ohio, Oklahoma, Pennsylvania and Texas.

Grade A Dairy

Description: 160-acre farm grows corn mainly for silage. Has free stall barn and upright silos. Milks 55 cows twice a day and has 19 other cows in the herd.

Assumptions: Cows daily diet consists of 35 lbs. silage and 12 lbs. purchased grain. Production, 40 lbs. per cow per day. Has 700-gallon bulk tank, 80-gallon 9-kW water heater, 1-hp water pump, and 3-hp barn cleaner.

Sources:

Don Price, "Electricity Use and Costs on Four New York Farms", Agricultural Engineer, Extension Bulletin #269, Cornell University.

B-30

~~This load profile used for dairy farms in Colorado, Idaho, Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, South Dakota and Wisconsin.~~

Hog-beef Farm

Description: The typical hog-beef farm has 400 steers; 100 sows, which are farrowed twice a year; and 200 acres of corn, approximately half of which is used for silage; 100 acres of soybeans. Approximately half of the feed is purchased.

Assumptions: Water must be pumped for all animals. The steers are on stubble and drylot. 20 sows are farrowed in a cycle and ventilation and heat lamp are provided in the farrowing house. Upright silo with unloader is used.

Sources:

Telephone interviews with several county agents and farm operators.

Midwest Plans Service, "Structures and Environment Handbook", September 1975, 7th edition, MWPS-1.

B-32

This load profile used for livestock farms in Iowa, Minnesota, Missouri and Nebraska.

Hog-Beef Fattening

Description: This hog-beef fattening farm has 80 sows, which are farrowed twice a year, and 50 steers. All feed is grown, with 50 acres in silage, 150 acres in corn and 100 acres in soybeans.

Assumptions: Water must be pumped for all animals with the steers on stubble or drylot. Ten sows are farrowed at a time with ventilation and heat lamps provided in the farrowing house. Upright silo with unloader is used.

Sources:

Telephone interviews with several county agents and farm operators.

Midwest Plans Service, "Structures and Environment Hnadbook", September 1975, 7th edition, MWPS-1.

Table 3.62. Hog-beef Fattening

SEASON	ITEM	LOAD (KWH)	<----- TIME OF DAY ----->																								TOTAL ENERGY (KWH)
			0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	
FALL	WATER	0.50	1						1					1				1		1					1		1.50
	VENTILATION	0.20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4.80
	HEAT LAMPS	2.50	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	30.00
	MISC.	0.25	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	12.00
																											48.30
WINTER	WATER	0.50	1											1				1									1.00
	VENTILATION	0.20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4.80
	HEAT LAMPS	2.50	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	60.00
	SILLO UNLOADER	7.50																									3.75
	MISC.	0.25	2	2	2	2	2	2	2	2	2	2	2	3	3	6	6	3	6	3	6	3	6	3	6	3	17.88
																											87.42
SPRING	WATER	0.50	1											1				1							1		1.50
	VENTILATION	0.20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4.80
	HEAT LAMPS	2.50	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	30.00
	SILLO UNLOADER	7.50																									3.75
	MISC.	0.25	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	12.00
																											52.05
SUMMER	WATER	0.50												1				1							1		2.50
	VENTILATION	0.25	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	8.63
	MISC.	0.25	1	1	1	1	1	1	1	1	1	1	1	5	1	5	1	5	1	5	1	5	1	5	1	5	8.00
																											19.13

This load profile used for livestock farms in Illinois, Indiana, Maryland, Michigan, Ohio and Pennsylvania.

Beef and winter wheat

Description: This 450-acre winter wheat farm has 70 cows with calves. 220 acres are in wheat with the remainder in corn, sorghum and alfalfa. All feed is grown on the farm.

Assumptions: 12,000 bu. of wheat storage with $4\frac{1}{2}$ hp fans for aeration. Water is pumped for the cattle in the fall and winter. An upright silo and silo unloader is used.

Source:

D.L. Chisian, Saline County Extension Agent, Salina, Kansas.

Table 3.63 Beef and Winter ...

		TIME OF DAY																								TOTAL	
SEASON	ITEM	LOAD (KWH)	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	ENERGY (KWH)
FALL	WATER PUMPING	0.75	1		1			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4.50
																											4.50
WINTER	WATER PUMPING	0.75	1		1			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4.50
	SILD UNLCADER	7.50						1												1							7.50
																											12.00
SPRING	WATER PUMPING	0.75	1		1			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4.50
																											4.50
SUMMER	GRAIN AEREATION	2.00	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	48.00
	WATER PUMPING	0.75	1		1			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4.50
																											52.50
This load profile used for livestock farms in Kansas, Oklahoma and Texas.																											

This load profile used for livestock farms in Kansas, Oklahoma and Texas.

Beef-other crops

Description: The typical dryland crop-cattle farm has 100 cows with calves and 500 acres of corn, barley and oats. All feed is grown on the farm.

Assumptions: The cattle are fed grain and silage year round from an upright silo with a silo unloader and an auger bunk feeder. Water is pumped for the cattle and a block heater is used for a tractor during the winter.

Sources:

Telephone interview with several county agents and farm operators in the area.

Table 3.64. Beef-other Crcps

SEASON	ITEM	LOAD (KW)	TIME OF DAY																										TOTAL ENERGY (KWH)
			0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3			
FALL	BUNK FEEDER	5.00							1														1					5.00	
	WATER PUMPING	0.75	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4.88	
																												9.88	
WINTER	GRAIN DRYING	9.00	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	216.00	
	BUNK FEEDER	5.00							1															1				5.00	
	WATERER HEATERS	2.40	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	57.60		
	WATER PUMPING	0.75	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4.88		
	TRACTOR HEATER	1.50							1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	5.25		
																											288.72		
SPRING	SILD UNLOADER	7.50							1														1					7.50	
	BUNK FEEDER	5.00							1														1					5.00	
	WATER PUMPING	0.75	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4.88		
																											17.38		
SUMMER	SILD UNLOADER	7.50							1														1					7.50	
	BUNK FEEDER	5.00							1														1					5.00	
	WATER PUMPING	0.75	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4.88		
																											17.38		
This load profile used for livestock farms in North Dakota, South Dakota and Wisconsin.																													

Feeder Cattle Farm

Description: This cattle operation has 1,200 feeder cattle, 100 acres of corn silage, 100 acres in alfalfa, 100 acres in small grains and 100 acres in sugar beets.

Assumptions: The farm has a mill which mixes its own feed and runs 5 days a week, 5 hours a day year around.

Source:

Ron Nielsen, farmer, Paul, Idaho

B-40

This load profile used for livestock farms in Colorado, Idaho, Montana and Wyoming.

LOAD AMPLITUDE FACTORS

In Table 4, the load amplitude factors are shown for each state and for each size farm for the various type farms that characterize that state. The original load profiles that were developed to characterize each type farm were developed for a specific size in a specific location.

In adapting these specific load profiles to a broad range of sizes and locations, a load factor was estimated to adapt that load profile to the size and location of the farms in the matrix of the wind states. The load factor represents a percentage of the total that the farm of the matrix bears to the original site and size specific farm profile. This percentage adjusts the magnitude of the load of each operation of the load profile but maintains the shape and frequency of the load curve.

Table 4. LOAD AMPLITUDE FACTORS (%) BY TYPE AND SIZE OF FARM IN THE WIND STATES.

#	STATE	NONIRRIGATED CROPS			IRRIGATED CROPS					FRUIT, NUT, VEGETABLE (ALL)	POULTRY AND EGGS (ALL)	DAIRY			LIVESTOCK			RESIDENCE ONLY
		S	M	L	UNIT TYPE							S	M	L	S	M	L	
		<180	180- 500	>500	1	2	3	4	5			<25	20- 50	>50	<75	75- 225	>225	
1	COLORADO	60	80	100	80	60	120	60	15			70	80	100	25	50	100	100
2	IDAHO	60			90	70	130		15			70	80	100	25	50	100	100
3	ILLINOIS	30	50	100	60							70	80	100	70	100	200	100
4	INDIANA	30	50	100	60	40		40			100	70	80	100	70	100	200	100
5	IOWA	30	50	100	60			40				70	80	100	30	60	100	100
6	KANSAS	60	80	100	80		120	60				70	80	100	80	90	100	100
7	MAINE	100	120								100	70	80	100				100
8	MARYLAND	30	50	100	60	40					100	70	80	100	70	100	200	100
9	MICHIGAN	30	50	100						100	100	70	80	100	70	100	200	100
10	MINNESOTA	30	50	100	60	40						70	80	100	30	60	100	100
11	MISSOURI	30	50	100	60							70	80	100	30	60	100	100
12	MONTANA	60	80	100	80										25	50	100	100
13	NEBRASKA	60	80	100	60	40	100					70	80	100	30	60	100	100
14	NEW JERSEY									100	100	70	80	100				100
15	NEW YORK					40	90					70	80	100				100
16	NORTH DAKOTA	30	50	100	70							70	80	100	40	65	100	100
17	OHIO	30	50	100		50						70	80	100	70	100	200	100
18	OKLAHOMA	60	80	100	80	60	130	70	15			70	80	100	80	90	100	100
19	PENNSYLVANIA										100	70	80	100	70	100	200	100
20	SOUTH DAKOTA	30	50	100	60		90		15			70	80	100	40	65	100	100
21	TEXAS	60	80	100	90	70	130	70	15		100	70	80	100	80	90	100	100
22	WISCONSIN				70	50	100					70	80	100	40	65	100	100
23	WYOMING				70	50	100		15						25	50	100	100

TECHNICAL APPENDIX C

TECHNICAL AND ECONOMIC WTGS PERFORMANCE DATA (Feasible Cases Only)

<u>State</u>	<u>Page</u>
Scenario 5	
Colorado	C-2
Indiana	C-3
Iowa	C-4
Kansas	C-5
Maine	C-6
Michigan	C-7
Missouri	C-8
Nebraska	C-9
New Jersey	C-10
North Dakota	C-11
Pennsylvania	C-12
South Dakota	C-13
Texas	C-14
Scenario 6	
Colorado	C-15
Illinois	C-16
Indiana	C-17
Iowa	C-18
Kansas	C-19
Maine	C-20
Maryland	C-21
Michigan	C-22
Minnesota	C-23
Missouri	C-24
Montana	C-25
Nebraska	C-26
New Jersey	C-27
North Dakota	C-28
Ohio	C-29
Oklahoma	C-30
Pennsylvania	C-31
South Dakota	C-32
Texas	C-33
Wisconsin	C-34
Wyoming	C-35

STATE SUMMARY FOR COLORADO FOR ELECTRICITY COST OF \$0.06/KWH
TECHNICAL AND ECONOMIC DATA OF 'BEST' WIND TURBINE GENERATOR SYSTEM

ITEM	NONIRRIGATED CROPS			IRRIGATED CROPS					FRUIT, NUT, VEGETABLE (ALL)	POULTRY AND EGGS (ALL)	DAIRY			LIVESTOCK			RESIDENCE ONLY
	S	M	L	1	2	3	4	5			S	M	L	S	M	L	
	180-			UNIT TYPE							20-			75-			
	2180	500	2500	1	2	3	4	5	(ALL)	(ALL)	20	50	250	575	325	2325	ONLY
NUMBER OF FARMS AND IRRIGATION SYSTEMS (THOUSANDS)	1.0	0.2	0.2	3.8	0.2	0.2	1.7	2.1			6.2	0.6	0.5	2.5	3.0	1.0	17.3
ENERGY GENERATED AND USED BY FARM (THOUSAND KWH)	15	15	18								19	10	19	30	38	48	14
ANNUAL NET SAVINGS BY FARM (\$)	89	102	117								126	133	145	328	403	432	44
PRATED POWER (KW)	10	10	10								10	10	10	25	35	50	10
RATED SPEED (M/S)	10	10	9								9	9	9	10	10	10	10

C-2

NUMBER (000) OF DISCRETIZED WIND TURBINE SYSTEMS
BY GENERATOR RATING AND RATED SPEED

GENERATOR RATING (KW)	<---- RATED SPEED (M/S) ---->				TOTAL
	7	9	9	10	
10			1.5	18.5	20.0
15					
25				2.5	2.5
35				3.0	3.0
50				1.0	1.0
100					
TOTAL			1.5	25.0	26.5

STATE SUMMARY FOR INDIANA FOR ELECTRICITY COST OF \$0.06/KWH
TECHNICAL AND ECONOMIC DATA OF 'BEST' WIND TURBINE GENERATOR SYSTEM

ITEM	NONIRRIGATED CROPS			IRRIGATED CROPS					FRUIT, NUT, VEGETABLE	POULTRY AND EGGS	DAIRY			LIVESTOCK			RESIDENCE ONLY
	S	M	L	1	2	3	4	5			S	M	L	S	M	L	
	180-	500	2500						(ALL)	(ALL)	20-	50	250	75-	325	2325	
NUMBER OF FARMS AND IRRIGATION SYSTEMS (THOUSANDS)	16.4	10.8	0.6	0.2	0.2			0.1		2.8	3.9	3.8	0.7	17.0	5.0	0.4	38.2 4/12
ENERGY GENERATED AND USED BY FARM (THOUSAND KWH)										29							
ANNUAL NET SAVINGS BY FARM (\$)										124							
PRATED POWER (KW) RATED SPEED (M/S)										15 8							

C-3

NUMBER (000) OF DISCRETIZED WIND TURBINE SYSTEMS
BY GENERATOR RATING AND RATED SPEED

GENERATOR RATING (KW)	RATED SPEED (M/S)				TOTAL
	7	8	9	10	
10					
15		2.8			2.8
25					
35					
50					
100					
TOTAL		2.8			2.8

STATE SUMMARY FOR ICWA FOR ELECTRICITY COST OF \$0.06/KWH
 TECHNICAL AND ECONOMIC DATA OF 'BEST' WIND TURBINE GENERATOR SYSTEM

ITEM	NONIRRIGATED CROPS			IRRIGATED CROPS					FRUIT, NUT, VEGETABLE	POULTRY AND EGGS	DAIRY			LIVESTOCK			RESIDENCE ONLY
	S	M	L	1	2	3	4	5			S	M	L	S	M	L	
	180-	500	2500								20-			75-			
	180	500	2500	1	2	3	4	5	TABLE	TABLE	220	50	250	275	325	325	
NUMBER OF FARMS AND IRRIGATION SYSTEMS (THOUSANDS)	12.9	17.6	0.3	0.4				0.2			3.8	6.1	0.6	27.5	30.2	4.0	34.3
ENERGY GENERATED AND USED BY FARM (THOUSAND KWH)	23	26	26								18	18	23	19	26	35	17
ANNUAL NET SAVINGS BY FARM (\$)	73	84	84								80	86	102	140	280	446	13
PRATED POWER (KW)	15	25	25								10	10	15	10	15	15	10
RATED SPEED (M/S)	9	10	10								9	9	9	9	9	8	9

C-4

NUMBER (000) OF DISCRETIZED WIND TURBINE SYSTEMS
 BY GENERATOR RATING AND RATED SPEED

GENERATOR RATING (KW)	RATED SPEED (M/S)				TOTAL
	7	8	9	10	
10			71.7		71.7
15		4.0	43.7		47.7
25				17.9	17.9
35					
50					
100					
TOTAL		4.0	115.4	17.9	137.3

STATE SUMMARY FOR KANSAS FOR ELECTRICITY COST OF \$0.06/KWH
TECHNICAL AND ECONOMIC DATA OF 'BEST' WIND TURBINE GENERATOR SYSTEM

ITEM	NONIRRIGATED CROPS			IRRIGATED CROPS					FRUIT, NUT, VEGETABLE	POULTRY AND EGGS	DAIRY			LIVESTOCK			RESIDENCE
	S	M	L	1	2	3	4	5			S	M	L	S	M	L	
	180-	250-	2500						(ALL)	(ALL)	20-	20-	250	75-	75-	2325	DAILY
NUMBER OF FARMS AND IRRIGATION SYSTEMS (THOUSANDS)	7.6	13.1	3.5	5.6	.04	0.2	10.3				1.8	2.4	0.6	11.9	9.9	2.9	24.0
ENERGY GENERATED AND USED BY FARM (THOUSAND KWH)	15	15	15								18	19	19	15	15	15	14
ANNUAL NET SAVINGS BY FARM (\$)	80	94	108								117	125	139	83	90	94	31
PRATED POWER (KW)	10	10	10								10	10	10	10	10	10	10
RATED SPEED (M/S)	10	10	10								9	9	9	10	10	10	10

C-5

NUMBER (000) OF DISCRETIZED WIND TURBINE SYSTEMS
BY GENERATOR RATING AND RATED SPEED

GENERATOR RATING (KW)	RATED SPEED (M/S)				TOTAL
	7	8	9	10	
10			4.8	72.9	77.7
15					
25					
35					
50					
100					
TOTAL			4.8	72.9	77.7

STATE SUMMARY FOR MAINE FOR ELECTRICITY COST OF \$0.05/KWH
TECHNICAL AND ECONOMIC DATA OF 'BEST' WIND TURBINE GENERATOR SYSTEM

ITEM	NONIRRIGATED CROPS			IRRIGATED CROPS					FRUIT, NUT, VEGETABLE	POULTRY AND EGGS	DAIRY			LIVESTOCK			RESIDENCE ONLY
	S	M	L	1	2	3	4	5			S	M	L	S	M	L	
	180-	500	2500						(ALL)	(ALL)	20-	50	250	75-	225	2325	
NUMBER OF FARMS AND IRRIGATION SYSTEMS (THOUSANDS)	0.5	0.6								1.0	0.3	0.6	0.2				4.4
ENERGY GENERATED AND USED BY FARM (THOUSAND KWH)										28							
ANNUAL NET SAVINGS BY FARM (\$)										59							
PRATED POWER (KW) RATED SPEED (M/S)										15 8							

C-6

NUMBER (000) OF DISCRETIZED WIND TURBINE SYSTEMS
BY GENERATOR RATING AND RATED SPEED

GENERATOR RATING (KW)	<---- RATED SPEED (M/S) ---->				TOTAL
	7	8	9	10	
10					
15		1.0			1.0
25					
35					
50					
100					
TOTAL		1.0			1.0

STATE SUMMARY FOR MICHIGAN FOR ELECTRICITY COST OF \$0.06/KWH
TECHNICAL AND ECONOMIC DATA OF 'BEST' WIND TURBINE GENERATOR SYSTEM

ITEM	NONIRRIGATED CROPS			IRRIGATED CROPS					FRUIT, NUT, VEGETABLE	POULTRY AND EGGS	DAIRY			LIVESTOCK			RESIDENCE ONLY
	S	M	L	1	2	3	4	5			S	M	L	S	M	L	
	180-	250-	325-						(ALL)	(ALL)	20-	25-	325-				
NUMBER OF FARMS AND IRRIGATION SYSTEMS (THOUSANDS)	7.7	4.7	0.1						4.1	1.4	7.0	7.5	1.1	5.0	1.2	0.2	40.6
ENERGY GENERATED AND USED BY FARM (THOUSAND KWH)										39							
ANNUAL NET SAVINGS BY FARM (\$)										207							
PRATED POWER (KW) RATED SPEED (M/S)										15 7							

C-7

NUMBER (000) OF DISCRETIZED WIND TURBINE SYSTEMS
BY GENERATOR RATING AND RATED SPEED

GENERATOR RATING (KW)	RATED SPEED (M/S)				TOTAL
	7	8	9	10	
10					
15	1.4				1.4
25					
35					
50					
100					
TOTAL	1.4				1.4

STATE SUMMARY FOR MISSOURI FOR ELECTRICITY COST OF \$0.06/KWH
TECHNICAL AND ECONOMIC DATA OF 'BEST' WIND TURBINE GENERATOR SYSTEM

ITEM	NONIRRIGATED CROPS			IRRIGATED CROPS					FRUIT, NUT, VEGETABLE	POULTRY AND EGGS	DAIRY			LIVESTOCK			RESIDENCE ONLY
	S	M	L	1	2	3	4	5			S	M	L	S	M	L	
	180-	220	250								20-			75-			
	180	220	250	1	2	3	4	5	ALL	ALL	20	50	250	575	225	2325	ONLY
NUMBER OF FARMS AND IRRIGATION SYSTEMS (THOUSANDS)	6.9	8.9	0.5	0.2							7.1	4.6	0.1	25.6	13.9	0.9	69.7
ENERGY GENERATED AND USED BY FARM (THOUSAND KWH)											16	17		18	25	33	
ANNUAL NET SAVINGS BY FARM (\$)											2	5		75	195	366	
PRATED PCWER (KW) RATED SPEED(M/S)											10 9	10 5		10 9	15 9	15 8	

C-8

NUMBER (000) OF DISCRETIZED WIND TURBINE SYSTEMS
BY GENERATOR RATING AND RATED SPEED

GENERATOR RATING (KW)	RATED SPEED (M/S)				TOTAL
	7	8	9	10	
10			30.9		30.9
15		0.9	13.9		14.8
25					
35					
50					
100					
TOTAL		0.9	44.8		45.7

STATE SUMMARY FOR NEBRASKA FOR ELECTRICITY COST OF \$0.06/KWH
TECHNICAL AND ECONOMIC DATA OF 'BEST' WIND TURBINE GENERATOR SYSTEM

ITEM	NONIRRIGATED CROPS			IRRIGATED CROPS					FRUIT, NUT, VEGETABLE (ALL)	POULTRY AND EGGS (ALL)	DAIRY			LIVESTOCK			RESIDENCE ONLY
	S	M	L	1	2	3	4	5			S	M	L	S	M	L	
	180-										20-			75-			
	<180	500	>500	1	2	3	4	5	(ALL)	(ALL)	<20	20	>20	<75	75	>75	
NUMBER OF FARMS AND IRRIGATION SYSTEMS (THOUSANDS)	3.2	7.7	1.6	13.6	0.1	0.2					1.2	1.6	0.3	13.5	14.0	3.0	15.5
ENERGY GENERATED AND USED BY FARM (THOUSAND KWH)	19	19	15								20	20	25	20	28	37	15
ANNUAL NET SAVINGS BY FARM (\$)	154	169	184								201	208	223	242	378	558	107
PRATED POWER (KW)	10	10	10								10	10	15	10	15	15	10
RATED SPEED (M/S)	9	9	9								9	9	9	9	9	8	10

C-9

NUMBER (000) OF DISCRETIZED WIND TURBINE SYSTEMS
BY GENERATOR RATING AND RATED SPEED

GENERATOR RATING (KW)	<---- RATED SPEED (M/S) ---->				TOTAL
	7	8	9	10	
10			28.8	15.5	44.3
15		3.0	14.3		17.3
25					
35					
50					
100					
TOTAL		3.0	43.1	15.5	61.6

STATE SUMMARY FOR NEW JERSEY FOR ELECTRICITY COST OF \$0.06/KWH
TECHNICAL AND ECONOMIC DATA OF 'BEST' WIND TURBINE GENERATOR SYSTEM

ITEM	NONIRRIGATED CROPS			IRRIGATED CROPS					FRUIT, NLT, VEGETABLE	POULTRY AND EGGS	DAIRY			LIVESTOCK			RESIDENCE ONLY
	S	M	L	1	2	3	4	5			S	M	L	S	M	L	
	180-	500	2500						1000	1000	200	50	250	275	325	2325	
NUMBER OF FARMS AND IRRIGATION SYSTEMS (THOUSANDS)									1.4	1.0	0.1	0.7	0.4				4.4
ENERGY GENERATED AND USED BY FARM (THOUSAND KWH)										28							
ANNUAL NET SAVINGS BY FARM (\$)										40							
PRATED POWER (KW) RATED SPEED (M/S)										15 8							

C-10

NUMBER (000) OF DISCRETIZED WIND TURBINE SYSTEMS
BY GENERATOR RATING AND RATED SPEED

GENERATOR RATING (KW)	RATED SPEED (M/S)				TOTAL
	7	8	9	10	
10					
15		1.0			1.0
25					
35					
50					
100					
TOTAL		1.0			1.0

STATE SUMMARY FOR NORTH DAKOTA FOR ELECTRICITY COST OF \$0.06/KWH
TECHNICAL AND ECONOMIC DATA OF 'BEST' WIND TURBINE GENERATOR SYSTEM

ITEM	NONIRRIGATED CROPS			IRRIGATED CROPS					FRUIT, NUT, VEGETABLE (ALL)	POULTRY AND EGGS (ALL)	DAIRY			LIVESTOCK			RESIDENCE ONLY
	S	M	L	UNIT TYPE							S	M	L	S	M	L	
	180-	180-	2500	1	2	3	4	5			20-	20-	250	75-	75-	2225	
NUMBER OF FARMS AND IRRIGATION SYSTEMS (THOUSANDS)	2.1	12.0	8.6	0.4							0.9	1.0	0.1	3.9	3.0	0.8	8.8
ENERGY GENERATED AND USED BY FARM (THOUSAND KWH)	21	29	46								2	20	25	20	26	26	15
ANNUAL NET SAVINGS BY FARM (\$)	223	282	344								214	222	239	202	249	293	117
PRATED POWER (KW)	15	25	50								10	10	15	10	15	15	10
RATED SPEED(M/S)	10	10	10								9	9	9	9	9	9	10

C-11

NUMBER (000) OF DISCRETIZED WIND TURBINE SYSTEMS
BY GENERATOR RATING AND RATED SPEED

GENERATOR RATING (KW)	RATED SPEED (M/S)				TOTAL
	7	8	9	10	
10			5.8	8.8	14.6
15			3.9	2.1	6.0
25				12.0	12.0
35					
50				8.0	8.6
100					
TOTAL			9.7	31.8	41.2

STATE SUMMARY FOR PENNSYLVANIA FOR ELECTRICITY COST OF \$0.06/KWH
TECHNICAL AND ECONOMIC DATA OF 'BEST' WIND TURBINE GENERATOR SYSTEM

	NONIRRIGATED CECPS			IRRIGATED CECPS					FRUIT, NUT, VEGETABLE	POULTRY AND EGGS	DAIRY			LIVESTOCK			RESIDENCE
	S	M	L								S	M	L	S	M	L	
ITEM	180-	500	2500	1	2	3	4	5	(ALL)	(ALL)	20-	50	250	75-	325	2325	(ONLY)
NUMBER OF FARMS AND IRRIGATION SYSTEMS (THOUSANDS)										3.4	6.6	11.9	0.2	4.0	0.7	0.1	44.1
ENERGY GENERATED AND USED BY FARM (THOUSAND KWH)										28							
ANNUAL NET SAVINGS BY FARM (\$)										59							
RATED POWER (KW) RATED SPEED (M/S)										15 8							

C-12

NUMBER (100) OF DISCRETIZED WIND TURBINE SYSTEMS
BY GENERATOR RATING AND RATED SPEED

GENERATOR RATING (KW)	<--- RATED SPEED (M/S) --->				TOTAL
	7	8	9	10	
10					
15		3.4			3.4
25					
35					
50					
100					
TOTAL		3.4			3.4

STATE SUMMARY FOR SOUTH DAKOTA FOR ELECTRICITY COST OF \$0.06/KWH
TECHNICAL AND ECONOMIC DATA OF 'BEST' WIND TURBINE GENERATOR SYSTEM

	NONIRRIGATED CROPS			IRRIGATED CROPS					FRUIT, NUT, VEGETABLE	POULTRY AND EGGS	DAIRY			LIVESTOCK			RESIDENCE
	S	M	L	UNIT TYPE							S	M	L	S	M	L	
VIEW	5180	180- 500	2500	1	2	3	4	5	(ALL)	(ALL)	20	20	250	275	325	2325	ONLY
NUMBER OF FARMS AND IRRIGATION SYSTEMS (THOUSANDS)	1.3	3.2	1.8	0.1	0.4	0.2					1.2	1.8	0.2	8.0	12.2	2.4	10.6
ENERGY GENERATED AND USED BY FARM (THOUSAND KWH)	21	29	46								20	20	25	20	26	26	15
ANNUAL NET SAVINGS BY FARM (\$)	223	282	344								214	222	239	202	249	293	117
PRATED POWER (KW)	15	25	50								10	10	15	10	15	15	10
RATED SPEED (M/S)	10	10	10								9	9	9	9	9	9	10

C-13

NUMBER (000) OF DISCRETIZED WIND TURBINE SYSTEMS
BY GENERATOR RATING AND RATED SPEED

GENERATOR RATING (KW)	RATED SPEED (M/S)				TOTAL
	7	8	9	10	
10			11.0	10.6	21.6
15			14.8	1.3	16.1
25				3.2	3.2
35					
50				1.8	1.8
100					
TOTAL			25.8	16.9	42.7

STATE SUMMARY FOR TEXAS FOR ELECTRICITY COST OF \$0.06/KWH
TECHNICAL AND ECONOMIC DATA OF 'BEST' WIND TURBINE GENERATOR SYSTEM

ITEM	NONIRRIGATED CROPS			IRRIGATED CROPS					FRUIT, NUT, VEGETABLE (ALL)	POULTRY AND EGGS (ALL)	DAIRY			LIVESTOCK			RESIDENCE ONLY
	S	M	L	UNIT TYPE							S	M	L	S	M	L	
	180-	500	2500	1	2	3	4	5			20-	50	250	75-	225	225	
NUMBER OF FARMS AND IRRIGATION SYSTEMS (THOUSANDS)	4.9	12.7	3.0	4.0	6.4	5.3	27.6	3.8		3.2	0.3	1.6	2.4	12.9	5.5	0.8	140.4
ENERGY GENERATED AND USED BY FARM (THOUSAND KWH)										49							
ANNUAL NET SAVINGS BY FARM (\$)										600							
PRATED POWER (KW RATED SPEED(M/S)										25 8							

C-14

NUMBER (000) OF DISCRETIZED WIND TURBINE SYSTEMS
BY GENERATOR RATING AND RATED SPEED

GENERATOR RATING (KW)	RATED SPEED (M/S)				TOTAL
	7	8	9	10	
10					
15					
25		3.2			3.2
35					
50					
100					
TOTAL		3.2			3.2

STATE SUMMARY FOR COLORADO FOR ELECTRICITY COST OF \$0.08/KWH
TECHNICAL AND ECONOMIC DATA OF 'BEST' WIND TURBINE GENERATOR SYSTEM

ITEM	NONIRRIGATED CROPS			IRRIGATED CROPS					FRUIT, NUT, VEGETABLE	POULTRY AND EGGS	DAIRY			LIVESTOCK			RESIDENCE
	S	M	L	1	2	3	4	5			S	M	L	S	M	L	
	180-	180-	2500						(ALL)	(ALL)	20-	20-	250	75-	75-	2225	ONLY
NUMBER OF FARMS AND IRRIGATION SYSTEMS (THOUSANDS)	1.0	0.2	0.2	3.8	0.2	0.2	1.7	2.1			0.2	0.6	0.5	2.5	3.0	1.0	17.3
ENERGY GENERATED AND USED BY FARM (THOUSAND KWH)	21	21	22								23	23	24	35	45	48	17
ANNUAL NET SAVINGS BY FARM (\$)	443	472	501								538	567	600	995	1259	1776	363
PRATED POWER (KW)	10	10	10								15	15	15	25	35	100	10
RATED SPEED(M/S)	8	8	8								9	9	9	9	9	10	9

C-15

NUMBER (000) OF DISCRETIZED WIND TURBINE SYSTEMS
BY GENERATOR RATING AND RATED SPEED

GENERATOR RATING (KW)	RATED SPEED (M/S)				TOTAL
	7	8	9	10	
10		1.4	17.3		18.7
15			1.3		1.3
25			2.5		2.5
35			3.0		3.0
50					
100				1.0	1.0
TOTAL		1.4	24.1	1.0	26.5

STATE SUMMARY FOR ILLINOIS FOR ELECTRICITY COST OF \$0.08/KWH
TECHNICAL AND ECONOMIC DATA OF 'BEST' WIND TURBINE GENERATOR SYSTEM

ITEM	NONIRRIGATED CROPS			IRRIGATED CROPS					FROIT, NUT, VEGETABLE (ALL)	POULTRY AND EGGS (ALL)	DAIRY			LIVESTOCK			RESIDENCE ONLY
	S	M	L	1	2	3	4	5			S	M	L	S	M	L	
	180-	2500									20-	250		75-	325	325	
NUMBER OF FARMS AND IRRIGATION SYSTEMS (THOUSANDS)	22.4	28.4	1.0	0.2							2.0	4.9	0.8	15.0	11.0	2.0	38.2
ENERGY GENERATED AND USED BY FARM (THOUSAND KWH)		23	29										16	16	17	30	
ANNUAL NET SAVINGS BY FARM (\$)		10	18										1	44	95	294	
PRATED POWER (KW) RATED SPEED (M/S)		25 9	35 9										10 8	10 8	10 8	15 7	

NUMBER (000) OF DISCRETIZED WIND TURBINE SYSTEMS
BY GENERATOR RATING AND RATED SPEED

GENERATOR RATING (KW)	RATED SPEED (M/S)				TOTAL
	7	8	9	10	
10			26.8		26.8
15	2.0				2.0
25			28.4		28.4
35			1.0		1.0
50					
100					
TOTAL	2.0	26.8	29.4		58.2

STATE SUMMARY FOR INDIANA FOR ELECTRICITY COST OF \$0.08/KWH
TECHNICAL AND ECONOMIC DATA OF 'BEST' WIND TURBINE GENERATOR SYSTEM

ITEM	NONIRRIGATED CROPS			IRRIGATED CROPS					FRUIT, NUT, VEGETABLE (ALL)	POULTRY AND EGGS (ALL)	DAIRY			LIVESTOCK			RESIDENCE ONLY
	S	M	L	UNIT TYPE							S	M	L	S	M	L	
	180-	500	2500	1	2	3	4	5			20-	50	250	75-	325	2325	
NUMBER OF FARMS AND IRRIGATION SYSTEMS (THOUSANDS)	16.4	10.6	0.6	0.2	0.2		0.1			2.8	3.9	3.8	0.7	17.0	5.0	0.4	44.2
ENERGY GENERATED AND USED BY FARM (THOUSAND KWH)		23	29							37			16	16	17	30	
ANNUAL NET SAVINGS BY FARM (\$)		10	18							847			1	44	95	294	
PRATED POWER (KW)		25	15							15			10	10	10	15	
RATED SPEED (M/S)		9	9							7			8	8	8	7	

C-17

NUMBER (000) OF DISCRETIZED WIND TURBINE SYSTEMS
BY GENERATOR RATING AND RATED SPEED

GENERATOR RATING (KW)	<---- RATED SPEED (M/S) ---->				TOTAL
	7	8	9	10	
10			22.7		22.7
15	3.2				3.2
25			10.8		10.8
35			0.6		0.6
50					
100					
TOTAL	3.2	22.7	11.4		37.3

STATE SUMMARY FOR ICWA FOR ELECTRICITY COST OF \$0.03/KWH
TECHNICAL AND ECONOMIC DATA OF 'BEST' WIND TURBINE GENERATOR SYSTEM

ITEM	NONIRRIGATED CROPS			IRRIGATED CROPS					FRUIT, NUT, VEGETABLE	POULTRY AND EGGS	DAIRY			LIVESTOCK			RESIDENCE ONLY
	S	M	L	1	2	3	4	5			S	M	L	S	M	L	
	130-										20-			75-			
	2500	500	2500	1	2	3	4	5	(ALL)	(ALL)	20	50	50	25	325	2325	
NUMBER OF FARMS AND IRRIGATION SYSTEMS (THOUSANDS)	12.9	17.6	0.3	0.4			0.2				3.8	6.1	0.6	27.5	30.2	4.0	34.3
ENERGY GENERATED AND USED BY FARM (THOUSAND KWH)	31	39	60								27	23	28	28	32	42	20
ANNUAL NET SAVINGS BY FARM (\$)	674	805	1023								561	573	610	632	891	1194	359
RATED POWER (KW)	25	35	50								15	15	15	15	15	15	10
RATED SPEED (M/S)	9	9	8								8	8	8	8	8	7	8

C-18

NUMBER (000) OF DISCRETIZED WIND TURBINE SYSTEMS
BY GENERATOR RATING AND RATED SPEED

GENERATOR RATING (KW)	RATED SPEED (M/S)				TOTAL
	7	8	9	10	
10			34.3		34.3
15	4.0	68.2			72.2
25			12.9		12.9
35			17.6		17.6
50		0.3			0.3
100					
TOTAL	4.0	102.8	30.5		137.3

STATE SUMMARY FOR KANSAS FOR ELECTRICITY COST OF \$0.08/KWH
TECHNICAL AND ECONOMIC DATA OF 'BEST' WIND TURBINE GENERATOR SYSTEM

	NONIRRIGATED CROPS			IRRIGATED CROPS					FRUIT, NUT, VEGETABLE	POULTRY AND EGGS	DAIRY			LIVESTOCK			RESIDENCE ONLY
	S	M	L	1	2	3	4	5			S	M	L	S	M	L	
ITEM	180-	500	2500						FALL	FALL	20-	75-	325	325	325		
NUMBER OF FARMS AND IRRIGATION SYSTEMS (THOUSANDS)	7.6	13.1	3.5	5.6	.04	0.2	10.3				1.8	2.4	0.6	11.9	9.9	2.9	24.0
ENERGY GENERATED AND USED BY FARM (THOUSAND KWH)	18	21	22								23	23	28	21	21	21	17
ANNUAL NET SAVINGS BY FARM (\$)	422	452	482								526	553	584	439	453	464	341
PRATED POWER (KW)	10	10	10								15	15	15	10	10	10	10
RATED SPEED (M/S)	9	8	8								9	9	8	8	8	8	9

C-19

NUMBER (000) OF DISCRETIZED WIND TURBINE SYSTEMS
BY GENERATOR RATING AND RATED SPEED

GENERATOR RATING (KW)	RATED SPEED (M/S)				TOTAL
	7	8	9	10	
10		41.3	31.5		72.9
15		0.6	4.2		4.8
25					
35					
50					
100					
TOTAL		41.9	35.8		77.7

STATE SUMMARY FOR MAINE FOR ELECTRICITY COST OF \$0.08/KWH
TECHNICAL AND ECONOMIC DATA OF 'BEST' WIND TURBINE GENERATOR SYSTEM

ITEM	NONIRRIGATED CROPS			IRRIGATED CROPS					FRUIT, NUT, VEGETABLE	POULTRY AND EGGS	DAIRY			LIVESTOCK			RESIDENCE ONLY
	S	M	L	UNIT TYPE							S	M	L	S	M	L	
	180-	500	2500	1	2	3	4	5	(ALL)	(ALL)	20-	75-	325	75-	325	325	
NUMBER OF FARMS AND IRRIGATION SYSTEMS (THOUSANDS)	0.5	0.6								1.0	0.3	0.6	0.2			4.4	
ENERGY GENERATED AND USED BY FARM (THOUSAND KWH)										49							
ANNUAL NET SAVINGS BY FARM (\$)										877							
PRATED POWER (KW)										25							
RATED SPEED(M/S)										7							

C-20

NUMBER (000) OF DISCRETIZED WIND TURBINE SYSTEMS
BY GENERATOR RATING AND RATED SPEED

GENERATOR RATING (KW)	RATED SPEED (M/S)				TOTAL
	7	8	9	10	
10					
15					
25	1.0				1.0
35					
50					
100					
TOTAL	1.0				1.0

STATE SUMMARY FOR MARYLAND FOR ELECTRICITY COST OF \$0.08/KWH
TECHNICAL AND ECONOMIC DATA OF 'BEST' WIND TURBINE GENERATOR SYSTEM

ITEM	NONIRRIGATED CROPS			IRRIGATED CROPS					FRUIT, NUT, VEGETABLE	POULTRY AND EGGS	DAIRY			LIVESTOCK			RESIDENCE
	S	M	L	1	2	3	4	5			S	M	L	S	M	L	
	180-										20-			75-			
	<180	500	500	1	2	3	4	5	(ALL)	(ALL)	<20	50	250	<75	225	225	ONLY
NUMBER OF FARMS AND IRRIGATION SYSTEMS (THOUSANDS)	1.0	0.3	0.1	0.1	0.1					1.4	0.5	1.7	0.9	0.8	0.3	0.1	10.5
ENERGY GENERATED AND USED BY FARM (THOUSAND KWH)										34						17	
ANNUAL NET SAVINGS BY FARM (\$)										590						111	
PRATED POWER (KW) RATED SPEED(M/S)										15 7						10 8	

C-21

NUMBER (000) OF DISCRETIZED WIND TURBINE SYSTEMS
BY GENERATOR RATING AND RATED SPEED

GENERATOR RATING (KW)	RATED SPEED (M/S)				TOTAL
	7	8	9	10	
10		0.1			0.1
15	1.4				1.4
25					
35					
50					
100					
TOTAL	1.4	0.1			1.5

STATE SUMMARY FOR MICHIGAN FOR ELECTRICITY COST OF \$0.08/KWH
TECHNICAL AND ECONOMIC DATA OF 'BEST' WIND TURBINE GENERATOR SYSTEM

ITEM	NONIRRIGATED CROPS			IRRIGATED CROPS					FRUIT, NUT, VEGETABLE	POULTRY AND EGGS	DAIRY			LIVESTOCK			RESIDENCE ONLY
	S	M	L	1	2	3	4	5			S	M	L	S	M	L	
UNIT TYPE	180	180	2500	1	2	3	4	5	CALL	CALL	20	50	250	75	225	2325	
NUMBER OF FARMS AND IRRIGATION SYSTEMS (THOUSANDS)	7.7	4.7	0.1						4.1	1.4	7.0	7.5	1.1	5.0	1.2	0.2	40.0
ENERGY GENERATED AND USED BY FARM (THOUSAND KWH)		23	29						23	52			16	16	17	30	
ANNUAL NET SAVINGS BY FARM (\$)		10	18						170	1133			1	44	55	294	
PRATED POWER (KW) RATED SPEED (M/S)		25 9	35 9						15 8	25 7			10 8	10 8	10 8	15 7	

C-22

NUMBER (000) OF DISCRETIZED WIND TURBINE SYSTEMS
BY GENERATOR RATING AND RATED SPEED

GENERATOR RATING (KW)	RATED SPEED (M/S)				TOTAL
	7	8	9	10	
10		7.3			7.3
15	0.2	4.1			4.3
25	1.4		4.7		6.1
35			0.1		0.1
50					
100					
TOTAL	1.6	11.4	4.8		17.8

STATE SUMMARY FOR MINNESOTA FOR ELECTRICITY COST OF \$0.08/KWH
TECHNICAL AND ECONOMIC DATA OF 'BEST' WIND TURBINE GENERATOR SYSTEM

ITEM	NONIRRIGATED CROPS			IRRIGATED CROPS					FRUIT, NUT, VEGETABLE	POULTRY AND EGGS	DAIRY			LIVESTOCK			RESIDENCE ONLY
	S	M	L	1	2	3	4	5			S	M	L	S	M	L	
	<180	180- 500	>500						(ALL)	(ALL)	<20	20- 50	>50	<75	75- 225	>225	
NUMBER OF FARMS AND IRRIGATION SYSTEMS (THOUSANDS)	7.9	11.1	0.7	0.8	0.1						14.6	17.6	1.0	10.4	7.0	0.6	46.3
ENERGY GENERATED AND USED BY FARM (THOUSAND KWH)		23	29													16	
ANNUAL NET SAVINGS BY FARM (\$)		10	18													1	
PRATED POWER (KW)		25	35													10	
RATED SPEED (M/S)		9	9													8	

C-23

NUMBER (000) OF DISCRETIZED WIND TURBINE SYSTEMS
BY GENERATOR RATING AND RATED SPEED

GENERATOR RATING (KW)	RATED SPEED (M/S)				TOTAL
	7	8	9	10	
10		1.0			1.0
15					
25			11.1		11.1
35			0.7		0.7
50					
100					
TOTAL		1.0	11.8		12.8

STATE SUMMARY FOR MISSOURI FOR ELECTRICITY COST OF \$0.03/KWH.
TECHNICAL AND ECONOMIC DATA OF 'BEST' WIND TURBINE GENERATOR SYSTEM

ITEM	NONIRRIGATED CROPS			IRRIGATED CROPS					FRUIT, NUT, VEGETABLE (ALL)	POULTRY AND EGGS (ALL)	DAIRY			LIVESTOCK			RESIDENCE ONLY
	S	M	L	UNIT TYPE							S	M	L	S	M	L	
	180-	500	2500	1	2	3	4	5			20-	75-	225	2325			
NUMBER OF FARMS AND IRRIGATION SYSTEMS (THOUSANDS)	6.9	8.9	0.5	0.2							7.1	4.6	0.7	25.6	13.9	0.9	69.7
ENERGY GENERATED AND USED BY FARM (THOUSAND KWH)	29	37	58								25	25	26	22	30	40	15
ANNUAL NET SAVINGS BY FARM (\$)	486	603	804								378	403	438	475	745	1051	224
PRATED POWER (KW)	25	35	50								15	15	15	10	15	15	10
RATED SPEED(M/S)	9	9	8								8	8	8	8	8	7	9

C-24

NUMBER (000) OF DISCRETIZED WIND TURBINE SYSTEMS
BY GENERATOR RATING AND RATED SPEED

GENERATOR RATING (KW)	RATED SPEED (M/S)				TOTAL
	7	8	9	10	
10		25.6	69.7		95.3
15	0.9	26.3			27.2
25			6.9		6.9
35			8.9		8.9
50		0.5			0.5
100					
TOTAL	0.9	52.4	85.5		138.8

STATE SUMMARY FOR MONTANA FOR ELECTRICITY COST OF \$0.08/KWH
TECHNICAL AND ECONOMIC DATA OF 'BEST' WIND TURBINE GENERATOR SYSTEM

ITEM	NONIRRIGATED CROPS			IRRIGATED CROPS					FRUIT, NUT, VEGETABLE (ALL)	POULTRY AND EGGS (ALL)	DAIRY			LIVESTOCK			RESIDENCE (DAILY)
	S	M	L	1	2	3	4	5			S	M	L	S	M	L	
	180-	500	2500								20-	50	250	75-	325	2325	
NUMBER OF FARMS AND IRRIGATION SYSTEMS (THOUSANDS)	1.1	2.2	4.1	0.2										1.8	2.5	0.9	11.9
ENERGY GENERATED AND USED BY FARM (THOUSAND KWH)	16	16	17											24	35	44	
ANNUAL NET SAVINGS BY FARM (\$)	48	63	80											317	444	480	
PRATED POWER (KW) RATED SPEED (M/S)	10 8	10 8	10 8											15 8	35 9	50 9	

C-25

NUMBER (000) OF DISCRETIZED WIND TURBINE SYSTEMS
BY GENERATOR RATING AND RATED SPEED

GENERATOR RATING (KW)	RATED SPEED (M/S)				TOTAL
	7	8	9	10	
10		7.4			7.4
15		1.8			1.8
25					
35			2.5		2.5
50			0.9		0.9
100					
TOTAL		9.2	3.4		12.6

STATE SUMMARY FOR NEBRASKA FOR ELECTRICITY COST OF \$0.08/KWH
TECHNICAL AND ECONOMIC DATA OF 'BEST' WIND TURBINE GENERATOR SYSTEM

ITEM	NONIRRIGATED CROPS			IRRIGATED CROPS					FRUIT, NUT, VEGETABLE (ALL)	POULTRY AND EGGS (ALL)	DAIRY			LIVESTOCK			RESIDENCE ONLY
	S	M	L	1	2	3	4	5			S	M	L	S	M	L	
	180-										20-			75-			
	5100	5200	5500	1	2	3	4	5			220	50	250	275	325	2325	
NUMBER OF FARMS AND IRRIGATION SYSTEMS (THOUSANDS)	3.2	7.7	1.6	13.6	0.1	0.2					1.2	1.6	0.3	13.5	14.0	3.0	15.5
ENERGY GENERATED AND USED BY FARM (THOUSAND KWH)	23	23	23								29	29	30	25	33	43	22
ANNUAL NET SAVINGS BY FARM (\$)	560	586	612								574	711	753	712	952	1254	476
PRATED POWER (KW) RATED SPEED (M/S)	10 8	10 8	10 8								15 8	15 8	15 8	15 9	15 8	15 7	10 8

C-26

NUMBER (000) OF DISCRETIZED WIND TURBINE SYSTEMS
BY GENERATOR RATING AND RATED SPEED

GENERATOR RATING (KW)	RATED SPEED (M/S)				TOTAL
	7	8	9	10	
10		28.0			28.0
15	3.0	17.1	13.5		33.6
25					
35					
50					
100					
TOTAL	3.0	45.1	13.5		61.6

STATE SUMMARY FOR NEW JERSEY FOR ELECTRICITY COST OF \$0.06/KWH
TECHNICAL AND ECONOMIC DATA OF 'BEST' WIND TURBINE GENERATOR SYSTEM

ITEM	NONIRRIGATED CROPS			IRRIGATED CROPS					FRUIT, NUT, VEGETABLE	POULTRY AND EGGS	DAIRY			LIVESTOCK			RESIDENCE
	S	M	L	1	2	3	4	5			S	M	L	S	M	L	
	180-	500	2500						(ALL)	(ALL)	20-	50	250	75-	325	2325	ONLY
NUMBER OF FARMS AND IRRIGATION SYSTEMS (THOUSANDS)									1.4	1.0	0.1	0.7	0.4				4.4
ENERGY GENERATED AND USED BY FARM (THOUSAND KWH)									22	47							
ANNUAL NET SAVINGS BY FARM (\$)									140	771							
RATED POWER (KW) RATED SPEED (M/S)									10 7	25 7							

C-27

NUMBER (OCC) OF DISCRETIZED WIND TURBINE SYSTEMS
BY GENERATOR RATING AND RATED SPEED

GENERATOR RATING (KW)	<--- RATED SPEED (M/S) --->				TOTAL
	7	8	9	10	
10	1.4				1.4
15					
25	1.0				1.0
35					
50					
100					
TOTAL	2.4				2.4

STATE SUMMARY FOR NORTH DAKOTA FOR ELECTRICITY COST OF \$0.08/KWH
TECHNICAL AND ECONOMIC DATA OF 'BEST' WIND TURBINE GENERATOR SYSTEM

ITEM	NONIRRIGATED CROPS			IRRIGATED CROPS					FRUIT, NUT, VEGETABLE	POULTRY AND EGGS	DAIRY			LIVESTOCK			RESIDENCE ONLY
	S	M	L	1	2	3	4	5			S	M	L	S	M	L	
	180-	180-	2500						(ALL)	(ALL)	20-	20-	250	75-	75-	2225	
NUMBER OF FARMS AND IRRIGATION SYSTEMS (THOUSANDS)	2.1	12.0	8.6	0.4							0.9	1.0	0.1	3.9	3.0	0.8	8.8
ENERGY GENERATED AND USED BY FARM (THOUSAND KWH)	33	35	55								29	30	30	29	30	34	22
ANNUAL NET SAVINGS BY FARM (\$)	804	951	1389								702	737	786	689	769	890	497
RATED POWER (KW)	25	25	50								15	15	15	15	15	25	10
RATED SPEED (M/S)	9	9	5								8	8	8	8	8	9	8

C-28

NUMBER (000) OF DISCRETIZED WIND TURBINE SYSTEMS
BY GENERATOR RATING AND RATED SPEED

GENERATOR RATING (KW)	RATED SPEED (M/S)				TOTAL
	7	8	9	10	
10		8.8			8.8
15		8.9			8.9
25			14.9		14.9
35					
50			8.6		8.6
100					
TOTAL		17.7	23.5		41.2

STATE SUMMARY FOR OHIO FOR ELECTRICITY CCST OF \$0.08/KWH
TECHNICAL AND ECONOMIC DATA OF 'BEST' WIND TURBINE GENERATOR SYSTEM

ITEM	NONIRRIGATED CROPS			IRRIGATED CROPS					FRUIT, NUT, VEGETABLE	POULTRY AND EGGS	DAIRY			LIVESTOCK			RESIDENCE
	S	M	L	1	2	3	4	5			S	M	L	S	M	L	
	180-	180-	2500	UNIT TYPE					(ALL)	(ALL)	20-	20-	250	75-	75-	2325	ONLY
NUMBER OF FARMS AND IRRIGATION SYSTEMS (THOUSANDS)	12.3	7.3	0.4	0.3							7.4	7.4	1.1	13.1	4.7	0.4	62.5
ENERGY GENERATED AND USED BY FARM (THOUSAND KWH)		23	29								16	16	16	16	17	30	
ANNUAL NET SAVINGS BY FARM (%)		10	18								5	18	30	44	95	294	
PRATED POWER (KW)		25	35								10	10	10	10	10	15	
RATED SPEED (M/S)		9	9								8	8	8	8	8	7	

C-29

NUMBER (000) OF DISCRETIZED WIND TURBINE SYSTEMS
BY GENERATOR RATING AND RATED SPEED

GENERATOR RATING (KW)	RATED SPEED (M/S)				TOTAL
	7	8	9	10	
10		33.7			33.7
15	0.4				0.4
25			7.3		7.3
35			0.4		0.4
50					
100					
TOTAL	0.4	33.7	7.7		41.8

STATE SUMMARY FOR OKLAHOMA FOR ELECTRICITY COST OF \$0.08/KWH
 TECHNICAL AND ECONOMIC DATA OF 'BEST' WIND TURBINE GENERATOR SYSTEM

ITEM	NONIRRIGATED CROPS			IRRIGATED CROPS					FRUIT, NUT, VEGETABLE	POULTRY AND EGES	DAIRY			LIVESTOCK			RESIDENCE ONLY
	S	M	L	1	2	3	4	5			S	M	L	S	M	L	
	180-	500	2500								20-			75-			
NUMBER OF FARMS AND IRRIGATION SYSTEMS (THOUSANDS)	3.0	3.8	6.4	1.1	1.1	1.2	2.3	0.5			0.8	1.5	0.7	7.5	4.7	0.8	59.5
ENERGY GENERATED AND USED BY FARM (THOUSAND KWH)	13	13	17								17	17	18	13	17	17	12
ANNUAL NET SAVINGS BY FARM (\$)	52	65	83								140	148	166	66	76	84	1
PRATED POWER (KW)	10	10	10								10	10	10	10	10	10	10
RATED SPEED (M/S)	9	9	8								8	8	8	9	8	8	9

C-30

NUMBER (000) OF DISCRETIZED WIND TURBINE SYSTEMS
 BY GENERATOR RATING AND RATED SPEED

GENERATOR RATING (KW)	RATED SPEED (M/S)				TOTAL
	7	8	9	10	
10		8.9	73.9		82.8
15					
25					
35					
50					
100					
TOTAL		8.9	73.9		82.8

STATE SUMMARY FOR PENNSYLVANIA FOR ELECTRICITY COST OF \$0.08/KWH
TECHNICAL AND ECONOMIC DATA OF 'BEST' WIND TURBINE GENERATOR SYSTEM

ITEM	NONIRRIGATED CROPS					FRUIT, NUT, VEGETABLE		POULTRY AND EGGS		DAIRY			LIVESTOCK			RESIDENCE ONLY	
	S	M	L	UNIT TYPE					(ALL)	(ALL)	S	M	L	S	M		L
	180-	500	2500	1	2	3	4	5			20-	50	250	75-	325	2325	
NUMBER OF FARMS AND IRRIGATION SYSTEMS (THOUSANDS)										3.4	6.6	11.9	0.2	4.0	0.7	0.1	44.1
ENERGY GENERATED AND USED BY FARM (THOUSAND KWH)										49					16	22	
ANNUAL NET SAVINGS BY FARM (\$)										877					11	161	
PRATED POWER (KW)										25					10	15	
RATED SPEED(M/S)										7					8	8	

C-37

NUMBER (000) OF DISCRETIZED WIND TURBINE SYSTEMS
BY GENERATOR RATING AND RATED SPEED

GENERATOR RATING (KW)	RATED SPEED (M/S)				TOTAL
	7	8	9	10	
10		0.7			0.7
15		0.1			0.1
25	3.4				3.4
35					
50					
100					
TOTAL	3.4	0.8			4.2

STATE SUMMARY FOR SOUTH DAKOTA FOR ELECTRICITY COST OF \$0.08/KWH
TECHNICAL AND ECONOMIC DATA OF 'BEST' WIND TURBINE GENERATOR SYSTEM

ITEM	NONIRRIGATED CROPS			IRRIGATED CROPS			FRUIT, NUT, VEGETABLE	POULTRY AND EGGS	DAIRY			LIVESTOCK			RESIDENCE ONLY
	S	M	L	S	M	L			S	M	L	S	M	L	
	180-								20-			75-			
	1	2	3	4	5				1	2	3	4	5	6	
NUMBER OF FARMS AND IRRIGATION SYSTEMS (THOUSANDS)	1.3	3.2	1.8	0.1	0.4	0.2			1.2	1.8	0.2	8.0	12.2	2.4	10.6
ENERGY GENERATED AND USED BY FARM (THOUSAND KWH)	33	35	55						29	30	30	29	30	34	22
ANNUAL NET SAVINGS BY FARM (\$)	804	951	1385						702	737	780	689	769	890	497
PRATED POWER (KW)	25	25	50						15	15	15	15	15	25	10
RATED SPEED (M/S)	9	9	9						8	8	8	8	8	9	8

C-32

NUMBER (000) OF DISCRETIZED WIND TURBINE SYSTEMS
BY GENERATOR RATING AND RATED SPEED

GENERATOR RATING (KW)	RATED SPEED (M/S)				TOTAL
	7	8	9	10	
10			10.6		10.6
15			23.4		23.4
25			6.9		6.9
35					
50			1.8		1.8
100					
TOTAL		34.0	8.7		42.7

STATE SUMMARY FOR TEXAS FOR ELECTRICITY COST OF \$0.08/KWH
 TECHNICAL AND ECONOMIC DATA OF 'BEST' WIND TURBINE GENERATOR SYSTEM

ITEM	NONIRRIGATED CROPS			IRRIGATED CROPS					FRUIT, NUT, VEGETABLE (ALL)	POULTRY AND EGGS (ALL)	DAIRY			LIVESTOCK			RESIDENCE ONLY
	S	M	L	1	2	3	4	5			S	M	L	S	M	L	
	180-	200-	250								20-	50	250	75-	225	225	
NUMBER OF FARMS AND IRRIGATION SYSTEMS (THOUSANDS)	4.9	12.7	3.0	4.0	6.4	5.3	27.6	3.8		3.2	0.3	1.6	2.4	12.9	5.5	0.8	140.4
ENERGY GENERATED AND USED BY FARM (THOUSAND KWH)	13	13	17							60	17	17	18	13	17	17	12
ANNUAL NET SAVINGS BY FARM (\$)	52	65	83							1737	140	148	166	66	76	84	1
RATED POWER (KW)	10	10	10							25	10	10	10	10	10	10	10
RATED SPEED (M/S)	9	9	8							7	8	8	8	9	8	8	9

C-33

NUMBER (000) OF DISCRETIZED WIND TURBINE SYSTEMS
 BY GENERATOR RATING AND RATED SPEED

GENERATOR RATING (KW)	RATED SPEED (M/S)				TOTAL
	7	8	9	10	
10		13.6	170.9		184.5
15					
25	3.2				3.2
35					
50					
100					
TOTAL	3.2	13.6	170.9		187.7

STATE SUMMARY FOR WISCONSIN FOR ELECTRICITY COST OF \$0.08/KWH
TECHNICAL AND ECONOMIC DATA OF 'BEST' WIND TURBINE GENERATOR SYSTEM

ITEM	NONIRRIGATED CROPS			IRRIGATED CROPS					FRUIT, NUT, VEGETABLE (ALL)	POULTRY AND EGGS (ALL)	DAIRY			LIVESTOCK			RESIDENCE ONLY
	S	M	L	1	2	3	4	5			S	M	L	S	M	L	
	180-	500	2500								20-	50	250	75-	325	2325	
NUMBER OF FARMS AND IRRIGATION SYSTEMS (THOUSANDS)				0.4	0.5	0.2					16.6	37.2	3.4	4.6	2.0	0.2	41.0
ENERGY GENERATED AND USED BY FARM (THOUSAND KWH)													16			21	
ANNUAL NET SAVINGS BY FARM (\$)													1			37	
PRATED POWER (KW) RATED SPEED (M/S)													10 8			15 8	

C-34

NUMBER (000) OF DISCRETIZED WIND TURBINE SYSTEMS
BY GENERATOR RATING AND RATED SPEED

GENERATOR RATING (KW)	RATED SPEED (M/S)				TOTAL
	7	8	9	10	
10		3.4			3.4
15		0.2			0.2
25					
35					
50					
100					
TOTAL		3.6			3.6

STATE SUMMARY FOR WYOMING FOR ELECTRICITY COST OF \$0.08/KWH
TECHNICAL AND ECONOMIC DATA OF 'BEST' WIND TURBINE GENERATOR SYSTEM

ITEM	NONIRRIGATED CROPS			IRRIGATED CROPS					FRUIT, NUT, VEGETABLE	POULTRY AND EGGS	DAIRY			LIVESTOCK			RESIDENCE ONLY
	S	M	L	1	2	3	4	5			S	M	L	S	M	L	
	180-	500	2500						(ALL)	(ALL)	20-	50	250	75-	225	2325	
NUMBER OF FARMS AND IRRIGATION SYSTEMS (THOUSANDS)				0.3	0.3	0.3		0.5						0.9	0.7	0.6	6.0
ENERGY GENERATED AND USED BY FARM (THOUSAND KWH)														23	33	42	
ANNUAL NET SAVINGS BY FARM (\$)														220	318	328	
PRATED PCWER (KW) RATED SPEED (M/S)														15 8	35 9	50 9	

NUMBER (000) OF DISCRETIZED WIND TURBINE SYSTEMS
BY GENERATOR RATING AND RATED SPEED

GENERATOR RATING (KW)	7	8	9	10	TOTAL
10					
15		0.6			0.6
25					
35			0.7		0.7
50			0.6		0.6
100					
TOTAL		0.6	1.3		2.2

TECHNICAL APPENDIX D 1/

SAMPLE OPTIMUM WTGS DIURNAL AND SEASONAL PERFORMANCE DATA

<u>Enterprise</u>	<u>Location</u>	<u>Page</u>
1. Grade A Dairy Farm	Syracuse, New York	D-1
8. Hog-Beef Operation	Fort Dodge, Iowa	D-5
17. Cattle Operation with Crops	Sioux Falls, South Dakota	D-13

1/ Appendix D results were developed during the preliminary screening and assessment. Preliminary wind data were used.

RESIDENCE						WIND ENERGY									
TIME	APPLT- HEATING & COOLING		FARM	GENERATED & USED		SOLD OR USED	KILOWATTS								
	AMPS	WATTS		AMPS	WATTS		0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0
0:00	0.52	0.0	0.0	0.33	2.64	1.4	W								
0:30	0.12	5.50	0.0	1.29	0.95	1.4	W								
1:00	0.52	0.0	0.0	0.33	2.64	1.4	W								
1:30	0.12	5.50	0.0	1.29	0.95	1.4	W								
2:00	5.02	0.0	0.0	1.82	1.11	1.4	W								
2:30	0.12	5.50	0.0	1.53	0.57	1.4	W								
3:00	0.52	0.0	0.0	0.34	2.69	1.4	W								
3:30	0.13	5.50	0.0	1.54	0.97	1.4	W								
4:00	0.53	0.0	0.0	0.34	2.68	1.4	W								
4:30	0.13	5.50	0.0	1.54	0.97	1.4	W								
5:00	0.57	0.0	0.0	0.36	2.72	1.4	W								
5:30	0.17	5.50	7.05	2.62	0.02	1.4	W								
6:00	0.30	0.0	12.05	2.61	0.05	1.4	W								
6:30	6.80	10.50	15.05	3.10	0.0	1.4	W								
7:00	7.69	0.0	11.95	3.16	0.0	1.4	W								
7:30	1.39	5.50	13.65	3.16	0.0	1.4	W								
8:00	5.64	0.0	8.00	3.21	0.0	1.4	W								
8:30	3.89	5.50	3.00	2.77	0.05	1.4	W								
9:00	3.63	0.0	3.00	2.33	0.80	1.4	W								
9:30	0.73	0.0	3.00	1.63	1.57	1.4	W								
10:00	2.25	5.50	3.00	3.24	0.25	1.4	W								
10:30	1.15	0.0	0.0	0.68	2.92	1.4	W								
11:00	0.64	5.50	0.0	2.79	1.14	1.4	W								
11:30	2.74	0.0	0.0	1.55	2.37	1.4	W								
12:00	0.95	5.50	0.0	3.07	1.23	1.4	W								
12:30	5.25	0.0	0.0	2.86	1.59	1.4	W								
13:00	0.23	0.0	0.0	0.20	4.09	1.4	W								
13:30	0.63	5.50	0.0	2.58	1.32	1.4	W								
14:00	3.23	0.0	0.0	0.20	4.09	1.4	W								
14:30	0.23	0.0	0.0	0.20	4.09	1.4	W								
15:00	0.32	0.0	0.0	0.27	4.02	1.4	W								
15:30	0.72	5.50	0.0	3.01	1.29	1.4	W								
16:00	0.39	0.0	0.0	0.26	3.33	1.4	W								
16:30	0.78	0.0	0.0	0.52	3.09	1.4	W								
17:00	0.53	0.0	7.05	2.33	0.64	1.4	W								
17:30	1.33	5.50	9.55	3.16	0.0	1.4	W								
18:00	2.77	0.0	12.55	2.67	0.0	1.4	W								
18:30	1.97	5.50	9.45	2.67	0.0	1.4	W								
19:00	5.95	0.0	5.40	2.72	0.0	1.4	W								
19:30	3.20	5.50	5.50	2.72	0.0	1.4	W								
20:00	5.70	0.0	3.00	2.02	0.40	1.4	W								
20:30	1.20	5.50	3.00	2.08	0.23	1.4	W								
21:00	1.13	0.0	3.00	1.46	1.21	1.4	W								
21:30	1.53	5.50	3.00	2.14	0.25	1.4	W								
22:00	5.64	0.0	0.0	1.01	0.85	1.4	W								
22:30	5.04	5.50	0.0	2.27	0.20	1.4	W								
23:00	0.13	0.0	0.0	0.11	2.77	1.4	W								
23:30	0.53	5.50	0.0	1.86	0.84	1.4	W								

D-2

* - RESIDENCE HEATING/COOLING LOAD

/ - RESIDENCE APPLIANCE LOAD

I - FARM LOAD

* - WIND ENERGY GENERATED & USED

/ - TOTAL WIND ENERGY

L.C.A.D.		WIND ENERGY				KILOWATTS			
RESIDENCE		GENERATED				KILOWATTS			
TIME	APPLI- ANCES	HEATING & COOLING	EARLY C	USED	SOLO OR BASIED	0	5.0	10.0	15.0
<----- KILOWATTS ----->						0	5.0	10.0	15.0
0:00	0.52	10.50	0.0	3.26	0.28	AA			
0:30	0.12	5.50	0.0	2.29	1.42	HHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHH			
1:00	0.52	5.50	0.0	2.31	1.26	AA			
1:30	0.12	10.50	0.0	3.00	0.33	HHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHH			
2:00	5.02	5.50	0.0	3.07	0.34	AA			
2:30	0.12	10.50	0.0	3.08	0.33	HHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHH			
3:00	0.52	5.50	0.0	2.26	1.23	AA			
3:30	0.13	5.50	0.0	2.17	1.33	HHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHH			
4:00	0.53	5.50	0.0	2.27	1.23	AA			
4:30	0.13	10.50	0.0	3.02	0.32	HHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHH			
5:00	0.57	5.50	0.0	2.27	1.22	AA			
5:30	0.17	10.50	7.05	3.62	0.0	FF			
6:00	0.30	5.50	12.05	3.62	0.0	FF			
6:30	6.80	10.50	15.05	3.62	0.0	FF			
7:00	7.69	15.50	11.95	4.10	0.0	FF			
7:30	1.39	10.50	13.90	4.10	0.0	FF			
8:00	5.64	5.50	8.00	4.68	0.0	FF			
8:30	3.89	5.50	3.00	4.41	0.10	FF			
9:00	3.83	5.50	3.00	5.04	0.13	FF			
9:30	0.73	5.50	3.00	4.31	0.03	FF			
10:00	2.25	5.50	3.00	4.78	0.49	FF			
10:30	1.15	5.50	0.0	3.56	1.72	AA			
11:00	0.64	5.50	0.0	3.49	1.87	AA			
11:30	2.74	5.50	0.0	4.15	1.21	AA			
12:00	0.95	10.50	0.0	5.20	0.35	AA			
12:30	5.25	5.50	0.0	5.02	0.52	AA			
13:00	0.23	5.50	0.0	3.34	2.20	HHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHH			
13:30	0.63	5.50	0.0	3.50	2.03	AA			
14:00	0.23	5.50	0.0	3.30	2.15	HHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHH			
14:30	0.23	5.50	0.0	3.30	2.15	HHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHH			
15:00	0.32	5.50	0.0	3.29	2.08	HHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHH			
15:30	0.72	5.50	0.0	3.45	1.92	AA			
16:00	0.38	5.50	0.0	3.22	1.97	AA			
16:30	0.78	5.50	0.0	3.37	1.02	AA			
17:00	0.53	10.50	7.05	4.99	0.0	FF			
17:30	1.33	5.50	9.55	4.59	0.0	FF			
18:00	2.77	10.50	12.55	4.83	0.0	FF			
18:30	1.97	5.50	9.45	4.83	0.0	FF			
19:00	5.95	10.50	9.40	4.46	0.0	FF			
19:30	3.20	5.50	5.50	4.46	0.0	FF			
20:00	5.70	15.50	3.00	4.10	0.0	FF			
20:30	1.20	5.50	3.00	3.34	0.54	FF			
21:00	1.13	10.50	3.00	3.75	0.0	FF			
21:30	1.53	5.50	3.00	3.67	0.43	FF			
22:00	5.04	10.50	0.0	3.75	0.0	AA			
22:30	5.04	5.50	0.0	3.13	0.35	AA			
23:00	0.13	10.50	0.0	3.21	0.34	AA			
23:30	0.53	5.50	0.0	2.39	1.31	AA			

D-3

H - RESIDENCE HEATING/COOLING LOAD

A - RESIDENCE APPLIANCE LOAD

F - FARM LOAD

* - WIND ENERGY GENERATED & USED

W - TOTAL WIND ENERGY

RESIDENCE		WIND ENERGY		GENERATED		SOLD OR		KILOWATTS	
TIME	APPLI- ANCES	HEATING & COOLING	FARM	USED	WASTED	0	5.0	10.0	15.0
0:00	0.52	0.0	0.0	0.29	1.82	*A			
0:30	0.12	0.0	0.0	0.09	2.03				
1:00	0.52	4.70	0.0	1.33	0.63	AAHHHHHHHHHHHHHHHHHH			
1:30	0.12	0.0	0.0	0.09	2.03				
2:00	5.02	0.0	0.0	1.28	0.65	AAAAA			
2:30	0.12	0.0	0.0	0.09	1.99				
3:00	0.52	4.70	0.0	1.30	0.62	AAHHHHHHHHHHHHHHHHHH			
3:30	0.13	0.0	0.0	0.10	1.98				
4:00	0.53	0.0	0.0	0.29	1.78	*A			
4:30	0.13	4.70	0.0	1.26	0.68	AAHHHHHHHHHHHHHHHHHH			
5:00	0.57	0.0	3.55	1.22	0.73	FFFFFWFFFFFFFFFFAA			
5:30	0.17	0.0	6.45	1.40	0.44	FFFFFFWFFFFFFFFFFF			
6:00	0.30	0.0	9.45	1.43	0.17	FFFFFFF			
6:30	6.80	4.70	9.45	2.09	0.0	FFFFFFF			
7:00	7.69	0.0	11.40	2.30	0.0	FFFFFFF			
7:30	1.39	4.70	5.50	1.66	0.37	FFFFFFF			
8:00	5.64	0.0	3.00	2.01	0.30	FFFFFFF			
8:30	3.89	4.70	3.00	2.05	0.07	FFFFFFF			
9:00	3.83	0.0	3.00	2.21	0.58	FFFFFFF			
9:30	0.73	4.70	3.00	2.39	0.37	FFFFFFF			
10:00	2.25	0.0	0.0	1.19	1.86	AAAAA			
10:30	1.15	4.70	0.0	2.29	0.82	AAAAA			
11:00	0.64	0.0	0.0	0.55	2.65	A			
11:30	2.74	4.70	0.0	2.77	0.50	AAAAA			
12:00	0.65	4.70	0.0	2.56	1.00	AAAAA			
12:30	5.25	4.70	0.0	3.46	0.28	AAAAA			
13:00	0.23	4.70	0.0	2.31	1.16	AAAAA			
13:30	0.63	4.70	0.0	2.43	1.05	AAAAA			
14:00	0.23	4.70	0.0	2.31	1.16	AAAAA			
14:30	0.23	4.70	0.0	2.31	1.16	AAAAA			
15:00	0.32	4.70	0.0	2.30	1.11	AAAAA			
15:30	0.72	4.70	0.0	2.41	1.01	AAAAA			
16:00	0.38	4.70	0.0	2.03	0.94	AAAAA			
16:30	0.78	4.70	3.55	2.70	0.28	FFFFFFF			
17:00	0.53	4.70	6.45	2.13	0.37	FFFFFFF			
17:30	1.33	4.70	9.45	2.57	0.0	FFFFFFF			
18:00	2.77	4.70	9.45	2.13	0.0	FFFFFFF			
18:30	1.97	4.70	9.40	2.13	0.0	FFFFFFF			
19:00	5.95	4.70	5.50	2.13	0.0	FFFFFFF			
19:30	3.20	4.70	3.00	1.45	0.10	FFFFFFF			
20:00	5.70	4.70	3.00	2.13	0.0	FFFFFFF			
20:30	1.20	0.0	3.00	1.21	0.80	FFFFFFF			
21:00	1.13	4.70	3.00	1.44	0.23	FFFFFFF			
21:30	1.53	0.0	0.0	0.59	1.47	A			
22:00	5.84	4.70	0.0	1.41	0.12	AAAAA			
22:30	5.04	4.70	0.0	1.43	0.17	AAAAA			
23:00	0.13	0.0	0.0	0.10	2.02	A			
23:30	0.53	4.70	0.0	1.33	0.63	AAHHHHHHHHHHHHHHHHHH			

D-5

H - RESIDENCE HEATING/COOLING LOAD

A - RESIDENCE APPLIANCE LOAD

F - FARM LOAD

* - WIND ENERGY GENERATED & USED

W - TOTAL WIND ENERGY

L O A D							WIND ENERGY															
TIME	RESIDENCE		FARM	GENERATED		SOLD OR WASTED	KILOWATTS															
	APPLI- ANCES	HEATING & COOLING		LOADS	LOADS		0	5.0	10.0	15.0												
0:00	0.52	0.0	6.20	2.53	1.12		1															
0:30	0.12	5.50	5.45	3.22	0.29		1															
1:00	0.52	0.0	6.20	2.53	1.12		1															
1:30	0.12	5.50	5.45	3.22	0.29		1															
2:00	5.02	0.0	6.20	3.31	0.27		1															
2:30	0.12	5.50	5.45	3.29	0.30		1															
3:00	0.52	0.0	6.20	2.58	1.15		1															
3:30	0.13	5.50	5.45	3.29	0.29		1															
4:00	0.53	0.0	6.20	2.58	1.14		1															
4:30	0.13	5.50	5.45	3.29	0.29		1															
5:00	0.57	0.0	6.20	2.64	1.16		1															
5:30	0.17	5.50	5.45	3.36	0.30		1															
6:00	0.30	0.0	6.20	2.58	1.23		1															
6:30	6.80	10.50	6.20	3.52	0.0		1															
7:00	7.69	0.0	6.45	3.59	0.0		1															
7:30	1.39	5.50	6.45	3.59	0.0		1															
8:00	5.64	0.0	6.45	3.52	0.15		1															
8:30	3.89	5.50	1.45	3.47	0.35		1															
9:00	3.83	0.0	1.45	2.39	1.67		1															
9:30	0.73	0.0	2.20	1.55	2.54		1															
10:00	2.25	5.50	1.45	3.59	0.76		1															
10:30	1.15	0.0	1.45	1.53	3.01		1															
11:00	0.84	5.50	2.20	3.86	1.02		1															
11:30	2.74	0.0	1.45	2.39	2.52		1															
12:00	0.55	5.50	1.45	3.59	1.33		1															
12:30	5.25	0.0	1.45	3.58	1.73		1															
13:00	0.23	0.0	2.20	1.53	3.69		1															
13:30	0.63	5.50	2.20	4.12	1.15		1															
14:00	0.23	0.0	1.45	1.16	4.16		1															
14:30	0.23	0.0	2.20	1.43	3.69		1															
15:00	0.32	0.0	1.45	1.22	4.10		1															
15:30	0.72	5.50	2.20	4.15	1.17		1															
16:00	0.38	0.0	1.45	1.13	3.42		1															
16:30	0.78	0.0	2.20	1.72	2.82		1															
17:00	0.53	0.0	1.45	1.09	2.33		1															
17:30	1.33	5.50	2.20	3.13	0.67		1															
18:00	2.77	0.0	1.45	1.71	1.63		1															
18:30	1.97	5.50	1.45	2.42	0.50		1															
19:00	5.55	0.0	1.20	2.29	0.92		1															
19:30	3.20	5.50	1.20	2.75	0.43		1															
20:00	5.70	0.0	1.20	2.35	0.93		1															
20:30	1.20	5.50	6.20	3.07	0.04		1															
21:00	1.13	0.0	6.20	2.47	0.90		1															
21:30	1.53	5.50	6.20	3.53	0.0		1															
22:00	5.84	0.0	6.20	3.12	0.14		1															
22:30	5.04	5.50	6.20	3.55	0.0		1															
23:00	0.13	0.0	6.20	2.36	1.17		1															
23:30	0.53	5.50	5.45	3.13	0.22		1															

H - RESIDENCE HEATING/COOLING LOAD

A - RESIDENCE APPLIANCE LOAD

F - FARM LOAD

* - WIND ENERGY GENERATED & USED

W - TOTAL WIND ENERGY

RESIDENCE						WIND ENERGY															
TIME	APPLI- FEATING & COOLING		FARM	GENERATED	SOLD OR	KILCHWATTS	KILCHWATTS														
	ANCES	COOLING					0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
0:00	0.52	10.50	1.45	4.38	0.14	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
0:30	0.12	5.50	0.70	2.99	1.67	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1:00	0.52	5.50	1.45	3.20	1.26	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1:30	0.12	10.50	0.70	4.01	0.35	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2:00	5.02	5.50	1.45	4.12	0.22	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2:30	0.12	10.50	0.70	4.01	0.35	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3:00	0.52	5.50	1.45	3.14	1.23	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3:30	0.13	5.50	0.70	2.84	1.56	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4:00	0.53	5.50	1.45	3.15	1.23	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4:30	0.13	10.50	0.70	3.52	0.34	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5:00	0.57	5.50	1.45	3.16	1.22	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5:30	0.17	10.50	0.70	3.54	0.33	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6:00	0.30	5.50	1.45	3.09	1.29	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6:30	6.80	10.50	0.70	4.49	0.0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7:00	7.69	15.50	1.45	5.08	0.0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7:30	1.39	10.50	0.70	4.78	0.12	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8:00	5.44	5.50	1.70	5.64	0.09	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8:30	3.89	5.50	1.70	5.20	0.54	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9:00	3.83	5.50	9.55	6.42	0.0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9:30	0.73	5.50	9.55	6.42	0.0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10:00	2.25	5.50	1.70	5.32	1.21	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10:30	1.15	5.50	2.45	5.19	1.35	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11:00	0.84	5.50	1.70	4.83	1.80	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11:30	2.14	5.50	2.45	5.84	0.79	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12:00	0.55	10.50	1.70	6.82	0.02	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12:30	5.25	5.50	1.70	6.60	0.24	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
13:00	0.23	5.50	1.70	4.67	2.14	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
13:30	0.63	5.50	2.45	5.18	1.64	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14:00	0.23	5.50	1.70	4.62	2.10	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14:30	0.23	5.50	2.45	4.55	1.78	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15:00	0.32	5.50	2.45	4.52	1.70	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15:30	0.72	5.50	1.70	4.78	1.85	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16:00	0.38	5.50	2.45	4.82	1.61	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16:30	0.78	5.50	0.55	4.37	2.07	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
17:00	0.53	10.50	2.20	6.15	0.0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
17:30	1.33	5.50	8.45	6.15	0.0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
18:00	2.77	10.50	0.55	5.57	0.0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
18:30	1.97	5.50	0.70	4.44	1.51	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19:00	5.95	10.50	1.45	5.52	0.0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19:30	3.20	5.50	0.70	4.49	0.57	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20:00	5.70	15.50	1.45	5.08	0.0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20:30	1.20	5.50	0.70	3.55	1.46	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
21:00	1.13	10.50	1.45	4.38	0.03	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
21:30	1.53	5.50	0.70	7.33	1.21	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
22:00	5.84	10.50	1.45	4.65	0.0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
22:30	5.04	5.50	0.70	4.08	0.37	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
23:00	0.13	10.50	1.45	4.31	0.21	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
23:30	0.53	5.50	0.70	3.11	1.54	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

D-7

H - RESIDENCE HEATING/COOLING LOAD

A - RESIDENCE APPLIANCE LOAD

F - FARM LOAD

* - WIND ENERGY GENERATED & USED

W - TOTAL WIND ENERGY

RESIDENCE						WIND ENERGY									
TIME	APPLI- ANCES	HEATING & COOLING	FARM	GENERATED & USED	SOLD OR BASIS	0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0
KILOWATTS						KILOWATTS									
0:00	0.52	5.50	6.20	5.38	0.25		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
0:30	0.12	0.0	5.45	3.23	2.48		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
1:00	0.52	5.50	6.20	4.97	0.22		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
1:30	0.12	0.0	5.45	3.03	2.27		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
2:00	5.02	5.50	6.20	5.07	0.0		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
2:30	0.12	0.0	5.45	2.08	2.13		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
3:00	0.52	5.50	6.20	4.37	0.19		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
3:30	0.13	5.50	5.45	4.16	0.43		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
4:00	0.53	0.0	6.20	3.05	1.55		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
4:30	0.13	5.50	5.45	4.06	0.42		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
5:00	0.57	5.50	6.20	4.19	0.17		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
5:30	0.17	0.0	5.45	2.65	1.88		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
6:00	0.30	5.50	6.20	4.15	0.23		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
6:30	6.60	5.50	6.20	4.61	0.0		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
7:00	7.69	0.0	6.45	5.55	0.0		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
7:30	1.39	5.50	6.45	5.55	0.0		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
8:00	5.64	0.0	6.45	5.97	0.32		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
8:30	3.89	5.50	1.45	5.55	0.71		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
9:00	3.83	0.0	8.55	7.01	0.15		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
9:30	0.73	5.50	9.70	7.14	0.0		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
10:00	2.25	0.0	1.45	2.80	4.55		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
10:30	1.15	5.50	1.45	5.25	2.05		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
11:00	0.84	0.0	2.20	2.37	5.07		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
11:30	2.74	5.50	1.45	6.06	1.39		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
12:00	0.55	0.0	1.45	1.53	5.61		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
12:30	5.25	5.50	1.45	7.19	0.30		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
13:00	0.23	0.0	2.20	1.58	5.74		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
13:30	0.63	0.0	2.20	2.27	5.47		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
14:00	0.23	5.50	1.45	5.06	2.78		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
14:30	0.23	0.0	2.20	1.59	5.85		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
15:00	0.32	0.0	1.45	1.48	6.45		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
15:30	0.72	5.50	2.20	5.78	2.16		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
16:00	0.38	0.0	1.45	1.53	6.41		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
16:30	0.78	5.50	2.20	5.31	2.13		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
17:00	0.53	0.0	1.45	1.65	6.29		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
17:30	1.33	5.50	9.70	7.54	0.0		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
18:00	2.77	5.50	8.55	8.04	0.0		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
18:30	1.97	0.0	1.45	2.75	5.28		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
19:00	5.95	5.50	1.20	7.36	0.20		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
19:30	3.20	0.0	1.20	3.21	4.03		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
20:00	5.70	5.50	1.20	6.37	0.23		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
20:30	1.20	5.50	6.20	6.52	0.10		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
21:00	1.13	0.0	6.20	4.05	1.85		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
21:30	1.53	5.50	6.20	5.94	0.0		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
22:00	5.84	5.50	6.20	5.84	0.0		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
22:30	5.04	0.0	6.20	5.23	0.52		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
23:00	0.13	5.50	6.20	5.29	0.35		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
23:30	0.53	5.50	5.45	5.20	0.44		FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF

* - WIND ENERGY GENERATED & USED
W - TOTAL WIND ENERGY

RESIDENCE				WIND ENERGY		KILOWATTS														
TIME	APPLI- HEATING & COOLING		GENERATED	SOLD OR DESIRED		KILOWATTS														
	ENCS	ENCS		ENCS	ENCS	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0
						1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0:00	0.52	0.0	6.20	3.01	2.12	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
0:30	0.12	5.50	5.45	4.07	0.95	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
1:00	0.52	0.0	6.20	3.01	2.12	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
1:30	0.12	5.50	5.45	4.07	0.95	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
2:00	5.02	0.0	6.20	4.17	0.94	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
2:30	0.12	5.50	5.45	4.14	0.97	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
3:00	0.52	0.0	6.20	3.06	2.17	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
3:30	0.13	5.50	5.45	4.15	0.97	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
4:00	0.53	0.0	6.20	3.07	2.16	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
4:30	0.13	5.50	5.45	4.15	0.97	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
5:00	0.57	0.0	6.20	3.13	2.19	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
5:30	0.17	5.50	5.45	4.23	0.98	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
6:00	0.30	0.0	6.20	3.04	2.23	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
6:30	6.80	10.50	6.20	5.42	0.0	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
7:00	7.69	0.0	6.45	4.86	0.36	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
7:30	1.39	5.50	6.45	4.73	0.51	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
8:00	5.54	0.0	6.45	4.59	0.79	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
8:30	3.29	5.50	1.45	4.33	1.39	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
9:00	3.83	0.0	1.45	2.75	2.68	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
9:30	3.73	0.0	2.20	1.72	3.95	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
10:00	2.25	5.50	1.45	4.42	1.75	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
10:30	1.15	0.0	1.45	1.57	4.58	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
11:00	0.84	5.50	2.20	4.54	2.17	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
11:30	2.74	0.0	1.45	2.66	4.07	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
12:00	0.55	5.50	1.45	4.60	2.64	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
12:30	5.25	0.0	1.45	4.08	3.16	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
13:00	3.23	0.0	2.20	1.74	5.51	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
13:30	0.63	5.50	2.20	4.78	2.46	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
14:00	0.23	0.0	1.45	1.22	6.03	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
14:30	0.23	0.0	2.20	1.74	5.51	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
15:00	0.32	0.0	1.45	1.29	5.96	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
15:30	0.72	5.50	2.20	4.62	2.43	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
16:00	0.38	0.0	1.45	1.20	5.03	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
16:30	0.78	0.0	2.20	1.88	4.36	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
17:00	0.53	0.0	1.45	1.17	4.32	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
17:30	1.33	5.50	2.20	3.82	1.54	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
18:00	2.77	0.0	1.45	1.66	2.71	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
18:30	1.97	5.50	1.45	3.24	1.31	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
19:00	5.55	0.0	1.20	2.88	1.30	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
19:30	3.20	5.50	1.20	3.50	1.11	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
20:00	5.70	0.0	1.20	2.82	1.87	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
20:30	1.20	5.50	6.20	4.00	0.51	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
21:00	1.13	0.0	6.20	2.53	1.79	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
21:30	1.53	5.50	6.20	4.12	0.45	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
22:00	5.34	0.0	6.20	4.02	0.70	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
22:30	5.04	5.50	6.20	4.98	0.0	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
23:00	0.13	0.0	6.20	2.60	2.17	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF
23:30	0.53	5.50	5.45	3.99	0.83	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF	FFFFFFFFFFF

D-10

R - RESIDENCE HEATING/COOLING LOAD

A - RESIDENCE APPLIANCE LOAD

F - FARM LOAD

* - WIND ENERGY GENERATED & USED

W - TOTAL WIND ENERGY

RESIDENCE		WIND ENERGY					
TIME	APPLI- HEATING & COOLING		FARM	GENERATED	SOLE OR	KILOWATTS	
	ANCES			5 USED	LASTED		
			KILOWATTS			0	5.0
							10.0
							15.0
0:00	0.52	10.50	1.45	5.30	0.89	FFFFFAA	
0:30	0.12	5.50	0.70	3.43	2.95	FFFFFAA	
1:00	0.52	5.50	1.45	3.74	2.40	FFFFFAA	
1:30	0.12	10.50	0.70	4.90	1.17	FFFFFAA	
2:00	5.02	5.50	1.45	5.06	0.99	FFFFFAA	
2:30	0.12	10.50	0.70	4.90	1.17	FFFFFAA	
3:00	0.52	5.50	1.45	3.68	2.35	FFFFFAA	
3:30	0.13	5.50	0.70	3.27	2.78	FFFFFAA	
4:00	0.53	5.50	1.45	3.60	2.35	FFFFFAA	
4:30	0.13	10.50	0.70	4.81	1.14	FFFFFAA	
5:00	0.57	5.50	1.45	3.69	2.34	FFFFFAA	
5:30	0.17	10.50	0.70	4.82	1.13	FFFFFAA	
6:00	0.30	5.50	1.45	3.60	2.43	FFFFFAA	
6:30	0.30	10.50	0.70	6.12	0.00	FFFFFAA	
7:00	7.49	15.50	1.45	6.89	0.00	FFFFFAA	
7:30	1.39	10.50	0.70	5.82	0.94	FFFFFAA	
8:00	5.64	5.50	1.70	6.72	1.03	FFFFFAA	
8:30	3.89	5.50	1.70	6.10	1.65	FFFFFAA	
9:00	3.33	5.50	9.95	8.58	0.00	FFFFFAA	
9:30	0.73	5.50	9.95	8.58	0.00	FFFFFAA	
10:00	2.25	5.50	1.70	6.04	2.67	FFFFFAA	
10:30	1.15	5.50	2.45	5.69	2.64	FFFFFAA	
11:00	0.34	5.50	1.70	5.41	3.43	FFFFFAA	
11:30	2.74	5.50	2.45	6.65	2.14	FFFFFAA	
12:00	0.95	10.50	1.70	7.94	1.15	FFFFFAA	
12:30	5.25	5.50	1.70	7.64	1.44	FFFFFAA	
13:00	6.23	5.50	1.70	5.18	3.83	FFFFFAA	
13:30	0.63	5.50	2.45	5.80	3.26	FFFFFAA	
14:00	0.23	5.50	1.70	5.13	3.81	FFFFFAA	
14:30	0.23	5.50	2.45	5.54	3.41	FFFFFAA	
15:00	0.32	5.50	2.45	5.53	3.31	FFFFFAA	
15:30	0.72	5.50	1.70	5.34	3.49	FFFFFAA	
16:00	0.39	5.50	2.45	5.44	3.16	FFFFFAA	
16:30	0.78	5.50	0.95	4.87	3.73	FFFFFAA	
17:00	0.53	10.50	2.20	7.27	0.97	FFFFFAA	
17:30	1.33	5.50	8.45	7.96	0.27	FFFFFAA	
18:00	2.77	10.50	8.95	8.01	0.00	FFFFFAA	
18:30	1.97	5.50	0.70	5.05	2.96	FFFFFAA	
19:00	5.95	10.50	1.45	7.45	0.00	FFFFFAA	
19:30	3.20	5.50	0.70	5.22	2.19	FFFFFAA	
20:00	5.70	15.50	1.45	6.89	0.00	FFFFFAA	
20:30	1.20	5.50	0.70	4.09	2.75	FFFFFAA	
21:00	1.13	10.50	1.45	5.42	0.72	FFFFFAA	
21:30	1.53	5.50	0.70	3.89	2.36	FFFFFAA	
22:00	5.44	10.50	1.45	6.34	0.00	FFFFFAA	
22:30	5.34	5.50	0.70	4.97	1.22	FFFFFAA	
23:00	0.13	10.50	1.45	5.28	1.00	FFFFFAA	
23:30	0.53	5.50	0.70	3.59	2.79	FFFFFAA	

H - RESIDENCE HEATING/COOLING LOAD

A - RESIDENCE APPLIANCE LOAD

F - FARM LOAD

* - WIND ENERGY GENERATED & USED

W - TOTAL WIND ENERGY

RESIDENCE			WIND ENERGY			KILOWATTS																	
TIME	APPLI-	HEATING &	FARM	GENERATED	SOLO OR USED	DESIED																	
	ANCES	COOLING					0	5.0	10.0	15.0													
							KILOWATTS																
0:00	0.52	5.50	6.20	6.38	1.25		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
0:30	0.12	0.0	5.45	3.58	4.10		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1:00	0.52	5.50	6.20	5.95	1.14		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1:30	0.12	0.0	5.45	3.59	3.79		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2:00	5.02	5.50	6.20	6.85	0.0		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2:30	0.12	0.0	5.45	3.24	3.56		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3:00	0.52	5.50	6.20	5.32	0.99		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3:30	0.13	5.50	5.45	5.01	1.33		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4:00	0.53	0.0	6.20	3.50	2.79		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4:30	0.13	5.50	5.45	4.91	1.30		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5:00	0.57	5.50	6.20	5.13	0.94		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5:30	0.17	0.0	5.45	3.01	3.13		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6:00	0.30	5.50	6.20	5.86	1.01		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6:30	6.80	5.50	6.20	6.25	0.0		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7:00	7.69	0.0	6.45	5.75	0.58		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7:30	1.39	5.50	6.45	6.51	0.83		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8:00	5.64	0.0	6.45	6.93	1.47		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8:30	3.49	5.50	1.45	6.44	1.59		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9:00	3.83	0.0	8.65	8.05	1.40		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9:30	0.73	5.50	9.70	9.37	0.05		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10:00	2.25	0.0	1.45	7.48	6.72		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10:30	1.15	5.50	1.45	9.80	3.86		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11:00	0.84	0.0	2.20	2.49	7.31		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11:30	2.74	5.50	1.45	6.76	3.05		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12:00	0.95	0.0	1.45	2.01	7.92		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12:30	5.25	5.50	1.45	8.15	1.79		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
13:00	0.25	0.0	2.20	2.05	6.11		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
13:30	0.63	0.0	2.20	2.37	7.79		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14:00	0.23	5.50	1.45	5.49	4.79		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14:30	0.23	0.0	2.20	2.36	6.21		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15:00	0.32	0.0	1.45	1.53	8.87		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15:30	0.72	5.50	2.20	6.32	4.05		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16:00	0.38	0.0	1.45	1.54	8.62		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16:30	0.78	5.50	2.20	6.36	4.04		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
17:00	0.53	0.0	1.45	1.70	8.70		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
17:30	1.33	5.50	9.70	10.40	0.0		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
18:00	2.77	5.50	8.95	10.52	0.0		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
18:30	1.97	0.0	1.45	2.38	7.63		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19:00	5.95	5.50	1.20	8.38	1.49		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19:30	3.20	0.0	1.20	3.43	6.13		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20:00	5.70	5.50	1.30	7.38	1.43		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20:30	1.20	5.50	6.20	7.59	1.23		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
21:00	1.13	0.0	6.20	4.56	3.36		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
21:30	1.53	5.50	6.20	6.44	0.94		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
22:00	5.84	5.50	6.20	7.53	0.0		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
22:30	5.04	0.0	6.20	6.13	1.64		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
23:00	0.13	5.50	6.20	6.24	1.39		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
23:30	0.53	5.50	5.45	6.12	1.51		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

F - RESIDENCE HEATING/COOLING LOAD

A - RESIDENCE APPLIANCE LOAD

F - FARM LOAD

W - WIND ENERGY GENERATED & USED

W - TOTAL WIND ENERGY

TIME	RESISTANCE			WIND ENERGY		KILOWATTS
	APPLIED	HEATING	COOLING	GENERATED	SOLED OR	
	AMPERE	WATTS	WATTS	WATTS	WATTS	
0:00	0.52	0.0	1.25	0.80	2.76	0
0:30	0.12	0.0	1.25	0.66	2.91	5.0
1:00	0.52	4.70	1.25	2.13	1.30	10.0
1:30	0.12	0.0	1.25	0.66	2.91	15.0
2:00	5.02	0.0	1.25	2.05	1.32	
2:30	0.12	0.0	1.25	0.65	2.86	
3:00	0.52	4.70	1.25	2.09	1.28	
3:30	0.13	0.0	1.25	0.66	2.85	
4:00	0.53	0.0	1.25	0.90	2.71	
4:30	0.13	4.70	1.25	2.02	1.37	
5:00	0.57	0.0	1.25	0.81	2.69	
5:30	0.17	0.0	1.25	0.67	2.84	
6:00	0.30	0.0	1.25	0.70	2.80	
6:30	6.00	4.70	1.25	2.77	0.32	
7:00	7.49	0.0	1.25	2.71	0.91	
7:30	1.30	4.70	1.25	2.46	1.22	
8:00	5.64	0.0	1.25	2.63	1.45	
8:30	3.99	4.70	1.25	3.15	0.83	
9:00	3.83	0.0	1.25	2.41	2.10	
9:30	0.73	4.70	2.25	3.14	1.42	
10:00	2.25	0.0	1.50	2.03	2.94	
10:30	1.15	4.70	1.50	2.34	1.67	
11:00	0.84	0.0	1.50	1.45	3.83	
11:30	2.74	4.70	2.50	4.19	1.09	
12:00	0.95	4.70	1.50	3.66	1.98	
12:30	5.25	4.70	1.50	4.66	0.83	
13:00	0.23	4.70	1.50	2.36	2.10	
13:30	0.63	4.70	2.50	3.60	1.73	
14:00	0.23	4.70	1.50	3.36	2.10	
14:30	0.23	4.70	1.50	3.36	2.10	
15:00	0.32	4.70	2.50	3.67	1.79	
15:30	0.77	4.70	1.50	3.48	1.95	
16:00	0.38	4.70	1.50	3.01	1.62	
16:30	0.73	4.70	1.50	3.13	1.71	
17:00	0.53	4.70	1.50	2.64	1.52	
17:30	1.33	4.70	1.50	2.81	1.32	
18:00	2.77	4.70	1.50	2.50	0.82	
18:30	1.97	4.70	1.50	2.40	0.97	
19:00	5.95	4.70	1.50	2.79	0.39	
19:30	3.20	4.70	1.50	2.65	0.76	
20:00	5.70	4.70	1.50	2.77	0.42	
20:30	1.20	0.0	1.25	1.07	2.48	
21:00	1.13	4.70	1.25	2.19	1.15	
21:30	1.53	0.0	1.25	1.17	2.31	
22:00	5.34	4.70	1.25	2.71	0.42	
22:30	5.04	4.70	1.25	2.65	0.52	
23:00	0.13	0.0	1.25	0.67	2.91	
23:30	0.53	4.70	1.25	2.13	1.30	

D-13

1 - RESIDENCE HEATING/COOLING LOAD
 2 - RESIDENCE APPLIANCE LOAD
 3 - FARM LOAD
 4 - WIND ENERGY GENERATED & USED
 5 - TOTAL WIND ENERGY

RESIDENCE				WIND ENERGY			KILOWATTS															
TIME	APPLI- HEATING & COOLING		EAPL	GENERATED SOLD OR		0	5.0 10.0 15.0															
	CHILLS	COOLING		ELSED	LOADED																	
							KILOWATTS															
0:00	0.52	0.0	0.75	0.61	2.77	F*FAA	W															
0:30	0.12	5.50	0.0	1.09	1.40	HHHHHH	HHHHHHHHHHHHHHHH															
1:00	0.52	0.0	0.0	0.22	3.07	*A	W															
1:30	0.12	5.50	0.0	1.88	1.40	HHHHHH	HHHHHHHHHHHHHHHH															
2:00	5.02	0.0	0.75	1.95	1.43	FFFAAAA	AAAAA															
2:30	0.12	5.50	0.0	1.92	1.43	HHHHHH	HHHHHHHHHHHHHHHH															
3:00	0.52	0.0	0.0	0.32	3.12	*A	W															
3:30	0.13	5.50	0.0	1.92	1.43	AFHHHH	HHHHHHHHHHHHHHHH															
4:00	0.53	0.0	0.75	0.52	2.82	F*FAA	W															
4:30	0.13	5.50	0.0	1.92	1.43	AFHHHH	HHHHHHHHHHHHHHHH															
5:00	0.57	0.0	0.0	0.30	3.15	*A	W															
5:30	0.17	5.50	0.0	1.93	1.45	AFHHHH	HHHHHHHHHHHHHHHH															
6:00	0.30	0.0	0.75	0.55	2.95	F*FAA	W															
6:30	6.30	10.50	0.0	3.50	0.0	AAAAAA	AAAAA															
7:00	7.69	0.0	0.0	2.30	1.05	AAAAAA	AAAAA															
7:30	1.59	5.50	0.0	2.23	1.23	AAAAAA	AAAAA															
8:00	5.04	0.0	0.75	2.11	1.34	FFFAAAA	AAAAA															
8:30	3.89	5.50	5.00	3.05	0.18	FFFFFF	FFFFF															
9:00	3.83	0.0	0.0	1.54	2.05	AAAAA*	AAAAAAW															
9:30	0.73	0.0	0.0	0.44	3.25	A*AA	W															
10:00	2.25	5.50	0.75	2.85	1.04	FFFAAAA	AAAAA															
10:30	1.15	0.0	0.0	0.60	3.41	AAAAA	W															
11:00	0.64	5.50	0.0	2.43	1.73	AAAAAA	AAAAA															
11:30	2.74	0.0	0.0	1.42	2.93	AAAAA*	AAAAA															
12:00	0.95	5.50	0.75	3.00	1.63	FFFAAAA	AAAAA															
12:30	5.25	0.0	0.0	2.51	2.23	AAAAAA	AAAAA															
13:00	0.23	0.0	0.0	0.15	4.60	*	W															
13:30	0.63	5.50	0.75	2.90	1.72	FFFAAAA	AAAAA															
14:00	0.23	0.0	0.0	0.15	4.60	*	W															
14:30	0.23	0.0	0.0	0.15	4.60	*	W															
15:00	0.32	0.0	0.75	0.70	4.09	F*FAA	W															
15:30	0.72	5.50	0.0	2.81	1.91	AAAAHH	HHHHH															
16:00	0.33	0.0	0.0	0.25	3.80	*A	W															
16:30	0.78	0.0	0.75	0.00	3.27	FFFAAA	W															
17:00	0.53	0.0	5.00	1.56	1.51	FFFFFF	FFFFFFF															
17:30	1.35	5.50	0.0	2.32	1.22	AAAAHH	HHHHH															
18:00	2.77	0.0	0.75	1.27	1.77	FFFAAA	AAAAA															
18:30	1.97	5.50	0.0	2.07	0.92	AAAAAA	AAAAA															
19:00	5.55	0.0	0.0	1.84	1.21	AAAAAA	AAAAA															
19:30	3.30	5.50	0.0	2.26	0.75	AAAAAA	AAAAA															
20:00	5.70	0.0	0.75	1.93	1.12	FFFAAAA	AAAAA															
20:30	1.20	5.50	0.0	1.57	1.07	AAAAHH	HHHHH															
21:00	1.13	0.0	0.0	0.53	2.63	AAAAA	W															
21:30	1.53	5.50	0.0	2.04	1.03	AAAAAA	AAAAA															
22:00	5.84	0.0	0.75	2.00	1.12	FFFAAAA	AAAAA															
22:30	5.04	5.50	0.0	2.51	0.55	AAAAAA	AAAAA															
23:00	0.13	0.0	0.0	0.10	3.17	A	W															
23:30	0.53	5.50	0.0	1.92	1.26	AAHHHH	HHHHH															

D-14

H - RESIDENCE HEATING/COOLING LOAD

A - RESIDENCE APPLIANCE LOAD

F - FPM LOAD

* - WIND ENERGY GENERATED & USED

W - TOTAL WIND ENERGY

RESIDENCE				WIND ENERGY		KILOWATTS									
TIME	APPLI- ANCES	HEATING & COOLING	EARN	GENERATED	SOLD OR USED	0	5.0	10.0	15.0						
0:00	0.52	10.50	12.15	3.40	0.0										
0:30	0.12	5.50	11.40	3.60	0.0										
1:00	0.52	5.50	11.40	3.48	0.0										
1:30	0.12	10.50	11.40	3.48	0.0										
2:00	5.02	5.50	12.15	3.48	0.0										
2:30	0.12	10.50	11.40	3.48	0.0										
3:00	0.52	5.50	11.40	3.42	0.0										
3:30	0.13	5.50	11.40	3.42	0.0										
4:00	0.53	5.50	12.15	3.42	0.0										
4:30	0.13	10.50	11.40	3.42	0.0										
5:00	0.57	5.50	11.40	3.42	0.0										
5:30	0.17	10.50	11.40	3.42	0.0										
6:00	0.30	5.50	12.15	3.42	0.0										
6:30	6.80	10.50	11.40	3.42	0.0										
7:00	7.49	15.50	12.90	3.86	0.0										
7:30	1.39	10.50	12.90	3.86	0.0										
8:00	5.64	5.50	13.65	4.42	0.0										
8:30	3.89	5.50	17.90	4.42	0.0										
9:00	3.83	5.50	12.90	4.55	0.0										
9:30	0.73	5.50	12.90	4.55	0.0										
10:00	2.25	5.50	13.65	5.03	0.0										
10:30	1.15	5.50	11.40	5.03	0.0										
11:00	0.84	5.50	11.40	5.11	0.0										
11:30	2.74	5.50	11.40	5.11	0.0										
12:00	0.95	10.50	12.15	5.28	0.0										
12:30	5.25	5.50	11.40	5.28	0.0										
13:00	0.23	5.50	11.40	5.28	0.0										
13:30	0.63	5.50	12.15	5.28	0.0										
14:00	0.23	5.50	11.40	5.20	0.0										
14:30	0.23	5.50	11.40	5.20	0.0										
15:00	0.32	5.50	12.15	5.11	0.0										
15:30	0.72	5.50	11.40	5.11	0.0										
16:00	0.38	5.50	11.40	4.95	0.0										
16:30	0.78	5.50	12.15	4.95	0.0										
17:00	0.53	10.50	16.40	4.72	0.0										
17:30	1.33	5.50	11.40	4.72	0.0										
18:00	2.77	10.50	12.15	4.97	0.0										
18:30	1.97	5.50	11.40	4.57	0.0										
19:00	5.65	10.50	11.40	4.20	0.0										
19:30	3.20	5.50	11.40	4.20	0.0										
20:00	5.70	15.50	12.15	3.36	0.0										
20:30	1.20	5.50	11.40	3.36	0.0										
21:00	1.13	10.50	11.40	3.54	0.0										
21:30	1.53	5.50	11.40	3.54	0.0										
22:00	5.64	10.50	12.15	3.54	0.0										
22:30	5.04	5.50	11.40	3.54	0.0										
23:00	0.13	10.50	11.40	3.50	0.0										
23:30	0.53	5.50	11.40	3.60	0.0										

RESIDENCE			WIND ENERGY			KILOWATTS														
TIME	APPL. HEATING & COOLING	GENERATED USED WASTED	0	5.0	10.0	15.0														
0:00	0.52 5.50 0.75 3.13 2.10	FFFFAHHH																		
0:30	0.12 0.0 0.0 0.11 5.21																			
1:00	0.52 5.50 0.0 2.70 2.15	AAHHHHH																		
1:30	0.12 0.0 0.0 0.11 4.83																			
2:00	5.02 5.50 0.75 3.67 0.77	FFFFAAAA																		
2:30	0.12 0.0 0.0 0.10 4.55																			
3:00	0.52 5.50 0.0 2.43 1.88	AAHHHHH																		
3:30	0.13 5.50 0.0 2.32 1.95	AAHHHHH																		
4:00	0.53 0.0 0.75 0.69 3.60	FFFAA																		
4:30	0.13 5.50 0.0 2.28 1.95	AAHHHHH																		
5:00	0.57 5.50 0.0 2.36 1.78	AAHHHHH																		
5:30	0.17 0.0 0.0 0.13 4.09																			
6:00	0.30 5.50 0.75 2.48 1.65	FFFFAHHH																		
6:30	6.30 5.50 0.0 3.48 0.52	AAAAAAA																		
7:00	7.65 0.0 0.0 3.27 1.73	AAAAAAA																		
7:30	1.39 5.50 0.0 3.05 1.57	AAAAAAA																		
8:00	5.64 0.0 0.75 3.32 2.55	FFFFAAAA																		
8:30	3.89 5.50 12.50 5.93 0.0	FFFFFFFF																		
9:00	3.83 0.0 0.0 2.49 4.29	AAAAAAA																		
9:30	0.13 5.50 0.0 3.66 2.10	AAHHHHH																		
10:00	2.25 0.0 0.75 2.00 4.54	FFFFAAAA																		
10:30	1.15 5.50 0.0 3.94 3.08	AAAAAAA																		
11:00	0.84 0.0 0.0 0.67 6.45																			
11:30	2.74 5.50 0.0 4.65 2.44	AAAAAAA																		
12:00	0.55 0.0 0.75 1.23 6.01	FFFFAA																		
12:30	5.25 5.50 0.0 5.61 1.59	AAAAAAA																		
13:00	0.23 0.0 0.0 0.21 7.28																			
13:30	0.63 0.0 0.75 1.05 6.42	FFFFAA																		
14:00	0.23 5.50 0.0 3.73 2.33	AAHHHHH																		
14:30	0.23 0.0 0.0 0.21 7.36																			
15:00	0.32 0.0 0.75 0.86 6.84	FFFA																		
15:30	0.72 5.50 0.0 4.02 3.65	AAAAAAA																		
16:00	0.38 0.0 0.0 0.34 7.35																			
16:30	0.78 5.50 0.75 4.42 3.26	FFFFAAH																		
17:00	0.53 0.0 12.50 6.69 0.97	FFFFFFFF																		
17:30	1.33 5.50 0.0 4.32 3.35	AAAAAAA																		
18:00	2.77 5.50 0.75 5.35 2.44	FFFFAAH																		
18:30	1.57 0.0 0.0 1.48 6.33	AAAAAA																		
19:00	5.95 5.50 0.0 5.57 1.23	AAAAAAA																		
19:30	3.20 0.0 0.0 2.16 4.73	AAAAAA																		
20:00	5.70 5.50 0.75 5.15 0.57	FFFFAAH																		
20:30	1.20 5.50 0.0 3.55 2.60	AAAAAAA																		
21:00	1.13 0.0 0.0 0.75 4.76	AAAA																		
21:30	1.53 5.50 0.0 3.31 2.11	AAAAAA																		
22:00	5.34 5.50 0.75 4.45 0.74	FFFFAAH																		
22:30	5.04 0.0 0.0 2.55 2.77	AAAAAA																		
23:00	0.13 5.50 0.0 2.76 2.49	AAHHHHH																		
23:30	0.53 5.50 0.0 2.89 2.35	AAHHHHH																		

L.C.A.D. --- BLDG ENERGY ---						KILOWATTS															
TIME	RESIDENCE APPL- ANCES	HEATING & COOLING	FARM KILOWATTS	GENERATED USED	SOLO OR WASTED	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0:00	0.52	C.C	0.75	0.58	2.40	F*FAA	W														
0:30	0.12	0.0	0.0	0.10	2.90		W														
1:00	0.52	4.70	0.0	1.66	1.23	AAAAAAAAAAAAAAAAAA															
1:30	0.12	C.C	0.0	0.10	2.90		W														
2:00	5.02	0.0	0.75	1.72	1.09	FFFAAAAA															
2:30	0.12	0.0	0.0	0.09	2.95		W														
3:00	0.52	4.70	0.0	1.63	1.20	AAAAAAAAAA															
3:30	0.13	C.C	0.0	0.10	2.84	A	W														
4:00	0.53	C.C	0.75	0.53	2.35	F*FAA	W														
4:30	0.13	4.70	0.0	1.55	1.25	AAAAAAAAAA															
5:00	0.57	0.0	0.0	0.33	2.61	*A	W														
5:30	0.17	C.C	0.0	0.12	2.82	A	W														
6:00	0.30	0.0	C.75	0.51	2.42	F*FA	W														
6:30	6.80	4.70	0.0	2.25	0.33	AAAAAAAAAA															
7:00	7.65	0.0	0.0	2.13	C.85	AAAAAAAAAA															
7:30	1.39	4.70	0.0	1.55	1.14	AAAAAAAAAA															
8:00	5.44	C.C	0.75	2.21	1.21	FFFAAAAA															
8:30	3.39	4.70	12.50	3.54	0.0	FFFFFFFFFF															
9:00	3.83	0.0	0.0	1.73	2.12	AAAAAAAAAA															
9:30	0.73	4.70	0.0	2.25	1.62	AAAAAAAAAA															
10:00	2.25	0.0	C.75	1.59	2.69	FFFAAAAA	W														
10:30	1.15	4.70	0.0	2.58	1.63	AAAAAAAAAA															
11:00	0.84	C.C	C.C	0.55	3.93	A*FA	W														
11:30	2.74	4.70	0.0	3.13	1.36	AAAAAAAAAA															
12:00	0.55	4.70	C.75	3.05	1.78	FFFAAAAA															
12:30	5.25	4.70	C.C	3.51	0.91	AAAAAAAAAA															
13:00	0.23	4.70	C.C	2.52	2.22	AAAAAAAAAA															
13:30	0.63	4.70	C.75	2.91	1.84	FFFAAAAA															
14:00	0.23	4.70	C.C	2.52	2.22	AAAAAAAAAA															
14:30	0.23	4.70	C.C	2.52	2.22	AAAAAAAAAA															
15:00	0.32	4.70	C.75	2.77	1.89	FFFAAAAA															
15:30	0.72	4.70	0.0	2.66	2.01	AAAAAAAAAA															
16:00	0.38	4.70	C.C	2.27	1.83	AAAAAAAAAA															
16:30	0.70	4.70	C.75	2.59	1.51	FFFAAAAA															
17:00	0.53	4.70	12.50	3.60	0.0	FFFFFFFFFF															
17:30	1.33	4.70	C.C	2.18	1.31	AAAAAAAAAA															
18:00	2.77	4.70	C.75	2.07	0.71	FFFAAAAA															
18:30	1.57	4.70	0.0	1.89	C.95	AAAAAAAAAA															
19:00	5.95	4.70	C.C	2.26	C.42	AAAAAAAAAA															
19:30	3.20	4.70	0.0	2.04	0.75	AAAAAAAAAA															
20:00	5.70	4.70	0.75	2.28	0.37	FFFAAAAA															
20:30	1.20	0.0	C.C	0.56	2.42	A*AAA	W														
21:00	1.13	4.70	0.0	1.73	1.08	AAAAAAAAAA															
21:30	1.53	C.C	C.C	0.64	2.28	A*AAA	W														
22:00	5.84	4.70	0.75	2.24	C.35	FFFAAAAA															
22:30	5.04	4.70	C.C	2.16	0.51	AAAAAAAAAA															
23:00	0.13	0.0	0.0	0.10	2.90	A	W														
23:30	0.53	4.70	0.0	1.66	1.23	AAAAAAAAAA															

H - RESIDENCE HEATING/COOLING LOAD

A - RESIDENCE APPLIANCE LOAD

F - FARM LOAD

* - WIND ENERGY GENERATED & USED

W - TOTAL WIND ENERGY

LIFE 2.0		WIND ENERGY		RESIDENCE		FARM		GENERATED & USED		SOLD OR		KILOWATTS		15.0	
TIME	APPLI- ANCES	HEATING & COOLING	HEATING & COOLING	HEATING & COOLING	HEATING & COOLING	HEATING & COOLING	HEATING & COOLING	HEATING & COOLING	HEATING & COOLING	HEATING & COOLING	HEATING & COOLING	HEATING & COOLING	HEATING & COOLING	HEATING & COOLING	HEATING & COOLING
0:00	0.52	0.0	0.75	0.69	4.05	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
0:30	0.12	5.50	0.0	2.27	2.42	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
1:00	0.52	0.0	0.0	0.35	4.41	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
1:30	0.12	5.50	0.0	2.27	2.42	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
2:00	5.72	0.0	0.75	2.34	2.41	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
2:30	0.12	5.50	0.0	2.30	2.46	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
3:00	0.52	0.0	0.0	0.35	4.49	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
3:30	0.13	5.50	0.0	2.30	2.46	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
4:00	0.53	0.0	0.75	0.70	4.13	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
4:30	0.13	5.50	0.0	2.30	2.46	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
5:00	0.57	0.0	0.0	0.38	4.54	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
5:30	0.17	5.50	0.0	2.35	2.49	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
6:00	0.30	0.0	0.75	0.61	4.50	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
6:30	6.20	10.50	0.0	4.31	0.21	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
7:00	7.65	0.0	0.0	2.92	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
7:30	1.39	5.50	0.0	2.72	2.17	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
8:00	5.64	0.0	0.75	2.53	2.35	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
8:30	3.49	5.50	5.00	4.14	0.62	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
9:00	3.83	0.0	0.0	1.82	3.30	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
9:30	0.73	0.0	0.0	0.43	4.50	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
10:00	2.75	5.50	0.75	3.52	2.33	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
10:30	1.15	0.0	0.0	0.73	4.95	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
11:00	0.84	5.50	0.0	3.12	2.46	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
11:30	2.74	0.0	0.0	1.52	4.54	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
12:00	0.95	5.50	0.75	3.56	2.90	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
12:30	5.25	0.0	0.0	2.50	3.84	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
13:00	0.23	0.0	0.0	0.20	6.42	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
13:30	0.63	5.50	0.75	3.54	3.02	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
14:00	0.23	0.0	0.0	0.20	6.42	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
14:30	0.23	0.0	0.0	0.20	6.42	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
15:00	0.32	0.0	0.75	0.75	5.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
15:30	0.72	5.50	0.0	3.20	3.23	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
16:00	0.38	0.0	0.0	0.29	5.39	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
16:30	0.78	0.0	0.75	0.90	4.77	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
17:00	0.53	0.0	5.00	2.34	3.58	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
17:30	1.33	5.50	0.0	2.71	2.19	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
18:00	2.77	0.0	0.75	1.46	2.82	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
18:30	1.57	5.50	0.0	2.54	1.71	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
19:00	5.55	0.0	0.0	2.21	2.12	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
19:30	3.20	5.50	0.0	2.82	1.47	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
20:00	5.70	0.0	0.75	2.33	1.59	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
20:30	1.20	5.50	0.0	2.39	1.92	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
21:00	1.13	0.0	0.0	0.40	3.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
21:30	1.53	5.50	0.0	2.30	1.83	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
22:00	5.34	0.0	0.75	2.43	2.02	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
22:30	5.04	5.50	0.0	3.33	1.15	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
23:00	0.13	0.0	0.0	0.10	4.50	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
23:30	0.53	5.50	0.0	2.32	2.21	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55

N - RESIDENCE HEATING/COOLING LOAD

A - RESIDENCE APPLIANCE LOAD

F - FARM LOAD

W - WIND ENERGY GENERATED & USED

N - TOTAL WIND ENERGY

RESIDENCE		WIND ENERGY				KILOWATTS			
TIME	APPL- HEATING & COOLING	GENERATED	USED	WASTED	0	5.0	10.0	15.0	
0:00	0.52 10.50 12.15 5.02 0.0	0.00							

TH - RESIDENCE HEATING/COOLING LOAD

A - RESIDENCE APPLIANCE LOAD

F - FARM LOAD

* - WIND ENERGY GENERATED & USED

W - TOTAL WIND ENERGY

RESIDENCE						WIND ENERGY																							
TIME	APPLI- HEATING & COOLING		EASEM	GENERATED SOLD OR		KILOWATTS	KILOWATTS																						
	APPLI-	HEATING & COOLING		USED	WASTED		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
0:00	0.52	5.50	0.75	3.62	3.51			FFFA	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF
0:30	0.12	0.0	0.0	0.11	7.09																								
1:00	0.52	5.50	0.0	3.12	3.52			AAHH	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF
1:30	0.12	0.0	0.0	0.11	6.60																								
2:00	5.02	5.50	0.75	4.55	1.63			FFFA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA
2:30	0.12	0.0	0.0	0.11	6.25																								
3:00	0.52	5.50	0.0	2.84	3.10			AAHH	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF
3:30	0.13	5.50	0.0	2.70	3.25			AAHH	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF
4:00	0.53	0.0	0.75	0.77	5.12			FFFA																					
4:30	0.13	5.50	0.0	2.65	3.18			AAHH	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF
5:00	0.57	5.50	0.0	2.76	2.96			AAHH	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF
5:30	0.17	0.0	0.0	0.14	5.65																								
6:00	0.30	5.50	0.75	2.92	3.79			FFFA	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF
6:30	0.50	5.50	0.0	4.39	1.22			AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA
7:00	7.05	0.0	0.0	3.85	5.01			AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA
7:30	1.35	5.50	0.0	3.56	3.32			AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA
8:00	5.64	0.0	0.75	3.78	4.14			FFFA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA
8:30	3.89	5.50	12.50	7.57	0.0			FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF
9:00	3.83	0.0	0.0	2.71	6.53			AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA
9:30	0.73	5.50	0.0	4.09	4.91			AAAA	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF
10:00	2.25	0.0	0.75	2.21	7.05			FFFA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA
10:30	1.15	5.50	0.0	4.41	4.36			AAAA	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF
11:00	0.84	0.0	0.0	0.71	8.72																								
11:30	2.74	5.50	0.0	5.28	4.12			AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA
12:00	0.55	0.0	0.75	1.32	6.24			FFFA																					
12:30	5.25	5.50	0.0	6.51	3.01			AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA
13:00	0.23	0.0	0.0	0.21	5.63																								
13:30	0.63	0.0	0.75	1.12	8.72			FFFA																					
14:00	0.23	5.50	0.0	4.10	5.85			AAHH	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF
14:30	0.23	0.0	0.0	0.22	5.74																								
15:00	0.37	0.0	0.75	0.91	5.20			FFFA																					
15:30	0.72	5.50	0.0	4.44	5.65			AAAA	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF
16:00	0.38	0.0	0.0	0.35	5.76																								
16:30	0.73	5.50	0.75	4.91	5.18			FFFA	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF
17:00	0.53	0.0	12.50	7.84	2.24			FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF
17:30	1.33	5.50	0.0	4.79	5.30			AAAA	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF
18:00	2.77	5.50	0.75	6.04	4.18			FFFA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA
18:30	1.97	0.0	0.0	1.56	6.69			AAAA																					
19:00	5.95	5.50	0.0	6.55	2.55			AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA
19:30	3.23	0.0	0.0	2.39	6.43			AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA
20:00	5.70	5.50	0.75	6.18	2.06			FFFA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA
20:30	1.20	5.50	0.0	4.03	4.24			AAAA	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF
21:00	1.13	0.0	0.0	0.21	6.54			AAAA																					
21:30	1.53	5.50	0.0	2.84	3.55			AAAA	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF
22:00	5.84	5.50	0.75	5.46	1.70			FFFA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA
22:30	5.04	0.0	0.0	2.93	4.36			AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA	AAAA
23:00	0.13	5.50	0.0	3.15	4.50			AAHH	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF
23:30	0.53	5.50	0.0	3.32	3.32			AAHH	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF

N - RESIDENCE HEATING/COOLING LOAD

A - RESIDENCE APPLIANCE LOAD

F - FARM LOAD

* - WIND ENERGY GENERATED & USED

W - TOTAL WIND ENERGY

H - RESIDENCE	HEATING/COOLING LOAD	* - WIND ENERGY GENERATED & USED
A - RESIDENCE	APPLIANCE LOAD	W - TOTAL WIND ENERGY
F - FARM LOAD		