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Wind Energy Conversion System Analysis Model (WECSAM) Computer Program Documentation

Arthur D. Little, Inc.
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Solar Energy Research Institute
Project Managers:
Martin J. Deutsch
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MASTER

SERI

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A Division of Midwest Research Institute

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Golden, Colorado 80401

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Foreword

As a continuation of the DOE-funded Wind Energy Conversion System (WECS) Applications Analysis Project, the Solar Energy Research Institute (SERI), with support from three subcontractors, has completed a project to develop and apply a wind turbine performance and economic analysis model. The model, using various data bases developed by the three subcontractors, has been used to determine the economic potential of eight residential, agricultural, commercial, and industrial applications in the Great Lakes Region.

Arthur D. Little, Inc., developed the Wind Energy Conversion System Analysis Model (WECSAM) to analyze the performance and economics of the WECS applications. This report on WECSAM provides a description of the model and its accompanying data base and includes a discussion of the methods used and information required to run the model. A companion piece, Economic Analysis of Wind Turbines in DOE Region V, documents the use of the computer model in selected applications in DOE Region V, the Great Lakes Region.

WECSAM is useful for users of WECS and for wind machine manufacturers and designers who are interested in determining the performance and economics of WECS in particular applications. The code is available through the National Energy Software Center, Argonne National Laboratory, 9700 S. Cass Ave., Argonne, IL 60439.

Users' comments which could enhance the value of this document should be directed to Susan M. Hock, Solar Energy Research Institute, 1617 Cole Blvd., Golden, CO 80401.

Martin J. Deutsch

Susan M. Hock

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Chapter 1

Introduction

This report describes a computer-based wind energy conversion system analysis model (WECSAM) developed to predict the technical and economic performance of wind energy conversion systems (WECS). The model, written in CDC FORTRAN V [1], resides on a model CDC 7600 computer owned and operated by the Solar Energy Research Institute (SERI). The version described accesses a data base containing wind resource data, application loads, WECS performance characteristics, utility rates, state taxes, and state subsidies for a six-state region (DOE Region V—Minnesota, Michigan, Wisconsin, Illinois, Ohio, and Indiana). The model is designed for analysis at the county level.

The computer model includes a technical performance module and an economic evaluation module. The modules can be run separately or together. The model can be run for any single user-selected county within the region or looped automatically through all counties within the region. In addition, the model has a restart capability that allows the user to modify any data-base value written to a scratch (i.e., temporary) file prior to the technical or economic evaluation. Thus, any user-supplied data for WECS performance, application load, utility rates, or wind resource may be entered into the scratch file to override the default data-base value.

Chapter 2 of this report describes the model in detail. Chapter 3 describes both the input required from the user and derived from the data base. The model output and the various output options that can be exercised by the user are detailed in Chapter 4. Chapter 5 sets forth the general operation and makes suggestions for efficient modes of operation. Finally, sample listings of various input, output, and data-base files are given in the appendices.

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Chapter 2

Model Description

STRUCTURE

The model contains approximately 5400 lines of source code including comment statements. Executing the model for a single county corresponding to the sample case listed in the appendices requires approximately 4 seconds of CPU execution time on a CDC 7600 computer. Executing the program in the county-cycling mode (524 counties) requires approximately 340 seconds of CPU execution time on a CDC 7600 computer.

The general structure of the code is modular. The overall program logic flow is governed by a main driver program (WECSAM) that reads the user file and determines the type of job requested. Once this is accomplished the driver calls the technical performance or evaluation economic module or both. Each module is controlled by its own driver (subroutines PERPRO and ECOPRO, respectively) and all input and output are controlled within the individual modules. Figure 2-1 shows a flow chart for the main driver program. A small algorithm built into the main driver allows the program to cycle through each county of DOE Region V if the FIPS county code of the user file is negative.

The only link between the technical performance and economic evaluation modules is a data file created by the technical performance module and subsequently read by the economic evaluation module. This file contains only the information required by the economic evaluation module and includes the following:

- utility rate data,
- energy purchased by WECS owner,
- maximum demand by WECS owner,
- energy purchased by non-WECS owner,
- maximum demand by non-WECS owner,
- energy sold to utility by WECS owner, and
- WECS annual performance results and cost data.

The technical performance module is largely responsible for reading the data base, which includes the following separate files accessed in the order listed:

Figure 2-1. Flow Chart of WECSAM Driver Program.

- wind resource data file (Tape 2);
- WECS machine characteristics data file (Tape 3);
- application demand data file (Tape 4); and
- utility rate pointer and rate files (Tapes 15 and 5, respectively).

The economic evaluation model reads only the state subsidy and tax data-base file (Tape 16). All other information required by the economic evaluation module is either passed by the technical performance module or read from the user file (Tape 1, see Chapter 3 and Appendix A) directly. Since the state subsidy and tax data base is not written to a scratch file, it must be edited directly if changes are required.

The source code is extensively documented with comment statements. Each subroutine has a header section containing the model name; client's name; author's name; date of last revision; function of subroutine; and definitions of input, output, and internal parameters. In addition, the mainline driver (WECSAM) contains a complete list with definitions of all variables passed in common blocks. Explanatory comments appear throughout the entire source code to help users understand the model.

TECHNICAL PERFORMANCE MODULE

Predicting WECS Power Output

A detailed evaluation of a wind energy conversion system (WECS) would simulate performance on an hourly basis using hourly wind resource data for the desired site. Unfortunately, this type of simulation is time-consuming to execute (and, therefore, expensive) and is limited to those sites for which hourly wind-speed measurements have been recorded. Therefore, wind resource data for this program are based on 12 average monthly wind speeds and an annual average diurnal wind-speed distribution consisting of 24 values. The combined use of these values results in an hourly simulation for one day during each month, or 12 days per year. A series of hourly wind-speed values are used in the analysis. These values are based on an annual diurnal wind-speed distribution and monthly average wind speeds. Each hourly value can be thought of as the average annual wind speed for that particular hour of the day weighted by the monthly average wind speed. It is a time-averaged quantity; the actual wind speed in any hour could vary substantially about this value. In recognition of this fact, each average hourly wind speed is represented by the widely used two-parameter Weibull probability distribution [2].

The Weibull probability density function, $p(V)$ is expressed as:

$$p(V) = (k/c)(V/c)^{k-1} \exp[-(V/c)^k] \quad (2-1)$$

where c is the Weibull scale factor ($\text{m/s} = \bar{V}/\Gamma(1+1/k)$);
 k is the Weibull shape factor (dimensionless);
 V is the wind speed (m/s); and
 Γ is the gamma function.

The corresponding integral (cumulative) probability distribution, $g(V)$, which gives the probability that the wind speed is below a given wind speed, V , is given by:

$$g(V) = \int_0^V p(V)dV = 1 - \exp[-(V/c)^k] \quad (2-2)$$

If the range of probabilities from zero to one, represented by $g(V)$, is divided into N equal probability intervals, then a single interval, Δg , is given by:

$$\Delta g = 1/N \quad (2-3)$$

where N is the number of equal probability intervals.

Likewise, the probability at the midpoint of the i th interval is given by:

$$g = i \Delta g - \Delta g/2 \quad (2-4)$$

Substitution of Equation 2-3 into Equation 2-4 yields:

$$g = (2i - 1)/2N \quad (2-5)$$

where i is the i th probability interval.

Equating Equations 2-5 and 2-2 gives:

$$(2i - 1)/2N = 1 - \exp[-(V_i/c)^k] \quad (2-6)$$

Solving for V_i/c results in:

$$V_i/c = [-\log (1 - (2i-1)/2N)]^{1/k} \quad (2-7)$$

where V_i is the wind speed corresponding to the i th probability interval; and
 $c = \bar{V}/\Gamma(1+1/k)$.

Equation 2-7 thus gives the wind speed corresponding to each of N equal-spaced probability intervals.

If the WECS output is related to velocity, V_i by some function, h , then:

$$O_i = h(V_i) \quad (2-8)$$

where O_i is the WECS output corresponding to wind speed, V_i .

In actuality, the function h is represented by a series of discrete points on a WECS performance curve between which linear interpolation is performed. However, given some function, h , the average WECS output for a given hourly average wind speed can be found by:

$$O = 1/N \sum_{i=1}^N O_i = 1/N \sum_{i=1}^N h(V_i) \quad (2-9)$$

where O is the average WECS output for a given average wind speed, V_i .

To calculate any excess, E , or deficiency, D , in energy relative to an application demand, A , we define:

$$E_i = O_i - A \quad ; O_i > A \quad (2-10)$$

$$E_i = 0 \quad ; O_i < A \quad (2-11)$$

$$D_i = A - O_i \quad ; A > O_i \quad (2-12)$$

$$D_i = 0 \quad ; A < O_i \quad (2-13)$$

where the application demand, A , is assumed constant over the hour in question. Given these definitions we can solve for the average excess and deficiency in a given hour as follows:

$$E = 1/N \sum_{i=1}^N E_i \quad (2-14)$$

$$D = 1/N \sum_{i=1}^N D_i \quad (2-15)$$

Also from a system energy balance we have:

$$D = A + E - O \quad (2-16)$$

which is used instead of Equation 2-15 to improve speed of computation.

Figure 2-2 shows an example of the process followed to predict the power output probability for a given average hourly wind speed, $\bar{V}$.

(A) V	(B) $P(V_i \leq V \leq V_{i+1})$	(C) $O @ V_i$	(B) × (C) Probability + Power
$0 \leq v \leq 1$	$1/N$	O_1	$1/N \times O_1$
$1 \leq v \leq 2$	$1/N$	O_2	$1/N \times O_2$
$2 \leq v \leq 3$	$1/N$	O_3	$1/N \times O_3$
$\vdots$	$\vdots$	$\vdots$	$\vdots$
$N-1 \leq v \leq N$	$1/N$	O_m	$1/N \times O_m$
Total			$\frac{1/N (O_1 + O_2 + O_3 + \cdots O_m)}{= \text{Mean Power Output for the Hour}}$

Figure 2-2. Power Output Determination.

Day Types

The code uses a single set of 24 wind-speed values to represent the average wind speed during each hour of the day for an entire month. Since the application demand and utility rates are assumed in some cases to be a function of day of the week, multiple day types are necessary. The application demand data are divided into two day types: production and nonproduction. Associated with each application day type is a set of 24 demand values representing the hourly demand for its respective day type. The application data also include information that permits the model to determine on which day of the week nonproduction starts and how many days it lasts (see Tables 3-4 and F-4 for format and data, respectively). Thus, it is necessary to compute the excess or deficit for each application day type for each hour. (An excess and a deficit can and usually do exist concurrently within the same hour because average wind speed is represented by a wind-speed distribution.) The code also allows for time-of-day rates, so days must be separated according to whether they are peak or off peak. A peak day is defined as a day in which peak utility rates are charged during some portion of the day. An off-peak day is defined as a day in which the off-peak rate applies throughout the entire day. The code reads in data giving the day of the week on which the off-peak period starts as well as the number of off-peak days per week. In addition, the code reads in the starting and ending hours of the peak period. The program automatically partitions energy purchases, sales, and peak purchase demand separately for both the peak and off-peak periods so that the economic evaluation module will have the information necessary to calculate monthly utility charges and revenues. Thus, four day types are possible: production/peak; production/off peak; nonproduction/peak; and nonproduction/off peak.

Energy Storage System

The model provides for an optional energy storage system module. The storage system can be of any type provided its performance can be adequately represented by its capacity, maximum charge rate, maximum discharge rate, and overall efficiency. The decision logic to store vs. sell or buy vs. discharge can be included as user-defined input according to whether peak or off-peak utility rates are in effect. When time-of-day rates do not apply and a storage system is specified, the code assumes that preference will always be given to storage (up to the maximum charge rate and within limitations imposed by capacity) when excess power exists and discharge (up to the maximum discharge rate and provided stored energy remains) when a power deficit exists. This will generally result in some storage and discharge during each hour provided the energy in storage is greater than zero or less than the capacity. Any excess energy not stored is assumed to be sold to the utility; any deficit not discharged from storage is assumed to be purchased from the utility.

When time-of-day rates apply, a series of storage options are available. The user may choose to store or sell during the peak period, store or sell during the off peak, discharge or purchase during the peak period, and discharge or purchase during the off peak. For example, a logical choice might be to store excess energy during the off-peak period when sell-back rates are lowest and discharge from storage during the peak period when utility rates are highest.

Because a maximum of four day types are calculated per month, the net charge and discharge values per day are weighted by the number of days of that type per week in

order to adjust the charge level prior to computing the performance during the next day type. This method is used to simulate the carryover of stored energy from one day type to the next within a given week.

Density Correction to WECS Performance

The performance of a WECS is known to be a function of air density. The correction technique described [3] transforms the WECS performance curve (assumed to be based on standard air density) to the site air density. The air density can affect both the cut-in velocity and the power output at a given wind speed. To account for both effects, the correction method adopted is applied in two parts. At wind speeds greater than that wind speed corresponding to 10% of the peak power output, WECS output is corrected by the density ratio as follows:

for $V > V_{10}$:

$$P_2 = [P_1 (\rho_2/\rho_1)] \quad (2-17)$$

or

$$P_2 = P_m \quad ; \text{ whichever is less} \quad (2-18)$$

where V is the wind speed (m/s);
 V_{10} is the wind speed (m/s) corresponding to a power output equal to 0.10 P_m ;
 P_1 is the WECS predicted power (kW) at standard air density, ρ_1 ;
 P_2 is the WECS corrected power (kW) at site air density, ρ_2 ;
 P_m is the WECS maximum power output (kW);
 ρ_1 is the standard air density; and
 ρ_2 is the site air density.

At wind speeds below V_{10} a correction is made to the wind speed of the performance curve to account for the density effect on cut-in speed as follows:

$$V_2 = V_1 \left[\frac{1 - 0.5(\rho_2 - \rho_1)}{\rho_1} \right] \quad ; V < V_{10} \quad (2-19)$$

where V_1 is the wind speed (m/s) from WECS performance curve; and
 V_2 is the wind speed (m/s) at site air density, ρ_2 .

The dual nature of this correction may cause a slight discontinuity in the corrected WECS performance curve near V_{10} . This is not considered serious enough, however, to warrant a more complicated correction technique.

Height Correction to WECS Performance

The wind velocity depends on height above the ground. A power law expression is most often used to transform wind speed measured at one height to a different height as follows:

$$V_2 = V_1(Z_2/Z_1)^\alpha \quad (2-20)$$

where Z is the height above ground (m);
 V is the wind speed (m/s); and
 α is the wind shear coefficient (dimensionless).

The exponent, α , depends on both the terrain and wind speed. Typical values are listed in Table 2-1.

In the case of the model described, values of α are included as part of the county-based wind resource data and, therefore, the user need not supply a value unless desired. The code applies the transformation to each wind-speed value of the input WECS performance curve. The effect of this correction is to transform the performance curve basis from hub height to the height at which the wind resource data were recorded (10 m). The transformation, based on Equation 2-4, is performed as follows:

$$V_c = V_r(Z_c/Z_r)^\alpha \quad (2-21)$$

where Z_r is the reference height upon which WECS performance curve is based (m);
 Z_c is the height at which wind resource data are measured (m);
 V_r is the reference wind speed from WECS performance curve (m/s); and
 V_c is the corrected wind speed corresponding to height at which wind resource data are measured (m/s).

Table 2-1. Typical Values of the Wind Shear Coefficient, α

Terrain	α
Flat land or open water	0.16
Wooded or city suburb	0.28
Built up urban area	0.40

An example of such a transformation is illustrated in Figure 2-3. Once accomplished, the transformed WECS performance data can be used directly with the 10 m wind resource data to predict WECS output.

Most performance data obtained from manufacturers are based on the wind speed at hub height. If the power output is based on a reference point different from hub height, the performance data must be corrected before entering them into the WECS machine characteristics data base (see Table F-3) or the scratch file (see Appendix B).

Figure 2-3. Transformation of WECS Performance Curve to the Height at Which the Wind Resource Data is Recorded.

ECONOMIC ANALYSIS MODULE

Background

The user can request a complete economic analysis which includes calculation of payback period, internal rate of return, discounted and undiscounted cash flow, present value of cost to WECS and non-WECS owners, annualized life-cycle cost to WECS and non-WECS owners, levelized cost to WECS and non-WECS owners, and WECS busbar levelized cost. A non-WECS owner is defined as one who has the same application demand as the WECS owner, but does not own a WECS. In general, economic parameters such as interest rate are supplied by the user and entered into the user file. Other parameters such as utility rates, energy sold back to the utility, and WECS cost are automatically read in from a data file created by the technical performance module. Thus, it is necessary to have run the technical performance module at least once. The economic analysis module also reads data from the state tax and subsidy file of the data base. All other portions of the data base are accessed by the technical performance module with only that information needed being passed to the economic analysis module.

Utility Bill Calculation

A utility bill is calculated for the WECS and non-WECS case for each month of the first year of the analysis. The 12 monthly bills are then summed to give the first year's cost of electricity. The analysis includes the capability for treating time-of-day rates as well, if specified in the data base. The rate structure format allows consideration of as many as seven energy and seven demand blocks for each of three utility-based sectors (i.e., residential/agricultural, commercial, and industrial).

The utility bill is calculated as follows: First, the fixed charge portion of the utility bill is determined. Next, the energy charge portion of the bill is calculated by summing the products of the energy charge rate and energy block width out to the monthly energy consumption. The result is then added to the bill. Next, the surcharge, if any, is applied to the bill. In a similar manner a demand charge is calculated by summing the products of the demand charge and demand block width out to the peak monthly demand. The total demand charge is added to the bill. Next, the monthly bill is compared with the minimum charge. If the calculated bill is less than the minimum charge, the bill is equated to the minimum monthly charge. Finally, the tax, if any, is added to the bill.

Within the same routine, the revenue from electricity sold back to the utility is calculated. Provision is made for both a peak and an off-peak sell-back rate if time-of-day rates are specified. As with the utility bill, the monthly revenues are summed over each month of the year to obtain the total revenue for the first year of the analysis.

Depreciation Allowance

The user selects one of the following types of depreciation allowance: (1) straight line, (2) declining balance, (3) sum-of-the-years' digits, or (4) none.

In the straight-line method (IDTYPE=1), the model calculates the depreciation in year t as follows:

$$D(t) = (I_0 - S)/t_d \quad ; t \leq t_d \quad (2-22)$$

$$D(t) = 0 \quad ; t > t_d \quad (2-23)$$

where D is the depreciation allowance;
 I_0 is the original investment;
 S is the salvage value; and
 t_d is the depreciation life (yr).

In the declining-balance method (IDTYPE=2), the depreciation in year t is calculated as follows:

$$R_d = P_s/t_d \quad (2-24)$$

$$V_b = I_0(1 - R_d)^{t-1} \quad (2-25)$$

$$D(t) = R_d V_b \quad ; t \leq t_d \quad (2-26)$$

$$D(t) = 0 \quad ; t > t_d \quad (2-27)$$

where R_d is the depreciation rate (%/yr);
 P_s is the percent of straight line (in decimal); and
 V_b is the book value.

For the sum-of-the-years'-digits method (IDTYPE=3), the calculation is performed as follows:

$$D(t) = 2(t_d - t + 1)(I_0 - S)/(t_d^2 + t_d) \quad ; t \leq t_d \quad (2-28)$$

$$D(t) = 0 \quad ; t > t_d \quad (2-29)$$

And in the event that no depreciation (IDTYPE=4) is selected, the depreciation allowance is set to zero for each year of the analysis.

Effective Federal Plus State Income Tax

The effective federal plus state income tax bracket is calculated using the marginal federal income tax bracket from the user data file and the state income tax data from the data base. The calculation is performed as follows:

$$TR = TR_s + TR_f - (TR_s)(TR_f)/100 \quad (2-30)$$

where TR is the effective federal plus state income tax bracket (%);

TR_f is the marginal federal income tax bracket (%); and

TR_s is the state income tax rate (%).

State and Federal Subsidies

Both state and federal subsidies are included in the analysis. For purposes of calculating subsidies there are two sectors: (1) residential/agricultural and (2) commercial/industrial. In the first sector the federal subsidy rate is internally set to 40% with a limit of \$4,000. In the second sector the subsidy rate is internally set to 25% with no limit. All rates are applied to the original investment, and credit is taken in year one of the analysis. Therefore, the subsidy is never used to reduce the down payment or WECS mortgage. The state subsidy is calculated in a manner directly analogous to the federal subsidy using both a state subsidy rate and state subsidy limit. In some cases, however, there is no limit applied. Finally, the state and federal subsidies are added together.

Payback Analysis

Three separate payback periods are calculated to suit the individual user. The first payback period represents the period in years to pay off the initial cash investment (i.e., down payment). A check is made to be sure that the savings are greater than the initial investment for all subsequent years once the payback period has been reached. If this criterion cannot be met over the length of the analysis, the output reports, "The WECS system does not pay back within the term of the analysis." The second payback period calculated represents the period in years to pay off the WECS mortgage. In the event that cumulative savings is never greater than the remaining principal within the term of the loan, the output reports, "Cumulative savings never exceeded the mortgage principal." The third payback period calculates the period in years to pay back the original investment. If the original investment is not paid back within the term of the analysis, the output reports, "Cumulative WECS savings never exceeded the investment."

Present Value Analysis

A present value analysis is performed in which all cash flows are discounted back to the present. Property tax, insurance, and maintenance are assumed to inflate with the general rate of inflation. Both the utility bill for electricity purchase and the revenue received from sale of electricity back to the utility are inflated by a user-supplied cost-of-energy escalation factor. For each year of the analysis the cost to the WECS and non-

WECS owner is calculated. In addition, a busbar WECS cost is derived. The busbar calculation is similar to the WECS owner case except that all utility-related charges and revenues are neglected. The down payment is included at time (t) = 0. The annual costs for each case are given below.

$$C_w(t) = U_w(t) + M(t) + X(t) + P(t) - TS_w(t) - R(t) \quad (2-31)$$

$$C_b(t) = M(t) + X(t) + P(t) - TS_b(t) \quad (2-32)$$

$$C_{nw}(t) = U_{nw}(t) - TS_{nw}(t) \quad (2-33)$$

where C is the cost;
w is the WECS owner case;
U is the utility bill;
M is the mortgage payment;
X is the maintenance and insurance;
P is the property tax;
TS is the tax savings;
R is the revenue from utility;
b is the busbar case; and
nw is the non-WECS owner case.

The calculation of income tax savings depends on the income-producing nature of the investment. Two distinct cases are analyzed.

In a business where the revenue is treated as income the following calculations apply:

$$TS_w(t) = TR[U_w(t) + X(t) + I(t) + D(t) + P(t) - R(t)] + S(t) \quad (2-34)$$

$$TS_b(t) = TR[X(t) + I(t) + D(t) + P(t)] \quad (2-35)$$

$$TS_{nw}(t) = TR[U_{nw}(t)] \quad (2-36)$$

where I is the interest charged;
D is the depreciation allowance;
TR is the effective federal plus state income tax rate; and
S is the subsidy (applied in year 1 only).

In the case of a residence or farm, either of two potential situations might apply. In the first case it is assumed that some fraction of the electricity generated is sold back to the utility. This fraction of the WECS cost is treated as an income-producing business; and insurance, maintenance, and depreciation charges for the WECS are prorated by this fraction. The calculation for tax savings and non-WECS cost is performed as follows:

$$TS_w(t) = TR\{SF[X(t) + D(t)] + I(t) + P(t) - R(t)\} + S(t) \quad (2-37)$$

$$TS_b(t) = TR\{SF[X(t)+D(t)]+I(t)+P(t)\}+S(t) \quad (2-38)$$

$$TS_{nw}(t) = 0 \quad (2-39)$$

where SF is the sell back fraction (1-utilization factor).

In the second case it is assumed that insurance, maintenance, and depreciation are not deductible on a prorated basis. Thus:

$$TS_w(t) = TR[I(t)+P(t)-R(t)]+S(t) \quad (2-40)$$

$$TS_b(t) = TR[I(t)+P(t)]+S(t) \quad (2-41)$$

$$TS_{nw}(t) = 0 \quad (2-42)$$

The present value of each annual cash flow is calculated over the length of the analysis as follows:

$$PV = C(t)/(1+DR)^t \quad (2-43)$$

where PV is the present value;
DR is the discount rate; and
t is the year of analysis.

For the last year of the analysis, proceeds are computed assuming a sale price equal to the salvage value unless the WECS is not fully depreciated. In this case, the book value is taken as the sale price. In either case, the proceeds are calculated as follows:

$$PR = (OP-SA)(1-TR) \quad (2-44)$$

where PR is the proceeds;
OP is the outstanding principal; and
SA is the sale price.

Proceeds are added to the WECS cost in the last year of the analysis.

A detailed printout option is available which tabulates the utility revenue, utility cost, insurance and maintenance cost, property tax, interest paid, depreciation deducted, tax savings, cost with WECS, cost without WECS, savings with WECS, present value of WECS savings, undiscounted cumulative WECS savings, and discounted WECS savings for each year of the analysis.

The program also reports both the annualized life-cycle cost and levelized cost. The capital recovery factor needed to calculate the annualized life-cycle cost is determined as follows:

$$CRF = DR(1+DR)^T / [(1+DR)^T - 1] \quad (2-45)$$

where CRF is the capital recovery factor;
DR is the nominal discount rate; and
T is the length of analysis.

Thus,

$$LCC_w = CRF PV_w \quad (2-46)$$

$$LCC_b = CRF PV_b \quad (2-47)$$

$$LCC_{nw} = CRF PV_{nw} \quad (2-48)$$

where LCC is the annualized life-cycle cost.

The levelized costs in dollars per kilowatt-hour are calculated as follows:

$$LEV_w = LCC_w / D \quad (2-49)$$

$$LEV_b = LCC_b / O \quad (2-50)$$

$$LEV_{nw} = LCC_{nw} / D \quad (2-51)$$

where D is the annual application demand; and
O is the annual WECS output.

Chapter 3

Model Input

USER-SUPPLIED INPUT

Parameters that are likely to change to suit the individual user are stored in a user data file. Typically, the user would invoke the system editor to effect changes in the user file. To facilitate the verification of correct data entry each parameter occupies a field of 10 characters and is right justified within its field. The format and a brief description of each input parameter in this file are given in Table 3-1. Appendix A gives a sample user input data file which corresponds to the sample output files in Appendices C, D, and E.

Table 3-1. Format and Description of User Input Parameters

Parameter	Description	Card	Column	Units	Format
UTITLE	A two line user-specified title that is repeated at the top of each page of output for easy identification.	1&2	1-80	None	20A4
IJOB	Job sequence flag where 1 = Run technical performance module only 2 = Run economic evaluation module only 3 = Run both modules	3	1-10	None	I10
IYR	Calendar year to start analysis (a two-digit value). The year selected is used as the basis for determining the first day of each month and is used to evaluate the number of day types per month.	3	11-20	Yr	I10
ISSP	Simultaneous sell-purchase flag where 0 = No 1 = Yes If specified, the code sells all WECS output at the sell-back rate and purchases all application demand at the utility-purchase rate. This option is useful in case where the sell-back rate is greater than the purchase rate.*	3	21-30	None	I10
IRESTR	Restart flag where 0 = Read from the data base and execute 1 = Read from the scratch file and execute This option allows a restart after the user has edited the scratch file.	3	31-40	None	I10
IEEXIT	Exit after reading data base and creating scratch file, where 0 = No 1 = Yes Used to exit from the code prior to execution to permit editing of the scratch file. A subsequent run can then exercise the restart option (IRESTR=1).	3	41-50	None	I10

Table 3-1. (Cont'd.) Format and Description of User Input Parameters

Parameter	Description	Card	Column	Units	Format
NINC	Number of intervals into which Weibull probability distribution is divided. The selection of this value is a tradeoff between cost of execution and accuracy. A value of 10 is reasonable. The allowable range is 1 to 100.	3	51-60	None	I10
IPRWEC	Performance print flag where -1 = No print 0 = Monthly summaries 1 = Hourly summaries 2 = Annual summary	3	61-70	None	I10
IREMO	Remote application flag where 0 = Utility-connected 1 = Non-utility-connected	3	71-80	None	I10
ICNTY	Five digit FIPS county code corresponding to one of the counties in DOE Region V. If ICNTY < 0 then code automatically cycles through all counties within the region.	4	1-10	None	I10
ILDPRO	Application demand code. This code dictates which application load profile will be read in from the data base. (See Table 3-2 for code values.)	4	11-20	None	I10
IWSIZE	WECS characteristics code corresponding to one of 11 WECS machines in data base. (See Table 3-3 for code values.)	4	21-30	None	I10
IBATT	Storage system flag where 0 = No 1 = Yes This flag is internally set to zero if ISSP=1.	4	31-40	None	I10
AVFAC	WECS availability factor, typically 0.95	4	41-50	None	F10.0
ENUSDT	Annual application demand energy	4	51-60	kWh	F10.0
MKTSEC	Market sector where 1 = Residential 2 = Agricultural 3 = Commercial 4 = Industrial	4	61-70	None	I10
AK	Weibull shape factor, typically 2.0	5	1-10	None	F10.0
CAPAC	Effective (net) storage capacity	6	1-10	kWh	F10.0
CHGRAT	Maximum charge rate	6	11-20	kW	F10.0
DISRAT	Maximum discharge rate	6	21-30	kW	F10.0
OAEFF	Overall storage system efficiency. Defined as the ratio of energy discharged from storage to the energy stored.	6	31-40	%	F10.0
BCACST	Storage system capital cost including installation charge	6	41-50	\$	F10.0
IPREF	Store discharge preference array where 0 = Prefer not to 1 = Prefer to IPREF(1,1) = Store during peak period IPREF(1,2) = Store during off-peak period IPREF(2,1) = Discharge during peak period IPREF(2,2) = Discharge during off-peak period For example, an input of IPREF(1,1) = 0, IPREF(1,2) = 1, IPREF(2,1) = 1, and IPREF(2,2) = 0 would give preference to storing during the off-peak period and discharging during the peak period. If IBATT = 0, then IPREF is internally set to 0. If time-of-day (TOD) rates do not apply, then each IPREF is internally set to 1.	7 7 7 7	1-10 11-20 21-30 31-40	None None None None	I10 I10 I10 I10
RATMOR	WECS mortgage rate	8	1-10	%	F10.0
TLIMOR	Mortgage term	8	11-20	Yr	F10.0
ULIFE	Life for depreciation purposes	8	21-30	Yr	F10.0

Table 3-1. (Cont'd.) Format and Description of User Input Parameters

Parameter	Description	Card	Column	Units	Format
XMISC1	First year maintenance plus insurance cost (% of installed cost). This value is inflated at the general rate of inflation (GINFLA).	8	31-40	\$	F10.0
PRPTXR	First year true property tax rate (% of installed cost). Inflates at GINFLA.	8	41-50	%	F10.0
GINFLA	General rate of inflation	8	51-60	%	F10.0
FEDTAX	Marginal federal income tax rate	8	61-70	%	F10.0
DISCNT	Nominal discount rate	8	71-80	%	F10.0
ALENTH	Length of analysis. WECS assumed to be sold in the last year.	9	1-10	Yr	F10.0
FRDOWN	Down payment. Percent of original investment before any subsidies are applied.	9	11-20	%	F10.0
SALVAL	Salvage value. Percent of original investment before any subsidies are applied.	9	21-30	%	F10.0
IOTYPE	Economics print flag where -1 = No print 0 = Summary only 1 = Print annual cash flows	9	31-40	None	I10
IROR	Internal rate of return flag where 0 = No 1 = Perform internal rate of return calculation	9	41-50	None	I10
ICOM	Income property flag where 0 = Nonincome-producing property 1 = Income-producing property 2 = Prorated income-producing property Business deductions multiplied by (1 - utilization factor).	9	51-60	None	I10
IDTYPE	Type of depreciation flag where 1 = Straight line method 2 = Declining balance method 3 = Sum-of-the-years' digits 4 = None	9	61-70	None	I10
POFSL	Percent of straight line (if IDTYPE=2)	9	71-80	%	F10.0
ESCAL	Real cost of energy escalation factor array. Reads (ALANTH-1) values for years 2 through ALANTH-1.				
	ESCAL(1)	10	1-10	%	F10.0
	ESCAL(2)	10	11-20	%	F10.0
	.	.	.	.	.
	.	.	.	.	.
	ESCAL(8)	10	71-80	%	F10.0
	ESCAL(9)	11	1-10	%	F10.0
	.	.	.	.	.
	.	.	.	.	.
	ESCAL(N)	.	.	.	.

* Schillaci, J. "The Simultaneous Buy and Sell Provision of PURPA Section 210 Regulations." *Public Utility Fortnightly*. October 9, 1980.

The user has the option of selecting one of 17 existing load demand profiles in the data base. Table 3-2 gives the correspondence between the application code (ILDPRO) and a description of the application in the data base.

Table 3-2. Correspondence Between the Application Code ILDPRO and Application Name in Data Base

ILDPRO	Application Demand Description
1	Total residential load without electric water heating 1974-1977
2	Total residential load with electric water heating 1974-1975
3	Total residential load with central air conditioning and water heating
4	Total residential load with central heating (electricity) and water heating
5	Total commercial load 1975-1977
6	Farm total load 1960
7	Large industrial load 1963
8	Flat load, 24 hr/day, 7 days/wk
9	Flat load, 24 hr/day, 6 days/wk
10	Flat load, 24 hr/day, 5 days/wk
11	Flat load, diurnal, 12 hr/day, 7 days/wk
12	Flat load, diurnal, 12 hr/day, 6 days/wk
13	Flat load, diurnal, 12 hr/day, 5 days/wk
14	Flat load, night only, 7 days/wk
15	Municipal pumping, primary service
16	Total farm load, central Connecticut
17	Dairy Farm

The user also has the option of selecting, via the code IWSIZE, one of 11 different WECS machines now included in the data base. Table 3-3 gives the correspondence between the value of IWSIZE, WECS nameplate rating, and some design data.

Table 3-3. WECS Machine Data from Data Base

IWSIZE	Rating (kW)	Rated Speed (m/s)	Blade Dia (m)	No. of Blades	Axis
1	1	9.8	3	3	Horiz
2	2	9.8	4.8	3	Horiz
3	5	13.4	4.8	3	Vert
4	10	11.1	7.3	3	Horiz
5	25	11.6	9.6	2	Horiz
6	40	13.4	11.3	4	Horiz
7	100	13.4	18.0	4	Horiz
8	200	12.5	24.0	3	Horiz
9	500	16.0	24.0	3	Vert
10	2500	12.2	90.0	2	Horiz
11	4	12.0	14.8	2	Horiz

SCRATCH FILE INPUT

The scratch file (Tape 10) is accessed during use of the restart option. Basically, the scratch file consists of excerpts from four separate data-base files accessed in the following order:

- Wind Resource Data (Tape 2);
- WECS Machine Characteristics (Tape 3);
- Application Demand Data (Tape 4); and
- Utility Rate Data (Tapes 5 and 15).

For the wind resource data compiled by Planning Research Co. [4], special integer codes are used to designate the annual diurnal wind-speed vector, the average monthly wind-speed vector, and the wind-shear coefficient. The vectors corresponding to each of these codes are stored internally within the source code as block data since they are common to the entire wind resource data base. The vectors rather than the codes are written to the scratch file to facilitate changes in the default data base values. The values can be altered by using the restart option (IRESTR) and the system editor. In addition, a series of market percentages are included in the data base for each of five wind-speed regimes (i.e., 3-4, 4-5, 5-6, 6-7, and >7 m/s) for four market sectors (i.e., residential, agricultural, commercial, and industrial). The values represent the fraction of the market sector having that particular range of wind speeds. In each case that a non-zero market percentage is read, the value of the average wind speed corresponding to that wind-speed regime is stored in the annual wind-speed vector (VANNUL) array and written to the scratch file. Table F-2 in Appendix F is an excerpt from the complete wind resource data-base file.

The program skips over the first two entries in the VANNUL corresponding to the first two wind-speed regimes. These wind speeds are automatically screened out of all performance and economics evaluations (i.e., it is anticipated that sites with wind speeds below approximately 5 m/s will not be economically attractive). Therefore, the user desiring a different annual wind speed should enter the value of the third field corresponding to VANNUL (3) and be sure that zeroes are in the field corresponding to VANNUL (4) and above if only one calculation is desired. A total of three calculations at once can be performed by entering values into the fields corresponding to VANNUL (3), VANNUL (4), and VANNUL (5).

For wind-machine data, characteristics for all 11 WECS in the data base are read into the scratch file. However, it would only be necessary to change the data for the WECS corresponding to the value of IWSIZE entered in the user file. See Table 3-3 for the correspondence between IWSIZE and WECS nameplate rating and design data. A description of the input format for each section of the scratch data file is given in Table 3-4. Table B-1 in Appendix B gives a sample listing of the scratch data file corresponding to the sample case listed in Appendices C, D, and E.

Table 3-4. Format and Description of Scratch File Input

Card	Column	Symbol	Description	Units	Forma
<i>Wind Resource Data Section</i>					
1	1-6	VBAR(1)	Average Monthly Wind Speed Multiplier	None	F6.0
		.	.	.	.
		.	.	.	.
	62-72	VBAR(12)	.	None	F6.0
2	1-6	VANNUL(1)	Average Annual Wind Speed	m/s	F6.0
		.	.	.	.
		.	.	.	.
	25-30	VANNUL(5)	.	m/s	F6.0
3	1-6	ADWND(1)	Annual Diurnal Wind Speed Multiplier	None	F6.0
		.	.	.	.
		.	.	.	.
	67-72	ADWND(12)	.	None	F6.0
4	1-6	ADWND(13)	.	None	F6.0
		.	.	.	.
		.	.	.	.
	67-72	ADWND(12)	.	None	F6.0
5	1-10	WINDHT	Height at Which Wind Speed Recorded	m	F10.0
	11-20	RHONW	Site Air Density	kg/m ³	F10.0
	21-30	ALPH	Wind Shear Coefficient	None	F10.0
<i>WECS Machine Characteristics Data Section</i>					
1	1-10	MAXWEC	Number of WECS Machines	None	I10
2	1-80	WMODEL	WECS Description	None	20A4
3	1-80	WMODEL	WECS Description (Cont'd.)	None	20A4
4	1-10	NUMB	Number of WECS Performance Points Entered	None	I10
	11-20	RATIN	WECS Nameplate Rating	kW	F10.0
	21-30	HUBHT	Height at Which WECS Performance Measured	m	F10.0
5	1-10	OUTVEL(1,1)	WECS Wind Speed	m/s	F10.0
	11-20	OUTVEL(1,2)	WECS Output	kW	F10.0
6	1-10	OUTVEL(2,1)	WECS Wind Speed	m/s	F10.0
	11-20	OUTVEL(2,2)	WECS Output	kW	F10.0
		.	.	.	.
		.	.	.	.
NUMB+4	1-10	OUTVEL(N,1)	WECS Wind Speed	m/s	F10.0
NUMB+5	11-20	OUTVEL(N,2)	WECS Output	kW	F10.0
			N=NUMB		
NOTE: Cards 2 through NUMB+5 are repeated MAXWEC times					
<i>Application Demand Data Section</i>					
1	1-12	ILDPRO	Application Load Number	None	I12
2	1-80	DTITLE	Description of Application	None	20A4
3	1-12	APPENE(1)	Average Monthly Demand Energy	kWh	F12.0
		.	.	.	.
		.	.	.	.
	61-72	APPENE(6)	.	kWh	F12.0
4	1-12	APPENE(7)	.	kWh	F12.0
		.	.	.	.
		.	.	.	.
	61-72	APPENE(12)	.	kWh	F12.0
5	1-6	HRDEM(1,1)	Hourly Demand for Production Type Day	kW	F6.0
		.	.	.	.
		.	.	.	.
		.	.	.	.
	67-72	HRDEM(12,1)	.	kW	F6.0

Table 3-4 (Cont'd). Format and Description of Scratch File Input

Card	Column	Symbol	Description	Units	Format
<i>Application Demand Data Section</i>					
6	1-6	HRDEM(13,1)	.	kW	F6.0
		.	.	.	.
	67-72	HRDEM(24,1)	.	kW	F6.0
7	1-6	HRDEM(1,2)	Hourly Demand for Non-Production Type Day	kW	F6.0
		.	.	.	.
	67-72	HRDEM(12,2)	.	kW	F6.0
8	1-6	HRDEM(13,2)	.	kW	F6.0
		.	.	.	.
	67-72	HRDEM(24,2)	.	kW	F6.0
9	1-6	FDAYNP(1)	Day of Week that Non-Production Starts (Monday=1)	None	F6.0
		.	.	.	.
	67-72	FDAYNP(12)	.	None	F6.0
10	1-6	ANUMNP(1)	Number of Non-Production Days/Week	None	F6.0
		.	.	.	.
	67-72	ANUMNP(12)	.	None	F6.0
<i>Utility Rate Data Section*</i>					
1	1-10	IUTCOD	Utility Code Number	None	I10
	11-58	UNAME	Utility Name	None	12A4
	59-68	SELBAK(1)	Sell Back Rate During Peak Period	\$/kWh	F10.0
	69-78	SELBAK(2)	Sell Back Rate During Off Peak Period	\$/kWh	F10.0
2	1-10	CHGMIN(L)	Minimum Bill	\$	F10.0
	11-20	FIXCHG	Fixed Charge Component	\$	F10.0
3	1-10	ENECHG(1,1,L)	Energy Charge Rate	\$/kWh	F10.0
		.	.	.	.
	61-70	ENECHG(7,1,L)	.	\$/kWh	F10.0
4	1-10	ENECHG(1,2,L)	Energy Charge Block Width	kWh	F10.0
		.	.	.	.
	61-70	ENECHG(7,2,L)	.	kWh	F10.0
5	1-10	DEMCHG(1,1,L)	Demand Charge Rate	\$/kW	F10.0
		.	.	.	.
	61-70	DEMCHG(7,1,L)	.	\$/kW	F10.0
6	1-10	DEMCHG(1,2,L)	Demand Charge Block Width	kW	F10.0
		.	.	.	.
	61-70	DEMCHG(7,2,L)	.	kW	F10.0
7	1-10	TAX(L)	Tax	%	F10.0
	11-20	SURCHG(L)	Surcharge	%	F10.0
	21-30	PKSTR	Hour that Peak Period Starts	Hr	F10.0
	31-40	PKEND	Hour that Peak Period Ends	Hr	F10.0
	41-50	FDAYOP	Day of Week that Off-Peak Day Begins	Day	F10.0
	51-60	ANUMOP	Number of Off Peak Days Per Week	Day	F10.0

* For time-of-day rates, L=1 for peak period and L=2 for off peak period. First set of six cards is for peak period and second set for off peak. Setting ANUMOP=0 signifies non-time-of-day rates and only six cards are read in.

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Chapter 4

Model Output

WECSAM generates up to three types of output—one for the technical performance module and two for the economic evaluation module.

TECHNICAL PERFORMANCE MODULE OUTPUT

By entering a value into the IPRWEC field in the user input file the user may select one of four print options. The print options govern the amount and type of output provided by the module. The source code, however, internally sets the print option to "no print" (IPRWEC=-1) if a negative county code is entered (ICNTY<0). This prevents the user from inadvertently requesting the very large amount of output associated with all six states contained in the data base. Table 4-1 shows the correspondence between the values of IPRWEC and the printed technical performance output.

Table 4-1. Summary of Performance Module Print Options

Table	IPRWEC			
	1	0	2	-1
User File Echo	x	x	x	-
Summary of User-Input Data	x	x	x	-
WECS Machine Characteristics	x	x	-	-
WECS Discrete Point Summary	x	x	-	-
Application/Utility Names	x	x	x	-
Hourly WECS Performance	x	-	-	-
Daily WECS Performance	x	x	-	-
Monthly WECS Performance	x	x	-	-
Annual WECS Performance	x	x	x	-

The first table repeats the values entered through card 7 of the user input data. The second briefly summarizes the user input data. The WECS machine characteristics table provides a summary of key WECS characteristics as specified in the IWSIZE field of the user input data. These characteristics are derived from the WECS machine characteristics data base (Table F-3). The WECS discrete point data table shows the WECS performance data before and after the application of the air density and height corrections. The code and name of the application are then listed as are the code and name of the utility. The proper utility code is derived from the utility rate pointer file which provides the correspondence between FIPS county code and utility code (see Table

F-6). All subsequent outputs relate to WECS performance results at the hourly, daily, monthly, and annual levels.

The extent of technical performance output (hourly, daily, monthly, and annual results) varies according to the number of wind regimes for a given county. A complete output is generated for each evaluated regime. Though a county may have as many as five wind regimes, a maximum of three complete outputs is generated because the model screens out the first two regimes from evaluation. (See the Scratch-File Data Input section in Chapter 3.) In addition, the extent of printed output of the hourly and daily performance summaries varies according to the number of application day types per month. Complete hourly and daily results are generated for both production and non-production day types.

Appendix C gives a sample output from the technical performance module using the most expanded print option.

ECONOMIC EVALUATION MODULE OUTPUT

The economic evaluation module provides three print options corresponding to the value entered in the IOTYPE field in the user input file. The source code internally sets the print option to "no print" (IOTYPE=-1) if a negative county code is entered (ICNTY<0). It is anticipated that most users will desire the expanded option (IOTYPE=1) since it provides the annual cash flow summary with only two additional pages of output per wind-speed regime. Table 4-2 lists the correspondence between the values of IOTYPE and the printed economic evaluation output.

Table 4-2. Summary of Economic Module Print Options

Table	IOTYPE		
	1	0	-1
Echo of User Input File	x	x	-
Echo of User-Supplied Economic Parameters	x	x	-
Utility Rate Data	x	x	-
Summary of Economic Input Parameters	x	x	-
Parameters Passed by Performance Module	x	x	-
Annual Cash Flow Summary	x	-	-
Economic Performance Indices	x	x	-

The first table repeats the values entered through card 7 of the user input data, the technical parameters. The second table repeats those entered through the remainder of the cards in the user input data, the economic parameters. The utility rate data table gives a summary of the utility rate structure. This output is derived from either of two sources: the utility rate data section of the scratch input file (Table 3-4) or the utility rate pointer data base and utility rate data base (Tables F-6 and F-5). The next table summarizes the economic input parameters. The fifth shows which parameters were passed by the technical performance module. This output is contingent upon the wind

regime and is derived from the wind resource data base. All subsequent outputs present the results of the economic evaluation of the given input data.

As with the technical performance module, the extent of the economic evaluation output (i.e., annual cash flow summary and economic performance indices outputs) varies according to the number of wind regimes for a given county. A complete output is generated for each evaluated regime.

The economic evaluation module automatically generates a data base output file which can be used as an input file for subsequent data reduction and manipulation. This data base file is particularly useful in the automatic county-cycling mode since the normal output of each model would be too great.

Appendix D lists a sample output from the economic evaluation module using the most expanded print option (IOTYPE=1). A sample listing of an automatically generated data base output file is presented in Appendix E.

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Chapter 5

Model Operation

GENERAL

WECSAM is coded in FORTRAN V [1] and currently runs on the linked Cyber 720/CDC 7600 of the SERI computer facility. All user interaction is with the Cyber 720 computer. Jobs are submitted as input to the 720 which in turn passes the job to the 7600 computer for job execution, which runs jobs at significantly less cost. Once the job is executed, the 7600 returns the job to the 720 computer as output. Unfortunately, the Cyber 720 uses the NOS VERSION 1 operating system [5] and the CDC 7600 uses the SCOPE 2.1 operating system [6]. The net effect is that the job control language (JCL) is written in SCOPE 2.1, but the user interacts via the terminal using a subset of NOS called the interactive facility (IAF) [7]. Since IAF supports the use of remote terminals and since SERI subscribes to the TYMNET computer network, it is possible to use these facilities from remote locations.

The SCOPE job control or "submit" file used to submit WECSAM for execution is listed in Table 5-1. As can be seen from this table, an association is established between tape number and file name within the JCL. For convenience, Table 5-2 lists all files, tape numbers, and a brief description of each file. In the event that the source program, WECSAM, is altered, the source program must be recompiled. The necessary job control language to recompile WECSAM and store the resulting binary object code as ECOLGO is listed in Table 5-3.

RESTART OPTION

Cases not corresponding to data in the data base can be run by using the restart option (IRESTR). This option may be used for overriding utility rates for remote applications, evaluating WECS machines of the user's choice, or for evaluating sites outside the six-state region for which the data base applies. In each case, a preliminary run is performed to read the appropriate data-base values into a scratch file. It is assumed that most data-base values will not be changed. To save on execution charges it is possible to make this preliminary run with IEXIT=1. This causes the program to exit immediately after writing default data-base values to the scratch data file. The user may now open the scratch file (Tape 10) for editing and change any default value. Once these steps are accomplished, the user may set IRESTR=1 and reexecute the program. The program will then skip the data-base reading portion and, instead, start execution by reading from the user and scratch files.

**Table 5-1. Scope 2.1 Job Control File
Used to Execute WECSAM**

```

WECSRUN.SP,STSD.T777.
ACCOUNT,DUM1234.
FILE,TAPE7,RT=Z,FL=80.
FILE,TAPE8,RT=Z,FL=80.
FILE,TAPE9,RT=Z,FL=80.
FILE,TAPE10,RT=Z,FL=80.
FILE,TAPE13,RT=Z,FL=80.
FILE,W,RT=Z,FL=80.
FILE,X,RT=Z,FL=80.
FILE,Y,RT=Z,FL=80.
FILE,Z,RT=Z,FL=80.
FILE,YY,RT=Z,FL=80.
FILE,TAPE1,RT=Z,FL=80,BT=C.
GETPF,TAPE1,IUSERM,TY=G,ST=CNS,UN=*,UP=†,CH=‡,PN=§.
FILE,TAPE2,RT=Z,FL=80,BT=C.
GETPF,TAPE2,IWIND,TY=G,ST=CNS,UN=*,UP=†,CH=‡,PN=§.
FILE,TAPE3,RT=Z,FL=80,BT=C.
GETPF,TAPE3,IWEC,TY=G,ST=CNS,UN=*,UP=†,CH=‡,PN=§.
FILE,TAPE4,RT=Z,FL=80,BT=C.
GETPF,TAPE4,IAPP,TY=G,ST=CNS,UN=*,UP=†,CH=‡,PN=§.
FILE,TAPE5,RT=Z,FL=80,BT=C.
GETPF,TAPE5,IRATE,TY=G,ST=CNS,UN=*,UP=†,CH=‡,PN=§.
FILE,TAPE15,RT=Z,FL=80,BT=C.
GETPF,TAPE15,IRATPT,TY=G,ST=CNS,UN=*,UP=†,CH=‡,PN=§.
FILE,TAPE16,RT=Z,FL=80,BT=C.
GETPF,TAPE16,ISUBS,TY=G,ST=CNS,UN=*,UP=†,CH=‡,PN=§.
GETPF,W,IDISK,TY=G,ST=CNS,UN=*,UP=†,CH=‡,PN=§.
COPY,W,TAPE7.
REWIND,TAPE7.
GETPF,Y,IOUTF,TY=G,ST=CNS,UN=*,UP=†,CH=‡,PN=§.
COPY,Y,TAPE8.
REWIND,TAPE8.
GETPF,Z,IECOT,TY=G,ST=CNS,UN=*,UP=†,CH=‡,PN=§.
COPY,Z,TAPE9.
REWIND,TAPE9.
GETPF,X,ISCRATT,TY=G,ST=CNS,UN=*,UP=†,CH=‡,PN=§.
COPY,X,TAPE10.
REWIND,TAPE10.
GETPF,YY,IECOUT,TY=G,ST=CNS,UN=*,UP=†,CH=‡,PN=§.
COPY,YY,TAPE13.
REWIND,TAPE13.
ATTACH,ECONOB,ECOLGO,ID=*.
MAP(ON)
ECONOB.
REWIND,TAPE7,TAPE8,TAPE9,TAPE10,TAPE13.
SAVEPF,TAPE7,IDISK,TY=R,ST=CNS,UN=*,UP=†,CH=‡,PN=§.
SAVEPF,TAPE8,IOUTF,TY=R,ST=CNS,UN=*,UP=†,CH=‡,PN=§.
SAVEPF,TAPE9,IECOT,TY=R,ST=CNS,UN=*,UP=†,CH=‡,PN=§.
SAVEPF,TAPE10,ISCRATT,TY=R,ST=CNS,UN=*,UP=†,CH=‡,PN=§.
SAVEPF,TAPE13,IECOUT,TY=R,ST=CNS,UN=*,UP=†,CH=‡,PN=§.
EXIT.
DMP(0,300000)

```

- * User number; on SERI system this is 6 alphanumeric characters.
- † User password; on SERI system this is from 4 to 7 alphanumeric characters.
- ‡ Account number; on SERI system this is 3 numeric characters.
- § Project number; on SERI system this is 6 numeric characters.

Table 5-2. Summary of Files Used with WECSAM

Tape Number	File Name	Description of File
1	IUSERM	User-supplied input data file
2	IWND	Wind resource data base file
3	IWEC	WECS characteristic data base file
4	IAPP	Application load data base file
5	IRATE	Utility rate data base file
7	IDISK	Performance module summary output file
8	IOUTF	Performance module output data file for subsequent input to economic module
9	IECOT	Economic module summary output file
10	ISCRATT	Temporary scratch data file used in conjunction with restart option
13	IECOUT	Economic module data base output file used for post processing, etc.
15	IRATPT	Utility rate pointer file to establish relationship between county and utility
16	ISUBS	Subsidy and state income tax data base file
NA	WECSAM	Wind energy conversion system analysis model FORTRAN Source Code
NA	ECONLG	"Submit" file used to execute WECSAM
NA	COMPILE	"Submit" file used to recompile WECSAM should changes in source code be required
NA	ECOLGO	Binary object code (stored on CDC 7600 for more efficient access)

**Table 5-3. Scope 2.1 Job Control File
Used to Compile WECSAM**

```
FTNORI,SP,STSBD,T300.
ACCOUNT,DUM1234.
FILE,ICOMP,RT=Z,FL=80.
REQUEST,LGO,**PF.
GETPF,ICOMP,WECSAM,TY=G,ST=CNS,UN=**,UP=†,CH=‡,PN=§.
REWIND,ICOMP.
PURGE,ECOLGO,ID=CAT043.
FTN5,I=ICOMP,B=LGO,LO=S.
REWIND,LGO.
CATALOG,LGO,ECOLGO,ID=*
```

** User number; on SERI system this is 6 alphanumeric characters.
† User password; on SERI system this is 4 to 7 alphanumeric characters.
‡ Account number; for SERI system this is 3 numeric characters.
§ Project number; on SERI system this is 6 numeric characters.

REMOTE SITE OPTION

The remote site option (i.e., nonutility connected application) may be selected by setting IREMO=1 in the user data file. In such a case any WECS energy deficiency not supplied from storage is assumed to be met by an on-site cogeneration plant. Also, any WECS energy excess not stored on site is assumed to be dumped (i.e., lost without revenue).

The method for simulating remote site application uses two values from the utility rate data base to determine the cost of cogeneration plant operation: (1) fixed-charge component (FIXCHG) and (2) energy charge rate for block 1 [ENECHG (1,1,1)]. The fixed-charge component is that portion of the cost in dollars that is independent of energy use. The energy charge rate is that portion of cost proportional to energy use in dollars per kilowatt-hour. For this reason, the user wishing to exercise the remote site option must override the utility rate data by exercising the restart option discussed in the previous section. A description of the scratch file format is provided in Chapter 3.

STORAGE SYSTEM OPTION

The storage system option can be enabled by setting IBATT=1 in the user data file. Once this is accomplished, however, the user must enter other parameters in the user data file to describe the particular storage system's characteristics and the criteria for charging and discharging. If time-of-day rates are in effect, the user should be sure that the values in the IPREF array accurately reflect the charging and discharging criteria as described in Chapter 3. The model assumes that the storage system is charged to one half of its effective storage capacity on the first day of the analysis. The method for treating stored energy carryover from one day type to another is approximate since a maximum of four days are considered per month corresponding to each of the four possible day types. The storage system is assumed to have an availability of 100%. The user could simulate an availability factor of less than 100% by reducing the overall storage system efficiency accordingly.

AUTOMATIC COUNTY-CYCLING OPTION

This option allows the user to obtain results for a large number of distinct counties, each having its own wind resources, state taxes, state incentives, and utility rates. A complete analysis of the six-state region covered by the data base can be accomplished by running the program in the county-cycling mode once for each of the four market sectors (MKTSEC): (1) residential, (2) agricultural, (3) commercial, and (4) industrial.

To exercise this option the user should set the FIPS county code to a negative number (ICNTY<0). The code will automatically override the normal output selection. The only output provided will be the output data-base file. Ordinarily, the user will prefer to process this large amount of data in a manner specific to his needs. Therefore, the

output data-base file is likely to become an input data-base file to a companion post-processor program. The format of the output data-base file is described in Appendix E.

TIME-OF-DAY UTILITY RATES

For time-of-day utility rates the technical performance module must keep track separately of the total energy purchased and sold during both the peak and off-peak periods. Also, the peak demand is tracked separately during both the peak and off-peak periods. This information is written to an output file (Tape 8), which is read by the economic evaluation module for calculating a monthly utility bill based on time-of-day rates.

If the user wishes to enter a time-of-day utility rate by overriding the data-base values, he must first gain access to the scratch data file by using the GET command. Once this is done, it is necessary to enter the utility rate twice in exactly the same format. The first rate should correspond to the peak period, and the second rate should correspond to the off-peak rate. The code will automatically read the second rate structure if the number of off-peak days (ANUMOP) is not equal to zero. Chapter 3 gives the format of the scratch data file.

References

1. Control Data Corporation. 1980. FORTRAN Version 5 Reference Manual. Report 60481300. St. Paul, MN: Control Data Corp.
2. Justus, C. G. 1978. Winds and Wind Systems Performance. Philadelphia, PA: The Franklin Institute Press.
3. Hansen, A. C. March 1980. Adjustment of SWEC'S Power Curves for Air Density Variations. Report No. TM-TO/80-2. Golden, CO: Rockwell International, Inc.
4. Groveman, B. S.; Easterly, J. L. February 1981. County-Level Wind Resource Estimates. SERI/TR-9095-1. Golden, CO: Solar Energy Research Institute.
5. Control Data Corporation. 1980. NOS Version 1 Reference Manual. Vol. 1. Report 60435400. St. Paul, MN: Control Data Corp.
6. Control Data Corporation. 1980. SCOPE 2.1 Reference Manual. Report 60342600. St. Paul, MN: Control Data Corp.
7. Control Data Corporation. 1980. Interactive Facility Version 1 Reference Manual. Report 60455250. St. Paul, MN: Control Data Corp.

Appendix A

Sample User Input Data

Table A-1 gives a sample of the user input data (file 1). This sample corresponds to the sample output files given in Appendices C, D and E. Each row of data in the table corresponds to what has been entered on a single card in the input file, while each block of data on a given line correlates to a field on the card. (See Table 3-1 in Chapter 3.) For example, the first two lines in the table come from the UTITLE field on cards 1 and 2; the third line is derived from card 3 and contains such fields as IJOB, IYR, ISSP, IRESTR, etc.; while the last three lines come from cards 11, 12 and 13, all of whose fields represent escalation factors for subsequent years of analysis.

Table A-1. Sample User Data File (Tape 1)

```

SAMPLE RUN FOR AGRICULTURAL CASE PERFORMED FOR COUNTY CODE = 55007
DATE: 2 NOV 81
      3      81      0      0      0      10      1      0
55007      017      005      000      .95      100000.      2
      2.0
      0.      0.      0.      0.      0.
      0      1      1      0
      08.      10.      05.      4.      0.      10.      25.0      15.0
      20.      20.      0.      1      1      1      3      000.
      17.      17.      17.      17.      17.      17.      17.      17.
      17.      17.      10.      10.      10.      10.      10.      10.
      10.      10.      10.

```


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Appendix B

Sample Scratch Input Data

Table B-1 presents a sample of the scratch input data corresponding to the sample outputs shown in Appendices C, D and E. For purpose of illustration, the sample has artificially been divided into four easily identifiable sections corresponding to the four sections of the scratch input data file given in Table 3-4. All of the values appearing in the sample are derived from various data bases; i.e., in this case the scratch file was not used to change input values.

The first five lines of information shown correspond to the five cards of data from the wind resource data section of the scratch file input. These data are derived from the source code via special integer codes in the wind resource data base (Table F-2).

The next eleven 'tables' of output correlate to the WECS machine characteristics data section of the scratch file input. These come from the WECS machine characteristics data base. (See Table F-3.)

Application demand data, relating to the application demand data section of the scratch input file, comprise the next ten lines of information. The application load data base (Table F-4) generates these data.

The last seven lines are utility rate data. Corresponding to the utility rate data section of the scratch input file, these data are derived from the utility rate data base (Table F-5) and the utility rate pointer data base (Table F-6).

Table B-1. Sample Scratch Input Data File (Tape 10)

Wind Resource Data

1.00	1.01	1.09	1.18	1.08	.95	.84	.83	.93	.98	1.10	1.01
3.50	4.50	5.50	6.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
.84	.83	.82	.82	.82	.82	.84	.91	1.00	1.07	1.16	1.22
1.26	1.28	1.29	1.27	1.21	1.12	1.01	.93	.88	.87	.86	.85
10.000		1.226		.350							

Table B-1 (Cont'd). Sample Scratch Input Data File (Tape 10)

WECS Machine Characteristics Data

```

11
12 VDC, 1KW AT 9.8M/S, H-A, UPWD, 30 ALT, 3WD BLADES,
RDIAM = 3M, 450 RPM, P/A = 14.15 W/M2, WTG COST = $3600 ($1981).
11 1.0 15.2
3.3 0.0
4.0 .1
5.0 .1
6.3 .2
6.6 .4
7.6 .5
8.2 .6
8.9 .9
9.8 1.2
11.2 1.3
22.3 1.3
11100.0
2KW 9.8 M/S, H-A, INWD, 0-180 VDC PERM. MAGNET, 3 ALUM
BLADES, RDIAM 4.8 M, 250 RPM, P/A = 110.5 W/M2, WTG COST = $4600 ($1981)
11 2.0 12.2
4.4 0.0
4.4 .1
6.3 .4
6.7 .6
7.1 .8
7.6 1.0
8.0 1.3
8.5 1.8
8.7 2.0
9.8 2.0
26.8 2.0
9500.0
5 KW AT 13.4 M/S, U-A, IND. GEN.,
3 ALUM BLADES, RDIAM=4.8M, 200 RPM,P/A=276.3 W/M2,WTG COST=$6000($1981)
9 5.0 18.3
3.2 0.0
3.6 .1
4.5 .2
6.1 .6
6.7 .8
8.5 1.4
11.0 2.8
13.4 5.0
25.0 5.0
10000.0
10 KW AT 11.1 M/S, H-A, UPWD, 220 V IND. GEN.,
3 ALUM BLADES, RDIAM = 7.3M, 80 RPM, P/A=238.9 W/M2, WTG COST=$10750($1981)
6 10.0 18.3
4.0 0.0
5.8 1.4
7.6 3.3
9.4 6.0
11.2 10.2
26.8 10.2
23484.0

```

Table B-1 (Cont'd). Sample Scratch Input Data File (Tape 10)

25 KW AT 11.6M/S, H-A DNWD, IND.GEN., 2 FIBERGL. FOAM BLADES,
RADIAM=9.6 M, 121 RPM, P/A=345.4 W/M2, WTG COST = \$15000 (\$1981)

13	25.0	18.3
3.7	0.0	
5.0	.5	
6.3	2.0	
7.5	4.5	
8.8	8.0	
10.1	14.0	
11.3	19.0	
12.6	24.0	
15.1	29.0	
16.6	30.0	
18.1	29.0	
19.1	29.0	
30.2	28.0	

34908.0

40KW AT 13.4M/S, H-A, DNWD, 3-0 IND. GEN., 4 ALUM
BLADES, RDIAM=11.3M, 60 RPM, P/A=3.99 W/M2, WTG AND TWR COST = \$30000 (\$1981)

10	40.0	12.2
2.2	0.0	
5.4	2.0	
8.1	8.0	
8.9	10.0	
9.8	15.0	
10.7	20.0	
11.2	25.0	
11.6	28.0	
13.4	40.0	
26.8	40.0	

51924.0

100 KW AT 13.4M/S, H-A, DNWD, 3 0 IND. GEN., 4 ALUM.
BLADES, RDIAM 18M, 60 RPM, P/A=393 W/M2, WTG+TOWER COST \$60000 (\$1981)

8	100.0	19.8
2.2	0.0	
4.8	2.5	
7.4	15.0	
8.9	25.0	
9.9	40.0	
10.7	50.0	
12.5	100.0	
26.8	100.0	

105924.0

200 KW AT 12.5M/S, H-A, UPWD, AC SYNC, 3 STEEL
BLADES, RDIAM = 24.0M, 30 RPM, P/A = 442 W/M2, WTC COST = \$400000 (\$1981)

9	200.0	24.4
3.6	0.0	
6.7	30.0	
8.5	50.0	
9.4	75.0	
10.3	105.0	
11.2	130.0	
12.1	155.0	
13.4	200.0	
22.3	200.0	

500000.0

Table B-1 (Cont'd). Sample Scratch Input Data File (Tape 10)

500 KW, AT 16.9 M/S, V-A 600 HP IND.GEN., 3 ALUM
 BLADES, RDIAM = 24.6 M, 41 RPM, WTG COST = \$350000 (\$1981)
 9 500.0 22.0
 6.3 0.0
 6.3 10.0
 8.6 105.0
 10.9 220.0
 13.2 395.0
 15.6 510.0
 17.9 445.0
 22.4 420.0
 26.9 420.0
 550000.0

2500 KW AT 12.2M/S, H-A, UPWD, SYNC. GEN., 2 STEEL BLADES,
 RDIAM = 90 M, 18 RPM, P/A = 393 W/M2, WTG COST APPROX. \$2100000(\$1981)
 6 2500.0 61.0
 6.3 0.0
 7.8 790.0
 9.2 1360.0
 10.7 2000.0
 12.3 2500.0
 26.8 2500.0
 2514000.0

4 KW WECS MACHINE
 SYNTHESIZED PERFORMANCE DATA
 7 4.0 18.3
 3.6 0.0
 5.3 .8
 7.0 1.4
 8.6 2.8
 10.3 3.9
 22.0 4.5
 22.3 0.0
 13996.0

Application Demand Data

17
 DAIRY FARM
 4240. 4150. 3980. 3901. 3650. 3582.
 3610. 3850. 4082. 4100. 4466. 4400.
 14. 14. 14. 14. 14. 14. 14. 14. 14. 14. 14. 14.
 14. 14. 14. 14. 14. 14. 14. 14. 14. 14. 14. 14.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 7. 7. 7. 7. 7. 7. 7. 7. 7. 7. 7. 7.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.

Utility Rate Data

14 LAKE SUPERIOR DISTRICT PW .025 0.000
 4.000 0.000 5.000
 .0424 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
 0. 0. 0. 0. 0. 0. 0.
 0.000 0.000 0.000 0.000 0.000 0.000 0.000
 0. 0. 0. 0. 0. 0. 0.
 4.000 0.000 0.000 0.000 0.000 0.000 0.000

Appendix C

Sample Technical Performance Output

The following sample output corresponds to the sample input of Appendices A and B where IPRWEC=1, the most expanded technical performance module print option available, was specified. This means that all performance results (hourly, daily, monthly, and annual) are given as output.

The first output simply repeats the input on the first seven cards of the user input file. The names of the fields into which the data have been entered are printed for easier understanding.

This user input is summarized in four or five lines in the second output set.

The third set of output summarizes the WECS machine performance characteristics. These data, selected with an IWSIZE=5 in the input file, come from the WECS machine characteristics data base (Table F-3). The height correction factor is the ratio of the hub height to the height at which the wind resource data were measured raised to a power equal to the wind shear coefficient, in this case

$$(18.30/10.00)^{0.350}$$

The rest of this output is self evident.

The next output summarizes the WECS performance data before and after correction for height and air density. The data in the third column are derived from the corresponding data in the first column times the height correction factor (1.236). This follows the algorithm summarized in equation 2-20. The fourth column of data comes from the second column according to equation 2-17.

The next output gives the code and name of the application and utility. The name and code of the utility are selected with the ICNTY field in the input file (in this case ICNTY=55007) and are generated from the utility rate pointer file (Table F-6). The code and name of the application are selected via the ILDPRO field (in this case ILDPRO=17) and derived from the application load data base (Table F-4).

The hourly, daily, monthly, and annual technical performance evaluations comprise all subsequent outputs. In the standard output there are usually 12 tables of output for the hourly, daily, and monthly performance results (one for each month) for each wind regime evaluated. For the sample output, however, we have included only one table of results for each wind regime to conserve space.

Please note that a performance evaluation output has been generated for each of two wind regimes. The first is for a wind regime of 5.5 m/s while the second is for one of 6.5 m/s. The generation of these outputs was dictated by the selection of ICNTY=55007 and was derived from the wind resource data base. Referring to Table F-2 we can see that there is a percentage of the market given for each of the first four wind regimes, but none for the fifth. The first two, however, were screened out from evaluation (see Chapter 3), leaving only the two performance evaluation outputs.

Table C-1. Sample Technical Performance Output File (Tape 7)

1

SERI WIND ENERGY CONVERSION PERFORMANCE MODEL
SAMPLE RUN FOR AGRICULTURAL CASE PERFORMED FOR COUNTY CODE = 55007
DATE: 2 NOV 81

USER DATA FILE

IJOB	IYR	ISSP	IRESTR	IEXIT	NINC	IPRVEC	IREMO
3	81	0	0	0	10	1	0
ICNTY	ILDFRO	IWSIZE	IBATT	AVFAC	ENUSDT	MKTSEC	
55007	17	5	0	.950	100000.	2	
AK							
2.000							
CAPAC	CHGRAT	DISRAT	OAEFF	BCACST			
0.0	0.0	0.0	0.0	0.0			
IPREF(1,1)	IPREF(1,2)	IPREF(2,1)	IPREF(2,2)				
0	0	0	0				

SUMMARY OF USER-INPUT DATA

A UTILITY CONNECTED APPLICATION WAS SPECIFIED

A STORAGE SYSTEM WAS NOT SPECIFIED

CALCULATION TO START IN 1981

NUMBER OF VELOCITY-PROBABILITY INTERVALS USED = 10

COUNTY CODE	APPLIC CODE	WECS CODE
55007	17	5

able C-1 (Cont'd). Sample Technical Performance Output File (Tape 7)

WECS MACHINE PERFORMANCE CHARACTERISTICS (CODE = 5)

25 KW AT 11.6M/S, H-A INWD, IND.GEN., 2 FIBERGL. FOAM BLADES,
RADIAM=7.6 M, 121 RPM, P/A=345.4 W/M2, WTG COST = \$15000 (\$1981)

RATING(KW)	PEAK OUTPUT(KW)	SPEED AT PK(M/S)
25.0	30.0	13.4
CUTIN VELO(M/S)	CUTOUT VELO(M/S)	AVAIL FACTOR
3.0	24.4	.950
HUB HEIGHT(M)	HT OF WND MEAS(M)	WND SHEAR COEFF
18.30	10.00	.350
HEIGHT CORRECTION FACTOR		
1.236		
STD AIR DENS(KG/M**3)	SITE AIR DENS(KG/M**3)	
1.226	1.226	

SUMMARY OF WECS OUTPUT DISCRETE POINT INPUT
(WITH WIND SPEED AND OUTPUT CORRECTED FOR SITE AIR DENSITY AND HEIGHT)

NUMBER OF OUTPUT POINTS ENTERED = 13

REF. SPEED (M/S)	REF. OUTPUT (KW)	CORR. SPEED (M/S)	CORR. OUTPUT (KW)
3.710	0.0	3.003	0.0
5.020	.5	4.063	.5
6.280	2.0	5.083	2.0
7.540	4.5	6.103	4.5
8.790	8.0	7.114	8.0
10.050	14.0	8.134	14.0
11.300	19.0	9.146	19.0
12.560	24.0	10.166	24.0
15.060	29.0	12.189	29.0
16.570	30.0	13.411	30.0
18.080	29.0	14.633	29.0
19.080	28.0	15.443	28.0
30.150	28.0	24.402	28.0

APPLICATION (CODE = 17)

DAIRY FARM

UTILITY (CODE = 14)

LAKE SUPERIOR DISTRICT PW

Table C-1 (Cont'd). Sample Technical Performance Output File (Tape 7)

RESULTS FOR MONTH NUMBER = 1

SUMMARY OF PRODUCTION TYPE DAY (DAYS/MO =31)

HOUR	SPEED (M/S)	OUTPUT (KW)	DEMAND (KW)	SOLD (KW)	PURCHASED (KW)
1	4.62	3.4	11.9	.6	9.0
2	4.57	3.3	11.9	.5	9.1
3	4.51	3.2	11.9	.5	9.2
4	4.51	3.2	11.9	.5	9.2
5	4.51	3.2	11.9	.5	9.2
6	4.51	3.2	11.9	.5	9.2
7	4.62	3.4	11.9	.6	9.0
8	5.01	4.5	11.9	.9	8.3
9	5.50	5.8	11.9	1.6	7.6
10	6.00	7.2	11.9	2.2	6.8
11	6.38	8.4	11.9	2.9	6.4
12	6.71	9.2	11.9	3.3	6.0
13	6.93	9.8	11.9	3.6	5.7
14	7.04	10.0	11.9	3.8	5.6
15	7.10	10.2	11.9	3.8	5.6
16	6.99	9.9	11.9	3.7	5.7
17	6.66	9.1	11.9	3.2	6.0
18	6.16	7.7	11.9	2.5	6.7
19	5.56	6.0	11.9	1.6	7.5
20	5.12	4.8	11.9	1.1	8.1
21	4.84	4.0	11.9	.8	8.6
22	4.79	3.9	11.9	.7	8.7
23	4.73	3.7	11.9	.7	8.8
24	4.68	3.6	11.9	.6	8.9
DAY	5.50	140.6	284.9	40.4	184.7

MONTHLY SUMMARY OF WECS PERFORMANCE

MONTH	SPEED (M/S)	OUTPUT (KWH)	DEMAND (KWH)	SOLD (KWH)	PURCHASED (KWH)
1	5.50	4359.	8831.	1253.	5726.

CAPACITY FACTOR 23.4 %

UTILIZATION FACTOR 71.3 %

Table C-1 (Cont'd). Sample Technical Performance Output File (Tape 7)

ANNUAL SUMMARY OF WECS PERFORMANCE

```

-----
WECS MACHINE RATING          25. KW
AVERAGE ANNUAL WIND SPEED    5.500 M/S
PERCENT OF MKT W/ WIND SPD    10 %
ANNUAL OUTPUT POWER          51443. KWH
ANNUAL DEMAND REQUIRED         100000. KWH
ANNUAL PURCHASED POWER       64195. KWH
ANNUAL SOLD POWER            15638. KWH
ANNUAL CAPACITY FACTOR       23.5 %
ANNUAL UTILIZATION FACTOR    69.6 %
  
```

WECS MACHINE PERFORMANCE CHARACTERISTICS (CODE = 5)

25 KW AT 11.6M/S, H-A DNWD, IND.GEN.,2 FIBERGL. FOAM BLADES,
 RADIAM=9.6 M, 121 RPM, P/A=345.4 W/M2, WTG COST = \$15000 (\$1981)

```

RATING(KW)          PEAK OUTPUT(KW)          SPEED AT PK(M/S)
  25.0                30.0                    13.4

CUTIN VELO(M/S)     CUTOUT VELO(M/S)         AVAIL FACTOR
   3.0                24.4                    .950

HUB HEIGHT(M)       HT-OF WND MEAS(M)         WND SHEAR COEFF
  18.30                10.00                    .350

HEIGHT CORRECTION FACTOR
   1.236

STD AIR DENS(KG/M**3)  SITE AIR DENS(KG/M**3)
   1.226                1.226
  
```

SUMMARY OF WECS OUTPUT DISCRETE POINT INPUT
 (WITH WIND SPEED AND OUTPUT CORRECTED FOR SITE AIR DENSITY AND HEIGHT)

NUMBER OF OUTPUT POINTS ENTERED = 13

REF. SPEED (M/S)	REF. OUTPUT (KW)	CORR. SPEED (M/S)	CORR. OUTPUT (KW)
3.710	0.0	3.003	0.0
5.020	.5	4.063	.5
6.280	2.0	5.083	2.0
7.540	4.5	6.103	4.5
8.790	8.0	7.114	8.0
10.050	14.0	8.134	14.0
11.300	19.0	9.146	19.0
12.560	24.0	10.166	24.0
15.060	29.0	12.189	29.0
16.570	30.0	13.411	30.0
18.080	29.0	14.633	29.0
19.080	28.0	15.443	28.0
30.150	28.0	24.402	28.0

Table C-1 (Cont'd). Sample Technical Performance Output File (Tape 7)

RESULTS FOR MONTH NUMBER = 1

SUMMARY OF PRODUCTION TYPE DAY (DAYS/MO =31)

HOUR	SPEED (M/S)	OUTPUT (KW)	DEMAND (KW)	SOLD (KW)	PURCHASED (KW)
1	5.43	5.7	11.9	1.5	7.7
2	5.40	5.5	11.9	1.4	7.8
3	5.33	5.4	11.9	1.4	7.9
4	5.33	5.4	11.9	1.4	7.9
5	5.33	5.4	11.9	1.4	7.9
6	5.33	5.4	11.9	1.4	7.9
7	5.46	5.7	11.9	1.5	7.7
8	5.92	7.0	11.9	2.1	6.9
9	6.50	8.7	11.9	3.0	6.2
10	7.09	10.1	11.9	3.8	5.6
11	7.54	11.3	11.9	4.5	5.1
12	7.93	12.1	11.9	4.9	4.7
13	8.19	12.6	11.9	5.3	4.5
14	8.32	12.9	11.9	5.5	4.4
15	8.39	13.1	11.9	5.6	4.4
16	8.26	12.8	11.9	5.4	4.5
17	7.87	12.0	11.9	4.8	4.7
18	7.28	10.6	11.9	4.1	5.4
19	6.57	8.9	11.9	3.1	6.1
20	6.05	7.4	11.9	2.3	6.8
21	5.72	6.4	11.9	1.8	7.3
22	5.66	6.3	11.9	1.7	7.4
23	5.59	6.1	11.9	1.7	7.5
24	5.53	5.9	11.9	1.6	7.6
DAY	6.50	202.7	284.9	71.3	153.5

MONTHLY SUMMARY OF WECS PERFORMANCE

MONTH	SPEED (M/S)	OUTPUT (KWH)	DEMAND (KWH)	SOLD (KWH)	PURCHASED (KWH)
1	6.50	6283.	8831.	2210.	4758.

CAPACITY FACTOR 33.8 %

UTILIZATION FACTOR 64.8 %

ANNUAL SUMMARY OF WECS PERFORMANCE

WECS MACHINE RATING 25. KW
 AVERAGE ANNUAL WIND SPEED 6.500 M/S
 PERCENT OF MKT W/ WIND SPD 5 %
 ANNUAL OUTPUT POWER 73711. KWH
 ANNUAL DEMAND REQUIRED 100000. KWH
 ANNUAL PURCHASED POWER 53490. KWH
 ANNUAL SOLD POWER 27201. KWH
 ANNUAL CAPACITY FACTOR 33.7 %
 ANNUAL UTILIZATION FACTOR 63.1 %
 SINGLE RUN TERMINATED AT FIPS CODE = 55007

Appendix D

Sample Economic Evaluation Output

The sample output shown in Table D-2 corresponds to the sample technical performance output of Appendix C and to the input of Appendices A and B. The most expanded form (IOTYPE=1) was chosen for this output.

The first three tables of output are, respectively, the repeat of the first seven records of the user input file (the technical parameters); the repeat of the user-supplied economic parameters (the last five records of the user input file); and a summary of the utility rate structure, which is a repeat of the utility rate data section of the scratch input file.

The fourth table summarizes the economic input parameters while the fifth lists the parameters passed by the technical performance module.

The next two tables of output give the annual cash flow summary. Table D-1 helps explain the 12 columns of the first output and whence arrives the values in those columns. It gives results for a 25-kW wind turbine in an annual average wind regime of 5.5 m/s. The three columns of the second output are self-evident. For both of these outputs, where units are not listed explicitly they are dollars.

The last output is a table of economic performance indices. Where a rate of return is requested and there is more than one cash-flow reversal, multiple roots are possible. This output will repeat this fact and indicate the value of the lowest root.

The first four tables of output are printed only once for a given economic evaluation output. For the rest, the module prints an output for each evaluated wind regime. In this case it prints an evaluation for 5.5 m/s and one for 6.5 m/s.

Table D-1. Year 1 Cash Flow for 25-kW WECS in 5.5-m/s Wind Regime

Column	Heading	Computation	Value (\$)
1	Electrical Energy Sales	$(15,638 \text{ kWh} \times \$0.025/\text{kWh})$	391
2	Energy Purchased	$[(64,195 \text{ kWh}) (\$0.042/\text{kWh}) + (\$5/\text{mo.}) (12)] \times 1.04$	2,866
3	Insurance and O&M	$(0.04 \times 34,908)$	1,396
4	Property Taxes		-0-
5	Interest Paid on Loan		2,234
6	Depreciation		11,636
7	Income Taxes Saved		12,099 ^a
	Federal and State Income Taxes	$(32.125\%) = 5,699$	
	Subsidy (Tax Credit)	$= 6,400$	
8	Cost with WECS = Cash Flow for Year		4,066 ^{a,b,c}
9	Cost without WECS	$[(100,000 \text{ kWh}) (\$0.042/\text{kWh}) (1.04)]$ $[(1 - .321250)]$	2,965
10	Savings with WECS	$[\$2,965 - (\$-4,066)]$	7,031
11	Present Worth of WECS Savings	$\$7,031 \div (1 + dr)^n$ where $dr = 0.15$	6,114

(a) Small rounding error

(b) Negative sign on computer run indicates *positive* cash flow since value is cost.

(c) Cash flow is calculated as:

Profit (Loss) before Taxes [Col 1 - (2+3+4+5+6)] =	(\$17,741)
Plus Federal and State Income Taxes Saved	5,699
Profit (Loss) after Taxes	(12,042)
Plus Depreciation	11,636
Plus Federal Tax Credit	6,400
Less Principal on Loan	(1,928)
Cash Flow	\$4,066

Table D-2. Sample Economic Evaluation Output File (Tape 9)

1
SERI WIND ENERGY ECONOMIC ANALYSIS PROGRAM
DATE: 19-JAN-82
TEST RUN USING AGRICULTURAL ECONOMIC PARAMETERS; A2 CASE

USER DATA FILE

IJOB	IYR	ISSP	IRESTR	IEXIT	NINC	IPRWEC	IREMO
3	81	0	0	0	10	1	0
ICNTY	ILDPRO	IWSIZE	IBATT	AVFAC	ENUSDT	MKTSEC	
55007	17	5	0	.950	100000.	2	
AK							
2.000							
CAPAC	CHGRAT	DISRAT	OAEFF	BCACST			
0.0	0.0	0.0	0.0	0.			
IPREF(1,1)	IPREF(1,2)	IPREF(2,1)	IPREF(2,2)				
0	0	0	0				

Table D-2 (Cont'd). Sample Economic Evaluation Output File (Tape 9)

ECHO OF USER-SUPPLIED ECONOMIC PARAMETERS

RATMO 8.0	TLIMOR 10.0	DLIFE 5.0	XMISC1 4.0	PRPTXR 0.0	GINFLA 10.0	FEDTAX 25.0	DISCNT 15.0
ALENT 20.0	FRDOWN 20.0	SALVAL 0.0	IOTYPE 1	IROR 1	ICOM 1	IDTYPE 3	POFSL 0.0
ESCAL FACTORS							
17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00
17.00	17.00	10.00	10.00	10.00	10.00	10.00	10.00
10.00	10.00	10.00					

***** SUMMARY OF UTILITY RATE STRUCTURE *****

NON TIME OF DAY UTILITY RATES HAVE BEEN SPECIFIED

NON-TOD RATE STRUCTURE

UTILITY (CODE = 14)

LAKE SUPERIOR DISTRICT PW

MINIMUM CHARGE (\$)		FIXED CHARGE (\$)		WECS FIXED CHARGE (\$)			
4.00		0.00		5.00			
ENERGY CHARGE RATES (CENTS/KWH)							
BLK 1	BLK 2	BLK 3	BLK 4	BLK 5	BLK 6	BLK 7	
.042	0.000	0.000	0.000	0.000	0.000	0.000	
ENERGY CHARGE BLOCK WIDTHS (KWH)							
BLK 1	BLK 2	BLK 3	BLK 4	BLK 5	BLK 6	BLK 7	
0.000	0.000	0.000	0.000	0.000	0.000	0.000	
DEMAND CHARGE RATE (\$/KW)							
BLK 1	BLK 2	BLK 3	BLK 4	BLK 5	BLK 6	BLK 7	
0.000	0.000	0.000	0.000	0.000	0.000	0.000	
DEMAND BLOCK WIDTHS (KW)							
BLK 1	BLK 2	BLK 3	BLK 4	BLK 5	BLK 6	BLK 7	
0.000	0.000	0.000	0.000	0.000	0.000	0.000	
TAX (%)		SURCHARGE (%)		SELBAK(1) (\$/KWH)			
4.00		0.00		.025			

Table D-2 (Cont'd). Sample Economic Evaluation Output File (Tape 9)

***** SUMMARY OF ECONOMIC INPUT PARAMETERS *****

MORTGAGE INTEREST RATE	8.0	%
MORTGAGE TERM	10.0	YRS
LIFE FOR DEPRECIATION	5.0	YRS
FIRST YEAR MAINTENANCE & INSURANCE COST	4.0	%
FIRST YEAR TRUE PROPERTY TAX	0.0	%
GENERAL RATE OF INFLATION	10.0	%
MARGINAL FEDERAL INCOME TAX BRACKET	25.0	%
NOMINAL DISCOUNT RATE	15.0	%
LENGTH OF ECONOMIC ANALYSIS	20.0	YRS
DOWN PAYMENT (% OF INVESTMENT)	20.0	%
SALVAGE VALUE (% OF INVESTMENT)	0.0	%
OUTPUT CODE (1=YEARLY; 0=SUMMARY ONLY)	1	
RATE OF RETURN CODE (1=DO R OF R CALC; 0=SKIP)	1	
PROPERTY TYPE CODE (0=RESID;1=COMM;2=RESID/COMM)	1	
DEPRECIATION CODE	3	
(1=ST LINE; 2=DECL BAL; 3=SUM OF YRS; 4=NONE)		
DEPRECIATION LIFE	5.	YRS

COST OF ELECTRICITY ESCALATION FACTORS

YEAR	ESCALATION (%)
2	17.0
3	17.0
4	17.0
5	17.0
6	17.0
7	17.0
8	17.0
9	17.0
10	17.0
11	17.0
12	10.0
13	10.0
14	10.0
15	10.0
16	10.0
17	10.0
18	10.0
19	10.0
20	10.0

***** PARAMETERS PASSED BY WECS PERFORMANCE MODULE *****

PERCENT OF MKT WITH WIND SPEED USED	10	%
WEC SYSTEM CAPITAL COST WITHOUT STORAGE	34908.	\$
ANNUAL WECS OUTPUT	51443.	KWH
ANNUAL APPLICATION DEMAND ENERGY	100000.	KWH
UTILIZATION FACTOR	69.60	%

Table D-2 (Cont'd). Sample Economic Evaluation Output File (Tape 9)

*** ECONOMIC ANALYSIS STARTING IN YEAR 1981 ***

TOTAL COST OF WECS SYSTEM BEFORE SUBSIDIES	= \$	34908.
AMOUNT BORROWED	= \$	27926.
DOWN PAYMENT	= \$	6982.
THE ANNUAL MORTGAGE PAYMENT FOR 10 YEARS	= \$	4162.
FEDERAL PLUS STATE SUBSIDY	= \$	6400.
SALVAGE VALUE	= \$	0.
EFFECTIVE FED + STATE INCOME TAX (%)	=	32.1 %

YR	ELEC ENER SALES	ELEC ENER COST	INSUR, MAINT COST	PROP TAX PAID	INTER PAID	DEPR DEDUCT	INC TAX SAVED	COST WITH WECS	COST W/O WECS	SAVNGS WITH WECS	PW OF WECS SAVNGS
0	0	0	0	0	0	0	0	6982	0	-6982	-6982
1	391	2866	1396	0	2234	11636	12100	-4065	2965	7031	6114
2	457	3354	1536	0	2080	9309	5083	3512	3469	-42	-31
3	535	3924	1690	0	1913	6982	4489	4751	4058	-692	-455
4	626	4591	1859	0	1733	4654	3923	6062	4748	-1313	-750
5	733	5371	2044	0	1539	2327	3389	7456	5556	-1899	-944
6	857	6285	2249	0	1329	0	2893	8945	6500	-2444	-1056
7	1003	7353	2474	0	1103	0	3189	9797	7605	-2191	-823
8	1173	8603	2721	0	858	0	3537	10776	8898	-1877	-613
9	1373	10066	2993	0	594	0	3945	11903	10411	-1491	-423
10	1606	11777	3292	0	308	0	4424	13201	12181	-1019	-251
11	1879	13779	3622	0	0	0	4986	10535	14251	3716	799
12	2067	15157	3984	0	0	0	5485	11588	15676	4088	764
13	2274	16672	4382	0	0	0	6033	12747	17244	4497	731
14	2501	18339	4820	0	0	0	6637	14022	18968	4946	699
15	2751	20173	5303	0	0	0	7300	15424	20865	5441	669
16	3027	22191	5833	0	0	0	8030	16967	22952	5985	640
17	3329	24410	6416	0	0	0	8833	18663	25247	6583	612
18	3662	26851	7058	0	0	0	9717	20530	27772	7242	585
19	4028	29536	7763	0	0	0	10688	22583	30549	7966	560
20	4431	32489	8540	0	0	0	11757	24841	33604	8763	535

YR	UNDISC CUM WECS SAVINGS	DISC CUM WECS SAVINGS
0	-6982	-6982
1	49	-867
2	6	-899
3	-686	-1355
4	-2000	-2106
5	-3900	-3051
6	-6345	-4108
7	-8536	-4932
8	-10414	-5546
9	-11907	-5970
10	-12927	-6222
11	-9211	-5423
12	-5123	-4659
13	-626	-3929
14	4319	-3229
15	9760	-2561
16	15745	-1921
17	22328	-1309
18	29570	-724
19	37536	-165
20	46299	370

Table D-2 (Cont'd). Sample Economic Evaluation Output File (Tape 9)

**** ECONOMIC PERFORMANCE INDICES STARTING IN YEAR 1981 ****

THE DISCOUNTED RATE OF RETURN HAS MULTIPLE ROOTS BETWEEN
0% AND 100%.

THE RATE OF RETURN ON WECS INVEST (LOWEST ROOT) (%)=	15.7
YRS UNTIL UNDISC. WECS SAVINGS = INIT CASH INVESTMENT	14.
CUMULATIVE SAVINGS NEVER EXCEEDED THE MORTGAGE PRINCIPAL	
YRS UNTIL UNDISC. WECS SAVINGS = ORIGINAL INVESTMENT	19.
UNDISCOUNTED CUMULATIVE WECS SAVINGS = \$	46299.
PRESENT WORTH OF YEARLY TOTAL COSTS WITH WECS = \$	52808.
PRESENT WORTH OF YEARLY TOTAL COSTS W/O WECS = \$	53178.
PRESENT WORTH OF CUMULATIVE WECS SAVINGS = \$	370.
BENEFIT TO COST RATIO FOR WECS =	1.05
CAPITAL RECOVERY FACTOR	.160
WECS ANNUALIZED LIFE CYCLE COST (\$)	8437.
NON-WECS ANNUALIZED LIFE CYCLE COST (\$)	8496.
WECS LEVELIZED COST (\$/KWH)	.084
NON-WECS LEVELIZED COST (\$/KWH)	.085
WECS BUS BAR LEVELIZED COST (\$/KWH)	.070

***** PARAMETERS PASSED BY WECS PERFORMANCE MODULE *****

PERCENT OF MKT WITH WIND SPEED USED	5	%
WEC SYSTEM CAPITAL COST WITHOUT STORAGE	34908.	\$
ANNUAL WECS OUTPUT	73711.	KWH
ANNUAL APPLICATION DEMAND ENERGY	100000.	KWH
UTILIZATION FACTOR	63.10	%

Table D-2 (Cont'd). Sample Economic Evaluation Output File (Tape 9)

*** ECONOMIC ANALYSIS STARTING IN YEAR 1981 ***

TOTAL COST OF WECS SYSTEM BEFORE SUBSIDIES = \$ 34908.
 AMOUNT BORROWED = \$ 27926.
 DOWN PAYMENT = \$ 6982.
 THE ANNUAL MORTGAGE PAYMENT FOR 10 YEARS = \$ 4162.
 FEDERAL PLUS STATE SUBSIDY = \$ 6400.
 SALVAGE VALUE = \$ 0.
 EFFECTIVE FED + STATE INCOME TAX (%) = 32.1 %

YR	ELEC ENER SALES	ELEC ENER COST	INSUR, MAINT COST	PROP TAX PAID	INTER PAID	DEPR DEDUCT	INC TAX SAVED	COST WITH WECS	COST W/O WECS	SAVNGS WITH WECS	PW OF WECS SAVNGS
0	0	0	0	0	0	0	0	6982	0	-6982	-6982
1	680	2399	1396	0	2234	11636	11857	-4579	2965	7544	6560
2	796	2807	1536	0	2080	9309	4798	2911	3469	558	422
3	931	3284	1690	0	1913	6982	4156	4048	4058	10	7
4	1089	3842	1859	0	1733	4654	3534	5240	4748	-490	-280
5	1274	4495	2044	0	1539	2327	2934	6494	5556	-937	-465
6	1491	5259	2249	0	1329	0	2360	7819	6500	-1318	-569
7	1744	6153	2474	0	1103	0	2565	8479	7605	-873	-328
8	2041	7200	2721	0	858	0	2807	9235	8898	-335	-109
9	2388	8423	2993	0	594	0	3091	10099	10411	311	89
10	2794	9855	3292	0	308	0	3425	11091	12181	1090	269
11	3269	11531	3622	0	0	0	3818	8066	14251	6185	1329
12	3596	12684	3984	0	0	0	4199	8873	15676	6804	1272
13	3955	13952	4382	0	0	0	4619	9760	17244	7484	1216
14	4351	15348	4820	0	0	0	5081	10736	18968	8232	1163
15	4786	16882	5303	0	0	0	5589	11810	20865	9056	1113
16	5264	18571	5833	0	0	0	6148	12991	22952	9961	1064
17	5791	20428	6416	0	0	0	6763	14290	25247	10957	1018
18	6370	22470	7058	0	0	0	7440	15719	27772	12053	974
19	7007	24717	7763	0	0	0	8183	17290	30549	13258	932
20	7708	27189	8540	0	0	0	9002	19019	33604	14584	891

	UNDISC CUM WECS SAVINGS	DISC CUM WECS SAVINGS
0	-6982	-6982
1	563	-420
2	1121	1
3	1131	7
4	640	-272
5	-297	-739
6	-1616	-1309
7	-2490	-1638
8	-2827	-1748
9	-2515	-1659
10	-1425	-1390
11	4759	-60
12	11562	1210
13	19046	2427
14	27279	3590
15	36334	4703
16	46295	5768
17	57253	6786
18	69306	7760
19	82564	8691
20	97148	9582

Table D-2 (Cont'd). Sample Economic Evaluation Output File (Tape 9)

**** ECONOMIC PERFORMANCE INDICES STARTING IN YEAR 1981 ****

THE DISCOUNTED RATE OF RETURN HAS MULTIPLE ROOTS BETWEEN
0% AND 100%

THE RATE OF RETURN ON WECS INVEST (LOWEST ROOT) (%)=	31.0
YRS UNTIL UNDISC. WECS SAVINGS = INIT CASH INVESTMENT	11.
CUMULATIVE SAVINGS NEVER EXCEEDED THE MORTGAGE PRINCIPAL	
YRS UNTIL UNDISC. WECS SAVINGS = ORIGINAL INVESTMENT	15.
UNDISCOUNTED CUMULATIVE WECS SAVINGS = \$	97148.
PRESENT WORTH OF YEARLY TOTAL COSTS WITH WECS = \$	43596.
PRESENT WORTH OF YEARLY TOTAL COSTS W/O WECS = \$	53178.
PRESENT WORTH OF CUMULATIVE WECS SAVINGS = \$	9582.
BENEFIT TO COST RATIO FOR WECS =	2.37
CAPITAL RECOVERY FACTOR	.160
WECS ANNUALIZED LIFE CYCLE COST (\$)	6965.
NON-WECS ANNUALIZED LIFE CYCLE COST (\$)	8496.
WECS LEVELIZED COST (\$/KWH)	.070
NON-WECS LEVELIZED COST (\$/KWH)	.085
WECS BUS BAR LEVELIZED COST (\$/KWH)	.049

Appendix E

Sample Data Base Output

The economic evaluation module automatically generates a data base output file (Tape 13) that can be used as an input file for subsequent data reduction and manipulation. It is currently being used as an input file to a table-generation program that produces summary economic results in tabular form for each county. The file contains a one- or two-line record per county depending upon the result of the wind-screening test (Chapter 3). If a county passes the wind-screening test, the following information is written: FIPS county code (ICNTY); application demand code (ILDPRO); WECS code (IWSIZE); wind speed regime; market sector (MKTSEC); percentage of market in a given wind-speed regime; annual application demand (ENUSDT); rate of return; years to pay back initial investment; levelized cost to WECS owner; levelized cost to non-WECS owner; county name; and utility name. If a county does not pass the screening test, a single one-line record is written, consisting of the county code (ICNTY) and the value -10 in the application demand field. For users interested in accessing this file the format suggested for input is

1000 Format (6I6, F10.0, F8.2, F8.0, 2F8.3, / 6A4, 8A4)

A short excerpt which includes the sample county (i.e., 55007) is listed in Table E-1.

Table E-1. Excerpt from Data Base Output File (Tape 13)

39105	-10									
39107	-10									
39109	-10									
39111	-10									
39113	-10									
39115	-10									
39117	17	5	3	2	15	100000.	8.05	16.	.097	.089
MORROW						OHIO EDISON CO				
39119	-10									
39121	-10									
39123	17	5	3	2	100	100000.	7.94	16.	.097	.089
OTTAWA						OHIO EDISON CO				
39125	-10									
39127	-10									
39129	-10									
39131	-10									
39133	17	5	3	2	30	100000.	8.05	16.	.097	.089
PORTAGE						OHIO EDISON CO				
39135	17	5	3	2	10	100000.	3.62	18.	.090	.077
PREBLE						DAYTON PWR & LT CO THE				
39137	-10									
39139	17	5	3	2	40	100000.	8.05	16.	.097	.089

Table E-1 (Cont'd). Excerpt from Data Base Output File (Tape 13)

RICHLAND			OHIO EDISON CO							
39141	-10									
39143	17	5	3	2	60	100000.	-1.00	999.	.082	.065
SANDUSKY			OHIO PWR CO							
39145	-10									
39147	17	5	3	2	20	100000.	-1.00	999.	.082	.065
SENECA			OHIO PWR CO							
39149	-10									
39151	-10									
39153	17	5	3	2	30	100000.	8.05	16.	.097	.089
SUMMIT			OHIO EDISON CO							
39155	17	5	3	2	10	100000.	7.94	16.	.097	.089
TRUMBULL			OHIO EDISON CO							
39157	-10									
39159	10									
39161	-10									
39163	-10									
39165	-10									
39167	-10									
39169	17	5	3	2	30	100000.	-1.00	999.	.082	.065
WAYNE			OHIO PWR CO							
39171	-10									
39173	-10									
39175	-10									
55001	-10									
55003	-10									
55005	-10									
55007	17	5	3	2	10	100000.	15.66	14.	.084	.085
BAYFIELD			LAKE SUPERIOR DISTRICT PW							
55007	17	5	4	2	5	100000.	31.03	11.	.070	.085
BAYFIELD			LAKE SUPERIOR DISTRICT PW							
55009	17	5	3	2	5	100000.	10.77	15.	.090	.096
BROWN			WISCONSIN PUB SERV CORP							
55011	-10									
55013	-10									
55015	-10									
55017	-10									
55019	-10									
55021	-10									
55023	-10									
55025	17	5	3	2	5	100000.	12.65	15.	.086	.084
DANE			WISCONSIN PWR & LT CO							
55027	-10									
55029	17	5	3	2	40	100000.	10.77	15.	.090	.086
DOOR			WISCONSIN PUB SERV CORP							
55031	17	5	3	2	10	100000.	11.55	15.	.079	.076
DOUGLAS			MINNESOTA PWR & LT CO							
55033	-10									
55035	-10									
55037	-10									
55039	17	5	3	2	5	100000.	10.09	15.	.089	.084
FOND DU LAC			WISCONSIN PWR & LT CO							
55041	-10									
55043	17	5	3	2	20	100000.	12.65	15.	.086	.084
GRANT			WISCONSIN PWR & LT CO							
55045	17	5	3	2	10	100000.	12.65	15.	.086	.084

Appendix F

Data Base Input Data

A total of six separate data base files are accessed by WECSAM (Table F-1).

Table F-1. Summary of Data Base Files

Tape No.	Description	Accessing Module
2	Wind Resource	Performance
3	WECS Characteristics	Performance
4	Application Demand	Performance
5	Utility Rates	Performance
15	Utility Rate Pointers	Performance
16	State Tax and Subsidy	Economic

The wind resource data base—an excerpt of which is listed in Table F-2—contains five one-line records per county. The first record gives the county code, the diurnal wind vector code, the monthly wind vector code, and the wind-shear coefficient code. Each of the following four records gives the percentage of the market in each of five wind regimes. The four records represent the following sectors: (1) residential, (2) agricultural, (3) commercial, and (4) industrial. The code automatically screens out the first two wind regimes for each record (i.e., ISCRN=2 within the source code). Thus, a calculation is not performed unless there is a positive number in the third or fourth or fifth field of a given sector.

The WECS characteristics data base—listed in Table F-3—is read into the scratch file (see the WECS machine characteristics in Table 3-4, also). The first record shown in Table F-3 gives the number of WECS machines for which data are stored in the data base. Each of the next 11 tables lists the data characterizing the machines. The first two records of each table describe the given machine. The third record lists the number of WECS performance points entered, the WECS nameplate rating, and the height at which the WECS performance is measured. The next several records are two-column records. The first column lists the measured WECS wind speed (m/s), while the second column lists the output (kW) corresponding to the given wind speed. The last record in each table gives the WECS installed cost (\$). Additional WECS machines can be appended to the data base. To do so, however, the authorized user must enter the number of machines included in the data base as the first record of the file.

The application demand data base (Table F-4) currently consists of 17 distinct application-load profiles. Each load profile has the format described in the application demand data section of Table 3-4. Several application demand loads in the data base include both production and nonproduction type days (i.e., ILDPRO=9, 10, 12, and 13).

The utility rate data base has the same basic format as the utility rate data section presented in Table 3-4. The first five of the utility rate data base are listed in Table F-5. There are three rate structures per utility: residential and agricultural, commercial, and industrial.

A utility rate pointer data base—an excerpt of which is given in Table F-6—is required to determine the correspondence between the county code (ICNTY) and utility. The file includes a single-line record per county with both the county code and rate pointer given. The rate pointer corresponds to the order in which the utility occurs in the utility rate data base, providing a means for the model to access the correct utility-rate structure. The data in the table are listed in order of the SMSA standing, state and county code, county name, utility name, and utility rate pointer. The SMSA standing relates to the type of county and is not read in or otherwise used in the analysis.

The tax-and-subsidy data base (Table F-7) is accessed by the economic evaluation module to obtain state income tax and subsidy data. The first one-line record contains information on the federal tax subsidy data. The parameters in the record correspond to the federal subsidy rate for residential/agricultural (%), the corresponding maximum subsidy (\$), the federal subsidy rate for commercial/industrial (%), and the corresponding maximum subsidy. Each of the following records of the data base relate to one of the six states in the data base. The parameters in each record correspond to the two-digit state code; the subsidy rate for residential/agricultural (%); the corresponding maximum subsidy (\$); the subsidy rate for commercial/industrial (%); the corresponding maximum subsidy (\$); and the state income tax for the residential/agricultural, commercial, and industrial sectors (%). A maximum subsidy value of -1 indicates no maximum subsidy.

Table F-2. Excerpt from Wind Resource Data Base (Tape 2)

39163	1	1	3	
80	20	0	0	0
90	10	0	0	0
80	20	0	0	0
80	20	0	0	0
39165	1	1	2	
20	80	0	0	0
30	70	0	0	0
40	60	0	0	0
40	60	0	0	0
39167	1	1	2	
60	40	0	0	0
70	30	0	0	0
70	30	0	0	0
80	20	0	0	0
39169	1	1	2	
0	60	40	0	0
0	70	30	0	0
0	60	40	0	0
0	60	40	0	0
39171	1	1	2	
0	100	0	0	0
0	100	0	0	0
0	100	0	0	0
0	100	0	0	0
39173	1	1	2	
0	90	10	0	0
0	100	0	0	0
0	100	0	0	0
0	100	0	0	0
39175	1	1	2	
0	90	10	0	0
0	100	0	0	0
0	100	0	0	0
0	100	0	0	0
55001	1	3	3	
90	10	0	0	0
60	40	0	0	0
95	5	0	0	0
95	5	0	0	0
55003	1	3	23	
20	75	5	0	0
70	30	0	0	0
15	80	5	0	0
10	85	5	0	0
55005	1	3	23	
30	70	0	0	0
40	60	0	0	0
20	80	0	0	0
20	80	0	0	0
55007	1	3	3	
25	30	40	5	0
35	50	10	5	0
25	30	40	5	0
25	30	40	5	0
55009	1	3	2	

Table F-2 (Cont'd). Excerpt from Wind Resource Data Base (Tape 2)

0	95	5	0	0
0	95	5	0	0
0	95	5	0	0
0	95	5	0	0
55011	1	3	3	
80	20	0	0	0
90	10	0	0	0
80	20	0	0	0
90	10	0	0	0
55013	1	3	3	
80	20	0	0	0
60	40	0	0	0
80	20	0	0	0
80	20	0	0	0
55015	1	3	2	
0	100	0	0	0
0	100	0	0	0
0	100	0	0	0
0	100	0	0	0
55017	1	3	23	
10	90	0	0	0
20	80	0	0	0
10	90	0	0	0
10	90	0	0	0
55019	1	3	23	
10	90	0	0	0
20	80	0	0	0
0	100	0	0	0
5	95	0	0	0
55021	1	3	2	
20	75	5	0	0
10	90	0	0	0
20	80	0	0	0
20	80	0	0	0
55023	1	3	3	
80	20	0	0	0
30	70	0	0	0
90	10	0	0	0
90	10	0	0	0
55025	1	3	23	
10	80	10	0	0
5	90	5	0	0
5	90	5	0	0
5	90	5	0	0

Table F-3. WECS Machine Characteristics Data Base (Tape 3)

11		
12 VDC, 1KW AT 9.8M/S, H-A, UPWD, 30 ALT, 3WD BLADES.		
RDIAM = 3M, 450 RPM, P/A = 14.15 W/M2, WTG COST = \$3600 (\$1981).		
11	1.0	15.24
3.30	0.00	
4.00	0.05	
5.00	0.10	
6.25	0.20	
6.60	0.35	
7.60	0.50	
8.20	0.60	
8.93	0.85	
9.82	1.20	
11.20	1.30	
22.30	1.30	
11100.		
2KW 9.8 M/S, H-A, DNWD, 0-180 VDC PERM. MAGNET, 3 ALUM		
BLADES, RDIAM 4.8 M, 250 RPM, P/A = 110.5 W/M2, WTG COST = \$4600 (\$1981)		
11	2.00	12.20
4.40	0.00	
4.40	0.10	
6.25	0.40	
6.70	0.55	
7.14	0.75	
7.59	1.00	
8.03	1.25	
8.48	1.75	
8.70	1.975	
9.80	2.00	
26.80	2.00	
9500.00		
, 5 KW AT 13.4 M/S, V-A, IND. GEN.,		
3 ALUM BLADES, RDIAM=4.8M, 200 RPM, P/A=276.3 W/M2, WTG COST=\$6000(\$1981)		
9	5.00	18.30
3.20	0.00	
3.60	0.10	
4.47	0.20	
6.10	0.60	
6.70	0.80	
8.50	1.40	
11.00	2.80	
13.40	5.00	
25.00	5.00	
10000.		
10 KW AT 11.1 M/S, H-A, UPWD, 220 V IND. GEN.,		
3 ALUM BLADES, RDIAM = 7.3M, 80 RPM, P/A=238.9 W/M2, WTG COST=\$10750(\$1981)		
6	10.00	18.30
4.00	0.00	
5.80	1.60	
7.60	3.30	
9.40	6.00	
11.20	10.20	
26.80	10.20	
23484.		

Table F-3 (Cont'd). WECS Machine Characteristics Data Base (Tape 3)

25 KW AT 11.6M/S, H-A DNWD, IND.GEN., 2 FIBERGL. FOAM BLADES,
RADIAM=9.6 M, 121 RPM, P/A=345.4 W/M2, WTG COST = \$15000 (\$1981)

13	25.00
3.71	0.00
5.02	0.50
6.28	2.00
7.54	4.50
8.79	8.00
10.05	14.00
11.30	19.00
12.56	24.00
15.06	29.00
16.57	30.00
18.08	29.00
19.08	28.00
30.15	28.00

34908.

40KW AT 13.4M/S, H-A, DNWD, 3-0 IND. GEN., 4 ALUM
BLADES, RDIAM=11.3M, 60 RPM, P/A=3.99 W/M2, WTG AND TWR COST = \$30000 (\$1981)

10	40.00
2.20	0.00
5.36	2.00
8.05	8.00
8.94	10.00
9.83	15.00
10.73	20.00
11.17	25.00
11.62	28.00
13.40	40.00
26.80	40.00

51924.

100 KW AT 13.4M/S, H-A, DNWD, 3 0 IND. GEN., 4 ALUM.
BLADES, RDIAM 18M, 60 RPM, P/A=393 W/M2, WTG+TOWER COST \$60000 (\$1981)

8	100.00
2.20	0.00
4.80	2.50
7.40	15.00
8.90	25.00
9.90	40.00
10.70	50.00
12.50	100.00
26.80	100.00

105924.

200 KW AT 12.5M/S, H-A, HPWD, AC SYNC, 3 STEEL
BLADES, RDIAM = 24.0M, 30 RPM, P/A = 442 W/M2, WTC COST = \$400000 (\$1981)

9	200.
3.57	0.0
6.70	30.0
8.48	50.0
9.38	75.0
10.27	105.0
11.16	130.0
12.05	155.0
13.40	200.0
22.32	200.0

500000.

Table F-3 (Cont'd). WECS Machine Characteristics Data Base (Tape 3)

500 KW, AT 16.9 M/S, V-A 600 HP IND.GEN., 3 ALUM
BLADES, RDIAM = 24.6 M, 41 RPM, WTG COST = \$350000 (\$1981)

9	500.	22.
6.25	0.	
6.30	10.	
8.60	105.	
10.90	220.	
13.20	395.	
15.60	510.	
17.90	445.	
22.40	420.	
26.90	420.	
550000.		

2500 KW AT 12.2M/S, H-A, UPWD, SYNC. GEN., 2 STEEL BLADES,
RDIAM = 90 M, 18 RPM, P/A = 393 W/M2, WTG COST APPROX. \$2100000(\$1981)

6	2500.	61.
6.30	0.	
7.80	790.	
9.20	1360.	
10.70	2000.	
12.30	2500.	
26.80	2500.	
2514000.		

4 KW WECS MACHINE

SYNTHESIZED PERFORMANCE DATA

7	004.00	18.30
3.60	0.00	
5.30	0.80	
7.00	01.40	
8.60	02.80	
10.30	03.90	
22.00	04.50	
22.30	000.00	
13996.		

Table F-4. Application Load Data Base (Tape 4)

01											
TOTAL RESIDENTIAL LOAD WITHOUT ELEC WATER HEATING 1974-1977											
	551.		519.		494.		482.		496.		536.
	653.		695.		513.		463.		499.		544.
0.595	.529	.504	.489	.502	0.526	0.594	0.648	0.651	0.654	0.694	0.733
0.754	0.763	0.776	0.826	0.924	0.994	0.999	0.988	0.977	0.949	0.871	0.718
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7.	7.	7.	7.	7.	7.	7.	7.	7.	7.	7.	7.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
02											
AVERAGE TOTAL RESIDENTIAL LOAD WITH ELEC WATER HEATING 1974-1975											
	1530.		1158.		1188.		1063.		966.		989.
	1133.		1192.		947.		930.		1030.		1371.
1.028	.942	.856	.876	.906	1.104	1.387	1.539	1.610	1.610	1.676	1.752
1.732	1.610	1.583	1.668	1.892	2.014	2.014	2.036	1.964	1.823	1.556	1.252
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7.	7.	7.	7.	7.	7.	7.	7.	7.	7.	7.	7.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
03											
TOTAL RESIDENTIAL LOAD WITH CENTRAL A/C AND WATER HEATING											
	1577.		1197.		1217.		1083.		2280.		1250.
	1842.		1502.		1049.		948.		1058.		1417.
1.179	1.071	.962	.967	.991	1.175	1.454	1.615	1.721	1.739	1.845	1.952
1.972	1.881	1.881	1.997	2.257	2.396	2.401	2.405	2.284	2.099	1.814	1.465
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7.	7.	7.	7.	7.	7.	7.	7.	7.	7.	7.	7.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
04											
TOTAL RESIDENTIAL LOAD WITH CENTRAL HEATING (ELEC) AND WATER HEATING											
	3678.		2780.		2577.		2007.		1717.		1056.
	1180.		1233.		1378.		1629.		2052.		2492.
2.276	2.190	2.104	2.124	2.154	2.352	2.635	2.787	2.858	2.858	2.924	3.000
2.980	2.858	2.831	2.916	3.140	3.262	3.252	3.284	3.212	3.071	2.804	2.500
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7.	7.	7.	7.	7.	7.	7.	7.	7.	7.	7.	7.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
05											
TOTAL COMMERCIAL LOAD 1975-1977											
	892.		779.		828.		814.		804.		920.
	1003.		943.		850.		936.		841.		854.
0.770	.700	.670	.650	.650	0.640	0.730	0.900	1.280	1.520	1.630	1.690
1.590	1.680	1.670	1.650	1.540	1.350	1.290	1.290	1.300	1.190	1.030	0.960
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7.	7.	7.	7.	7.	7.	7.	7.	7.	7.	7.	7.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
06											
FARM TOTAL LOAD 1960											
	1128.		1073.		1019.		952.		893.		853.
	852.		862.		899.		958.		1084.		1151.
1.225	1.075	.975	.925	.950	1.025	1.475	1.550	1.575	1.400	1.350	1.425
1.275	1.165	1.150	1.225	1.450	1.850	1.775	1.615	1.500	1.375	1.400	1.335
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7.	7.	7.	7.	7.	7.	7.	7.	7.	7.	7.	7.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

Table F-4 (Cont'd). Application Load Data Base (Tape 4)

07											
LARGE INDUSTRIAL LOAD 1963											
3580596.	3580596.	3580596.	3580596.	3580596.	3580596.	3580596.	3580596.	3580596.	3580596.	3580596.	3580596.
3580596.	3580596.	3580596.	3580596.	3915520.	3756609.	3884580.					
4240.	3930.	3620.	3470.	3550.	3930.	5010.	5700.	5930.	5930.	5860.	5400.
5860.	5930.	5700.	5240.	5170.	5170.	5170.	5090.	5090.	5090.	5010.	4860.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7.	7.	7.	7.	7.	7.	7.	7.	7.	7.	7.	7.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
08											
FLAT LOAD 24 HRS/DAY, 7 DAYS/WK											
1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.
1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.
1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37
1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7.	7.	7.	7.	7.	7.	7.	7.	7.	7.	7.	7.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
09											
FLAT LOAD 24 HRS/DAY, 6 DAYS/WK											
1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.
1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.
1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7.	7.	7.	7.	7.	7.	7.	7.	7.	7.	7.	7.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
10											
FLAT LOAD 24 HRS/DAY, 5 DAYS/WK											
1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.
1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.
1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
6.	6.	6.	6.	6.	6.	6.	6.	6.	6.	6.	6.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
11											
FLAT LOAD, DIURNAL :12 HRS/DAY, 7 DAYS/WK											
1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.
1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.
0.00	0.00	0.00	0.00	0.00	0.00	2.74	2.74	2.74	2.74	2.74	2.74
2.74	2.74	2.74	2.74	2.74	2.74	0.00	0.00	0.00	0.00	0.00	0.00
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7.	7.	7.	7.	7.	7.	7.	7.	7.	7.	7.	7.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
12											
FLAT LOAD, DIURNAL :12 HRS/DAY, 6 DAYS/WK											
1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.
1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.
0.00	0.00	0.00	0.00	0.00	0.00	3.20	3.20	3.20	3.20	3.20	3.20
3.20	3.20	3.20	3.20	3.20	3.20	0.00	0.00	0.00	0.00	0.00	0.00
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7.	7.	7.	7.	7.	7.	7.	7.	7.	7.	7.	7.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.

Table F-4 (Cont'd). Application Load Data Base (Tape 4)

13											
FLAT LOAD, DIURNAL :12 HRS/DAY, 5 DAYS/WEEK											
1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.
1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.
0.00	0.00	0.00	0.00	0.00	0.00	3.85	3.85	3.85	3.85	3.85	3.85
3.85	3.85	3.85	3.85	3.85	3.85	0.00	0.00	0.00	0.00	0.00	0.00
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
6.	6.	6.	6.	6.	6.	6.	6.	6.	6.	6.	6.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
14											
FLAT LOAD, NIGHT ONLY, 7 DAYS/WK											
1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.
1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.
2.74	2.74	2.74	2.74	2.74	2.74	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	2.74	2.74	2.74	2.74	2.74	2.74
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7.	7.	7.	7.	7.	7.	7.	7.	7.	7.	7.	7.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
15											
MUNICIPAL PUMPING, PRIMARY SERVICE											
34657.	33055.	36010.	33260.	36365.	45142.						
69997.	39696.	52003.	39995.	32561.	35016.						
55.	32.	51.	49.	46.	47.	50.	32.	56.	58.	60.	62.
63.	63.	63.	62.	62.	63.	62.	62.	62.	61.	58.	57.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7.	7.	7.	7.	7.	7.	7.	7.	7.	7.	7.	7.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
16											
TOTAL FARMLOAD, CENTRAL CONNECTICUT											
2130.	2135.	2099.	1765.	1709.	1480.						
1500.	1605.	1615.	1846.	1900.	2141.						
1.4	1.5	1.7	1.9	2.4	3.0	3.2	3.6	3.3	3.0	2.8	2.5
2.3	2.2	2.3	2.4	2.9	3.3	3.2	3.0	2.6	2.2	1.9	1.5
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7.	7.	7.	7.	7.	7.	7.	7.	7.	7.	7.	7.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
17											
DAIRY FARM											
4240.	4150.	3980.	3901.	3650.	3582.						
3610.	3850.	4082.	4100.	4466.	4400.						
13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7
13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7.	7.	7.	7.	7.	7.	7.	7.	7.	7.	7.	7.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

Table F-5. Excerpt from Utility Rate Data Base (Tape 5)

1	CENTRAL ILLINOIS LIGHT					.025
17.8600	0.0	5.0000				
0.0714	0.0645	0.0569	0.0569	0.0512	0.0512	
250.0	250.0	250.0	250.0	500.0	0.0	
0.0	0.0	0.0	0.0			
0.0	0.0	0.0	0.0			
0.0	0.0	0.0	0.0	0.0	0.0	
0.0	0.0	15.0000				
0.0873	0.0800	0.0752	0.0632	0.0688	0.0631	
750.0	750.0	4500.0	4000.0	2500.0	0.0	
0.0	0.0	0.0	0.0			
0.0	0.0	0.0	0.0			
0.0	0.0	0.0	0.0	0.0	0.0	
0.0	0.0	30.0000				
0.0558	0.0504	0.0500	0.0481	0.0319	0.0283	
30000.0	30000.0	60000.0	100000.0	200000.0	0.0	
3.2967	3.1880	1.1890	4.8733			
300.0	200.0	500.0	0.0			
0.0	0.0	0.0	0.0	0.0	0.0	
2	CENTRAL ILLINOIS PUBLIC SERVICE					.025
17.7550	0.0	5.0000				
0.0710	0.0604	0.0604	0.0604	0.0604	0.0604	
250.0	250.0	250.0	250.0	500.0	0.0	
0.0	0.0	0.0	0.0			
0.0	0.0	0.0	0.0			
0.0	0.0	0.0	0.0	0.0	0.0	
0.0	0.0	15.0000				
0.0840	0.0727	0.0661	0.0584	0.0564	0.0749	
750.0	750.0	4500.0	4000.0	2500.0	0.0	
0.0	0.0	0.0	0.0			
0.0	0.0	0.0	0.0			
0.0	0.0	0.0	0.0	0.0	0.0	
0.0	0.0	30.0000				
0.0342	0.0283	0.0271	0.0272	0.0279	0.0222	
30000.0	30000.0	60000.0	100000.0	200000.0	0.0	
6.8500	7.0730	6.2350	5.3041			
300.0	200.0	500.0	0.0			
0.0	0.0	0.0	0.0	0.0	0.0	
3	CINCINNATI GAS AND ELECTRIC					.025
13.2600	0.0	5.0000				
0.0530	0.0376	0.0373	0.0372	0.0346	0.0347	
250.0	250.0	250.0	250.0	500.0	0.0	
0.0	0.0	0.0	0.0			
0.0	0.0	0.0	0.0			
0.0	0.0	0.0	0.0	0.0	0.0	
0.0	0.0	15.0000				
0.0653	0.0553	0.0673	0.0396	0.0456	0.0393	
750.0	750.0	4500.0	4000.0	2500.0	0.0	
0.0	0.0	0.0	0.0			
0.0	0.0	0.0	0.0			
0.0	0.0	0.0	0.0	0.0	0.0	
0.0	0.0	30.0000				
0.0287	0.0242	0.0239	0.0234	0.0233	0.0222	
30000.0	30000.0	60000.0	100000.0	200000.0	0.0	
4.8100	4.3590	4.6620	4.6931			
300.0	200.0	500.0	0.0			
0.0	0.0	0.0	0.0	0.0	0.0	

Table F-5 (Cont'd). Excerpt from Utility Rate Data Base (Tape 5)

4	CLEVELAND ELECTRIC ILLUMINATING					.025
17.2000	0.0	5.0000				
0.0688	0.0566	0.0566	0.0566	0.0493	0.0493	
250.0	250.0	250.0	250.0	500.0	0.0	
0.0	0.0	0.0	0.0			
0.0	0.0	0.0	0.0			
0.0	0.0	0.0	0.0	0.0	0.0	
0.0	0.0	15.0000				
0.0660	0.0607	0.0678	0.0556	0.0624	0.0546	
750.0	750.0	4500.0	4000.0	2500.0	0.0	
0.0	0.0	0.0	0.0			
0.0	0.0	0.0	0.0			
0.0	0.0	0.0	0.0	0.0	0.0	
0.0	0.0	30.0000				
0.0455	0.0402	0.0372	0.0330	0.0329	0.0287	
30000.0	30000.0	60000.0	100000.0	200000.0	0.0	
3.6467	2.8925	3.4430	1.9519			
300.0	200.0	500.0	0.0			
0.0	0.0	0.0	0.0	0.0	0.0	
5	COLUMBUS AND SOUTHERN OHIO ELECTRIC					.025
17.3150	0.0	5.0000				
0.0693	0.0492	0.0640	0.0470	0.0452	0.0452	
250.0	250.0	250.0	250.0	500.0	0.0	
0.0	0.0	0.0	0.0			
0.0	0.0	0.0	0.0			
0.0	0.0	0.0	0.0	0.0	0.0	
0.0	0.0	15.0000				
0.0813	0.0873	0.0667	0.0554	0.0504	0.0522	
750.0	750.0	4500.0	4000.0	2500.0	0.0	
0.0	0.0	0.0	0.0			
0.0	0.0	0.0	0.0			
0.0	0.0	0.0	0.0	0.0	0.0	
0.0	0.0	30.0000				
0.0320	0.0308	0.0248	0.0248	0.0248	0.0235	
30000.0	30000.0	60000.0	100000.0	200000.0	0.0	
5.9500	7.1625	7.1630	6.3949			
300.0	200.0	500.0	0.0			
0.0	0.0	0.0	0.0	0.0	0.0	

Table F-6. Excerpt from Utility Rate Pointer Data Base (Tape 15)

2 17 1	ADAMS	CENTRAL ILL PUB SERV CO	2
3 17 3	ALEXANDER	CENTRAL ILL PUB SERV CO	2
2 17 5	BOND	ILLINOIS PWR CO	10
1 17 7	BOONE	COMMONWEALTH EDISON CO	6
2 17 9	BROWN	ILLINOIS PWR CO	10
2 17 11	BUREAU	ILLINOIS PWR CO	10
2 17 13	CALHOUN	ILLINOIS PWR CO	10
2 17 15	CARROLL	COMMONWEALTH EDISON CO	6
2 17 17	CASS	CENTRAL ILL PUB SERV CO	2
1 17 19	CHAMPAIGN	ILLINOIS PWR CO	10
2 17 21	CHRISTIAN	CENTRAL ILL PUB SERV CO	2
2 17 23	CLARK	CENTRAL ILL PUB SERV CO	2
2 17 25	CLAY	CENTRAL ILL PUB SERV CO	2
2 17 27	CLINTON	ILLINOIS PWR CO	10
2 17 29	COLES	CENTRAL ILL PUB SERV CO	2
1 17 31	COOK	COMMONWEALTH EDISON CO	6
2 17 33	CRAWFORD	CENTRAL ILL PUB SERV CO	2
2 17 35	CUMBERLAND	CENTRAL ILL PUB SERV CO	2
2 17 37	DE KALB	COMMONWEALTH EDISON CO	6
2 17 39	DE WITT	ILLINOIS PWR CO	10
2 17 41	DOUGLAS	CENTRAL ILL PUB SERV CO	2
1 17 43	DU PAGE	COMMONWEALTH EDISON CO	6
2 17 45	EDGAR	CENTRAL ILL PUB SERV CO	2
2 17 47	EDWARDS	CENTRAL ILL PUB SERV CO	2
2 17 49	EFFINGHAM	CENTRAL ILL PUB SERV CO	2
2 17 51	FAYETTE	ILLINOIS PWR CO	10
2 17 53	FORD	CENTRAL ILL PUB SERV CO	2
2 17 55	FRANKLIN	CENTRAL ILL PUB SERV CO	2
2 17 57	FULTON	CENTRAL ILL PUB SERV CO	2
2 17 59	GALLATIN	CENTRAL ILL PUB SERV CO	2
2 17 61	GREENE	CENTRAL ILL PUB SERV CO	2
2 17 63	GRUNDY	COMMONWEALTH EDISON CO	6
2 17 65	HAMILTON	CENTRAL ILL PUB SERV CO	2
2 17 67	HANCOCK	CENTRAL ILL PUB SERV CO	2
3 17 69	HARDIN	CENTRAL ILL PUB SERV CO	2
2 17 71	HENDERSON	ILLINOIS PWR CO	10
1 17 73	HENRY	ILLINOIS PWR CO	10
2 17 75	IROQUOIS	CENTRAL ILL PUB SERV CO	2
2 17 77	JACKSON	CENTRAL ILL PUB SERV CO	2
2 17 79	JASPER	CENTRAL ILL PUB SERV CO	2
2 17 81	JEFFERSON	ILLINOIS PWR CO	10
2 17 83	JERSEY	CENTRAL ILL PUB SERV CO	2
2 17 85	JO DAVIESS	COMMONWEALTH EDISON CO	6
3 17 87	JOHNSON	CENTRAL ILL PUB SERV CO	2
1 17 89	KANE	COMMONWEALTH EDISON CO	6
2 17 91	KANKAKEE	COMMONWEALTH EDISON CO	6
2 17 93	KENDALL	COMMONWEALTH EDISON CO	6
2 17 95	KNOX	ILLINOIS PWR CO	10
1 17 97	LAKE	COMMONWEALTH EDISON CO	6
2 17 99	LA SALLE	COMMONWEALTH EDISON CO	6
2 17101	LAWRENCE	CENTRAL ILL PUB SERV CO	2
2 17103	LEE	COMMONWEALTH EDISON CO	6
2 17105	LIVINGSTON	COMMONWEALTH EDISON CO	6
2 17107	LOGAN	CENTRAL ILLINOIS LT CO	1
2 17109	MCDONOUGH	CENTRAL ILL PUB SERV CO	2
1 17111	MCHENRY	COMMONWEALTH EDISON CO	6
1 17113	MCLEAN	ILLINOIS PWR CO	10
1 17115	MACON	ILLINOIS PWR CO	10

Table F-6 (Cont'd). Excerpt from Utility Rate Pointer Data Base (Tape 15)

2	17117	MACOUPIN	ILLINOIS PWR CO	10
1	17119	MADISON	ILLINOIS PWR CO	10
2	17121	MARION	ILLINOIS PWR CO	10
2	17123	MARSHALL	CENTRAL ILLINOIS LT CO	1
2	17125	MASON	CENTRAL ILL PUB SERV CO	2
3	17127	MASSAC	CENTRAL ILL PUB SERV CO	2
1	17129	MENARD	ILLINOIS PWR CO	10
2	17131	MERCER	ILLINOIS PWR CO	10
1	17133	MONROE	ILLINOIS PWR CO	10
2	17135	MONTGOMERY	ILLINOIS PWR CO	10
2	17137	MORGAN	ILLINOIS PWR CO	10
2	17139	MOULTRIE	CENTRAL ILL PUB SERV CO	2
2	17141	OGLE	COMMONWEALTH EDISON CO	6
1	17143	PEORIA	CENTRAL ILLINOIS LT CO	1
2	17145	PERRY	ILLINOIS PWR CO	10
2	17147	PIATT	ILLINOIS PWR CO	10
2	17149	PIKE	CENTRAL ILL PUB SERV CO	2
3	17151	POPE	CENTRAL ILL PUB SERV CO	2
3	17153	PULASKI	CENTRAL ILL PUB SERV CO	2
2	17155	PUTNAM	CENTRAL ILLINOIS LT CO	1
2	17157	RANDOLPH	COMMONWEALTH EDISON CO	6
2	17159	RICHLAND	CENTRAL ILL PUB SERV CO	2
1	17161	ROCK ISLAND	ILLINOIS PWR CO	10
1	17163	ST CLAIR	ILLINOIS PWR CO	10
2	17165	SALINE	CENTRAL ILL PUB SERV CO	2
1	17167	SANGAMON	CENTRAL ILLINOIS LT CO	1
2	17169	SCHUYLER	CENTRAL ILL PUB SERV CO	2
2	17171	SCOTT	ILLINOIS PWR CO	10
2	17173	SHELBY	CENTRAL ILL PUB SERV CO	2
2	17175	STARK	ILLINOIS PWR CO	10
2	17177	STEPHENSON	COMMONWEALTH EDISON CO	6
1	17179	TAZEWELL	CENTRAL ILLINOIS LT CO	1
3	17181	UNION	CENTRAL ILL PUB SERV CO	2
2	17183	VERMILION	ILLINOIS PWR CO	10
2	17185	WARASH	CENTRAL ILL PUB SERV CO	2
2	17187	WARREN	ILLINOIS PWR CO	10
2	17189	WASHINGTON	ILLINOIS PWR CO	10
2	17191	WAYNE	CENTRAL ILL PUB SERV CO	2
2	17193	WHITE	CENTRAL ILL PUB SERV CO	2
2	17195	WHITESIDE	COMMONWEALTH EDISON CO	6
1	17197	WILL	COMMONWEALTH EDISON CO	6
2	17199	WILLIAMSON	CENTRAL ILL PUB SERV CO	2

Table F-7. State Tax and Subsidy Data Base (Tape 16)

.40	4000	.25	-1.				
17	.00	-1.	.00	-1.	2.5	6.5	6.5
18	.25	3000.	.25	10000.	1.9	6.0	6.0
26	.12	1200.	.00	-1.	4.6	2.35	2.35
27	.20	2000.	.00	-1.	16.0	12.0	12.0
39	.10	1000.	.10	50000.	3.0	8.0	8.0
55	.24	2400.	.10	100000.	9.5	7.9	7.9
-1							