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Renewable Energy Data Requirements

A Review of User Opinions and Data Collection Efforts

Glenn G. Stevenson

MANAGED BY
MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

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A Review of User Opinions and Data Collection Efforts

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Energy Division

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EXECUTIVE SUMMARY

Interest in the contribution of renewable energy to U. S. energy supply is growing. This interest stems from environmental and energy security concerns and the desire to develop domestic resources. In order to plan for the use of renewable energy, data are essential to a variety of users both inside and outside the government. The purpose of this study is to identify priorities and requirements for gathering different types of renewable energy data. Results of this study are to be used by the U. S. Department of Energy, Energy Information Administration (EIA), in planning and evaluating its ongoing and future renewable energy information programs. The types of renewable energy addressed in this study include biomass (wood, agricultural residues, and crops grown for energy), municipal solid waste, geothermal energy, solar energy, and wind.

To assess the relative importance of different types of information, we reviewed existing renewable energy data collection efforts and asked the opinions of renewable energy data users. Individuals in government, private industry, research organizations, industry trade associations, and public interest research groups were contacted and questioned about particular renewable energy data items. An analysis of their responses provides the basis for the conclusions in this report.

The types of information about which we asked each respondent included resource stock and flow information; quantities of energy inputs (e.g., wood) and outputs (e.g., electricity, heat); energy input and output costs and prices; numbers, location, and production capacities of energy conversion facilities; quantities and costs of energy conversion equipment; and quantities of pollutant emissions from energy conversion.

For woodfuels, respondents rated information on quantities of woodfuel consumed, first of all for all sectors and then by sector, to be most important. The sector of most interest appears to be the industrial sector. In fact, there is high interest not just in total industrial woodfuel consumed, but also in woodfuel consumed by specific industry groups and the total number of industrial woodfuel-burning facilities. The most important information item for agricultural residues was the average cost of energy products in dollars per kilowatt-hour ($/kWh) or dollars per million Btu ($/MMBtu). Respondents ranked the next most important data as being the total quantity of energy produced (quads) and a breakdown of this energy production into types (steam, heat, electricity, fuel, etc.). The most important category of information for energy crops, as with woodfuels, was total quantities of energy crops produced and used, with a breakdown by type of energy crop also being deemed very important. The overall average cost of energy crop supply in dollars per ton, as for agricultural residues, received one of the highest rankings among energy crop information.

For geothermal energy, the most important type of information was installed electricity generation capacities in kilowatts (kW) or megawatts (MW). Also ranked very highly were plans for additional capacity and the average busbar cost of this electricity. Of similarly high importance were total direct heat production and the average cost of this direct heat ($/MMBtu).

At the top of the importance ratings for municipal solid waste (MSW) information were again data on total quantities: quantities of MSW consumed for energy; quantities of energy output in the forms of steam, heat, electricity, and fuel; total MSW produced per year; and quantities of pollutants in air emissions from combustion. Of nearly equal importance were tipping fees ($/ton) by location.

For both active and passive solar systems, numbers and sizes of systems fell in the top half of the ratings, generally exceeding the importance of systems costs and prices. For active systems, one global cost measure, the average cost ($/MMBtu) of the heat energy from the systems, also ranked near the top of the importance ratings. For photovoltaics, the average installed capital cost ($/Watt) topped the importance list. The top three items for solar thermal energy related to solar thermal electricity: amount of generation (kWh), installed capacity (MW), and average generation cost ($/kWh). Below this, in roughly decreasing order of importance, were information items on solar thermal industrial process heat, solar thermal collector manufacture, and solar thermal residential energy.

The results for wind energy differ from those of other renewable energy information types in that costs rather than quantities of energy inputs or outputs topped the list. Installed cost by machine size and type and operating and maintenance costs by machine size and type are the two top information items, and the average cost of electricity ($/kWh) was rated among the top group of information items.

In summary, renewable energy data users appear to be more interested in obtaining "quantity data," i.e., information on amounts of inputs and energy outputs from existing renewable systems rather than price and cost information. The exception to this generality is that some overall average cost of energy ($/kWh, $/MMBtu) ranks as an important piece of information for many of the renewable energy data types. Generally speaking, participants in this study gave low value to renewable energy equipment manufacturing information. This included both quantity information (numbers of units produced, number of units shipped, production capacity, etc.) and data on costs of manufacture.

We also asked respondents what level of data aggregation they desire (national, regional, state, or county). Generally, state-level aggregation is preferred. Geothermal and municipal solid waste data users strongly favor state-level data, with 62% and 64% calling for it. Solar energy information analysts desire state-level data by a slight majority (55%), with regional level data being satisfactory to almost one-third of them. Biomass (woodfuels, agricultural residues, and energy crops) data users, on the other hand, split between desiring regional (multi-state) and state-level data, 42% to 33%. A plurality (44%) of wind energy data users favors state-level aggregation of their information, although a significant minority, 31%, requires it only at the national level. Solar and wind energy experts noted that resource information (insolation, wind speeds, wind densities, etc.) must be reported at a local level.

The study reviewed a number of existing governmental and nongovernmental sources of data to determine the extent to which analysts' and policy makers' renewable energy data needs are currently met. Renewable energy information is collected by a diversity of sources, but few of them result in comprehensive, national data sets. Some of our recommendations to remedy this situation include clarification of renewable fuels categories on the EIA Manufacturing Energy Consumption Survey and the addition of a sampling stratum to this survey that will result in reliable renewable fuels information. The EIA Monthly Power Plant Report (EIA-759), the EIA Annual Electric Generator Report (EIA-860), and the EIA Annual Nonutility Power Plant Report (EIA-867) also provide greater or lesser amounts of useful renewable energy information, but extending the coverage to more renewable energy fuel users, particularly under the former two surveys, is needed to improve the quality of renewable energy information. For waste-to-energy plants, Government Advisory Associates, Inc., provides a thorough source of data, although they do not collect two data items that ranked highly among MSW experts: quantities of air pollutants from MSW incineration and total MSW produced annually. Similarly, the California Energy Commission's Wind Project Performance

Reporting System provides extensive wind energy information on the bulk of the U. S. wind energy industry, although it does not cover the economic data rated highly by wind energy experts. For solar data, adding observations to solar sampling strata in the EIA Residential Energy Consumption Survey and the Nonresidential Buildings Energy Consumption Survey or conducting a new, independent survey may be necessary to obtain statistics with acceptable relative standard errors.

Thus, a number of renewable energy data items are collected, although often for reasons other than to produce renewable energy information. Therefore, to provide consistent, widely available renewable energy information, efforts are necessary to collate data gathered under present programs, to expand the samples of and the questions contained in some current surveys, and to conduct new surveys where this is the most economical means.

1. THE IMPORTANCE OF RENEWABLE ENERGY INFORMATION

1.1 BACKGROUND

Interest in the contribution of renewable energy to the nation's energy supply is growing rapidly. In fact, the 1991/1992 National Energy Strategy highlights renewable energy resources as one method of securing future energy supplies. This interest in renewable energy stems from both environmental and energy security concerns, as well as from the desire to develop domestic resources. From the environmental standpoint, renewable energy from biomass, solar, and wind technologies can effectively reduce the amount of CO_2 emitted to the atmosphere and help mitigate global climate change. From the energy security standpoint, renewable energy helps to diversify our energy sources and reduce dependence on foreign oil. From the standpoint of employing domestic resources, many renewable energy resources and technologies have an inherently local base and go hand-in-hand with developing new national technological expertise.

In the most recent *Annual Energy Outlook* (AEO), the Energy Information Administration of the U.S. Department of Energy projected that consumption of energy from renewable sources, including hydropower, would increase from 6.02 quadrillion Btus (quads) in 1988 to 10.12 quads in 2010. This represents a 2.4% per year compound growth rate, compared to a 1.2% annual growth rate projected for all energy sources taken together.

1.2 PURPOSE OF THE STUDY

The Nuclear and Alternate Fuels Division within the Energy Information Administration (EIA) of the U.S. Department of Energy (DOE) has the responsibility of providing data and other information on renewable energy on a regular basis. These data and information are used within EIA itself, by other offices within DOE that have major renewable energy research and development (R&D) programs, by Congress, by firms and trade associations, by environmental- and consumer-advocacy groups, by researchers in universities and research institutes, by government contractors, by the media, and by the public at large. Because of the increased emphasis on renewable energy, EIA is considering increasing its gathering and dissemination of data and other information on renewable energy.

The purpose of this study was to define priorities and requirements for gathering different types of renewable energy data. Results of this study are to be used by EIA in planning and evaluating its ongoing and future renewable energy information programs. The types of renewable energy addressed in this study include biomass (i.e., wood, agricultural residues, and woody and herbaceous crops grown for energy), municipal solid waste, geothermal, solar, and wind. The study did not address hydropower, because well-developed information gathering programs exist for hydropower already.

1.3 APPROACH

To assess the relative importance of different types of information, Oak Ridge National Laboratory reviewed existing renewable energy data collection efforts and polled opinions of renewable energy data users. Lists of individuals in government, private industry, research organizations, industry trade associations, and nonprofit interest group organizations were identified and a subset of people on these lists was contacted. Participants were questioned about particular renewable energy data items, their responses analyzed, and general conclusions were drawn. Chapter 2 describes the methodology used to gather renewable energy data user opinions and the results of these efforts. Chapter 3 summarizes existing data sources, focussing on those published on a periodic basis. Chapter 4 presents general as well as more specific conclusions.

2. DATA USER OPINIONS OF RENEWABLE ENERGY DATA REQUIREMENTS

To define better the desirable set of renewable energy data to be collected and disseminated, opinions were gathered from a variety of data user types. Five major types of renewable fuels were included in the study: biomass, geothermal, municipal solid waste (MSW), solar, and wind energy. Again, biomass was understood to include woodfuels, agricultural residues, and energy crops (herbaceous and short-rotation woody crops grown for energy). Under solar technologies were active solar, passive solar, photovoltaics, and solar thermal energy.

Potential data users included in the investigation were federal government officials, both within and outside the Department of Energy (DOE), Congressional office and committee staff, government contractors, National Laboratory researchers, state government personnel, local government representatives, university researchers, private energy forecasting firms, renewable energy industry executives, renewable energy industry trade association representatives, and personnel with environmental and public interest research groups. Appendix A contains a list of respondents to our efforts to gather user opinions.

2.1 METHODOLOGY

We constructed lists of the types of renewable energy information that the Energy Information Administration (EIA) might gather and/or disseminate. Five forms were constructed corresponding to the five major types of renewable energy included in the study: biomass, geothermal, MSW, solar, and wind energies. The types of information for each renewable energy form included resource stock and flow information, quantities of energy inputs (e.g., wood) and outputs (e.g., electricity, heat), energy input and output costs and prices, numbers, location, and production capacities of energy conversion facilities, quantities and costs of energy conversion equipment, and quantities of pollutant emissions from conversion. A major source of the types of information included in the forms was the 1983 Oak Ridge National Laboratory (ORNL) alternative fuels information requirements study (Cantor, Stulberg, Halbert, and Zuschneid 1983), but many other data types were selected by reviewing the information cited in a variety of renewable energy publications. The specific types of information included in the lists are shown in the tables in the results section of this chapter. The original forms, which also present the types of information examined are in Appendix B.

The sample of individuals chosen to be included in the study was drawn from a variety of places. Sources included the 1983 ORNL alternate fuels study respondents list, rosters of reviewers for EIA renewable energy reports, an EIA renewable energy memorandum distribution list, the participants list from a 1990 ORNL Biomass Energy Strategies Workshop, registers of state contacts for DOE's Regional Biomass Energy Program printed in *Biologue* (September/October 1990), reviewers and survey respondents lists given in appendixes to renewable energy reports, a compilation of renewable energy university programs given in the *Research Centers Directory* (15th ed.), a list of renewable energy industry trade associations extracted from the volume *National Trade and Professional Associations of the United States* (25th ed.), and further individuals recommended by respondents themselves. The participants cannot be considered a random sample of a hypothetical population of renewable energy data users, because no random drawing was conducted from a comprehensive list of users. The wide diversity of users contacted and included in the study, however, lends credibility to the results.

Potential participants, with few exceptions, were contacted by telephone, given an explanation of the study's purposes and the content of the lists of renewable energy data types and asked to participate. One hundred twenty-four individuals were contacted directly by the ORNL analyst or indirectly through colleagues at their organizations. Some of these 124 individuals received more than one renewable energy data list. In fact, 217 forms were distributed to various individuals. Response rates from these 124 individuals contacted and 217 forms sent are shown in Table 2.1.

Table 2.1. Response rates from individuals and of forms sent

	Contacted/sent	Returned	Percent
No. of individuals	124	81	65
No. of forms	217	118	54

The forms asked respondents to rank the importance of gathering each piece of renewable energy information on a scale of 1 to 5 (5 being the most important). Participants were instructed to conduct the ranking according to their own uses for the data. Thus, this study ranks the importance of governmental gathering of renewable energy data for public information purposes as well as for federal agency objectives. The use of a subjective importance scale means that the value of a particular type of information to one respondent cannot be compared to the value of that type of information to another respondent. This follows because some respondents tend to give higher scores across all information types. However, the averages of the ratings give an overall importance ranking for all participants of one type of information *relative to* another type of information. This conclusion also follows because all respondents can be assumed to rate the importance of the information types consistently within their own general range of ranking alternatives.

Thus, importance ranking responses were compiled from all individuals' responses, and simple averages and standard deviations were computed. Information types with the highest average scores were ranked as the most important to gather. In the case of equal average scores, information items with lower standard deviations of their scores were ranked higher. Because the respondents were not selected randomly using a statistically valid sampling technique, the results have not been tested for statistical significance of the differences in average scores. Still, the rankings of the information can be used as a general guide to the importance of different types of renewable energy information, as long as small differences in ranking, say between adjacently ranked items, are not given great emphasis. Groups of information of similar types were gleaned from inspection of the rankings without assigning specific cutoff points in scores to form the groups.

Several other questions were asked on the questionnaires. Respondents were asked to indicate whether they used or could use historical series on each information item. They were asked to specify whether the use of historical series would be for projections or for other purposes. The questionnaires also asked the users to specify the level of geographic aggregation of data that they would prefer having--national, regional (multi-state), state, or county. Another question addressed the potential sources of renewable energy data. Some renewable energy information could be gathered either by surveying manufacturers of equipment or by surveying users of the equipment. Respondents were asked whether it would be sufficient for their purposes to survey the manufacturers or whether they desired information from surveys of users. Another question allowed participants to give further explanation of their needs for the collection of historical series for projections or other reasons. Finally, an open-ended question allowed for any general comments regarding the collection of renewable energy information.

2.2 RESULTS OF DATA ITEM RANKINGS

2.2.1 Biomass Information

The biomass questionnaire was divided into three parts: woodfuels, agricultural residues, and energy crops. Analysis of the ranking of the information types was separated for each part.

2.2.1.1 Woodfuels

For woodfuels, respondents rated the most important types of information as being quantities of woodfuel consumed, first of all for all sectors and then by sector (Table 2.2). The sector of most interest appears to be the industrial sector. In fact, there is high interest not just in total industrial woodfuel consumed, but also in woodfuel consumed by specific industry groups and the total number of industrial woodfuel-burning facilities. Lower ratings were given to collecting information on residential and commercial sector woodfuel consumption. A second grouping of importance relates to the types of outputs from burning woodfuel: the quantity of wood consumed by energy product (electricity, steam, direct heat, etc.), the quantity of energy product by type, the quantity of electricity sold to the grid, and the quantity of air pollutant emissions. Third in priority appears to be a group of input costs: hauling costs for woodfuel, capital costs and operating and maintenance (O&M) costs for wood-fired energy products, harvest costs, and stumpage costs. At this level of priority also comes the location of wood-burning facilities. Fourth in importance were two types of information that intermixed in their importance rankings. The first is resource information: forest biomass inventory by tree type and quality, net growth in commercial forests, area of commercial forest land by site class, percent of commercial forest land forested, and area of commercial forest. The other was quantities of woodfuel burned in commercial and residential buildings, both totals and breakdowns by geographic region. Fifth on the priority list was information on prices of woodfuels, with the exception of the cost of industrial woodfuel, which, along with other information on industrial woodfuel, ranked much higher. Toward the bottom of the respondents' ranking came woodfuel burning equipment information (cost and number of units manufactured and used in industrial, commercial, and residential applications), and woodfuel amounts and costs for commercial and residential users. Number of employees in combustion unit manufacture was completely unimportant.

The last two columns of Table 2.2 show that the correlation between historical data series desired for making projections or for other purposes and the importance rankings is extremely high for woodfuels. If the data items were ranked in decreasing order of the number of people who use them for projections, seven of the top ten items so ranked would be the same as those appearing among the ten most highly ranked by importance value. The only items that appear among the top ten in importance that would not appear among the top ten used for projections are potential annual energy wood by source, hauling costs for woodfuel, and quantities of pollutants in air emissions. This pattern--that highly ranked data items are also deemed most useful for making projections--is found, with rare exception, throughout the other data types (i.e., other biomass, geothermal, MSW, solar, and wind).

Table 2.2. Ranking by average respondent score for biomass--woodfuels

Data Item	Respondents	Ave.	Std. Dev.	Min.	Max.	Hist. Series Used for Projection	Hist. Series Used for Other
Total quantity of woodfuel consumed (all sectors)	39	4.51	0.84	1	5	20	4
Potential annual energy wood by source (logging residues, etc.)	38	4.45	0.91	1	5	13	3
Quantity of industrial woodfuel consumed	39	4.21	1.18	1	5	17	5
Quantity of woodfuel consumed, categorized by industry	40	4.10	0.97	1	5	16	4
Cost of industrial woodfuel by type	38	4.08	0.96	2	5	16	4
Number of industrial wood-burning facilities	39	4.05	1.24	1	5	15	5
Quantity of wood consumed by type of energy product	40	4.05	0.86	2	5	16	4
Quantities of pollutants in air emissions	40	4.05	1.12	1	5	11	4
Quantity of energy product by type	40	4.03	0.96	2	5	15	4
Quantity of electricity sold to grid	40	3.98	1.04	2	5	15	4
Quantity of industrial woodfuel consumed by type (pellets, etc.)	39	3.92	1.23	1	5	17	5
Hauling costs for woodfuel ($/ton-mile) by hauling distance category	38	3.89	1.17	1	5	13	1
Capital costs for wood-fired energy products (electricity, etc.)	40	3.85	1.06	1	5	13	5
Operating and maintenance costs for wood-fired energy products	40	3.85	1.06	1	5	12	5
Location of facilities	40	3.85	1.33	1	5	8	4
Harvest costs for woodfuel ($/ton)	38	3.84	1.16	1	5	14	1
Capacity factor of wood-fired electricity plants	39	3.79	1.16	1	5	10	5
Stumpage costs for woodfuel ($/ton)	38	3.79	1.24	1	5	15	1
Forest biomass inventory by tree type by quality	36	3.75	1.23	1	5	9	3
Net growth in commercial forest	36	3.64	1.34	1	5	8	2
Quantity of woodfuel burned in commercial buildings by geographic region	39	3.51	1.32	1	5	11	3
Quantity of woodfuel consumed in commercial buildings	39	3.44	1.26	1	5	11	4
Quantity of woodfuel burned in residences by geographic region	39	3.44	1.46	1	5	14	3
Quantity of woodfuel consumed in residences	39	3.31	1.45	1	5	15	3
Area of commercial forest land by site class	35	3.26	1.34	1	5	8	2
Percent of commercial forest land forested	33	3.24	1.33	1	5	7	3
Area of commercial forest	36	3.17	1.40	1	5	7	3
Installed cost of combustion units	39	3.15	1.29	1	5	8	1
Quantity of woodfuel burned in commercial bldgs. by type (pellets, etc.)	39	3.10	1.48	1	5	11	3
Price of woodfuel burned in commercial buildings by type (pellets, etc.)	39	3.05	1.38	1	5	13	1
Price of purchased residential woodfuel	39	3.05	1.48	1	5	12	2
Total sales of combustion units by type	37	3.03	1.40	1	5	9	2
Number of industrial/utility combustion units manufactured by type	39	3.00	1.34	1	5	6	3
Number of residences burning woodfuel	38	3.00	1.43	1	5	15	5
Percentage of residential space heating needs met by woodfuel	39	2.87	1.45	1	5	9	2
Manufacturing capacity of combustion units by type	38	2.87	1.47	1	5	6	2
Quantity of woodfuel burned in commercial buildings by end use	39	2.85	1.37	1	5	8	1
Number of residential/commercial combustion units manufactured by type	37	2.76	1.28	1	5	4	2
Percentage of residential woodfuel purchased	38	2.71	1.37	1	5	8	1
Manufacturing cost of combustion units	38	2.58	1.33	1	5	7	1
Quantity of woodfuel consumed in residences by end use	39	2.56	1.43	1	5	8	1
Commercial square footage heated by woodfuel	39	2.54	1.32	1	5	5	1
Residential square footage heated by woodfuel	39	2.49	1.39	1	5	6	1
Number of employees in combustion unit manufacture	38	2.03	1.09	1	5	2	1

Appendix C contains a list of information items that were not included on our list but that respondents wrote in, indicating they thought the items should be included in future renewable energy

Table 2.3. Ranking by average respondent score for biomass--agricultural residues

Data Item	Respondents	Ave.	Std. Dev.	Min.	Max.	Hist. Series Used for Projection	Hist. Series Used for Other
Average cost of energy product ($/kWh, $/MMBtu)	36	4.33	1.05	1	5	17	4
Total quantity of energy produced (quads)	37	4.11	1.18	1	5	16	4
Quantity of energy produced by type (steam, etc.)	37	3.95	1.21	1	5	13	3
Number of facilities burning agricultural residues by residue type	35	3.91	1.32	1	5	12	4
Quantities of pollutants in air emissions	36	3.86	1.32	1	5	7	3
Total quantities of agricultural residues available by type	35	3.83	1.21	1	5	13	3
Sales price of energy product	36	3.81	1.33	1	5	14	3
Quantity of residue burned by type	35	3.77	1.24	1	5	9	4
Quantity of energy produced by end-use	37	3.68	1.38	1	5	9	4
Operating and maintenance costs by facility type	36	3.64	1.08	1	5	7	2
Capital costs by facility type	36	3.61	1.09	1	5	7	1
Location of facilities	37	3.59	1.26	1	5	5	2
Capacity factor of plants	36	3.56	1.19	1	5	8	2
Cost of disposal of excess waste at landfill	33	3.55	1.26	1	5	7	3
Quantity of energy used to operate conversion equipment by type	37	3.43	1.37	1	5	6	2
Numbers of units of equipment (combustors, digestors, etc.)	36	3.25	1.36	1	5	6	4

information gathering activities. For woodfuels, items mentioned by more than one respondent include moisture contents and/or combustion heat (Btu/lb) of woodfuel burned by type and adding aesthetic use to the end use categories of residential fuelwood. Two respondents also requested information on woodfuel boiler types and capacities.

2.2.1.2 Agricultural Residues

As Table 2.3 indicates, the most important information item for agricultural residues was the average cost of energy products ($/kWh, $/MMBtu). Of course, this is a piece of information that must be constructed from other primary information on input costs and output amounts. Respondents ranked the next most important data as being the total quantity of energy produced (quads) and a breakdown of this energy production into types (steam, heat, electricity, fuel, etc.). The number of facilities burning agricultural residues was also rated highly. Quantities of air pollutant emissions was next. Unlike woodfuels, for which quantities of woodfuels burned ranked at the top of the list, the total quantities of agricultural residues available by type and the quantity of residue burned by type came in only in a third-rung position. The sales price of the energy product took a similar, third-tier importance ranking, and as with woodfuels, capital costs and operating and maintenance costs took a middle priority position. Of lesser importance were deemed the location of facilities, plant capacity factors, cost of disposal of excess waste at landfills, and quantity of energy used to operate conversion equipment. As with woodfuels, the numbers of units of equipment in use (combustors, digestors, etc.) ranked lowly.

As with woodfuels, two respondents added the moisture content and/or combustion heat of the agricultural residue type as "other information" that they desired. Number of facilities burning agricultural residues by residue type and location, collection and handling costs by residue types, capacity of boilers, and cofiring information were other items mentioned (Appendix C).

Table 2.4. Ranking by average respondent score for biomass--energy crops

Data Item	Respondents	Ave.	Std. Dev.	Min.	Max.	Hist. Series Used for Projection	Hist. Series Used for Other
Total quantity of biomass produced	37	4.49	0.79	2	5	15	3
Quantity of biomass produced by crop	36	4.42	0.76	2	5	13	3
Overall average cost of biomass produced ($/ton) by crop	36	4.33	0.91	1	5	10	3
Yields per acre by geographic area by crop	36	4.31	0.97	2	5	9	2
Land area in energy crops	35	4.29	0.85	2	5	13	3
Quantities of biomass feedstocks used	34	4.26	0.98	2	5	13	3
Production capacity for fuel-grade ethanol (gal.)	36	4.25	0.95	2	5	11	3
Number of ethanol facilities	35	4.14	1.10	1	5	9	3
Quantities of energy crops combusted by type	36	4.14	1.06	2	5	12	2
Production cost of ethanol ($/gal.)	36	4.14	1.11	1	5	13	2
Quantity of ethanol produced	35	4.09	1.08	2	5	11	2
Quantity of energy product (electricity, etc.) by type	38	4.08	1.04	2	5	12	6
Quantity of energy crop combusted by type of energy product	38	4.05	0.94	2	5	12	6
Quantity of electricity sold to grid	37	4.03	1.08	2	5	12	5
Harvest costs by crop ($/ton)	36	4.00	1.00	1	5	11	2
Location of ethanol facilities	35	4.00	1.15	1	5	6	0
Number of energy crop burning facilities	36	3.92	1.11	1	5	11	2
Location of plantations	35	3.91	1.13	1	5	7	2
Input costs (seed, land, etc.) by crop ($/ton)	36	3.89	1.02	1	5	10	2
Hauling costs by crop ($/ton-mile) by hauling distance category	36	3.89	1.12	1	5	10	2
Price of ethanol shipped ($/gal.)	36	3.89	1.20	1	5	10	2
Location of energy crop burning facilities	36	3.86	1.21	1	5	8	1
Quantities of pollutants in air emissions	37	3.81	1.23	1	5	8	1
Land area for potential cultivation by current use	35	3.80	1.19	1	5	11	3
Capital costs for energy products (electricity, etc.) from energy crops	38	3.79	1.06	1	5	7	4
Capacity factor of ethanol plants	35	3.77	1.24	1	5	6	2
Quantities of pollutants from ethanol facilities	34	3.74	1.31	1	5	8	2
Quantity of ethanol blended with gasoline	34	3.74	1.36	1	5	9	3
Capacity factor of energy crop electricity plants	37	3.73	1.20	1	5	7	3
Production capacity for ethanol-gasoline blends (gal.)	33	3.73	1.38	1	5	7	3
Capital costs for ethanol production facilities	35	3.66	1.09	1	5	7	3
Number of energy crop plantations	35	3.63	1.35	1	5	8	3
Operating and maintenance costs for ethanol production facilities	35	3.60	1.10	1	5	7	1
Operating and maintenance costs for energy products	37	3.59	1.10	1	5	7	3
Quantity of ethanol shipped	35	3.49	1.34	1	5	6	0
Handling losses per acre by crop	35	3.46	1.29	1	5	6	1
Number of employees for ethanol facilities	35	2.54	1.15	1	5	3	1

2.2.1.3 Energy Crops

The most important category of information for energy crops, as with woodfuels, was total quantities of energy crops produced and used, with a breakdown by type of energy crop being deemed very important (Table 2.4). Also receiving one of the highest rankings, similarly to agricultural residues, is the overall average cost of energy crop biomass in dollars per ton. Second in priority are certain types of resource information such as yields per acre by geographic area and crop and land area in energy crops. Other types of resource information, however, such as location of plantations, land area for potential cultivation by current use, numbers of energy crop plantations, and handling losses per acre, ranked further down the list. A third group of highly rated information types involves the energy products from energy crops. Most important among product information was ethanol production information: production capacity, number of facilities, and quantity of ethanol produced. The quantity of ethanol blended with gasoline and the quantity of ethanol shipped, however, received low ratings. Ethanol's production cost in dollars per gallon also rated highly, although as with other renewable energy information types, information on quantities of energy seem to exceed in importance information on the costs of energy. After ethanol information, the next most important energy product information is quantity information on other energy outputs (electricity, steam, direct heat), the amount of energy crop inputs necessary to produce them, and how much electricity is sold to the grid. Of middling importance were harvest costs by crop, input costs (seed, land, etc.) by crop, and hauling costs by crop. Of similar medium importance were location of ethanol facilities, location of plantations, and location and number of energy crop burning facilities. Unlike woodfuels and agricultural residues, the importance of air pollutant quantities from ethanol plants and energy crop electricity, steam, and direct heat plants rated below the median. Capital costs and O&M costs for ethanol facilities and for electricity, steam, and direct heat plants rated from just below the median to well below it. Also rated rather lowly was capacity information, such as production capacity for ethanol-gasoline blends, capacity factor of ethanol plants, and capacity factor of energy crop electricity plants. Similarly to other biomass energy types, the number of employees in ethanol facilities was considered completely unimportant.

Table 2.5. Geographic aggregation and source of information desired--biomass experts' opinions

Geographic Aggregation Desired	No.	Percent
National	3	9.1
Regional	14	42.4
State	11	33.3
County	5	15.2

Source of Information Desired	No.	Percent
Manufacturers	12	38.7
Users	19	61.3

Respondents suggested a moderately long list of additional energy crop information items that might be collected (Appendix C). Mentioned more than once were data on the types of biomass feedstocks and of biomass-fossil fuel mixtures being used in ethanol production, presumably meaning quantity information by type. Also mentioned twice were data on fuel-grade ethanol imports (gals.) and information on ethanol facilities by type (wet milling vs. dry milling). Several other items, although mentioned only once, might be valuable additions to future data gathering efforts. See Appendix C.

As Table 2.5 indicates, a plurality (42%) of respondents to the biomass information questions require aggregation of the data only at the regional (multi-state level). However, a significant minority (one-third) desire data at the state level. Table 2.5 also shows that a majority (61%) of biomass energy data users require responses from the users of equipment (producers/consumers of energy) rather than from surveys of manufacturers of the equipment.

2.2.2 Geothermal Information

Results of our queries about geothermal energy data requirements are more difficult to categorize into groups of more important and less important types of information. As a whole, respondents ranked some types of information within each general class of information (resource information, quantities of inputs and outputs, costs of inputs and outputs, etc.) as more important than others in the same class. This will become clearer as we examine the results contained in Table 2.6.

Far and away the most important type of information is geothermal electricity installed capacities in kilowatts (kW) or megawatts (MW). Also ranked very highly were plans for additional capacity and the average busbar cost of this electricity. Of similarly high importance were total direct heat production and the average cost of this direct heat in dollars per million Btu ($/MMBtu).

In a third rung of importance came reservoir thermal energy contents. This type of resource information exceeded the estimated value of other types of resource information, which in decreasing order of importance appeared throughout the list of geothermal information types as follows: estimated obtainable wellhead energy by type (electric power, direct heat), reservoir volumes, reservoir mean temperatures, reservoir depths, well flow rates, well depths by type (exploration, development, production), and reservoir brine salinities. It should be noted that geothermal energy comes in five major forms. According to interviewee responses, the value of gathering information is highest for high temperature (>150°C) hydrothermal (vapor or water dominated) reservoirs and decreases through low temperature (>40°C) geothermal waters and igneous or magmatic geothermal systems. Tied for least important were geopressured reservoirs and hot dry rock.

At levels of importance similarly as high as reservoir thermal energy content were total geothermal electricity production (kW), the capacity factor of geothermal electricity plants, and the amounts of geothermal energy consumed for electricity. In the next group down came direct heat production by end use (building heat, process heat, residential or commercial hot water, etc.) as well as capital costs and O&M costs for both these facilities and electricity plants. Location of these facilities follows in importance.

Sectoral consumption (residential, commercial, industrial, and agricultural) of geothermal direct heat ranked at the middle of the ratings.

Geothermal energy exploration and development information also begins to appear in the middle of the ranking. Number of wells by type (exploration, development, and production) is the most highly rated type of exploration and development information. In decreasing order of importance, private expenditures on exploration and resource definition, average cost per well by type, private expenditures on development, cost per foot drilled, and total footage drilled by type of well follow, reaching quite far down in the overall rankings.

Environmental information also appears for the first time in the middle of the ranking. The most important of this type of information is numbers of plants using various brine disposal methods. Expenditures for resource management (e.g., subsidence prevention) and amounts of wastewater released by various disposal methods both rank lower than this.

As we have observed before, number of employees by plant type rates last.

Table 2.6. Ranking by average respondent score for geothermal

Data Item	Respondents	Ave.	Std. Dev.	Min.	Max.	Hist. Series Used for Proj-ection	Hist. Series Used for Other
Geothermal electricity installed capacities (MW)	15	4.60	0.61	3	5	7	3
Average cost for direct-use heat ($/MMBtu)	15	4.27	0.77	2	5	4	3
Average busbar cost of electricity ($/kWh)	15	4.27	1.06	1	5	4	3
Plans for additional capacity (MW)	15	4.20	0.91	3	5	4	2
Total direct heat production	15	4.20	1.22	1	5	5	3
Reservoir thermal energy contents	15	4.07	1.18	2	5	3	1
Capacity factor of electricity plants	15	4.07	1.24	1	5	4	4
Electricity production (kWh)	15	4.07	1.29	1	5	5	2
Estimated obtainable wellhead energy by type (elec. power, direct heat)	15	4.00	1.15	1	5	5	2
Geothermal energy consumed for electricity	15	4.00	1.21	1	5	4	2
Resource depletion rates	14	4.00	1.41	1	5	4	3
Reservoir locations	15	4.00	1.41	1	5	1	0
Capital costs for facilities by type (electric power, direct heat)	15	3.87	1.20	1	5	6	3
Direct heat prod, by end use (bldg. heat, process heat, hot water, etc.)	14	3.79	1.21	1	5	3	3
Operating & maintenance costs by facility type (elec. power, dir. heat)	15	3.73	1.18	1	5	6	4
Location of facilities	15	3.73	1.29	1	5	2	1
Number of wells by type (exploration, development, production)	15	3.67	1.14	1	5	5	4
Geothermal direct heat consumed by sector (resid., comm., ind., agric.)	15	3.67	1.14	1	5	2	3
Information on high temperature (>150°C) hydrothermal reservoirs	14	3.64	1.44	1	5	4	3
Number of geothermal conversion facilities by type	15	3.53	1.20	1	5	3	2
Reservoir volumes	15	3.53	1.31	1	5	2	0
Numbers of plants using diff. disposal methods (reinjection, release, etc.)	15	3.47	1.15	1	5	0	1
Private expenditures on exploration and resource definition	15	3.47	1.20	1	5	4	1
Reservoir mean temperatures	15	3.47	1.26	1	5	1	0
Reservoir depths	15	3.47	1.36	1	5	2	0
Average cost per well by type (exploration, production)	15	3.47	1.45	1	5	5	2
Private expenditures on development	15	3.33	1.25	1	5	4	1
Well flow rates (kg/sec.)	15	3.33	1.25	1	5	3	2
Cost per foot drilled	15	3.33	1.45	1	5	5	2
Information on low temperature (>40°C) geothermal waters	15	3.33	1.45	1	5	3	4
Well depths by type	15	3.27	1.18	1	5	3	3
Reservoir brine salinities (ppm total dissolved solids)	15	3.07	1.34	1	5	0	3
Expenditures for resource management (e.g., subsidence prevention)	15	3.00	1.21	1	5	0	2
Amounts of wastewater released by various disposal methods	15	3.00	1.37	1	5	1	2
Total footage drilled by type of well	15	2.80	1.17	1	5	2	2
Information on igneous or magmatic geothermal systems	15	2.60	1.40	1	5	1	1
Information on hot dry rock	15	2.53	1.31	1	5	1	1
Information on geopressured reservoirs	15	2.53	1.31	1	5	2	1
Number of employees by plant type (hydrothermal, geopressured, etc.)	15	2.20	1.33	1	5	1	1

Geothermal respondents specified several "other information" items that might be valuable to collect. Information on groundwater heat pumps was asked for twice. Several resource and well characteristics were specified, including reservoir permeability, which was mentioned twice. See Appendix C for more information.

Geothermal data users more strongly favor state level data than do biomass energy data users, with 62% of the former asking for this level of data aggregation (Table 2.7). They also wish data collection from equipment users rather than equipment manufacturers more strongly than do biomass energy users, with 69% of geothermal information users giving this response.

2.2.3 Municipal Solid Waste Information

At the top of the importance ratings for municipal solid waste (MSW) information were again total quantity type information: quantities of MSW consumed for energy; quantities of energy output in the forms of steam, heat, electricity, and fuel; total MSW produced per year; and quantities of pollutants in air emissions from combustion (Table 2.8). Of nearly equal importance were tipping fees ($/ton) by location.

Of second priority was the amount of materials recovered for recycling by type.

In third position, came number of facilities by type and their energy output capacities. Input capacities (tons) by type of waste rate further down the scale. Of similar importance, however, were average cost of energy products ($/kWh, $/MMBtu) and a breakdown of total energy products into end-use types (on-site use, district heat, industrial process heat, electrcity sold to grid, gas sold to pipeline, etc.).

Table 2.7. Geographic aggregation and source of information desired--geothermal experts' opinions

Geographic Aggregation Desired	No.	Percent
National	3	23.1
Regional	0	0.0
State	8	61.5
County	2	15.4

Source of Information Desired	No.	Percent
Manufacturers	4	30.8
Users	9	69.2

As with other renewable energy types, the average cost of energy products is followed in importance by the capital costs by facility type and, even lower in the ratings, by the O&M costs by facility type. In the midst of these types of cost information and below the middle of all types of MSW information were the average cost ($/ton) of processing MSW into energy and the sales price of the energy product.

Location of facilities, heat content of MSW, and the number of employees by type of facility received rather low importance ratings.

For "other information" that we did not ask respondents to rate but they wrote in themselves, information on ash disposal (tons, cost, haul distance, potential treatment, test requirements) was mentioned much more frequently than another items (5 respondents). A sixth asked for ash disposal environmental impacts and a seventh about amount of material composted. Information on quantities of air pollutants, specified in different ways than in our lists, was also brought into the discussion: quantities of pollutants for all energy and material recovery facilities, not just combustors, and information on pollution control technologies used. One respondent also asked for information on materials recovery/source separation programs (curb side or central collection, quantity of waste by

Table 2.8. Ranking by average respondent score for municipal solid waste (MSW)

Data Item	Respondents	Ave.	Std. Dev.	Min.	Max.	Hist. Series Used for Projection	Hist. Series Used for Other
Quantities of energy output (steam, heat, electricity, fuel, etc.)	25	4.32	0.73	3	5	9	4
Quantity of MSW consumed for energy	25	4.32	0.79	3	5	9	2
Quantities of air pollutants (CO, SO_x, NO_x, CO_2, particulates, etc.)	26	4.27	1.13	1	5	5	4
Total MSW produced per year	23	4.26	0.99	2	5	12	6
Tipping fees ($/ton) by location	25	4.24	0.86	2	5	8	1
Amount of materials recovered for recycling by type	24	4.17	1.07	1	5	9	2
Number of facilities by type (mass-burn, RDF, landfill gas, etc.)	26	4.04	1.02	1	5	9	4
Output capacity by energy product (steam, elec., fuels, hot water, etc.)	24	4.00	1.00	2	5	10	4
Average cost of energy product ($/kWh, $/MMBtu)	26	4.00	1.07	1	5	5	2
Quantities of energy by end-use (district heat, process heat, sold, etc.)	24	4.00	1.22	1	5	8	4
Capital costs by facility type	24	3.92	1.11	1	5	6	1
Input capacity (tons) by type of waste	23	3.91	1.14	1	5	4	2
Average cost of process ($/ton of MSW)	25	3.88	0.99	1	5	7	1
Sales price of energy product	26	3.85	1.06	1	5	5	2
Location of facilities	25	3.84	1.05	1	5	4	2
Operating and maintenance costs by facility type	25	3.84	1.19	1	5	4	1
Heat content of MSW (MMBtu/ton)	25	3.60	1.13	1	5	7	4
Number of employees by type of facility	22	2.09	1.04	1	5	1	2

type, markets and market prices, location, and year started). See Appendix C for additional items.

MSW data users favor state level aggregation of the data by a margin of 64% to 20% for national level aggregation (Table 2.9). They also overwhelmingly (84%) want their data gathered from MSW facilities themselves rather than from equipment manufacturers. This majority is the strongest shown for any of the five renewable energy types covered by this study.

2.2.4 Solar Information

Data requirements for four types of solar energy were investigated: active solar systems, passive solar systems, photovoltaics, and solar thermal systems. Some interviewees responded to all four sections of the solar energy questions while others who were experts in only one, two, or three of the solar systems types responded only to a subset of the questionnaire. The four classes of solar information were analyzed separately.

2.2.4.1 Active Solar

As Table 2.10 indicates, numbers and sizes of active solar systems, which fall in the top half of the table, exceed the importance of systems costs and prices, which fall predominately in the lower half of the table. Numbers of systems by use and one global cost measure, the average cost ($/MMBtu) of the heat energy from the systems, are the two pieces of information that respondents consider most important. The size of the collectors also rates highly. Geographic location of systems rates more highly for active solar systems than for other types of renewable energy reviewed so far. The resource measure, average insolation level, rates above median importance. As mentioned, system costs and prices follow in the lower half of the importance ratings. Knowing systems costs to installers by building type exceeds the importance of knowing the price to consumers and both are more important than gathering heat-storage unit costs and prices.

Items that were not on our list to be rated but that several active solar respondents requested included total energy collected (Btu) by state or region, installed cost of collectors (rather than price of collectors as specified in our list), a breakdown by building type of the number of systems, and number of systems in use as compared to number installed. There seemed to be some general desire to know about the operational status of installed systems, their repair rates, and their repair costs. Tax credits claimed were mentioned by one respondent. For a number of other potential data items to collect, see Appendix C.

Table 2.9. Geographic aggregation and source of information desired--MSW experts' opinions

Geographic Aggregation Desired

	No.	Percent
National	5	20.0
Regional	1	4.0
State	16	64.0
County	3	12.0

Source of Information Desired

	No.	Percent
Manufacturers	4	16.0
Users	21	84.0

2.2.4.2 Passive Solar

Passive solar system information requirements ranked very similarly to those for active solar systems. Numbers and sizes of systems take precedence over costs to installers and customers (Table 2.11). At the top of the importance ratings were number of new passive solar homes built and the number of installations by system type (direct-gain, indirect-gain, retrofit, etc.). Of somewhat lesser importance was a categorization of the number of systems by building type (single-family dwellings, multiple-family dwellings, commercial buildings, and industrial buildings). Building floor space, geographic location of installations, and annual building heat loads by building type round out the types of quantity information found in the upper half of the rankings. The only cost datum deemed extremely important, similarly to the case of active systems, was an overall average cost ($/MMBtu) by system type. Resource information ranks in the middle for passive solar, including average insolation levels and percent south glazing ratio by geographic location. Unlike active solar systems, costs to customers of passive solar retrofits and new systems exceeded the importance of costs to installers of retrofit and new systems, although the differences in average scores were small.

Table 2.11 also shows that passive solar shows one of the rare exceptions to the pattern that highly rated data are also most often used in making renewable energy projections. The most often used item in making projections, "annual building heat loads by building type," ranks only in the middle of the ratings of Table 2.11.

"Other information" on passive solar systems that respondents would like to see includes total energy saved (or "provided") by state or region (asked for twice). One respondent wanted information on cooling loads and passive cooling. Another wanted the same types of information that we listed, but he wanted it subdivided into more categories than we specified. He specified system type, location,

Table 2.10. Ranking by average respondent score for solar--active systems

Data Item	Respondents	Ave.	Std. Dev.	Min.	Max.	Hist. Series Used for Projection	Hist. Series Used for Other
Numbers of systems by use (hot water, space heat, both, pool heat, etc.)	15	4.13	1.09	2	5	7	0
Average cost of heat energy ($/MMBtu)	16	4.06	1.30	1	5	5	0
Size (ft^2) of collectors	16	3.88	0.86	2	5	5	0
Geographic location of systems	15	3.87	1.02	2	5	4	0
Average insolation levels (kWh/m^2) by geographic location	14	3.71	1.10	2	5	2	0
System cost to installers by bldg type (single/multiple-fam., comm., ind.)	16	3.69	1.36	1	5	3	1
Number of heat storage units installed	15	3.33	1.01	2	5	1	0
System prices by building type	15	3.17	1.12	1	5	3	0
Prices for heat-storage units by type	14	2.86	0.91	1	5	1	0
Costs to installers for heat-storage units by type	13	2.77	0.89	1	4	1	0

Table 2.11. Ranking by average respondent score for solar--passive systems

Data Item	Respondents	Ave.	Std. Dev.	Min.	Max.	Hist. Series Used for Projection	Hist. Series Used for Other
Number of new passive solar houses built by system type	15	4.27	0.85	3	5	3	0
Number of installations by system type (direct-gain, indirect-gain, retrofit)	14	4.21	0.86	3	5	3	0
Cost of heat energy ($/MMBtu) by system type	15	4.07	1.06	1	5	2	0
Number of installations by bldg. type (single/multiple-fam., comml., ind.)	15	4.07	1.06	2	5	2	0
Building floor space (ft^2)	15	3.93	0.93	3	5	3	0
Geographic location of installations	15	3.93	1.06	2	5	2	0
Annual building heat loads by bldg. type (single/multiple-fam., comml., ind.)	14	3.86	0.91	3	5	4	0
Average insolation levels (kWh/m^2) by geographic location	12	3.75	1.09	2	5	0	0
% south glazing ratio by region	13	3.69	1.07	2	5	1	0
Cost to customer of passive solar retrofit by system type	14	3.57	0.90	2	5	2	0
Costs to customers of new systems by system type	14	3.50	0.91	2	5	2	0
Cost to installers of passive solar retrofit by system type	14	3.43	0.98	2	5	2	1
Costs to installers of new systems by system type	14	3.43	0.98	2	5	2	1

building type, and construction date. Again, tax credits claimed were mentioned. See Appendix C.

2.2.4.3 Photovoltaics

The data importance ratings for solar photovoltaics differed from those of other renewable energy forms in a number of ways. First, the average installed capital cost ($/watt) topped the importance list for photovoltaics (Table 2.12). This differs from the average cost of energy, in this case dollars per kWh, which ranked near the top of some other renewable energy sources. For photovoltaics, the equivalent type of information, average cost of electricity ($/kWh), placed in the middle of the importance ratings. Solar photovoltaics is also unlike other renewable energy forms in that installed capacity (kW or MW) by geographic area rated highly. An alternative measure of installed capacity,

Table 2.12. Ranking by average respondent score for solar--photovoltaics

Data Item	Respondents	Ave.	Std. Dev.	Min.	Max.	Hist. Series Used for Proj-ection	Hist. Series Used for Other
Average installed cost by photovoltaic type ($/watt)	14	4.43	0.73	3	5	4	1
Installed capacity (MW) by geographic area	15	4.33	0.87	3	5	6	1
Number of systems by photovoltaic type	15	4.00	0.89	2	5	4	2
Battery costs ($/kWh)	14	4.00	0.93	2	5	3	1
Average insolation levels (kWh/m^2) by geographic location	15	4.00	1.15	2	5	1	0
No. of systems by wattage category (e.g., ≤100 W, 100-1000 W, 1000 W+)	15	3.93	1.12	1	5	4	2
Wattage shipped by end use (util, ind/comml, resid, consumer goods, etc.)	15	3.87	1.02	2	5	2	0
Manufacturing capital costs by photovoltaic type	15	3.87	1.15	2	5	3	1
Geographic location of systems	15	3.80	1.22	1	5	3	1
Average manufacturing costs by photovoltaic type ($/watt)	15	3.80	1.28	1	5	5	1
Average cost of electricity by photovoltaic type ($/kWh)	15	3.80	1.47	1	5	5	1
Wattage produced by photovoltaic type	15	3.73	1.12	2	5	3	1
Manufacturing operating and maintenance costs by photovoltaic type	14	3.71	1.28	1	5	3	1
Efficiencies (% energy converted to electricity) by photovoltaic type	15	3.67	1.35	1	5	2	1
Wattage imported by photovoltaic type by country	15	3.60	0.95	2	5	3	1
Manufacturing capacity by photovoltaic type	15	3.60	1.08	2	5	4	1
Wattage shipped by photovoltaic type	15	3.53	1.02	2	5	3	1
Wattage exported by photovoltaic type by country	15	3.47	1.15	1	5	3	1
Installed capacity (m^2) by geographic area	15	3.27	1.39	1	5	2	0
Value of shipments by photovoltaic type	13	3.15	1.23	1	5	3	0
Concentration ratios by photovoltaic type	14	3.00	1.20	1	5	2	0
Number of employees in manufacturing by photovoltaic type	14	2.86	1.30	1	5	2	0

square meters by geographic area, rated near the bottom of the importance ratings.

The number of systems by photovoltaic type, number of systems by wattage category, and wattage shipped by end use form part of a second-tier group of information items. Again, unlike other solar technologies, cost items such as battery costs and manufacturing capital cost by photovoltaic type rate about equally and surprisingly highly. Like other solar technologies, average insolation levels by geographic location and geographic location of systems rate in a second or third level of important information.

Average manufacturing costs ($/watt) and, as has been mentioned, the average cost of electricity ($/kWh) rank only in the middle of the importance rankings. Again surprisingly (because it contrasts to other renewable energy types), the amount of electricity (wattage) produced by photovoltaic type ranks only in the middle of the importance ratings. Of moderate to low importance are wattage imported and wattage exported by photovoltaic type and country, the two types of information currently gathered by the Department of Commerce. The former is deemed more important than the latter. Much of the lower half of the importance ratings is filled out by different types of manufacturing information: manufacturing O&M costs, manufacturing capacity by photovoltaic type, wattage shipped by photovoltaic type, and value of shipments by photovoltaic type. Two technical characteristics of photovoltaics, efficiencies by photovoltaic type and concentration ratios by photovoltaic type rank below the median in importance. The number of employees in manufacture of photovoltaics, as before, is least important.

Table 2.13. Ranking by average respondent score for solar–thermal

Data Item	Respondents	Ave.	Std. Dev.	Min.	Max.	Hist. Series Used for Projection	Hist. Series Used for Other
Amount of electricity generation (kWh)	16	4.56	0.70	3	5	5	0
Installed electricity capacity (MW)	15	4.47	0.81	3	5	5	0
Electricity generation cost ($/kWh)	15	4.33	1.14	1	5	4	0
Geographic location of systems	14	3.86	0.99	2	5	3	0
Number of systems by type (electric, process heat, residential heat)	15	3.80	0.91	2	5	3	0
Average insolation levels (kWh/m^2) by geographic location	13	3.77	1.19	2	5	2	0
Amount of industrial process heat (MMBtu)	16	3.69	1.26	1	5	3	0
Average cost of industrial process heat ($/MMBtu)	16	3.63	1.32	1	5	3	0
Solar collectors imported by type by country	15	3.53	1.15	2	5	2	0
Installed cost by collector type	15	3.53	1.26	1	5	2	0
Collectors shipped by end use (hot water, space heat, process heat, etc.)	15	3.53	1.36	1	5	1	0
Area (ft^2) of solar collectors produced by type	16	3.50	1.22	2	5	2	0
Solar thermal electric collector area (m^2) by geographic location	15	3.47	1.15	2	5	2	0
Manufacturing operating and maintenance costs by collector type	14	3.43	1.05	2	5	2	0
Solar collectors exported by type by country	15	3.40	1.20	2	5	2	0
Number of solar collectors produced by type	16	3.38	1.17	2	5	2	0
Collectors shipped by market sector (resid., comml., indust., util., other)	16	3.38	1.27	1	5	1	0
Manufacturing capital costs by collector type	14	3.36	1.29	1	5	2	0
Amount of residential solar thermal heat (MMBtu)	15	3.33	1.45	1	5	2	0
Residential solar thermal collector area (m^2) by geographic area	15	3.27	1.39	1	5	3	0
Number of solar collectors shipped by type	16	3.25	1.15	2	5	2	0
Total manufacturing costs by collector type	16	3.25	1.15	1	5	2	0
Manufacturing capacities by collector type (low, medium, high temp.)	14	3.21	0.94	2	5	2	0
Area (ft^2) of solar collectors shipped by type	16	3.19	1.24	1	5	1	0
Average cost of residential solar thermal heat ($/MMBtu)	15	3.13	1.41	1	5	3	0
Value of shipments by collector type	15	3.07	1.12	1	5	2	0
Number of employees in manufacturing by collector type	16	2.75	1.20	1	5	2	0

Under "other information," two respondents mentioned that they desired an important omission from our list of information items. This item is total annual estimated photovoltaic generation (kWh), with a breakdown by state or region. Another potentially important item was installed system O&M. One respondent again mentioned a desire for information on tax credits claimed. For other items, see Appendix C.

2.2.4.4 Solar Thermal

In the importance ratings for solar thermal energy, the types of information group themselves into data items on solar thermal electricity, solar thermal industrial process heat, solar thermal collector manufacture, and solar thermal residential energy, with the preceding sequence giving an approximate order of decreasing precedence (Table 2.13). The top three items for solar thermal energy relate to solar thermal electricity: amount of generation (kWh), installed capacity (MW), and average generation cost ($/kWh). There is a clear break in the average importance scores between these three items and the second-tier of items. In this second tier are more general information items, including number of solar thermal systems by type (electric, process heat, and residential heat), geographic location of these systems, and average insolation levels (which, as with the other solar systems, ranks fairly highly). Next in importance comes information on industrial process heat: its amount (MMBtu) and average cost ($/MMBtu). Next come several items relating to solar thermal collector manufacture and supply: solar collectors shipped by end use (hot water, space heating, pool heating, process heating, etc.), area (ft^2) of solar collectors produced by type, solar collectors imported by type and country, and installed cost by collector type. The importance of items in this list exceeds that of other related or comparable data items occurring later in the list. The categorization of solar collectors shipped by end use is more valuable than a categorization by market sector (residential, commercial, industrial, and utilities). Solar thermal collector imports are deemed more important to know than solar thermal collector exports. And area of solar collectors produced by type is more important than number of solar collectors produced by type.

Solar collector area installed by geographic location falls in the middle of the importance rankings. In a switch from other renewable energy forms, O&M costs for solar thermal collector manufacture are considered more important than capital costs of collector manufacture. The lower half of the importance ratings are filled out by two types of information. The first relates to residential solar thermal applications: the amount of residential solar thermal heat produced (MMBtu), residential solar thermal collector area by geographic area, and the average cost of residential solar heat ($/MMBtu). The other type consists of data items relating to solar thermal collector manufacture: solar collector manufacturing capacities by collector type, number of solar collectors shipped by type, area of solar collectors shipped by type, total manufacturing costs by collector type, value of shipments by collector type, and number of employees in manufacturing by collector type.

"Other information" types desired by solar thermal respondents was dominated by requests from three individuals. These three tended to want information on service requirements and service costs (thinking of residential systems?), performance of different types of systems (OEM, turnkey, components, etc.), and information reported in finer breakdowns or different units, e.g., not just MMBtu but $MMBtu/m^2$. See Appendix C.

Table 2.14 shows that solar energy information analysts desire state level data by a slight majority (55%). Regional level data is satisfactory to almost one-third. Unlike experts of other renewable energy forms, they are much more evenly split as to whether data are necessary from equipment users or equipment manufacturers. Perhaps this reflects the fact that more information about energy production and consumption can be inferred from equipment installed in solar energy fields than can be done in other renewable energy forms. Nevertheless, a marginal majority (53%) still wants data collected from equipment users.

2.2.5 Wind Information

The results from our inquiry into wind energy data requirements differ from those of other renewable energy information types in that costs rather than quantities of energy inputs or outputs top the list of information desired. Installed cost by machine size and type and O&M costs by machine size and type are the two top information items, and the average cost of electricity ($/kWh) is rated among the top group of information items (Table 2.15). Energy output and output capacity constitute the second most highly rated group of data items. This set includes, in decreasing order of importance, electricity sold to the utilities (kWh), total electricity produced (kWh), and installed electricity generation capacity (MW). Wind characteristics (speeds, directions, frequencies, densities, power classes, land areas by wind power class, and land areas by wind density) are next most important.

Then comes a single important manufacturing characteristic: manufacturing cost by machine size and type. All other manufacturing characteristics receive considerably lower average scores, including efficiency of wind turbines, manufacturing capacity by machine size and type, numbers of units produced and shipped by machine size and type, total value of machines sold, and number of employees in wind machine manufacture.

Of medium importance, as with other renewable energy forms, is the location of plants, in this case windfarms. Of somewhat less importance, but still in the middle range, are numbers of units installed, units imported, and units exported. A breakdown of units installed by usage (electricity generation, water pumping, etc.) and the costs of units imported and exported are less important still.

At the bottom of the importance list, along with many of the manufacturing characteristics already cited, are several resource and environmental characteristics: acreages occupied by wind farms, tower heights, and noise levels of wind machines.

Table 2.14. Geographic aggregation and source of information desired--solar experts' opinions

Geographic Aggregation Desired	No.	Percent
National	1	5.0
Regional	6	30.0
State	11	55.0
County	2	10.0

Source of Information Desired	No.	Percent
Manufacturers	9	47.4
Users	10	52.6

"Other information" desired by wind experts included quite a varied list, with only the value to the utilities (what utilities are paying wind generators for electricity) being mentioned twice. Utilities' avoided costs, which under the Public Utility Regulatory Policies Act (PURPA) amount to the same thing as the amount utilities are paying wind generators, were also mentioned. Other potentially important items include the transmission efficiency and costs from wind turbine to utility grid, the form for reporting efficiency data, the capacity of installed systems, and a characterization of the industry (types and sizes of manufacturers, developers, and operators). For other items, see Appendix C.

A plurality (44%) of wind energy data users favors state-level aggregation of their information (Table 2.16). A significant minority, 31%, requires it only at the national level, however. Repeating the pattern set by users of other renewable energy data, wind energy experts strongly favor (73%) data collection from equipment users.

2.3 RESULTS OF OPEN-ENDED QUESTIONS

2.3.1 Use of Data for Projections/Other Uses

Question 2.3 asked the respondents if they wished to elaborate on their needs for data to make projections or for other uses. A complete listing of responses is contained in Appendix D. By and

Table 2.15. Ranking by average respondent score for wind energy

Data Item	Respondents	Ave.	Std. Dev.	Min.	Max.	Hist. Series Used for Projection	Hist. Series Used for Other
Installed cost by machine size and type	15	4.47	0.72	3	5	3	1
Operating and maintenance costs by machine size and type	16	4.38	0.78	3	5	4	2
Electricity sold (kWh) to utilities	16	4.38	1.05	2	5	4	3
Average cost of electricity ($/kWh)	16	4.31	1.04	2	5	4	3
Electricity produced (kWh)	16	4.25	1.09	2	5	4	3
Installed electricity generation capacity (MW)	16	4.13	1.22	2	5	4	3
Wind characteristics (speeds, directions, frequencies, densities, etc.)	14	4.07	1.16	2	5	4	0
Manufacturing cost by machine size and type	15	4.00	1.15	1	5	5	1
Capacity factor (availability) of installed systems by mach. size by location	16	3.94	1.14	1	5	3	1
Location of windfarms	15	3.67	1.07	2	5	1	0
Number of units installed by machine size and type	15	3.33	1.01	2	5	1	3
Units imported by machine size by country of manufacture	15	3.27	1.06	2	5	2	3
Efficiency of wind turbines (%) by mach, size and type (horiz./vert. axis)	15	3.27	1.06	1	5	2	1
Units exported by machine size by country of destination	15	3.27	1.18	2	5	2	3
Cost of imports by machine size	13	3.23	1.12	1	5	1	2
Number of units installed by usage (elec. gen., water pumping, etc.)	15	3.13	1.26	1	5	1	2
Cost of exports by machine size	13	3.08	1.14	1	5	1	2
Manufacturing capacity by machine size and type	15	3.07	1.18	1	5	4	2
Number of units produced by machine size and type	15	2.87	1.09	1	5	1	2
Number of units shipped by machine size and type	15	2.87	1.15	1	5	1	2
Acreages occupied by wind farms	15	2.87	1.15	1	5	2	0
Noise level (decibels) of wind machines	15	2.87	1.31	1	5	1	1
Total value of machines sold	14	2.71	1.03	1	5	1	1
Tower heights	15	2.60	1.25	1	5	1	0
Number of employees in wind machine manufacture	15	2.60	1.25	1	5	1	2

large, these responses indicated that users of renewable energy data of all five types make projections to evaluate alternative government policies and for program planning purposes. Economic impacts of renewable energy development was a recurring subject of investigation, and a number of responses also indicated that the evaluation of R&D is the aim of using historical data series. Some use the data to evaluate resource and commercialization potential, as in the case of private firms, power producers, and consultants. Finally, state officials cited their need for the statistics to disseminate information to users and to evaluate local level policies, especially with respect to choosing and siting waste-to-energy facilities. These results cover the usual uses of government-gathered statistics. For a closer feel for the respondents' answers, see Appendix D.

2.3.2 Further Suggestions from Respondents

Question 2.4 asked respondents if they had any further suggestions in collecting renewable energy data of the type they reviewed in our lists. We received a variety of answers and an exhaustive listing is also given in Appendix D. Here we will highlight themes and striking suggestions that arose.

2.3.2.1 Biomass

A number of respondents mentioned that some biomass energy data, particularly woodfuels data, are already collected--under some of the DOE Regional Biomass Energy Programs, by the U.S. Forest Service, and by the states. One of the Regional Biomass Energy Programs not yet collecting such data said they are about to embark on such efforts and suggested collaboration with the sponsors of the current work. Another potential source of biomass-related information, particularly land areas devoted to certain uses such as commercial forest, certain agricultural crops, etc., is the USDA Soil Conservation Service's National Resources Inventory. Although Chapter 3 lays out some of the sources available, it appears that future DOE data gathering and dissemination efforts would benefit from developing ties with the sources just mentioned, so that efforts are not duplicated.

Table 2.16. Geographic aggregation and source of information desired--wind experts' opinions

Geographic Aggregation Desired	No.	Percent
National	5	31.3
Regional	2	12.5
State	7	43.8
County	2	12.5

Source of Information Desired	No.	Percent
Manufacturers	4	26.7
Users	11	73.3

Some respondents mentioned that energy crops, as such, do not yet exist. (Biomass currently used for ethanol production is from corn that is diverted from food and feed production; it is not from dedicated energy crops.) Therefore, gathering some of the energy crop production information does not yet make sense. Furthermore, once energy crops begin to be raised commercially, separation of what is grown for energy and what for fiber may be difficult. The same crop may go to either market depending upon market prices.

Other biomass suggestions are specific to survey question content and survey design. See Appendix D.

2.3.2.2 Geothermal

One respondent suggested that the data collection method and the determination of what data to collect should be coordinated with people who are directly involved in geothermal development, such as representatives of the Geothermal Resources Council. Other suggestions dealt with particular data topics to include: reinjection, environmental mitigation, energy input, and energy output. As already mentioned, two respondents wished for the collection of groundwater or geothermal heat pumps, in addition to the larger scale power and direct-use heat applications of geothermal energy.

2.3.2.3 Municipal Solid Waste

One respondent noted that his state has found that MSW facilities consider some of the types of information studied in this report to be proprietary or sensitive. As a result, much of the information comes back in an aggregated form. The respondent warned that survey wording must be clear to avoid this problem.

Other respondents emphasized the need for facility-level data because of locally highly specific nature of MSW problems. Comparability of MSW situations may only be possible at the facility level. Two respondents (one referring only to emissions data) also noted the need for reporting results in ranges, i.e., with minima and maxima or with 95% confidence intervals, and not just with averages.

Finally, one respondent warned against reinventing the wheel by collecting data already collected. Chapter 3 recounts sources of MSW data.

2.3.2.4 Solar

Further suggestions from solar respondents were scarce. The most serious response involved the definition of passive solar, which the respondent indicated is integral to the design of buildings. Therefore, number of installations is a difficult number to define, and system costs to installers or consumers are even harder to separate from overall building costs. The respondent had a number of suggestions on how to design passive solar data gathering questions (see Appendix D).

Another respondent noted that insolation data must be reported on a local level to be useful, even if other data are more aggregated.

2.3.2.5 Wind

One respondent noted the extensive wind energy information collected under the California Wind Performance Reporting System. Section 3.5 of the current report elaborates on this system. Another indicated that county level resource data (wind speeds, wind densities, etc.) are again essential for wind, whereas other information types may be reported at a more aggregated level. Finally, one respondent made the important technical point that efficiency data must be reported in the form $(kWh/m^2)/(W/m^2)$. See Appendix D for details.

3. SOURCES OF CURRENTLY COLLECTED RENEWABLE ENERGY DATA

A few agencies and organizations regularly collect renewable energy data. This chapter reviews current sources of data and the types of data collected. To the extent that the data currently collected match the requirements of analysts and policy makers reviewed in the previous chapter, the Energy Information Administration (EIA) could make use of these other data collection efforts and avoid duplication. Repackaging of information from these other sources for wider distribution may be a viable strategy.

3.1 BIOMASS DATA

This study divides biomass for energy into three types: woodfuels, agricultural residues, and energy crops (herbaceous and short-rotation woody crops grown for energy). Several sources regularly collect information on these fuels, particularly woodfuels. These include:

1. EIA Residential Energy Consumption Survey (RECS) - The RECS is a triennial survey of household characteristics and energy consumption and expenditure conducted by the Office of Energy Markets and End Use of EIA. It was last completed in 1987. Data collected relevant to wood energy use include main and secondary heating fuels used (including a wood category), main and secondary heating equipment used (including the categories of fireplace and a heating stove burning wood, coal, or coke), amount of wood burned in cords, main and secondary water heating fuels (including a wood category), type of pool heating fuel (including a wood category), main cooking fuel (including a wood category), household characteristics (number of persons, education, income, etc.), housing type (single-family, multiple-family, etc.), occupancy (year-round, seasonal, etc.), number of rooms, and dwelling dimensions. A relative standard error of 13% to 17% is associated with the wood data at the national level in 1987, a level of error that increases at the regional level (EIA 1990).

2. EIA Manufacturing Energy Consumption Survey (MECS) - The MECS is a triennial survey of manufacturing energy consumption and expenditure conducted by the Office of Energy Markets and End Use of EIA for which the last year of compiled and published data is 1985. Among the categories of fuels surveyed are roundwood; wood chips, bark, and waste wood; pulping or black liquor; and biomass (obviously defined in narrower terms than this report defines it). For these categories of fuel, data on quantities purchased, total expenditures, quantities produced on site, and quantities consumed on site are collected. Renewable energy, however, is not considered in designing the sampling scheme for the MECS, which results in large sampling errors for estimated renewable energy statistics from MECS data.

3. EIA Nonresidential Buildings Energy Consumption Survey (NBECS) - Form EIA-871A-G. Publication (most recently published results): *Nonresidential Buildings Energy Consumption Survey: Characteristics of Commercial Buildings 1986*, DOE/EIA-0246(86). The NBECS is a triennial survey of nonresidential (i.e., commercial, governmental, educational, professional, warehouse, and nonprofit organizational) building space conducted by the Office of Energy Markets and End Use of EIA, last completed for 1986. Wood is among its categories of fuels used. By fuel, it collects data on amount of fuel used, use of fuels (space heating, water heating, etc.), total square footage, principal building uses, amount of time building space is in use,

building envelope characteristics (glass area, roofing materials, etc.), heated/cooled area, heating and cooling equipment, and energy conservation practices. The survey also collects information on energy expenditures. National and regional (census region) results are published. Results at the national level for woodfuel display relative standard errors from 12% to over 50%. Regional estimates have relative standard errors from 27% to over 50%.

4. Department of Energy (DOE) Regional Biomass Energy Program - This program under the Assistant Secretary for Conservation and Renewable Energy divides the country into six regions and delegates to regional representatives the collection of biomass energy data. The amounts and types of data collected vary regionally. The Tennessee Valley Authority (TVA) is the Southeastern Regional Biomass Energy Program representative, and it collects extensive data for 13 southeastern states. These data include commercial forest land area; area of commercial forest land by site class (over 120 ft^3 per acre, 85-120 ft^3 per acre, 50-85 ft^3 per acre, and 20-50 ft^3 per acre); area of commercial forest land by stand size class (sawtimber, poletimber, and sapling and seedling); pulpwood production; and total and per-acre green and oven-dry weights of woody biomass broken into several categories: species group (hardwood, softwood) and tree component (growing stock, cull trees, and small trees); annual growth, removals, and net change; and potential annual energy wood by source (logging residues, cull trees, and surplus growth) and species group (hardwood, softwood). These categories are only a sampling of the type of information that the Southeastern Regional Biomass Program can provide. By contrast, little information is collected in some other regions. In the Midwest Regional Biomass Energy Program, no data are collected on a regional basis. States in this region conduct their own, varied data collection programs on wood, wood waste, and biomass availability. The Midwest Regional Biomass Energy Program does survey and publish a directory of biomass energy producers and users every three years.

5. American Paper Institute (API), New York, New York - The API collects and publishes annual data on woodfuel used in the pulp and paper industry, which was estimated to burn over 70% of industrial woodfuel in 1987 (Klass 1990). API breaks down woodfuel types into hog fuel, bark, and black liquor categories. Their annual publication is entitled "U.S. Pulp and Paper Industry's Energy Use: Calendar Year. . . ."

6. U.S.D.A. Forest Service Renewable Resources Assessment - This decennial assessment, last completed in 1989, includes an appraisal of current and projected timber removals, pulpwood demand, and fuelwood production by region (Haynes [1988]). Fuelwood projections are categorized by roundwood and growing stock, subcategorized into species group (hardwood, softwood) and also divided into industrial/commercial and residential use.

7. U.S.D.A. Regional Forest Survey Research Units - These units carry out ongoing state and regional data collection on forest roundwood (sawlogs, pulpwood, veneer logs, fuelwood, and other) products and forest residues (fiber products and fuel, subdivided into bark and wood residue). They also collect many other forest-related statistics. The research is pursued on a cyclical basis within the U.S.F.S. Research Units, with no common reporting period for them all. They similarly produce their own reports. A national report based on their work appears every ten years. The most recent edition is *Forest Statistics of the United States, 1987* (Waddell, Oswald, and Powell 1989). Current Washington coordinator for the U.S.F.S. Research Units is James Bones (202-382-9343.)

8. EIA Annual Electric Generator Report - Form EIA-860. All electric utilities file this form annually with EIA. Publication: *Inventory of Power Plants in the United States.* Data disseminated are state, company, plant name, county, maximum generator nameplate capacity (kW), summer and winter capabilities (kW), energy source (including categories for wood or wood waste, refuse, bagasse, and other nonwood waste), prime mover (steam turbine, etc.), year of initial operation, and heat rates (Btu/kWh). The census collects similar information for electric generating units started, retired, and planned within the next ten years. The form also collects dates of planned retirements, dates of cancellation of plans to construct, and plans for fuel conversions or repowering.

9. EIA Monthly Power Plant Report - Form EIA-759. Publications: *Electric Power Monthly, Electric Power Annual, Monthly Energy Review, Annual Energy Review.* This form collects information on plant name, prime mover, fuel type, nameplate capacity, and net generation (gross generation less plant use and pumped storage) on a monthly basis. Its fuel type categories lump wood, refuse, geothermal, solar, and wind in a single category called "other."

10. EIA Annual Nonutility Power Producer Report - Form EIA-867. This survey collects information from nonutility power producers, including cogenerators, small power producers, and other nonutility generators. For all facilities, the form asks an operator for the number of facilities to be operated, classified into four size categories (<1 megawatt [MW], 1-5 MW, 5-25 MW, and 25 MW or more). For facilities over 1 MW, the form asks for generator nameplate rating and whether any electricity was produced during the reporting period (a yes-no question). For facilities of 5 MW or more, it also asks the quantity of fuel used (including wood and wood waste, municipal solid waste, and other waste and sludge categories), heat contents of fuels, generation (kWh), generation used at the facility, generation delivered to the grid, generation delivered to other users, useful thermal output (MMBtu), use for the useful thermal output (direct heating, process steam, space heating and/or cooling, and other), and detailed information for each generation unit, such as nameplate rating, operating status, date first operated, its prime mover (gas turbine, steam turbine, internal combustion engine, wind turbine, solar photovoltaics, hydraulic turbine, fuel cell, etc.), energy source (fuel type), and gross amount of electricity generated (kWh). For facilities of 25 MW or more, the form also asks air emissions questions.

11. Federal Energy Regulatory Commission (FERC) filings under the Public Utilities Regulatory Policy Act (PURPA) - Publication: *The Qualifying Facilities Report: A Cumulative List of Filings Made for Small Power Production and Cogeneration Facilities Fiscal Year 1980 through Fiscal Year 1990.* Data are collected from small power producers and cogenerators when they file for qualifying facility status under PURPA. Summary statistics in the report include cogeneration capacity by fuel type (total and by year filed), small power producer capacity by fuel type (total and by year filed), and number of facilities and capacity (kW) by region and by state for both small power producers and cogenerators. Information on individual applications includes applicant city, county, and state, filing date, date certified, date that facility installation will begin, prime mover, and primary energy source (including categories for biomass and wood waste).

12. FERC Form 1 - Detailed financial characteristics (including capital, operating, and maintenance expenses) and operating attributes (installed capacity, generation, capacity factor, and summer and winter capabilities) are collected on FERC Form 1, administered by EIA since 1977. Electric generating plants must be owned by major, privately owned utilities and be greater than 25 MW

for steam plants. For this reason, most biomass facilities are excluded from data collection under this form.

13. U.S. Department of Transportation, Federal Highway Administration (FHWA) Monthly Motor Fuel Report by States - Publication No. FHWA-PL-91-011. Reports monthly gasohol sales by state in thousands of gallons. Approximately ten percent of these gasohol sales can be used as an estimate of the amount of ethanol blended with gasoline. Because of undercoverage of actual gasohol sales, however, such an estimate is biased below the actual value of ethanol produced. Data reported to the FHWA during 1989 led to an estimate of 691 million gallons of ethanol, using the 10% rule. Private industry estimates, however, that 840 million gallons of ethanol were consumed nationally (EIA 1990).

14. U.S.D.A. National Agricultural Statistics Service and U.S. Dept. of Commerce Bureau of the Census (*Census of Agriculture*) - These government agencies collect data on crop production and crop production costs. This information would fulfill some of the requirements for energy crop data users where the crops grown for food or agricultural purposes can also be converted to energy. This principle is exemplified in corn, the current primary feedstock for ethanol.

3.2 GEOTHERMAL DATA

Regular sources of geothermal data include:

1. EIA Annual Electric Generator Report - Form EIA-860. Energy source question includes a geothermal category and prime mover question includes a steam turbine - geothermal classification. This report suffers from underreporting of geothermal electricity sources according to individuals within EIA. See section 3.1 for a further description of data collected with this form.

2. EIA Monthly Power Plant Report - Form EIA-759. As noted in section 3.1, this form lumps wood, refuse, geothermal, solar, and wind in a single fuel category called "other." However, the prime mover categorization denotes a steam geothermal class, making geothermal plants differentiable from other renewable fuels. This report, however, also suffers from underreporting of geothermal electricity according to EIA. For other information gathered by this form, see section 3.1.

3. EIA Annual Nonutility Power Producer Report - Form EIA-867. This survey collects information from nonutility power producers, including small geothermal power producers. As noted in section 3.1, the form collects certain information only from facilities over 5 MW, and for such facilities, geothermal would fit in the "other" category for fuel used. This report also suffers from underreporting of geothermal electricity. For other information collected with Form EIA-867, see section 3.1.

4. Federal Energy Regulatory (FERC) filings under the Public Utility Regulatory Policy Act (PURPA) - A primary energy source category for geothermal exists on the filing application. For other information collected on the FERC PURPA filing form, see section 3.1.

5. FERC Form 1 - The Geysers, owned and operated by Pacific Gas and Electric Company, is the only geothermal plant reported by a major, privately owned utility. See section 3.1 for the detailed financial and operating characteristics reported on FERC Form 1.

6. Geothermal Resources Council, Davis, California - Publishes results of a quinquennial survey on geothermal resources in its monthly *Geothermal Resources Council Bulletin*. The last survey was completed in 1990 and presented in the July/August 1990 issue of the publication. Information presented includes total installed capacity for the country and new capacity installed in the previous five years by facility name, locality, year built, number of units, operational status, and type of unit (D steam, binary, D flash, S flash). Capacity is also projected five years hence.

7. EIA Residential Energy Consumption Survey (RECS) - The RECS includes a heat pump category in its questions on main and secondary heating equipment used. For other information in the RECS, see section 3.1.

8. EIA Manufacturing Energy Consumption Survey (MECS) - The MECS collects the amount of electricity generated on site by solar, wind, hydro-, and geothermal power. These four power sources are not segregated into separate categories, however. The MECS collects the amount of steam (in MMBtu) generated from solar and geothermal sources, without separating the two sources. For other information in the MECS, see section 3.1.

3.3 MUNICIPAL SOLID WASTE DATA (MSW)

Regular collection of data on municipal solid waste occurs through the following sources:

1. Governmental Advisory Associates, Inc. (GAA), New York, New York - Annually, the GAA publishes the *Resource Recovery Yearbook: Directory and Guide*. The 1988-89 edition of this publication covered 368 waste-to-energy projects that were operational, in advanced planning, in the conceptual stage, or permanently shut down. By facility, it includes facility name, location, operational status, start-up date, type of process (mass burn, refuse-derived fuel, pyrolysis, etc.), design capacity in tons per day (TPD), average operating throughput (TPD), ash residue (TPD), ash disposal method (landfill - materials recovery, landfill without processing, etc.), number of boilers, primary energy form, gross and net power output ratings (MW), power (kWh) per ton processed, heat produced (Btus/lb.), lbs/hr steam produced, pressure rating, temperature (°F), average power cost (cents/kWh), air pollution control equipment used, materials recovered, average tonnage per year, number of employees, capital costs, operating and maintenance (O&M) costs ($/ton with and without debt service), ash residue disposal fee, tipping fee ($/ton), and other financial, operating, and owner information. This source of information is fairly comprehensive. Estimates of the amounts of MSW combusted and energy produced from this source may be overstated, however, because industrial organizations are hesitant to report facility downtime to private surveying organizations (EIA 1990).

2. Don Walter, DOE Waste Material Management Division - Mr. Walter maintains an undocumented database on MSW facilities. Information in the database includes waste-to-energy plant locations, year plant began operation, design throughput (TPD), actual throughput, facility status if not operating (under construction, under contract, planning activities), capital cost information (size of bond issue or other financing, construction cost), type of facility

(cogeneration, refuse-derived fuel dedicated boiler, ecofuel II, gasifier, mass burn, refuse-derived fuel, etc.), principal product, equipment supplier, percent availability, thousands of pounds of steam, electric generation capacity (MW), steam conditions (pressure, temperature), electricity sales, materials recovered (refuse-derived fuel, iron, aluminum, glass, compost, other), type of financing (general obligation bonds, tax exempt industrial development bonds, private equity, etc.), capital construction costs (millions of dollars), capital costs for modification, operating and maintenance costs ($/ton), and tipping fee at the facility.

3. Steven Levy, U.S. Environmental Protection Agency, Office of Solid Waste - Mr. Levy maintains an undocumented database on MSW facilities. Included in the database is information on facility name, state, capacity (TPD), cost (partial data), facility status (conceptual, procurement underway, under contract or construction, operational), type of energy recovered (steam, methanol, electricity, none), energy amount, start-up year, vendor, and system type (company name that designed the system).

4. EIA Manufacturing Energy Consumption Survey (MECS) - The MECS also collects quantity of waste materials (wastepaper, packing materials, etc.) consumed as fuel and other energy-related information for the manufacturing waste materials specified in section 3.1. (Note: The 1988 MECS seems to have subsumed manufacturing waste energy into the fuel category "other-specify" [EIA 1990].)

5. EIA Annual Electric Generator Report - Form EIA-860. Energy source question includes a refuse, bagasse, or other nonwood waste category. See section 3.1 for further description of data collected with this form.

6. EIA Annual Nonutility Power Producer Report - Form EIA-867. This survey collects information from nonutility power producers, including small waste-to-energy plants. As noted in section 3.1, the form collects certain information only from facilities over 5 MW, and for such facilities, MSW would fit in the "other" category for fuel used. For other information collected by Form EIA-867, see section 3.1.

7. Federal Energy Regulatory (FERC) filings under the Public Utility Regulatory Policy Act (PURPA) - A primary energy source category for MSW exists on the filing application. For other information collected on the FERC PURPA filing form, see section 3.1.

8. Institute of Resource Recovery (IRR) *Directory of Resource Recovery Projects and Services* - A small directory of member projects by project name, city, state, design capacity (TPD), start-up year, and IRR member that constructed or will construct the project. The IRR is an institute of the National Solid Wastes Management Association, Washington, D.C.

3.4 SOLAR DATA

Regular sources of solar energy information include the following:

1. EIA Residential Energy Consumption Survey (RECS) - The RECS has a solar collector category for the main and secondary household space heating fuels, main and secondary water heating fuels, and pool heating fuel. For other information in the RECS, see section 3.1.

2. EIA Manufacturing Energy Consumption Survey (MECS) - The MECS also collects the amount of electricity generated on site by solar, wind, hydro-, and geothermal power. These four power sources are not segregated into separate categories, however. The MECS collects the amount of steam (in MMBtu) generated from solar and geothermal sources, without separating the two sources. For other information in the MECS, see section 3.1.

3. Nonresidential Buildings Energy Consumption Survey (NBECS) - Form EIA-871A-G. The NBECS also includes an active solar category among its energy sources. Typically, however, this energy source is lumped into a "minor fuels" or a "minor fuels excluding wood" category in the NBECS statistics reported. Even though the results have been reported for aggregated fuel sources, the results reported for minor fuels have relative standard errors exceeding 20%, many of them being above 50%.

4. EIA Annual Electric Generator Report - Form EIA-860. Energy source question includes a solar category and prime mover question includes photovoltaic and steam turbine - solar classifications. See section 3.1 for further description of data collected with this form.

5. EIA Monthly Power Plant Report - Form EIA-759. As noted in section 3.1, this survey lumps wood, refuse, geothermal, solar, and wind fuels into a single category called "other." However, the prime mover classification includes solar photovoltaic and solar steam categories, making solar photovoltaic and solar thermal plants differentiable from other renewable fuels. For other information collected by EIA-759, see section 3.1.

6. EIA Annual Nonutility Power Producer Report - Form EIA-867. This survey collects information from nonutility power producers, including solar photovoltaic and solar thermal plants. As noted in section 3.1, the form collects certain information only from facilities over 5 MW, and for such facilities, solar technologies would fit in the "other" category for fuel used. A solar (photovoltaic) prime mover category exists on the form. For other information collected by Form EIA-867, see section 3.1.

7. Federal Energy Regulatory (FERC) filings under the Public Utility Regulatory Policy Act (PURPA) - A primary energy source category for solar exists on the filing application. For other information collected on the FERC PURPA filing form, see section 3.1.

8. Annual Solar Thermal Collector Manufacturers Survey - Form CE-63A. Publication: *Solar Collector Manufacturing Activity 1988*, DOE/EIA-0174(88). Includes data collected annually by EIA on collector shipments (sq. feet) by collector type (low temperature metallic and nonmetallic, medium temperature thermosiphon, flat plat, integral collector storage, evacuated tube, etc.), total value of collector shipments by collector type, purchaser market sector (residential, commercial, etc.) in square feet, end use (pool heating, hot water, space heating, etc.) in square feet, imports and exports (sq. feet), countries of origin/destination of imports and exports, state of manufacture, and shipping state destination.

9. Annual Photovoltaic Module Manufacturers Survey - Form CE-63B. Publication: *Solar Collector Manufacturing Activity 1988*, DOE/EIA-0174(88). Consists of data collected annually by EIA on manufacture, importation, exportation, and shipment of photovoltaic modules. Data include total net module shipments (kW) by module type: crystalline silicon (single-crystal, cast, or ribbon), thin film (amorphous silicon), or concentrator (silicon or gallium arsenide); total value of

shipments by module type; end use (water pumping, transportation, residential, industrial/commercial, etc.) in kW by module type; imports and exports by module type; and countries of origin/destination of imports and exports.

10. U.S. Department of Commerce, International Trade Administration, Office of Capital Goods - Also collects export data on solar panels and collectors (but not cells) and import data on solar panels and cells (but not collectors).

3.5 WIND DATA

Wind energy data are collected on a regular basis by the following:

1. California Energy Commission - Publications: Quarterly and annual reports, e.g., *Results from the Wind Project Performance Reporting System: 2nd Quarter 1988*, *Results from the Wind Project Performance Reporting System: 1989 Annual Report*. The Commission collects and reports extensive information on wind energy plants. Because approximately 99% of national wind energy capacity is in California, this information is fairly comprehensive for the U. S. as a whole. California regulations require all wind operators with projects rated greater than 100 kW and who sell electricity to a power purchaser to report. The reports give statewide and resource area information on capacity, new capacity, generation, the ratio of actual to projected output, actual capacity factors, kWh per square meter, number of turbines, and number of new turbines. The same types of information are given in breakdowns by turbine size, by turbine axis, by domestic vs. foreign manufacture, by turbine manufacturer, and by project operator. A detailed section gives individual project operator information, including location; operator; project name; turbine model, axis, rotor, and size (kW); quarterly and annual projected production per turbine; number of existing and new turbines installed; and generation (kWh). A summary section at the beginning of the annual report contains bar graphs and pie charts depicting capacity; generation; capacity by turbine size, by turbine axis, by turbine origin (domestic or foreign), by turbine manufacturer, and by project operator; capacity factors by new and cumulative turbine stock, by area, by turbine size, by turbine axis, by turbine manufacturer, and by project operator; and kWh per square meter production by new and cumulative turbine stock, by turbine axis, by turbine origin (domestic, foreign), by turbine manufacturer, and by project operator.

2. EIA Annual Electric Generator Report - Form EIA-860. Energy source question includes a wind category and prime mover question includes a wind turbine classification. See section 3.1 for further description of data collected with this form.

3. EIA Monthly Power Plant Report - Form EIA-759. The prime mover classification includes a wind category, making wind plants differentiable from other renewable fuels. For other information collected by EIA-759, see section 3.1.

4. EIA Annual Nonutility Power Producer Report - Form EIA-867. This survey collects information from nonutility power producers, including wind energy plants. As noted in section 3.1, the form collects certain information only from facilities over 5 MW, and for such facilities, wind would fit in the "other" category for fuel used. A wind turbine prime mover category exists on the form. For other information collected by Form EIA-867, see section 3.1.

5. Federal Energy Regulatory (FERC) filings under the Public Utility Regulatory Policy Act (PURPA) - A primary energy source category for wind exists on the filing application. For other information collected on the FERC PURPA filing form, see section 3.1.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 GENERAL CONCLUSIONS AND RECOMMENDATIONS

General themes can be drawn from the results of the five different types of renewable energy opinion polls. First, renewable energy data users appear to be generally more interested in obtaining "quantity data," i.e., information on amounts of inputs and energy outputs from existing renewable systems rather than price and cost information. The type of quantity information varies some according to the type of renewable energy. For instance, for woodfuels and energy crops it is the fuel itself that ranks at the top of the data requirements of users, while for some of the solar technologies it is the quantity of energy produced that ranks at the top. Nevertheless, the emphasis is on inputs and output quantities, not detailed cost data.

The exception to this generality is that frequently some overall average cost of energy ($/kWh, $/MMBtu) ranks as an important piece of information. Of course, calculating such an average cost requires gathering of detailed cost data, but the results of our work indicate that substantial efforts to disseminate such data should occur only if efforts to disseminate quantity data can be maintained.

Certain types of resource information tended to rank above the median or in the middle of the rankings. Based on the results of this investigation, these types of information should be gathered and disseminated before other types. Forest biomass inventory, total quantities of agricultural residues, land area in energy crops, geothermal reservoir thermal contents, average insolation levels by geographic location, and wind characteristics are examples of these resource information items. At the same time, other types of resource information can be ignored, for instance, number of energy crop plantations and geothermal well depths and brine salinities.

Generally speaking, participants in this study gave low precedence to gathering information on renewable energy conversion equipment manufacture. This result held for both quantity information (numbers of units produced, number of units shipped, production capacity, etc.) and cost of manufacture data.

Also, in cases in which both the industrial and the residential/commercial sectors employ a form of renewable energy, respondents consistently ranked the acquisition of industrial data as more important. Thus, industry and utility surveys that fill gaps in current knowledge should be undertaken before efforts to survey the household and commercial sectors.

The review of current data collection efforts shows that an elaborate infrastructure to collect major electric utility data is already in place. Modification of the EIA forms used to collect these data, especially EIA-860 and EIA-759, to include clearer definitions of renewable electricity generation fuels and prime movers would help to gather information on generation capacity, net summer and winter capabilities, and heat rates for renewable fuels (EIA-860) and generation capacity, net generation, and amounts of fuels consumed (EIA-759). Such efforts, however, should be coordinated with the present collectors of information for the Nonutility Power Producers Report (Form EIA-867), since the bulk of the relevant interviewees and hence the relevant information may already be addressed under this latter report. The Manufacturing Energy Consumption Survey (MECS) survey form also could be altered to better serve renewable energy data collection efforts by differentiating the various types of renewable energy forms.

Across the renewable energy data types, the general trend was that the higher ranking information items were also the information items that people said they used for projections. Therefore, for governmental and nongovernmental forecasting of renewable energy usage, the rankings as presented in the tables of Chapter 2 are good guides to what data should be collected. There are some exceptions to this rule, which are apparent from information items in the lower reaches of the tables that nevertheless have relatively high counts in the "Projection" column.

4.2 SPECIFIC COMPARISONS OF EXISTING DATA COLLECTION EFFORTS WITH USER DESIRES

In this section, we take a closer look at existing data collection efforts and user desires for data as expressed in Chapter 2.

4.2.1 Biomass Information

4.2.1.1 Woodfuels

Table 4.1 indicates sources that collect data on the information items ranked in Table 2.2. As the table shows, some of the most important data items, such as total quantity of woodfuel consumed by all sectors, potential annual energy wood by source, and quantities of industrial woodfuel, are collected by current surveys. These surveys, however, are not adequate sources for the information desired. The Forest Service's Renewable Resources Assessment (RRA) is conducted every ten years, which is too infrequent for many data users. EIA's Manufacturing Energy Consumption Survey is not adequate in the area of woodfuels, because the sample of manufacturers is not designed with woodfuels in mind. Woodfuel users are consequently underrepresented in the sample and large sampling error biases exist in the resulting statistics. The information from the American Paper Institute, while important, covers only the pulp and paper industry. Finally, EIA's Nonutility Power Producers Report (NPPR) collects information primarily from electricity generators. Firms that generate and use electricity or steam internally would be missed.

To improve coverage of the woodfuels information rated most highly by experts in Chapter 2, changes could be made to the MECS sampling procedure to include more woodfuel users. Alternatively, the Nonutility Power Producers Report might be expanded to include industries that do not generate electricity but use woodfuels for steam production. This second alternative seems more cumbersome, however, because it would be redefining both the questionnaire and the population surveyed.

Two seemingly important pieces of woodfuels information that are currently collected were neglected in the lists of information that experts rated. These information items are the number of nonutility power producers and their total generation capacity (MW), which are collected by the Nonutility Power Producer Report (EIA-867) and the FERC filing under the Public Utility Regulatory Policies Act (PURPA).

4.2.1.2 Agricultural Residues

As Table 4.2 shows, the Nonutility Power Producer Report and the MECS again provide data on some of the top-rated information types for agricultural residues. However, these surveys would suffer from the same problems in estimating data items for agricultural residues as they do for

Table 4.1. Sources of woodfuels information (ranked by average respondent score)

Data Item	Information Sources[a]
Total quantity of woodfuel consumed (all sectors)	RRA
Potential annual energy wood by source (logging residues, etc.)	RRA
Quantity of industrial woodfuel consumed	MECS, *API*, RRA
Quantity of woodfuel consumed, categorized by industry	MECS, *NPPR*
Cost of industrial woodfuel by type	MECS,
Number of industrial wood-burning facilities	MECS
Quantity of wood consumed by type of energy product	
Quantities of pollutants in air emissions	
Quantity of energy product by type	*NPPR*
Quantity of electricity sold to grid	*NPPR*
Quantity of industrial woodfuel consumed by type (pellets, etc.)	MECS, API
Hauling costs for woodfuel ($/ton-mile) by hauling distance category	
Capital costs for wood-fired energy products (electricity, etc.)	
Operating and maintenance costs for wood-fired energy products	
Location of facilities	NPPR, PURPA-F
Harvest costs for woodfuel ($/ton)	
Capacity factor of wood-fired electricity plants	
Stumpage costs for woodfuel ($/ton)	
Forest biomass inventory by tree type by quality	
Net growth in commercial forest	
Quantity of woodfuel burned in commercial buildings by geographic region	NBECS
Quantity of woodfuel consumed in commercial buildings	NBECS, RRA
Quantity of woodfuel burned in residences by geographic region	RECS
Quantity of woodfuel consumed in residences	RECS, RRA
Area of commercial forest land by site class	
Percent of commercial forest land forested	
Area of commercial forest	
Installed cost of combustion units	
Quantity of woodfuel burned in commercial bldgs. by type (pellets, etc.)	
Price of woodfuel burned in commercial buildings by type (pellets, etc.)	NBECS
Price of purchased residential woodfuel	
Total sales of combustion units by type	
Number of industrial/utility combustion units manufactured by type	
Number of residences burning woodfuel	RECS
Percentage of residential space heating needs met by woodfuel	
Manufacturing capacity of combustion units by type	
Quantity of woodfuel burned in commercial buildings by end use	
Number of residential/commercial combustion units manufactured by type	*RECS, NBECS*
Percentage of residential woodfuel purchased	
Manufacturing cost of combustion units	
Quantity of woodfuel consumed in residences by end use	RECS
Commercial square footage heated by woodfuel	NBECS
Residential square footage heated by woodfuel	RECS
Number of employees in combustion unit manufacture	

[a]API = American Paper Institute; MECS = EIA Manufacturing Energy Consumption Survey; NBECS = EIA Nonresidential Buildings Energy Consumption Survey; NPPR = EIA Annual Nonutility Power Producer Report; PURPA-F = FERC filings under PURPA; RECS = EIA Residential Energy Consumption Survey; RRA = U.S.D.A. Forest Service Renewable Resources Assessment. Roman type means the source provides full information on the data item; italic type means the source provides only partial information on the data item.

Table 4.2. Sources of agricultural residues information (ranked by average respondent score)

Data Item	Information Sources[a]
Average cost of energy product ($/kWh, $/MMBtu)	MECS
Total quantity of energy produced (quads)	*NPPR*
Quantity of energy produced by type (electricity, steam, etc.)	NPPR
Number of facilities burning agricultural residues by residue type	*MECS*, *NPPR*, PURPA-F
Quantities of pollutants in air emissions	*NPPR*
Total quantities of agricultural residues available by type	
Sales price of energy product	
Quantity of residue burned by type	*MECS*
Quantity of energy produced by end-use	NPPR
Operating and maintenance costs by facility type	
Capital costs by facility type	
Location of facilities	
Capacity factor of plants	
Cost of disposal of excess waste at landfill	
Quantity of energy used to operate conversion equipment by type	
Numbers of units of equipment (combustors, digestors, etc.)	

[a]MECS = EIA Manufacturing Energy Consumption Survey; NPPR = EIA Annual Nonutility Power Producer Report; PURPA-F = FERC filings under PURPA. Roman type means the source provides information for all facilities on the data item; italic type means the source provides information for only some facilities on the data item.

woodfuels. In fact, the problem of sampling errors for agricultural residues in the MECS is likely to be even greater than for woodfuels.

As with woodfuels, the important information item of total generation capacity (MW) of nonutility power producers who burn agricultural residues was neglected in this study. This information is collected by the Nonutility Power Producer Report (EIA-867) and the FERC filing under PURPA.

If extra information on agricultural residue use for energy is desired, expanding the sampling frame of the MECS and more precisely defining a category for agricultural residues on the survey form may be one course to take.

4.2.1.3 Energy Crops

Almost no regularly collected energy crop data are available from government sources (Table 4.3). None of the most highly ranked items on biomass energy crop production are available. An estimate of the total amount of ethanol produced is available from the Federal Highway Administration. However, as already noted, this estimate suffers from underreporting.

To gather more accurate statistics on ethanol production, production capacity, and production costs, EIA could require reporting from the ethanol producers. These producers already have some form of data gathering capability, as their private estimate of 1989 production (EIA 1990) shows. Coordination in data gathering could be instituted through the ethanol producers industry association, the Renewable Fuels Association of Washington, D.C.

Table 4.3. Sources of energy crop information (ranked by average respondent score)

Data Item	Information Sources[a]
Total quantity of biomass produced	
Quantity of biomass produced by crop	*NASS/BOC*
Overall average cost of biomass produced ($/ton) by crop	*NASS/BOC*
Yields per acre by geographic area by crop	*NASS/BOC*
Land area in energy crops	*NASS/BOC*
Quantities of biomass feedstocks used	
Production capacity for fuel-grade ethanol (gal.)	
Number of ethanol facilities	
Quantities of energy crops combusted by type	
Production cost of ethanol ($/gal.)	
Quantity of ethanol produced	*FWHA*
Quantity of energy product (electricity, etc.) by type	
Quantity of energy crop combusted by type of energy product	
Quantity of electricity sold to grid	
Harvest costs by crop ($/ton)	*NASS/BOC*
Location of ethanol facilities	
Number of energy crop burning facilities	
Location of plantations	
Input costs (seed, land, etc.) by crop ($/ton)	*NASS/BOC*
Hauling costs by crop ($/ton-mile) by hauling distance category	*NASS/BOC*
Price of ethanol shipped ($/gal.)	
Location of energy crop burning facilities	
Quantities of pollutants in air emissions	
Land area for potential cultivation by current use	
Capital costs for energy products (electricity, etc.) from energy crops	
Capacity factor of ethanol plants	
Quantities of pollutants from ethanol facilities	
Quantity of ethanol blended with gasoline	
Capacity factor of energy crop electricity plants	
Production capacity for ethanol-gasoline blends (gal.)	
Capital costs for ethanol production facilities	
Number of energy crop plantations	
Operating and maintenance costs for ethanol production facilities	
Operating and maintenance costs for energy products	
Quantity of ethanol shipped	
Handling losses per acre by crop	
Number of employees for ethanol facilities	

[a]FHWA = Federal Highway Administration Monthly Motor Fuel Report by States. NASS/BOC = USDA National Agricultural Statistical Service/U.S. Bureau of the Census. Roman type means the source provides information for all facilities on the data item; italic type means the source provides information for only some facilities on the data item.

Only a small number of dedicated energy crop plantations exist to date. A new form asking the questions ranked highly in Tables 2.4 and 4.3 could be devised for these facilities. Energy crops that may be used either for fuel or other uses, e.g., corn, might look first to data collection efforts by the National Agricultural Statistics Service and the U.S. Bureau of the Census before new forms are devised.

Table 4.4. Sources of geothermal information (ranked by average respondent score)

Data Item	Information Sources[a]
Geothermal electricity installed capacities (MW)	FERC-1, GRC, *EIA-860*, *PURPA-F*
Average cost for direct-use heat ($/MMBtu)	
Average busbar cost of electricity ($/kWh)	*FERC-1*
Plans for additional capacity (MW)	GRC, *EIA-860*
Total direct heat production	
Reservoir thermal energy contents	
Capacity factor of electricity plants	FERC-1, *EIA-759*
Electricity production (kWh)	FERC-1, *EIA-759*
Estimated obtainable wellhead energy by type (elec. power, direct heat)	
Geothermal energy consumed for electricity	
Resource depletion rates	
Reservoir locations	
Capital costs for facilities by type (electric power, direct heat)	*FERC-1*
Direct heat prod, by end use (bldg. heat, process heat, hot water, etc.)	
Operating & maintenance costs by facility type (elec. power, dir. heat)	*FERC-1*
Location of facilities	*PURPA-F*
Number of wells by type (exploration, development, production)	
Geothermal direct heat consumed by sector (resid., comm., ind., agric.)	
Information on high temperature (>150°C) hydrothermal reservoirs	
Number of geothermal conversion facilities by type	*PURPA-F*
Reservoir volumes	
Numbers of plants using diff. disposal methods (reinjection, release, etc.)	
Private expenditures on exploration and resource definition	
Reservoir mean temperatures	
Reservoir depths	
Average cost per well by type (exploration, production)	
Private expenditures on development	
Well flow rates (kg/sec.)	
Cost per foot drilled	
Information on low temperature (>40°C) geothermal waters	
Well depths by type	
Reservoir brine salinities (ppm total dissolved solids)	
Expenditures for resource management (e.g., subsidence prevention)	
Amounts of wastewater released by various disposal methods	
Total footage drilled by type of well	
Information on igneous or magmatic geothermal systems	
Information on hot dry rock	
Information on geopressured reservoirs	
Number of employees by plant type (hydrothermal, geopressured, etc.)	

[a]EIA-759 = EIA Monthly Power Plant Report; EIA-860 = EIA Annual Electric Generator Report; FERC-1 = FERC Form 1; GRC = Geothermal Resources Council quinquennial survey on geothermal resources (*Geothermal Resources Council Bulletin*); PURPA-F = FERC filings under PURPA. Roman type means the source provides information for all facilities on the data item; italic type means the source provides information for only some facilities on the data item.

4.2.2 Geothermal Information

Table 4.4 indicates that many of the top-rated geothermal information items are partially or fully available from current sources. Information from the EIA Monthly Power Plant Report (EIA-759) and the EIA Annual Electric Generator Report (EIA-860) are marked as providing only partial information, because underreporting in the area of geothermal generators occurs. FERC Form 1 is marked as providing partial information on average busbar cost of electricity ($/kWh), because this form too addresses only geothermal power generated by major utilities. Elsewhere in Table 4.4, FERC Form 1 also is marked as providing only partial information, because this form provides information only on electricity generation; energy production in the form of geothermal direct heat is not considered. FERC filings under PURPA are marked as providing only partial information, because it is not clear from PURPA filings which plants are operating and which are not. The Geothermal Resources Council information, although complete, appears only once every five years.

The best approach to providing geothermal electricity production information might be two-pronged. First, a geothermal category on the Annual Nonutility Power Producers Report (EIA-867) needs to be better defined. This report is not found as a source of information anywhere in Table 4.4, because geothermal is classified in the "other" category on the current form. Secondly, efforts should be expended to acquire better geothermal coverage of major utilities through EIA forms 759 and 860. Cost information did not rank highly among geothermal experts. FERC Form 1 may currently be gathering adequate information from major utilities. Despite the moderate to low ranking of cost information for this study, if it is deemed advisable to gather further information from small producers, either an extension of the Annual Nonutility Power Producers Report to include costs or a new survey on costs could be undertaken.

A new survey would be necessary to gather information on direct heat applications of geothermal resources. Resource characteristics were not found in any present government statistics, although the U.S. Geological Survey may gather some such statistics.

4.2.3 Municipal Solid Waste Information

As Table 4.5 shows, information on municipal solid waste is fairly well represented, particularly by the private data collection efforts of Government Advisory Associates. Although the database maintained by DOE Waste Material Management Division's Don Walter covers many of the same data items, this database could not serve as a basis for EIA reported statistics. To our knowledge, Mr. Walter collects information from the "best available sources" and does not employ a formal survey as may be necessary for EIA to report statistics. The same is true of the database kept by Steve Levy of EPA. Partial information only is available from the EIA Annual Electric Generator Report (Form EIA-860), namely information from major utilities that use waste to generate electricity. PURPA filings give some indication of nonutility power production through waste incineration, but again they have the flaw that it is difficult to know whether a qualifying facility is actually generating power. Finally, the two data items available form the Institute of Resource Recovery are very incomplete, because such a small number of plants are represented.

EIA might (1) leave municipal solid waste information gathering to the private sector, since Government Advisory Associates (GAA) provides fairly comprehensive coverage, (2) contract with GAA to use and publish the information that GAA gathers, or (3) initiate its own survey form that would gather essential information independently. In any case, two MSW data items that GAA does not publish ranked highly among experts contacted for this report: quantities of air pollutants from MSW incineration and total MSW produced annually. If either option 2 or 3 is chosen, some arrangement should be made to include these items in data gathering efforts.

Table 4.5. Sources of municipal solid waste information (ranked by average respondent score)

Data Item	Information Sources[a]
Quantities of energy output (steam, heat, electricity, fuel, etc.)	GAA, DW, *SL*
Quantity of MSW consumed for energy	GAA, DW
Quantities of air pollutants (CO, SO_x, NO_x, CO_2, particulates, etc.)	
Total MSW produced per year	
Tipping fees ($/ton) by location	GAA, DW
Amount of materials recovered for recycling by type	GAA, DW
Number of facilities by type (mass-burn, RDF, landfill gas, etc.)	GAA, DW, *PURPA-F*
Output capacity by energy product (steam, elec., fuels, hot water, etc.)	GAA, DW, SL, *EIA-860*, PURPA-F, *IRR*
Average cost of energy product ($/kWh, $/MMBtu)	GAA, *DW*
Quantities of energy by end-use (district heat, process heat, sold, etc.)	
Capital costs by facility type	GAA, DW
Input capacity (tons) by type of waste	GAA, DW
Average cost of process ($/ton of MSW)	GAA, *DW*
Sales price of energy product	
Location of facilities	GAA, DW, SL, *PURPA-F*, IRR
Operating and maintenance costs by facility type	GAA, DW
Heat content of MSW (MMBtu/ton)	
Number of employees by type of facility	GAA

[a]DW = Don Walter's database (DOE Waste Material Management Division); EIA-860 = EIA Annual Electric Generator Report; GAA = Government Advisory Associates *Resource Recovery Yearbook: Directory and Guide*; IRR = Institute of Resource Recovery *Directory of Resource Reovery Projects and Services*; PURPA-F = FERC filings under PURPA; SL = Steven Levy's database (Environmental Protection Agency, Office of Solid Waste). Roman type means the source provides information for all facilities on the data item; italic type means the source provides information for only some facilities on the data item.

4.2.4 Solar Information

4.2.4.1 Active Solar

The availability of active solar information from current data sources is shown in Table 4.6. Several of the top data items are available from current sources. The Residential Energy Consumption Survey (RECS) and the Nonresidential Buildings Energy Consumption Survey (NBECS) provide information on the numbers of systems by use (hot water, space heat, pool heat, etc.) and could give geographic breakdowns of this information. The Annual Solar Thermal Collector Manufacturers Survey (Form CE-63A) also provides data on numbers of systems by use, but from the standpoint of the number manufactured and shipped. It also could provide information on the size of collectors manufactured and shipped and the location of installation, since the shipping state destination is included on the form.

Despite the fact that the top pieces of active solar information are apparently available, the quality of the data from current sources may not be satisfactory. The RECS and the NBECS may yield results for active solar systems with high sampling errors, because the number of solar systems found in the samples for these surveys is undoubtedly relatively small. Although information from the manufacturers survey is undoubtedly more accurate, the inference must be made that units manufactured and shipped are eventually installed in the uses that the manufacturers assume. Hence to get accurate information on installed systems and their costs, new surveying may be necessary.

Table 4.6. Sources of active solar information (ranked by average respondent score)

Data Item	Information Sources[a]
Numbers of systems by use (hot water, space heat, both, pool heat, etc.)	RECS, NBECS, CE-63A
Average cost of heat energy ($/MMBtu)	
Size (ft^2) of collectors	CE-63A
Geographic location of systems	RECS, NBECS, CE-63A
Average insolation levels (kWh/m^2) by geographic location	
System cost to installers by bldg type (single/multiple-fam., comml., ind.)	
Number of heat storage units installed	
System prices by building type	
Prices for heat-storage units by type	
Costs to installers for heat-storage units by type	

[a]CE-63A = Annual Solar Thermal Collector Manufacturers Survey; NBECS = EIA Nonresidential Buildings Energy Consumption Survey; RECS = EIA Residential Energy Consumption Survey. Roman type means the source provides full information on the data item; italic type means the source provides only partial information on the data item.

This could involve a simple expansion of the RECS and the NBECS to include a sampling stratum that concentrates on active solar systems in residences and commercial buildings. Alternatively, an independent survey might be undertaken. In any case, data users would be interested in a calculation of average heat energy ($/MMBtu). For active solar systems this task is difficult at best, because no fuel is burned, but data on volume of heated air and the amount of temperature rise (or heating degree-days) that the system provides would allow such a calculation.

4.2.4.2 Passive Solar

No data source reviewed for this study collected information on passive solar energy. Thus, no table comparable to others in this section is given for passive solar systems. The most important pieces of information for passive solar, number of new passive solar houses built by system type, the number of installations by system type, the number of installations by building type (single/multiple-family, commercial, industrial), and the cost of heat energy ($/MMBtu) by system type could be gathered by similar means to those suggested for active solar. Either the RECS and the NBECS could be expanded to include a passive solar sampling stratum or the new solar survey suggested in section 4.2.4.1 could include passive solar.

4.2.4.3 Photovoltaics

As Table 4.7 indicates, a number of solar photovoltaics information items are already gathered, particularly by the Annual Photovoltaic Module Manufacturers Survey (Form CE-63B). Items rated highly, including installed capacity (MW) and number of systems, are gathered or partially gathered by the EIA Annual Electric Generator Report (EIA-860), the EIA Monthly Power Plant Report (EIA-759), and the Annual Nonutility Power Producer Report (EIA-867). The number of systems is considered only partially gathered by EIA-860 and EIA-867 because these forms would not give the photovoltaic system type. Moreover, EIA-860 survey only major utilities, precious few if any of whom use photovoltaics. Nevertheless, highly rated items not collected currently include average installed cost of photovoltaics, the top-rated item, as well as battery costs and average insolation levels by location.

Table 4.7. Sources of photovoltaic information (ranked by average respondent score)

Data Item	Information Sources[a]
Average installed cost by photovoltaic type ($/watt)	
Installed capacity (MW) by geographic area	EIA-860, EIA-759
Number of systems by photovoltaic type	*EIA-860, NPPR*, CE-63B
Battery costs ($/kWh)	
Average insolation levels (kWh/m^2) by geographic location	
No. of systems by wattage category (e.g., ≤100 W, 100-1000 W, 1000 W+)	
Wattage shipped by end use (util, ind/comml, resid, consumer goods, etc.)	CE-63B
Manufacturing capital costs by photovoltaic type	
Geographic location of systems	EIA-860
Average manufacturing costs by photovoltaic type ($/watt)	CE-63B
Average cost of electricity by photovoltaic type ($/kWh)	
Wattage produced by photovoltaic type	CE-63B
Manufacturing operating and maintenance costs by photovoltaic type	
Efficiencies (% energy converted to electricity) by photovoltaic type	
Wattage imported by photovoltaic type by country	CE-63B, ITA
Manufacturing capacity by photovoltaic type	
Wattage shipped by photovoltaic type	CE-63B
Wattage exported by photovoltaic type by country	CE-63B
Installed capacity (m^2) by geographic area	
Value of shipments by photovoltaic type	CE-63B
Concentration ratios by photovoltaic type	
Number of employees in manufacturing by photovoltaic type	

[a]CE-63B = Annual Photovoltaic Module Manufacturers Survey; EIA-759 = EIA Monthly Power Plant Report; EIA-860 = EIA Annual Electric Generator Report; ITA = Dept. of Commerce, International Trade Administration, Office of Capital Goods import/export data; NPPR = EIA Annual Nonutility Power Producer Report. Roman type means the source provides full information on the data item; italic type means the source provides only partial information on the data item.

It should be noted that the Annual Nonutility Power Producers Report also collects several important items that were omitted from our poll of the experts, namely photovoltaic generation, generation delivered to the grid, and generation delivered to other users.

Given the current partial coverage of highly valued items by Forms EIA-759, EIA-860, and EIA-867, it appears logical to expand the coverage of these surveys by adding questions to them that will obtain the desired information and by including a large enough stratum of photovoltaic generators in the sample to get reliable statistics. The Annual Nonutility Power Producer Report (EIA-867) is the most plausible vehicle, since photovoltaic electricity generators are likely not to be major utilities. Battery costs would require an independent survey of battery manufacturers. Average insolation levels might be available from the U.S. Weather Service.

4.2.4.4 Solar Thermal

As with photovoltaics, Forms EIA-759 and EIA-860 provide information on some of the top-rated solar thermal data items (Table 4.8). These include amount of electricity generation, installed capacity, and location of systems. EIA-759 and EIA-860 are indicated as providing only partial information on the location of systems, because these forms would not give details on solar thermal

Table 4.8. Sources of solar thermal information (ranked by average respondent score)

Data Item	Information Sources[a]
Amount of electricity generation (kWh)	EIA-759
Installed electricity capacity (MW)	EIA-860, EIA-759
Electricity generation cost ($/kWh)	
Geographic location of systems	*EIA-860*, *EIA-759*, CE-63A
Number of systems by type (electric, process heat, residential heat)	*RECS*
Average insolation levels (kWh/m^2) by geographic location	
Amount of industrial process heat (MMBtu)	
Average cost of industrial process heat ($/MMBtu)	
Solar collectors imported by type by country	CE-63A
Installed cost by collector type	
Collectors shipped by end use (hot water, space heat, process heat, etc.)	CE-63A
Area (ft^2) of solar collectors produced by type	CE-63A
Solar thermal electric collector area (m^2) by geographic location	CE-63A
Manufacturing operating and maintenance costs by collector type	
Solar collectors exported by type by country	CE-63A, ITA
Number of solar collectors produced by type	
Collectors shipped by market sector (resid., comml., indust., util., other)	CE-63A
Manufacturing capital costs by collector type	
Amount of residential solar thermal heat (MMBtu)	
Residential solar thermal collector area (m^2) by geographic area	
Number of solar collectors shipped by type	
Total manufacturing costs by collector type	
Manufacturing capacities by collector type (low, medium, high temp.)	
Area (ft^2) of solar collectors shipped by type	CE-63A
Average cost of residential solar thermal heat ($/MMBtu)	
Value of shipments by collector type	CE-63A
Number of employees in manufacturing by collector type	

[a]CE-63A = Annual Solar Thermal Collector Manufacturers Survey; EIA-759 = EIA Monthly Power Plant Report; EIA-860 = EIA Annual Electric Generator Report; ITA = Dept. of Commerce, International Trade Administration, Office of Capital Goods import/export data; RECS = EIA Residential Energy Consumption Survey. Roman type means the source provides full information on the data item; italic type means the source provides only partial information on the data item.

steam systems and because they do not cover nonutility generators. To cover nonutility power producers, the Annual Nonutility Power Producers Report (EIA-867) should be altered to define a solar thermal category. The RECS would give the number of residential heat systems, but not on electric or process heat systems. Again, the RECS would yield a high sampling error on this piece of information. The Annual Solar Thermal Collector Manufacturers Survey (Form CE-63A) provides information on many items listed in Table 4.8, but they tend to be rated of only moderate or low importance.

The cost of electricity generation would require additional questions on the forms or perhaps an expansion of efforts under FERC Form 1. In order to get information on industrial solar thermal, which generally rated second in importance to electricity capacity and generation information, the MECS might be expanded. Such expansion would mean both the addition of questions to define more clearly a solar thermal category and the addition of a solar thermal sampling stratum.

Table 4.9. Sources of wind information (ranked by average respondent score)

Data Item	Information Sources[a]
Installed cost by machine size and type	
Operating and maintenance costs by machine size and type	
Electricity sold (kWh) to utilities	NPPR
Average cost of electricity ($/kWh)	
Electricity produced (kWh)	CEC, NPPR, *EIA-759*
Installed electricity generation capacity (MW)	CEC, NPPR, *EIA-860, EIA-759, PURPA-F*
Wind characteristics (speeds, directions, frequencies, densities, etc.)	
Manufacturing cost by machine size and type	
Capacity factor (availability) of installed systems by mach. size by location	CEC
Location of windfarms	CEC, *PURPA-F*
Number of units installed by machine size and type	CEC
Units imported by machine size by country of manufacture	*CEC*
Efficiency of wind turbines (%) by mach, size and type (horiz./vertical axis)	
Units exported by machine size by country of destination	
Cost of imports by machine size	
Number of units installed by usage (elec. gen., water pumping, etc.)	
Cost of exports by machine size	
Manufacturing capacity by machine size and type	
Number of units produced by machine size and type	
Number of units shipped by machine size and type	
Acreages occupied by wind farms	
Noise level (decibels) of wind machines	
Total value of machines sold	
Tower heights	
Number of employees in wind machine manufacture	

[a]CEC = California Energy Commission quarterly and annual reports; EIA-759 = EIA Monthly Power Plant Report; EIA-860 = EIA Annual Electric Generator Report; NPPR = EIA Annual Nonutility Power Producer Report; PURPA-F = FERC filings under PURPA. Roman type means the source provides full information on the data item; italic type means the source provides only partial information on the data item.

4.2.5 Wind Information

As Table 4.9 shows, several sources impart information on basic measures of wind energy capacity and generation. This information includes breakdowns by turbine size and type (horizontal and vertical axes). The information from the California Energy Commission, which covers 99% of the wind energy capacity in the United States, is the most comprehensive source of information of this type. The best federal source is the Annual Nonutility Power Producers Report (EIA-867), which also covers installed electricity generation capacity, generation, and electricity sold to utilities. The other federal sources, the EIA Monthly Power Plant Report (EIA-759) and the EIA Annual Electric Generator Report (EIA-860), are marked as *providing only limited information*, because these reports cover only electric utilities; these forms do not capture data on wind energy produced by small power producers, who produce the vast majority of wind power. The FERC filings under PURPA provide only partial information, because it is difficult to know from these filings which facilities are actually generating and which are not.

Between the information gathered by the California Energy Commission and the Annual Nonutility Power Producers Report, important information items on capacity and generation could be repackaged and reported by federal authorities.

Table 4.9 also shows, however, that the financial information that was highly ranked by wind experts for this study--including installed costs of equipment, O&M costs, and average costs of electricity ($/kWh)--are not collected by either the California Energy Commission or the Annual Nonutility Power Producers Report. Federal authorities cannot change the information gathered by the California survey, except through possible persuasion of California officials. Alternatives that might be used to gather cost information include alteration of the Annual Nonutility Power Producers Report to include questions on costs, extension of FERC Form 1 to nonutility power producers, or the introduction of a new, nonutility survey on costs.

4.3 CONCLUSION

As this chapter has shown, a number of renewable energy data items are collected, although often for reasons other than to produce renewable energy information. Therefore, to provide consistent, widely available renewable energy information, efforts are necessary to collate data gathered under present programs, to expand the samples of and questions contained in some current surveys, and to conduct new surveys where this is the most economical means.

APPENDIX A
RESPONDENTS PROVIDING OPINIONS ON RENEWABLE ENERGY DATA REQUIREMENTS

A.1 BIOMASS INFORMATION

Phillip C. Badger, TVA Southeastern Regional Biomass Energy Program, Muscle Shoals, Alabama
Jonathan Becker, Public Citizen's Critical Mass Energy Project, Washington, D.C.
Dave Bischel, Ultrapower Biomass Fuels Corp., Auburn, California
Dale Bradshaw, Tennessee Valley Authority, Chattanooga, Tennessee
Craig L. Chase, Biomass Energy Management/Support, Bellevue, Washington
Janet Cushman, Oak Ridge National Laboratory, Oak Ridge, Tennessee
Dave Dawson, Forest Policy Consultant, Rhinelinder, Wisconsin
Harold Draper, Tennessee Valley Authority, Norris, Tennessee
Jim Easterly, Meridian Corporation, Alexandria, Virginia
Brigette Ellis, TVA Forest Industry Program, Norris, Tennessee
John E. Ferrell, Biofuels Systems Division, U.S. Department of Energy, Washington, D.C.
John Fisher, Fiber Fuels Institute, Duluth, Minnesota
Sigmund Gronich, Solar Thermal and Biomass Power Division, U.S. Department of Energy, Washington, D.C.
Ed Hansen, USDA Forest Service, Grand Rapids, Minnesota
Lemar Harris, USDA Cooperative States Research Service, Washington, D.C.
Norm Hinman, Solar Energy Research Institute, Golden, Colorado
Dave Hudson, Solar Energy Research Institute, Golden, Colorado
Paul Hughes, National Wood Energy Association, Washington, D.C.
R.M. Jolley, Scott Paper Co., Mobile, Alabama
Jim Kerstetter, State Energy Office, Olympia, Washington
Fred Kuzel, Council of Great Lakes Governors, Midwest Regional Biomass Energy Program, Chicago, Illinois
Russell Lee, Oak Ridge National Laboratory, Oak Ridge, Tennessee
Nick Lenssen, World Watch Institute, Washington, D.C.
Gregg Marland, Oak Ridge National Laboratory, Oak Ridge, Tennessee
Dan Moran, Wisconsin Division of Energy, Madison, Wisconsin
Charles Mortensen, Natural Resources Department, Ball State University, Muncie, Indiana
O. P. Overend, Solar Energy Research Institute, Golden, Colorado
Jeffrey M. Peterson, New York State Energy Research and Development Authority, Albany, New York
Jack Ranney, Oak Ridge National Laboratory, Oak Ridge, Tennessee
Gary T. Satterfield, Wood Heating Alliance, Washington, D.C.
William Schroeer, Office of Policy Analysis, U.S. Environmental Protection Agency, Washington, D.C.
George Simons, California Energy Commission, Sacramento, California
Ken Skog, Forest Products Laboratory, U.S. Forest Service, Madison, Wisconsin
Nancy Sutley, National Independent Energy Producers, Washington, D.C.
Dave Swanson, Western Area Power Administration, Western Regional Biomass Energy Program, Golden, Colorado
Anthony Turhollow, Oak Ridge National Laboratory, Oak Ridge, Tennessee
Shaine Tyson, Solar Energy Research Institute, Golden, Colorado

Susan Williams, Investor Responsibility Research Center, Plainfield, New Hampshire
Lynn Wright, Oak Ridge National Laboratory, Oak Ridge, Tennessee

A.2 GEOTHERMAL INFORMATION

David Anderson, Geothermal Resources Council, Davis, California
Jonathan Becker, Public Citizen's Critical Mass Energy Project, Washington, D.C.
Gordon Bloomquist, Washington State Energy Office, Olympia, Washington
Richard H. Counihan, Staff, House Subcommittee on Energy and Power, Washington, D.C.
Harold Draper, Tennessee Valley Authority, Norris, Tennessee
James C. Dunn, Sandia National Laboratories, Albuquerque, New Mexico
Dan Entingh, Meridian Corporation, Alexandria, Virginia
Dave Hudson, Solar Energy Research Institute, Golden, Colorado
Alan Jelacic, Geothermal Division, U.S. Department of Energy, Washington, D.C.
Nick Lenssen, World Watch Institute, Washington, D.C.
Marcelo Lippmann, Lawrence Berkeley Laboratory, Berkeley, California
Ben Lunis, Idaho National Engineering Laboratory, Idaho Falls, Idaho
Marshall Reed, Geothermal Division, U.S. Department of Energy, Washington, D.C.
Mike Smith, California Energy Commission, Sacramento, California
Susan Williams, Investor Responsibility Research Center, Plainfield, New Hampshire

A.3 MUNICIPAL SOLID WASTE INFORMATION

Anonymous, Solar Energy Research Institute, Golden, Colorado
Phillip C. Badger, TVA Southeastern Regional Biomass Energy Program, Muscle Shoals, Alabama
Jonathan Becker, Public Citizen's Critical Mass Energy Project, Washington, D.C.
Frank Caponi, Solid Waste Management Department, Los Angeles County Sanitation District, Whittier, California
Richard H. Counihan, Staff, House Subcommittee on Energy and Power, Washington, D.C.
Randy Curlee, Oak Ridge National Laboratory, Oak Ridge, Tennessee
Harold Draper, Tennessee Valley Authority, Norris, Tennessee
Tom Fiesinger, New York State Energy Research and Development Authority, Albany, New York
John Fisher, Fiber Fuels Institute, Duluth, Minnesota
Marjorie Franklin, Franklin Associates, Prairie Village, Kansas
Martha Gildart, California Integrated Waste Management Board, Sacramento, California
Barbara Goodman, Solar Energy Research Institute, Golden, Colorado
Dave Hudson, Solar Energy Research Institute, Golden, Colorado
Peter J. Ince, Forest Products Laboratory, U.S. Forest Service, Madison, Wisconsin
Jim Kerstetter, State Energy Office, Olympia, Washington
John Kiser and Kent Burton, National Solid Wastes Management Association, Washington, D.C.
Steve Levy, Office of Solid Waste, Environmental Protection Agency, Washington, D.C.
Dan Moran, Wisconsin Division of Energy, Madison, Wisconsin
Ed Repa, National Solid Wastes Management Association, Washington, D.C.
George Simons, California Energy Commission, Sacramento, California
Nancy Sutley, National Independent Energy Producers, Washington, D.C.
Shaine Tyson, Solar Energy Research Institute, Golden, Colorado

Carl Wallace, Solar Energy Research Institute, Golden, Colorado
Don Walter, Waste Material Management Division, U.S. Department of Energy, Washington, D.C.
Kevin Williams, Solid Waste Management Division, Environmental Resources Department, Modesto, California
Susan Williams, Investor Responsibility Research Center, Plainfield, New Hampshire

A.4 SOLAR INFORMATION

Robert Annan, Office of Solar Energy Conversion, U.S. Department of Energy, Washington, D.C.
Jonathan Becker, Public Citizen's Critical Mass Energy Project, Washington, D.C.
Richard H. Counihan, Staff, House Subcommittee on Energy and Power, Washington, D.C.
Harold Draper, Tennessee Valley Authority, Norris, Tennessee
Ed Glenn, Florida Solar Energy Industries Association, Homestead, Florida
Sigmund Gronich, Solar Thermal and Biomass Power Division, U.S. Department of Energy, Washington, D.C.
Bim Gupta, Solar Energy Research Institute, Golden, Colorado
Lemar Harris, USDA Cooperative States Research Service, Washington, D.C.
Dave Hudson, Solar Energy Research Institute, Golden, Colorado
Mary-Margaret Jenior, Building Systems and Materials Division, U.S. Department of Energy, Washington, D.C.
Alec Jenkins, California Energy Commission, Sacramento, California
William R. King, Scientific Applications International Corp., Alexandria, Virginia
Hans Landsberg, Resources for the Future, Washington, D.C.
Nick Lenssen, World Watch Institute, Washington, D.C.
Bob Lorand, Scientific Applications International Corp., Alexandria, Virginia
Ken May, Industrial Solar Technology Corporation, Denver, Colorado
Dan Moran, Wisconsin Division of Energy, Madison, Wisconsin
Rick Sellers, Solar Energy Industries Association, Washington, D.C.
Walter Short, Solar Energy Research Institute, Golden, Colorado
Jack Stone, Solar Energy Research Institute, Golden, Colorado
Susan Williams, Investor Responsibility Research Center, Plainfield, New Hampshire

A.5 WIND INFORMATION

Jonathan Becker, Public Citizen's Critical Mass Energy Project, Washington, D.C.
Richard H. Counihan, Staff, House Subcommittee on Energy and Power, Washington, D.C.
Harold Draper, Tennessee Valley Authority, Norris, Tennessee
Tom Gray, Second Wind, Norwich, Vermont
Lemar Harris, USDA Cooperative States Research Service, Washington, D.C.
Susan Hock, Solar Energy Research Institute, Golden, Colorado
Dave Hudson, Solar Energy Research Institute, Golden, Colorado
Matt Hussey, U.S. Windpower, Inc., Livermore, California
Nick Lenssen, World Watch Institute, Washington, D.C.
John K. Leslie, Windland, Inc., Escondido, California
Barry Liebowitz, New York State Energy Research and Development Authority, Albany, New York
Dan Moran, Wisconsin Division of Energy, Madison, Wisconsin

Brian Parsons, Solar Energy Research Institute, Golden, Colorado
Sam Rashkin, California Energy Commission, Sacramento, California
Nancy Sutley, National Independent Energy Producers, Washington, D.C.
Carl Wallace, Solar Energy Research Institute, Golden, Colorado
Susan Williams, Investor Responsibility Research Center, Plainfield, New Hampshire

APPENDIX B
RENEWABLE ENERGY DATA REQUIREMENTS
INFORMATION LISTS

RENEWABLE ENERGY DATA REQUIREMENTS STUDY
OAK RIDGE NATIONAL LABORATORY

Biomass Survey

Part 1. Please rate the importance to you of regularly collecting information on each item in the following list. Check the box in the appropriate column on a scale of 1 (lowest) to 5 (highest) to rate the importance of each information item.

If having *historical* renewable energy data is important to you, please also check the box(es) to indicate whether a data item would be used for projections, other purposes, or for both. If you are not interested in historical series, please leave the final two columns blank.

Leave blank items or sections for which you have no opinion or which you are not qualified to answer.

INFORMATION ITEM	Importance Rating Low				High	Historical Series Valuable for:	
	1	2	3	4	5	Projections	Other
Biomass – Woodfuels							
Area of commercial forest							
Percent of commercial forest land forested							
Area of commercial forest land by site class (growth of 20-50, 50-85, 85-120, 120+ ft^3/acre)							
Forest biomass inventory (standing stock) by tree type (hardwood, softwood) by quality (merchantable trees, cull trees, understory/small trees)							
Net growth in commercial forest							
Potential annual energy wood by source (logging residues, cull trees, tree mortality, land clearing, urban tree removals, urban waste, etc.)							
Stumpage costs for woodfuel ($/ton)							
Harvest costs for woodfuel ($/ton)							
Hauling costs for woodfuel ($/ton-mile) by hauling distance category							
Total quantity of woodfuel consumed (all sectors)							
Number of industrial wood-burning facilities							
Location of facilities							
Quantity of industrial woodfuel consumed							
Quantity of woodfuel consumed, categorized by industry (paper & allied prods., lumber and wood prods., furniture mfg., electric power production, etc.)							

INFORMATION ITEM	Importance Rating Low				High	Historical Series Valuable for:	
	1	2	3	4	5	Projec-tions	Other
Quantity of industrial woodfuel consumed by type (pellets, briquettes, chips, residue, sawdust, bark, hogged fuel, energy crop feedstock)							
Quantity of wood consumed by type of energy product (electricity, steam, direct heat, etc.)							
Quantity of energy product by type (electricity, steam, direct heat, etc.)							
Quantity of electricity sold to grid							
Capital costs for wood-fired energy products (electricity, steam, direct heat, etc.)							
Operating and maintenance costs for wood-fired energy products (electricity, steam, direct heat, etc.)							
Cost of industrial woodfuel by type							
Capacity factor of wood-fired electricity plants							
Quantities of pollutants in air emissions (CO, SO_x, NO_x, CO_2, particulates, etc.)							
Number of residences burning woodfuel							
Quantity of woodfuel consumed in residences							
Quantity of woodfuel burned in residences by geographic region							
Quantity of woodfuel consumed in residences by end use (space heating, water heating, cooking, etc.)							
Percentage of residential space heating needs met by woodfuel							
Residential square footage heated by woodfuel							
Percentage of residential woodfuel purchased							
Price of purchased residential woodfuel							
Quantity of woodfuel consumed in commercial buildings							
Quantity of woodfuel burned in commercial buildings by type (firewood, wood pellets, wood briquettes, wood chips, etc.)							
Quantity of woodfuel burned in commercial buildings by geographic region							
Quantity of woodfuel burned in commercial buildings by end use (space heating, water heating, cooking, etc.)							
Commercial square footage heated by woodfuel							

INFORMATION ITEM	Importance Rating Low				High	Historical Series Valuable for:	
	1	2	3	4	5	Projec-tions	Other
Price of woodfuel burned in commercial buildings by type (firewood, wood pellets, wood briquettes, wood chips, etc.)							
Manufacturing capacity of combustion units by type (air-tight wood stoves, nonair-tight wood stoves, fireplace inserts, wood-fired industrial boilers, wood-fired electric utility boilers, etc.)							
Number of industrial/utility combustion units manufactured by type							
Number of residential/commercial combustion units manufactured by type							
Number of employees in combustion unit manufacture							
Manufacturing cost of combustion units							
Installed cost of combustion units							
Total sales of combustion units by type							
Other information (specify):							
Biomass – Agricultural Residues							
Total quantities of agricultural residues available by type (rice wheat, corn, or sorghum residues, food processing wastes, manures, etc.)							
Number of facilities burning agricultural residues by residue type							
Location of facilities							
Numbers of units of equipment (combustors, digestors, etc.)							
Quantity of residue burned by type							
Total quantity of energy produced (quads)							
Quantity of energy produced by type (steam, heat, electricity, fuel, etc.)							
Quantity of energy produced by end-use (on-site use, district heat, industrial process heat, sold to grid, gas to pipeline, etc.)							
Quantity of energy used to operate conversion equipment by type (steam, electricity, fuel, etc.)							

INFORMATION ITEM	Importance Rating Low 1	2	3	4	High 5	Historical Series Valuable for: Projections	Other
Capacity factor of plants							
Capital costs by facility type							
Operating and maintenance costs by facility type							
Average cost of energy product ($/kWh, $/MMBtu)							
Sales price of energy product							
Cost of disposal of excess waste at landfill							
Quantities of pollutants in air emissions (CO, SO_x, NO_x, CO_2, particulates, etc.)							
Other information (specify):							
Biomass – Energy Crops							
Land area for potential cultivation by current use							
Land area in energy crops							
Number of energy crop plantations							
Location of plantations							
Total quantity of biomass produced							
Quantity of biomass produced by crop (corn, sorghum, other herbaceous crop, hardwood trees, softwood trees, etc.)							
Input costs (seed, land, etc.) by crop ($/ton)							
Harvest costs by crop ($/ton)							
Hauling costs by crop ($/ton-mile) by hauling distance category							
Overall average cost of biomass produced ($/ton) by crop							
Yields per acre by geographic area by crop							
Handling losses per acre by crop							
Number of ethanol facilities							
Location of ethanol facilities							
Production capacity for fuel-grade ethanol (gal.)							

INFORMATION ITEM	Importance Rating Low				High	Historical Series Valuable for:	
	1	2	3	4	5	Projec-tions	Other
Production capacity for ethanol-gasoline blends (gal.)							
Quantities of biomass feedstocks used							
Number of employees for ethanol facilities							
Quantity of ethanol produced							
Quantity of ethanol shipped							
Quantity of ethanol blended with gasoline							
Capacity factor of ethanol plants							
Capital costs for ethanol production facilities							
Operating and maintenance costs for ethanol production facilities							
Production cost of ethanol ($/gal.)							
Price of ethanol shipped ($/gal.)							
Quantities of pollutants in air and water emissions from ethanol facilities							
Number of energy crop burning facilities							
Location of energy-crop burning facilities							
Quantities of energy crops combusted by type							
Quantity of energy crop combusted by type of energy product (electricity, steam, direct heat, etc.)							
Quantity of energy product (electricity, steam, direct heat) by type							
Quantity of electricity sold to grid							
Capital costs for energy products (electricity, steam, direct heat, etc.) from energy crops							
Operating and maintenance costs for energy products (electricity, steam, direct heat, etc.) from energy crops							
Capacity factor of energy crop electricity plants							
Quantities of pollutants in air emissions (CO, SO_x, NO_x, CO_2, particulates, etc.)							
Other information (specify):							

INFORMATION ITEM	Importance Rating Low				High	Historical Series Valuable for:	
	1	2	3	4	5	Projec-tions	Other
Other information (specify):							

Part 2.

2.1. In general, what level of geographic aggregation do you require for the above information items? Please enter the most aggregate level with which you would be satisfied. ("National" is the greatest level of aggregation.)

☐ National ☐ Regional (Multi-state) ☐ State ☐ County

2.2. Some of the information in the preceding table could be inferred by surveying manufacturers of equipment or by surveying users of the equipment (e.g., number of industrial wood-burning facilities). In such cases, is it sufficient to survey the manufacturers or do you require information from the users?

☐ Survey of manufacturers sufficient ☐ Survey of users desired

2.3. If you have indicated that you make projections or use historical series of renewable energy data for other reasons and you would like to provide extra explanation of your needs, please do so here:

____

____

____

____

2.4. Do you have any further suggestions about the collection of renewable energy data of the type found in Part 1?

____

____

____

____

2.5. Optional:

Respondent name ________________________________

Organization ________________________________

Address ________________________________

Phone No. ________________________________

Fax No. ________________________________

Thank you.

Please return this form to:

Glenn G. Stevenson
Oak Ridge National Laboratory
Bldg. 4500N, MS 6205
Oak Ridge, TN 37831

Telephone: (615) 576-5585
FTS: 626-5585
Fax: (615) 574-8884

RENEWABLE ENERGY DATA REQUIREMENTS STUDY
OAK RIDGE NATIONAL LABORATORY

Geothermal Survey

Part 1. Please rate the importance to you of regularly collecting information on each item in the following list. Check the box in the appropriate column on a scale of 1 (lowest) to 5 (highest) to rate the importance of each information item.

If having *historical* renewable energy data is important to you, please also check the box(es) to indicate whether a data item would be used for projections, other purposes, or for both. If you are not interested in historical series, please leave the final two columns blank.

Leave blank items or sections for which you have no opinion or which you are not qualified to answer.

INFORMATION ITEM	Importance Rating Low				High	Historical Series Valuable for:	
	1	2	3	4	5	Projections	Other
Geothermal							
Information on high temperature (>150°C) hydrothermal (vapor or water dominated) reservoirs							
Information on low temperature (>40°C) geothermal waters							
Information on geopressured reservoirs							
Information on hot dry rock							
Information on igneous or magmatic geothermal systems							
Reservoir locations							
Reservoir depths							
Reservoir mean temperatures							
Reservoir volumes							
Reservoir thermal energy contents							
Reservoir brine salinities (ppm total dissolved solids)							
Estimated obtainable wellhead energy by type (electric power, direct heat)							
Number of geothermal conversion facilities by type							
Location of facilities							
Number of wells by type (exploration, development, production)							
Well depths by type							
Well flow rates (kg/sec.)							

INFORMATION ITEM	Importance Rating Low				High	Historical Series Valuable for:	
	1	2	3	4	5	Projec- tions	Other
Total footage drilled by type of well							
Resource depletion rates							
Number of employees by plant type (hydrothermal, geopressured, hot dry rock)							
Geothermal electricity installed capacities (MW)							
Geothermal energy consumed for electricity							
Electricity production (kWh)							
Capacity factor of electricity plants							
Plans for additional capacity (MW)							
Total direct heat production							
Direct heat production by end use (building heat, process heat, residential or commercial hot water, etc.)							
Geothermal direct heat consumed by sector (residential, commercial, industrial, agricultural)							
Private expenditures on exploration and resource definition							
Private expenditures on development							
Average cost per well by type (exploration, production)							
Cost per foot drilled							
Capital costs for facilities by type (electric power, direct heat)							
Operating and maintenance costs for facilities by type (electric power, direct heat)							
Average busbar cost of electricity ($/kWh)							
Average cost for direct-use heat ($/MMBtu)							
Numbers of plants using various disposal methods by method (reinjection, selective reinjection, waterway release, other)							
Amounts of wastewater released by various disposal methods							
Expenditures for resource management (e.g., subsidence prevention)							
Other information (specify):							

INFORMATION ITEM	Importance Rating Low				High	Historical Series Valuable for:	
	1	2	3	4	5	Projec- tions	Other
Other information (specify):							

Part 2.

2.1. In general, what level of geographic aggregation do you require for the above information items? Please enter the most aggregate level with which you would be satisfied. ("National" is the most aggregate level.)

☐ National ☐ Regional (Multi-state) ☐ State ☐ County

2.2. Some of the information in the preceding table could be inferred by surveying manufacturers of equipment or by surveying users of the equipment (e.g., number of facilities by type). In such cases, is it sufficient to survey the manufacturers or do you require information from the users?

☐ Survey of manufacturers sufficient ☐ Survey of users desired

2.3. If you have indicated that you make projections or use historical series of renewable energy data for other reasons and you would like to provide extra explanation of your needs, please do so here:

____

____

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2.4. Do you have any further suggestions about the collection of renewable energy data of the type found in Part 1?

____

____

____

____

2.5. Optional:

Respondent name ______________________________

Organization ______________________________

Address ______________________________

Phone No. ______________________________

Fax No. ______________________________

Thank you.

Please return this form to:

Glenn G. Stevenson
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Oak Ridge, TN 37831

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Fax: (615) 574-8884

RENEWABLE ENERGY DATA REQUIREMENTS STUDY
OAK RIDGE NATIONAL LABORATORY

Municipal Solid Waste Survey

Part 1. Please rate the importance to you of regularly collecting information on each item in the following list. Check the box in the appropriate column on a scale of 1 (lowest) to 5 (highest) to rate the importance of each information item.

If having *historical* renewable energy data is important to you, please also check the box(es) to indicate whether a data item would be used for projections, other purposes, or for both. If you are not interested in historical series, please leave the final two columns blank.

Leave blank items or sections for which you have no opinion or which you are not qualified to answer.

INFORMATION ITEM	Importance Rating Low				High	Historical Series Valuable for:	
	1	2	3	4	5	Projections	Other
Municipal Solid Waste (MSW)							
Total MSW produced per year							
Heat content of MSW (MMBtu/ton)							
Number of facilities by type (mass-burn incinerator, refuse derived fuel facility, dedicated RDF steam or electricity, RDF-coal/fuel-oil cofired facility, sewage digestor, land-fill gas, LFG upgrading, etc.)							
Location of facilities							
Input capacity (tons) by type of waste							
Quantity of MSW consumed for energy							
Number of employees by type of facility							
Output capacity by energy product (steam, electricity, fuels, hot water, dry heat, other)							
Quantities of energy output (steam, heat, electricity, fuel, etc.)							
Quantities of energy product by end-use (on-site use, district heat, industrial process heat, sold to grid, gas to pipeline, etc.)							
Capital costs by facility type							
Operating and maintenance costs by facility type							
Tipping fees ($/ton) by location							
Average cost of process ($/ton of MSW)							
Average cost of energy product ($/kWh, $/MMBtu)							

INFORMATION ITEM	Importance Rating Low				High	Historical Series Valuable for:	
	1	2	3	4	5	Projec-tions	Other
Sales price of energy product							
Amount of materials recovered for recycling by type							
Quantities of pollutants in air emissions (CO, SO_x, NO_x, CO_2, particulates, methane, hydrogen sulfide, etc.)							
Other information (specify):							

Part 2.

2.1. In general, what level of geographic aggregation do you require for the above information items? Please enter the most aggregate level with which you would be satisfied. ("National" is the most aggregate level.)

☐ National ☐ Regional (Multi-state) ☐ State ☐ County

2.2. Some of the information in the preceding table could be inferred by surveying manufacturers of equipment or by surveying users of the equipment (e.g., number of facilities by type). In such cases, is it sufficient to survey the manufacturers or do you require information from the users?

☐ Survey of manufacturers sufficient ☐ Survey of users desired

2.3. If you have indicated that you make projections or use historical series of renewable energy data for other reasons and you would like to provide extra explanation of your needs, please do so here:

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2.4. Do you have any further suggestions about the collection of renewable energy data of the type found in Part 1?

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____

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____

2.5. Optional:

Respondent name ____

Organization ____

Address ____

Phone No. ____

Fax No. ____

Thank you.

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RENEWABLE ENERGY DATA REQUIREMENTS STUDY
OAK RIDGE NATIONAL LABORATORY

Solar Survey

Part 1. Please rate the importance to you of regularly collecting information on each item in the following list. Check the box in the appropriate column on a scale of 1 (lowest) to 5 (highest) to rate the importance of each information item.

If having *historical* renewable energy data is important to you, please also check the box(es) to indicate whether a data item would be used for projections, other purposes, or for both. If you are not interested in historical series, please leave the final two columns blank.

Leave blank items or sections for which you have no opinion or which you are not qualified to answer.

INFORMATION ITEM	Importance Rating Low				High	Historical Series Valuable for:	
	1	2	3	4	5	Projections	Other
Solar – Active Systems							
Average insolation levels (kWh/m^2) by geographic location							
Numbers of systems by use (hot water only, space heat only, hot water and space heat, pool heat, etc.)							
Geographic location of systems							
Size (sq. ft.) of collectors							
Number of heat storage units installed							
System costs to installers by building type (single-family dwelling, multiple-family dwelling, commercial, industrial)							
System prices by building type							
Costs to installers for heat-storage units by type							
Prices for heat-storage units by type							
Average cost of heat energy ($/MMBtu)							
Other information (specify):							

INFORMATION ITEM	Importance Rating Low				High	Historical Series Valuable for:	
	1	2	3	4	5	Projec-tions	Other
Solar – Passive Systems							
Average insolation levels (kWh/m^2) by geographic location							
% south glazing ratio by region							
Annual building heat loads by building type (single-family dwelling, multiple-family dwelling, commercial, industrial)							
Building floor space (ft^2)							
Number of installations by system type (direct-gain, indirect-gain, retrofit, etc.)							
Number of installations by building type (single-family dwelling, multiple-family dwelling, commercial, industrial)							
Number of new passive solar houses built by system type							
Geographic location of installations							
Costs to installers of new systems by system type							
Costs to customers of new systems by system type							
Cost to installers of passive solar retrofit by system type							
Cost to customer of passive solar retrofit by system type							
Cost of heat energy ($/MMBtu) by system type							
Other information (specify):							
Solar – Photovoltaics							
Average insolation levels (kWh/m^2) by geographic location							
Number of systems by photovoltaic type (Flat plate: single crystal, poly-crystal, or ribbon S_i; tracking or nontracking. Concentrating: point-focus or line-focus fresnel, point-focus or line-focus reflective; tracking or nontracking; active or passive cooling. Thin film: G_aA_s multijunction or amorphous S_i)							
Number of systems by wattage category (e.g. ≤100 W, 100-1000 W, 1000 W+)							

INFORMATION ITEM	Importance Rating Low				High	Historical Series Valuable for:	
	1	2	3	4	5	Projec-tions	Other
Geographic location of systems							
Installed capacity (MW) by geographic area							
Installed capacity (sq. meters) by geographic area							
Concentration ratios by photovoltaic type							
Efficiencies (% energy converted to electricity) by photovoltaic type							
Manufacturing capacity by photovoltaic type							
Number of employees in manufacturing by photovoltaic type							
Wattage produced by photovoltaic type							
Wattage shipped by photovoltaic type							
Wattage shipped by end use (utility, industrial/commercial, residential, military, consumer goods, communication, transportation, water pumping, space applications, other)							
Wattage imported by photovoltaic type by country							
Wattage exported by photovoltaic type by country							
Manufacturing capital costs by photovoltaic type							
Manufacturing operating and maintenance costs by photovoltaic type							
Average manufacturing costs by photovoltaic type ($/watt)							
Value of shipments by photovoltaic type							
Average installed cost by photovoltaic type ($/watt)							
Average cost of electricity by photovoltaic type ($/kWh)							
Battery costs ($/kWh)							
Other information (specify):							

INFORMATION ITEM	Importance Rating Low				High	Historical Series Valuable for:	
	1	2	3	4	5	Projec-tions	Other
Solar – Thermal							
Average insolation levels (kWh/m^2) by geographic location							
Number of systems by type (electric, process heat, residential heat)							
Geographic location of systems							
Installed electricity capacity (MW)							
Amount of electricity generation (kWh)							
Electricity generation cost ($/kWh)							
Solar thermal electric collector area (m^2) by geographic location							
Amount of industrial process heat (MMBtu)							
Average cost of industrial process heat ($/MMBtu)							
Residential solar thermal collector area (m^2) by geographic area							
Amount of residential solar thermal heat (MMBtu)							
Average cost of residential solar thermal heat ($/MMBtu)							
Solar collector manufacturing capacities by collector type (low temperature, medium temperature, high temperature)							
Number of employees in manufacturing by collector type							
Number of solar collectors produced by type							
Area (sq. feet) of solar collectors produced by type							
Number of solar collectors shipped by type							
Area (sq. feet) of solar collectors shipped by type							
Solar collectors shipped by market sector (residential, commercial, industrial, utility, other)							
Solar collectors shipped by end use (hot water, space heating, combined space and water heating, pool heating, space cooling, process heating, electricity generation, other)							
Solar collectors imported by type by country							
Solar collectors exported by type by country							
Manufacturing capital costs by collector type							
Manufacturing operating and maintenance costs by collector type							

INFORMATION ITEM	Importance Rating Low				High	Historical Series Valuable for:	
	1	2	3	4	5	Projec-tions	Other
Total manufacturing costs by collector type							
Value of shipments by collector type							
Installed cost by collector type							
Other information (specify):							

Part 2.

2.1. In general, what level of geographic aggregation do you require for the above information items? Please enter the most aggregate level with which you would be satisfied. ("National" is the most aggregate level.)

☐ National ☐ Regional (Multi-state) ☐ State ☐ County

2.2. Some of the information in the preceding table could be inferred by surveying manufacturers of equipment or by surveying users of the equipment (e.g., number of installations by system type). In such cases, is it sufficient to survey the manufacturers or do you require information from the users?

☐ Survey of manufacturers sufficient ☐ Survey of users desired

2.3. If you have indicated that you make projections or use historical series of renewable energy data for other reasons and you would like to provide extra explanation of your needs, please do so here:

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2.4. Do you have any further suggestions about the collection of renewable energy data of the type found in Part 1?

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2.5. Optional:

Respondent name ______________________________

Organization ______________________________

Address ______________________________

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Thank you.

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RENEWABLE ENERGY DATA REQUIREMENTS STUDY
OAK RIDGE NATIONAL LABORATORY

Wind Survey

Part 1. Please rate the importance to you of regularly collecting information on each item in the following list. Check the box in the appropriate column on a scale of 1 (lowest) to 5 (highest) to rate the importance of each information item.

If having *historical* renewable energy data is important to you, please also check the box(es) to indicate whether a data item would be used for projections, other purposes, or for both. If you are not interested in historical series, please leave the final two columns blank.

Leave blank items or sections for which you have no opinion or which you are not qualified to answer.

INFORMATION ITEM	Importance Rating Low				High	Historical Series Valuable for:	
	1	2	3	4	5	Projec-tions	Other
Wind Energy							
Wind characteristics (speeds, directions, frequencies, densities, power classes, land areas by wind power class; land areas by wind density)							
Acreages occupied by wind farms							
Location of windfarms							
Tower heights							
Efficiency of wind turbines (%) by machine size and type (horizontal, vertical axis)							
Installed electricity generation capacity (MW)							
Electricity produced (kWh)							
Electricity sold (kWh) to utilities							
Average cost of electricity ($/kWh)							
Capacity factor (availability) of installed systems by machine size by location							
Manufacturing capacity by machine size and type							
Number of employees in wind machine manufacture							
Number of units produced by machine size and type							
Number of units shipped by machine size and type							
Number of units installed by machine size and type							

INFORMATION ITEM	Importance Rating Low				High	Historical Series Valuable for:	
	1	2	3	4	5	Projec-tions	Other
Number of units installed by usage (electricity generation, water pumping, etc.)							
Units imported by machine size by country of manufacture							
Units exported by machine size by country of destination							
Manufacturing cost by machine size and type							
Installed cost by machine size and type							
Operating and maintenance costs by machine size and type							
Total value of machines sold							
Cost of imports by machine size							
Cost of exports by machine size							
Noise level (decibels) of wind machines							
Other information (specify):							

Part 2.

2.1. In general, what level of geographic aggregation do you require for the above information items? Please enter the most aggregate level with which you would be satisfied. ("National" is the most aggregate level.)

☐ National ☐ Regional (Multi-state) ☐ State ☐ County

2.2. Some of the information in the preceding table could be inferred by surveying manufacturers of equipment or by surveying users of the equipment (e.g., installed electricity generation capacity). In such cases, is it sufficient to survey the manufacturers or do you require information from the users?

☐ Survey of manufacturers sufficient ☐ Survey of users desired

2.3. If you have indicated that you make projections or use historical series of renewable energy data for other reasons and you would like to provide extra explanation of your needs, please do so here:

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2.4. Do you have any further suggestions about the collection of renewable energy data of the type found in Part 1?

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Respondent name ______________________________

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APPENDIX C
OTHER INFORMATION DESIRED BY RESPONDENTS

Unless otherwise noted, each item was given by one respondent.

C.1 WOODFUELS

Quantity of woodfuel burned in commercial buildings by category (schools, hospitals, prisons, etc.)
Capacities of boilers or burners in Btu/hr (a check on wood quantity or used to derive wood quantity)
Moisture content and/or combustion heat (Btu/lb) of woodfuel burned by type (2 respondents)
Biomass boiler type (fixed bed, fluidized bed, gasifier, etc.)
Wood residue produced and disposition by secondary wood processing plants (e.g., furniture production)
Add esthetic use to residential woodfuel end use categories [data item No. 27] (2 respondents)
Price of purchased residential woodfuel by type of commodity and by location
Ash (fly/bottom ash) uses/disposal
Cofiring of wood/other fuels
Number of industrial facilities not burning wood but could

C.2 AGRICULTURAL RESIDUES

Number of facilities burning agricultural residues by residue type and by location
Residue collection and handling costs by residue type
Capacity [of boilers] in Btu/hr or other unit
Moisture content and/or combustion heat of residue burned by type (2 respondents)
Cofiring direct combustion/other

C.3 ENERGY CROPS

Type of biomass feedstocks and biomass-fossil fuel mixtures used in ethanol production (2 respondents)
Quantity of ethanol blended with gasoline in states with no tax credits (of which the Federal Highway Administration keeps no records)
Fuel-grade ethanol imports to the U.S. (gals.) (2 respondents)
Quantity of ethanol exported
Biomass conversion equipment exported (no. of boilers, etc.)
Ethanol facility type (wet milling vs. dry milling) (2 respondents)
Quantities of ethanol co-products/by-products (e.g., distillers dry grain)
Sales value of ethanol co-products/by-products (e.g., distillers dry grain)
Handling and storage costs ($/ton) by crops
Overall average cost of biomass produced ($/MMBtu) by crop
Cofiring applications/opportunities
Number of facilities, location of facilities, and production capacity for fuel grade methanol
Regional consumption of ethanol

C.4 GEOTHERMAL

Information on groundwater heat pumps (2 respondents)
Well diameters in reservoirs
Reservoir permeability (matrix; fracture) (2 respondents)
Energy conversion type (single-flash, double flash, binary, other)
Make-up water consumption rate (kg/sec)
Reservoir noncondensible gases
Reservoir thickness
Electricity plants availability factor
Average cost per injection well (in addition to per exploration and per production well)

C.5 MUNICIPAL SOLID WASTE

Information on ash disposal (tons; cost; haul distance; potential treatment, test requirements) (5 respondents)
Sales prices of recyclable materials by type (glass, aluminum, etc.)
Ash disposal environmental impacts
Occupational health related measures (worker injuries, illness, and accidents; blood, urine, and hearing test results; process emissions and noise)
Quantities of pollutants in air emissions for all energy and material recovery facilities, not just combustors
Amount of materials composted
Information on nonhazardous industrial waste
Landfill capacities by location
Types of air pollution control technology used at each facility (grouped by pollutant type)
Listing of types of combustion technology at each facility by vendor/supplier (as well as the generic name of technology)
Technical problems encountered at each facility
Year of initial operation
Information on materials recovery/source separation programs (curb side or central collection, quantity of waste by type, markets and market prices, location, year started)

C.6 ACTIVE SOLAR

Total energy collected (Btu) by state or region (2 respondents)
Installed cost of collectors (rather than price of collectors) (2 respondents)
Cooling systems information
Number of systems in use vs. number installed (3 respondents)
Number of service calls per year
Average months/year system is down for service
Average cost per service call
Tax credits claimed
System costs to homeowners or building owners
Number of systems by building type (2 respondents)

Wind speed, wind direction, and ambient temperature (in addition to insolation)
Number of systems reparable and made operational
User satisfaction
Number of systems by installation date, and by location
Size of collectors (sq. feet) by end use and location
Average cost of heat energy ($/MMBtu) by location, system type, and building type
Performance of existing systems (MMBtu/m^2) by location, system type, age
Age of structure on which system installed
Breakdown by building type of data collected on commercial buildings

C.7 PASSIVE SOLAR

Total energy savings estimated
Total energy provided (Btu), by state or region
Annual building cooling loads by building type (single-family, multiple-family, commercial, industrial)
Total and auxiliary building heating and cooling loads by building type
Natural ventilation cooling information (whole house fans, paddle fans, night flushing)
Tax credits claimed
Size of south facing aperatures (windows) (in sq. feet) by building type
Costs of systems by building type
User satisfaction
% south glazing ratio (% of wall area, % of floor area) by region, building type, system type, and age
Breakdown by building type of data collected on commercial buildings
Number of installations by system type, location and age
Distinguish building floor space (ft.^{2}) between perimeter and core for commercial buildings
Number of new passive solar houses built by system type, date, and location
Cost of heat energy ($/MMBtu) by system type, location, and building type
Average % south glazing ration (wall, floor) of all existing buildings by year of construction

C.8 PHOTOVOLTAICS

Total annual estimated generation (kWh) by state or region (2 respondents)
Add agricultural applications as an end use to "Wattage shipped by end use"
Tax credits claimed
Installed system O&M ($/kW/yr or $/kWh)
System replacement costs ($/kW)
Wattage produced by size of modules and of arrays

C.9 SOLAR THERMAL

Tax credits claimed
Number of systems in use vs. number installed
Number of service calls/year
Average months/year system is down for service
Average cost/service call

Wind speed, wind direction, and ambient temperature (in addition to insolation)
Performance ratings
Stand alone or part of OEM
Supplier type (OEM, turnkey, components, etc.)
Amount of electricity generation (kWh) by installation
Amount of industrial process heat (MMBtu/m^2)
Average cost of industrial process heat ($/MMBtu) by system type and load application
Remaining IPH systems

C.10 WIND

Efficiency data in the form (kWh/m^2)/(W/m^2)
Utilities' "avoided cost" of electricity
Five to ten year projections of utilities' "avoided cost" of electricity
Electricity produced by machine type and size
Transmission efficiency from wind turbine to utility grid
Operating costs as a % of gross revenues from electricity sales to utility, by machine type and size
Downtime (hrs) by subsystem
Capacity of installed, on-site systems
Cost of small (<20kw) wind turbines
Efficiency of small (<20kw) wind turbines
Characterization of industry (types and sizes of manufacturers, developers, operators)
Value to the utilities (what are they paying?) (2 respondents)
Value to remote applications
Transmission access and costs
Regulation/land use impacts (tough to quantify)

APPENDIX D
ANSWERS TO OPEN-ENDED QUESTIONS

D.1 USE OF DATA FOR PROJECTIONS/OTHER USES (QUESTION 2.3)

D.1.1 Biomass

To estimate the effect of past government policies on biomass development.

To estimate economic impacts of biomass development.

To provide technical assistance/input to national (DOE) biomass energy R&D programs.

For annual publication of "Wisconsin Energy Statistics," which currently lacks up-to-date data on renewables.

For academic needs: A course in energy resources and interest in wood-fired electricity generation.

To plan for [state] research projects in the areas of greatest impact.

The USFS projects wood energy use by region, hardwood and softwood, growing stock and nongrowing stock, stock to use in forest sector economic models and inventory projection models. These models project timber inventory and pulpwood, sawlog, veneer log, fuelwood, lumber, panels, paper and paperboard price and consumption out 50 years. USFS industrial/economical and residential wood energy projection models require information to form (1) wood supply functions; (2) energy conversion technology, installation costs, and operating costs; and (3) wood energy demand by type of wood material, type of technology/user, and end user, respectively.

For technology transfer, matching local resources to local energy needs, promoting biomass as the preferred energy option, and technical assistance.

D.1.2 Geothermal

To analyze resource potential, cost competitiveness, and relative economic benefits.

To evaluate impact of new technology.

To help DOE/CE report historical progress. Also, cost information is important for projecting effects of federal incentives on near-to mid-term growth of this industry.

Historical data would be useful to map trends in technology and point to areas in which improvements are possible with enhanced R&D.

We use cost, resource, and production data over time. Therefore, series are particularly helpful.

Data are used for local, regional, and national planning.

Historical information is needed for projections of future development, decline rate, and price.

D.1.3 Municipal Solid Waste

To measure effect of recycling programs on energy content of waste.

I prepare characterization of MSW for EPA and others. Projections are based on historical data. Projections include generation, combustion, recycling, and composting.

To anticipate changes in quantity and quality of MSW as a function of time and to assess potential impact on air emissions.

To predict where MSW-to-energy facilities may be needed at the city/county level. This requires information on the landfill capacities in the area, costs of landfilling and other disposal options (i.e., what is the most cost effective waste disposal option available to the municipal officials), and the reliability/environmental issues associated with each available option.

The increase or decrease in output versus time would be a useful sales tool. Historical environmental data would indicate whether equipment deteriorates across time and indicate replacement schedules. Tipping fees could be used to determine the stabilization of disposal costs to the city.

D.1.4 Solar

To track how photovoltaic efficiencies and photovoltaic manufacturing capital costs have changed over time.

To assess the need for and effects of R&D programs, commercialization activities, and tax credit policies of the state. To assess business development impacts of solar technology.

For economic competitiveness, market research, and industrial strategic planning exercises.

D.1.5 Wind

We search out trends. Series are a tool.

For program planning needs.

We have a need for resource land area estimates for potential supply projections and temporal variations for evaluation of operational/planning impacts.

D.2 FURTHER SUGGESTIONS FROM RESPONDENTS (QUESTION 2.4)

D.2.1 Biomass

Information on resources should be collected through the USDA Agricultural Census and Forest Service surveys. Information [collection] on facilities and end uses should be performed by or coordinated with the [DOE] Regional Biomass Energy Programs, since (1) they already have some of this data, and (2) the relationship with the states [otherwise] can be jeopardized.

We are formulating methods for collecting similar data in the Western Regional Biomass Energy Program region. Might there be a way to collaborate in this effort?

In the U.S., there would be several thousand commercial/industrial woodfuel users to survey, at most. The traditional way to survey residential fuelwood users is a random telephone survey. For crop residues, ethanol, and methane facilities, a nationwide survey would be no problem, since there are only a small number of each.

It would take a very concerted effort/combination of mail and follow-up phone contact of users to produce useful information.

All of the items listed are of interest. Some will be very difficult to survey (e.g., energy crop handling losses), and some may be considered confidential information (e.g., cost data). Some activities presently do not exist (e.g., growing energy crops). Some data is already collected by the USDA National Resources Inventory (e.g., land area for potential cultivation by current use, commercial forest area) and Information Resources, Inc. (number of ethanol facilities, location of ethanol facilities, and production capacity for fuel-grade ethanol).

The first 12 items on the information items list for Energy Crops would be hard to collect currently, because "energy crops" don't exist yet.

Some of the information items can be derived from others listed, if needed. Therefore, it is useful to collect boiler or burner capacities, feedstock moisture content, and feedstock combustion heat information. Many small biomass facilities may not be able to provide complete information. In these cases, energy consumption can be estimated from other public data, such as boiler capacities listed in air quality permits.

Many of the attributes listed in the "Biomass--Woodfuels" section are already collect by various agencies (State & Federal). Would not need to duplicate effort.

[Under the Biomass--Woodfuels category,] data on area of commercial forest, percent of commercial forest land forested, area of commercial forest land by site class, forest biomass inventory by tree type and by quality, and net growth in commercial forest are available from the USDA Forest Service. Don't duplicate data published elsewhere.

The states have access to much of this information. Collection should be done by the states.

Competition for renewables is of concern, e.g., [for use as] fiber, etc.

Pollution concentrations need to be reported in consistent unit types. If pollutant concentrations are reported in different units, enough information needs to be supplied so different unit types can all be converted to the same unit type. For example, you cannot convert between lbs/hr and parts per million, unless you know the total exhaust flow rate in lbs/hr or lbs/s.

Most critical needs are for:
(1) Prices on selected uniform fuelwood commodities, e.g., 1 cord, split, delivered, mixed hardwood (softwood) to households in (a) urban, (b) rural areas in various regions (states?); dirty (whole tree) chips delivered to nonforest product firms.
(2) Costs of installation and operation of residential/commercial/industrial wood conversion technologies.

For agricultural residues, it would be difficult to gather information on total quantities of agricultural residues available by type.

It's probable that many energy crop plantations will be for fiber and energy. Therefore, biomass use will have to be defined. It's [also] unlikely that either ethanol or combustion facilities will use just one type of feedstock, such as "energy crops." Therefore information collection on feedstocks and conversion facilities may need to be reorganized. Information on the number of energy crop plantations and the total quantity of biomass (energy feedstock) produced will [otherwise] be subjective.

[For energy crops, it is necessary to define the] total quantity of biomass produced for energy.

The units for energy crop costs need to be more precisely defined as $/dry ton.

Data should be on an interactive system. It would be beneficial to have the data available of PC disk. The data/system should be PC (MS-DOS) compatible.

D.2.2 Geothermal

The Geothermal Resources Council at this time does not collect historical data on a routine basis, but it is vital to the development of geothermal resources in the U.S. [that this be done]. We do have some historical data and dispense it regularly. We think that the method of collection and exactly what data is collected is extremely important. Therefore, we suggest that someone who is directly involved with geothermal development do the collecting.

Groundwater heat pumps are common in Florida and a few other eastern states. They are a type of renewable energy. If not geothermal, the could be considered solar energy. Their energy contribution could be substantial.

Add geothermal heat pumps. They are more extensive than "direct heat" projects, and they affect electric utilities through load-leveling.

More data in the following topical areas would be helpful to determine the state of the technology: reinjection, environmental mitigation, and energy conversion train/surface facilities.

Detailed information about energy input and energy output for both electric and direct-use geothermal systems would allow us to calculate efficiency and to track changes with time.

D.2.3 Municipal Solid Waste

Data collected should represent a range rather than a single value (e.g., emission data reported as minimum, maximum, average, using 95% confidence level).

Since local governments are generally associated with waste-to-energy facilities, this information is easier to collect than wood energy information. Also, if you surveyed individual installations, you only have several hundred, at most.

The heat content is an important item. . . . In order for persons developing an energy recover facility to understand how applicable different types of facilities might be to their situation, it is important to know not only what heat content has been measured or estimated at the potentially comparable facility, but also what components of the waste stream (and what fraction of those components) are being processed through the energy recovery facility. . . . I would suggest that the category "Total MSW producer per year" be requested by waste component. In order to judge comparability of energy recovery processes for heat content, operating and maintenance requirements, process emissions and other factors, it is important to have a better idea about what types of materials are being handled than just quantity and heat content.

It would also be desirable to include in the list of facility types "materials recover facilities" or MRF's which are used to prepare collected recyclables for marketing as part of a materials recovery program.

Identification of where the different components are disposed of would be useful for identifying opportunities for future combinations of some components that will result in energy producing or conserving technologies. For example, knowing that sewage sludge was being burned with oil with an energy loss and that leaves were being landfilled would show the potential for (1) co-composing of the sludge and leaves which could result in energy conservation or (2) anaerobic digenstion of the sludge and leaves which might yield a biogas gas product.

Since the energy savings potential from different materials and for different products is a subject worthy of serious debate, it [would be] good [if] the survey does not ask the respondents to quantify any such savings.

For all types of facilities it would be of interest to learn how the quantities of pollutants from individual facilities might change over time. One factor affecting this may well be changes in waste stream composition, which again emphasizes the need for some information on the components of the MSW. . . .

An important question to consider here is how the quantities of the various pollutants will be reported, e.g., means, maxima, ranges, standard deviations, etc. Whatever measures are requested, the respondents should be asked to identify how may test results the measurements are based on and the methods used. Perhaps a valuable piece of information would be a citation of specific test reports released. . . .

Most, if not all, of the survey results should be identified by facility rather than aggregated on the state or region level. Aggregated results will be of much less use to persons interested in comparing potential facilities in their jurisdictions to those of others.

Don't reinvent existing information, e.g., number of facilities by type, location of facilities, input capacities, number of employees by type of facility, output capacity by energy product (steam, electricity, fuels, hot water, dry heat, other), quantities of energy output, quantities of energy product by end use (on-site use, district heat, industrial process heat, sold to grid, gas to pipeline, etc.), capital costs by facility type, and O&M costs by facility type. Much information on MSW is site specific. Having some fundamental data with sensitivities to parameters such as tipping fee is most useful.

We have been collecting similar information for California and have found that many of the facilities believe the information requested is proprietary or sensitive. As a result, much of the reported information comes back in an aggregate form (e.g., total capital costs include financing costs and, in some instances, vehicle costs) that can make the results misleading. The wording used in the survey must be very clear to avoid this problem.

Owner/operator data is almost essential.

D.2.4 Solar

While I have indicated an importance rating for various types of data, please note that all of the higher rated data (3-5) is already being collected by labs, contractors, private companies, etc.

For passive solar, annual building heating and cooling loads by building type are a design question. They are unlikely to be acquired via survey. Building floor space (sq. feet) is relevant only to commercial/institutional/industrial sectors. Your three information items "number of installations by system type," "number of installations by building type," and "number of new passive solar houses built by system type," should be reorganized, because they address the same item. They should be "number of new passive buildings (residential, commercial/institutional/industrial) and type of systems by building type. On the system types, you should delete indirect gain and retrofit and add sunspace and trombe wall. Passive solar is not a piece of equipment; it is integral to the building design. Thus, system cost to installers is hard to define and must be carefully calculated. Such items as costs to customers of new systems and retrofits should not be collected. (Will also need to be careful to separate conservation and solar.) County level data are desirable because passive solar is very site specific.

State-level data are sufficient for my needs with the exception of insolation, for which county-level data are required.

D.2.5 Wind

Efficiency data is meaningful only in the form $(kWh/m^2)/(W/m^2)$. kWh/m^2 and capacity factor are of little value, because they are heavily influenced by wind speed and energy content (W/m^2). This is extremely important! Misleading data is worse than no data at all.

Resource data should be collected at the county level. Collection at the regional level for the other data is sufficient for my purposes.

California's Wind Performance Reporting System (WPRS) already documents extensive data of types of turbines, manufacturers, geographic distribution, turbine source, turbine size for 80%± of World's installed capacity, and EPRI does extensive studies on cost, O&M, etc. Thus, I suggest that this technology is already well understood and documented with empirical data.

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