OPTIMIZING TECHNOLOGY TO REDUCE MERCURY AND ACID GAS EMISSIONS FROM ELECTRIC POWER PLANTS

Semi-Annual Report

August 1, 2003 to January 30, 2004

Principle Authors Jeffrey C. Quick
David E. Tabet
Sharon Wakefield
Roger L. Bon

Published February 2004

Prepared for The United States Department of Energy
Contract No. DE-FG26-03NT41901
Contract Officer David Hyman
National Energy Technology Laboratory
Pittsburgh, Pennsylvania

Prepared by The Utah Geological Survey
1594 West North Temple, Suite 3110
Salt Lake City, Utah 84114-6100
(801) 537-3300

DISCLAIMER

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

Although this product represents the work of professional scientists, the Utah Department of Natural Resources, Utah Geological Survey, makes no warranty, expressed or implied, regarding its suitability for a particular use. The Utah Department of Natural Resources, Utah Geological Survey, shall not be liable under any circumstances for any direct, indirect, special, incidental, or consequential damages with respect to claims by users of this product.

ABSTRACT

More than 56,000 coal quality data records from five public data sets have been selected for use in this project. These data will be used to create maps showing where coals with low mercury and acid-gas emissions might be found for power plants classified by air-pollution controls.

Average coal quality values, calculated for 51,156 commercial coals by U.S. county-of-origin, are listed in the appendix. Coal moisture values are calculated for commercially shipped coal from 163 U.S. counties, where the raw assay data (including mercury and chlorine values) are reported on a dry basis. The calculated moisture values are verified by comparison with observed moisture values in commercial coal. Moisture in commercial U.S. coal shows provincial variation. For example, high volatile C bituminous rank coal from the Interior province has 3% to 4% more moisture than equivalent Rocky Mountain province coal.

Mott-Spooner difference values are calculated for 4,957 data records for coals collected from coal mines and exploration drill holes. About 90% of the records have Mott-Spooner difference values within ±250 Btu/lb.

TABLE OF CONTENTS

ABSTRACT 3
INTRODUCTION 6
Background 6
Scope of this Report 7
EXECUTIVE SUMMARY 8
EXPERIMENTAL 9
Assembling and Selecting Data (Tasks 1 and 2) 9
FERC 423 Data 9
ICR Data 11
CTRDB Data 13
COALQUAL Data 13
DOE-PSU Data 17
Estimating Moisture (Task 3) 18
Moisture Estimation Method 18
Verification of Estimated Moisture Values 19
Evaluation of COALQUAL Mott-Spooner Values (Task 4) 21
RESULTS AND DISCUSSION 24
CONCLUSIONS 25
REFERENCES 26
LIST OF ACRONYMS AND ABBREVIATIONS 28
APPENDIX-Average Coal Quality Values by U.S. County-of-Origin 29

FIGURES

Figure 1. Coal provinces of the contiguous United States (after Trumbell, 1960) 6
Figure 2. Project milestone chart showing the tasks included in this reporting period 7
Figure 3. Geographic distribution of selected FERC 423 data 9
Figure 4. Geographic distribution of selected ICR data 11
Figure 5. Geographic distribution of selected CTRDB data 14
Figure 6. Geographic distribution of selected COALQUAL data 15
Figure 7. Geographic distribution of selected DOE-PSU data 17
Figure 8. Algebraic method used to estimate ICR moisture values 19
Figure 9. The calculated ICR moisture values are nearly the same as the observed CTRDB moisture values 21
Figure 10. The essentially identical relationships between the coal heating value and coal moisture content for the ICR and CTRDB data 22
Figure 11. The distribution of Mott-Spooner difference values for 4,957 selected COALQUAL data records 23

TABLES

Table 1. Summary of FERC 423 data fields 10
Table 2. Tabulation of selected and ignored 1999, FERC 423 data records 10
Table 3. Summary of ICR data fields 12
Table 4. Tabulation of selected and ignored 1999, ICR data records 13
Table 5. Summary of CTRDB data fields 14
Table 6. Tabulation of selected and ignored 1992–1999, CTRDB data records 15
Table 7. Summary of COALQUAL data fields 16
Table 8. Tabulation of selected and ignored COALQUAL data records 16
Table 9. Summary of DOE-PSU data fields 18
Table 10. Equations used to estimate regional ash vs. Btu plot intercept values 20
Table 11. Provincial variation of Mott-Spooner difference values in the COALQUAL data 23
Table A.1 Average quality, including mercury and chlorine content of commercially shipped coal indicated by selected records from the ICR data 30
Table A.2 Average quality of commercially shipped coal indicated by three data sets 36

INTRODUCTION

Background

Despite proven emission control technology, burning low-sulfur coal is the most popular method to reduce sulfur emissions. Because technology to reduce mercury emissions is considerably less certain, burning low-mercury coal is a likely method to reduce mercury emissions. Like sulfur, the amount of mercury in U.S. coal shows substantial geographic variation. Furthermore, mercury emissions from similar types of power plants are largely correlated with the amount of mercury in the coal. However, unlike sulfur, mercury emissions also vary with the abundance of other elements in the coal such as chlorine and sulfur, which influence the amount of mercury removed by emission control technologies. Consequently, mercury emission factors vary according to the relative abundance of several elements in the coal and are specific to different emission control technologies.

This 24-month project will create 10 or more detailed maps of the contiguous U.S. to show where coals with low mercury and acid-gas emissions might be found. Published coal quality data and Geographic Information System technology (ArcView GIS) will be used to create a series of maps that show the geographic variation of mercury and acid-gas precursors (sulfur, chlorine, fluorine) in coal. The series will also include maps showing mercury emission factors calculated for groups of power plants classified by boiler type and flue gas emission controls. Although each map will cover the entire lower 48 states, the data will be aggregated by county-of-origin to show local variation of coal chemistry within different coal provinces (figure 1) and regions.

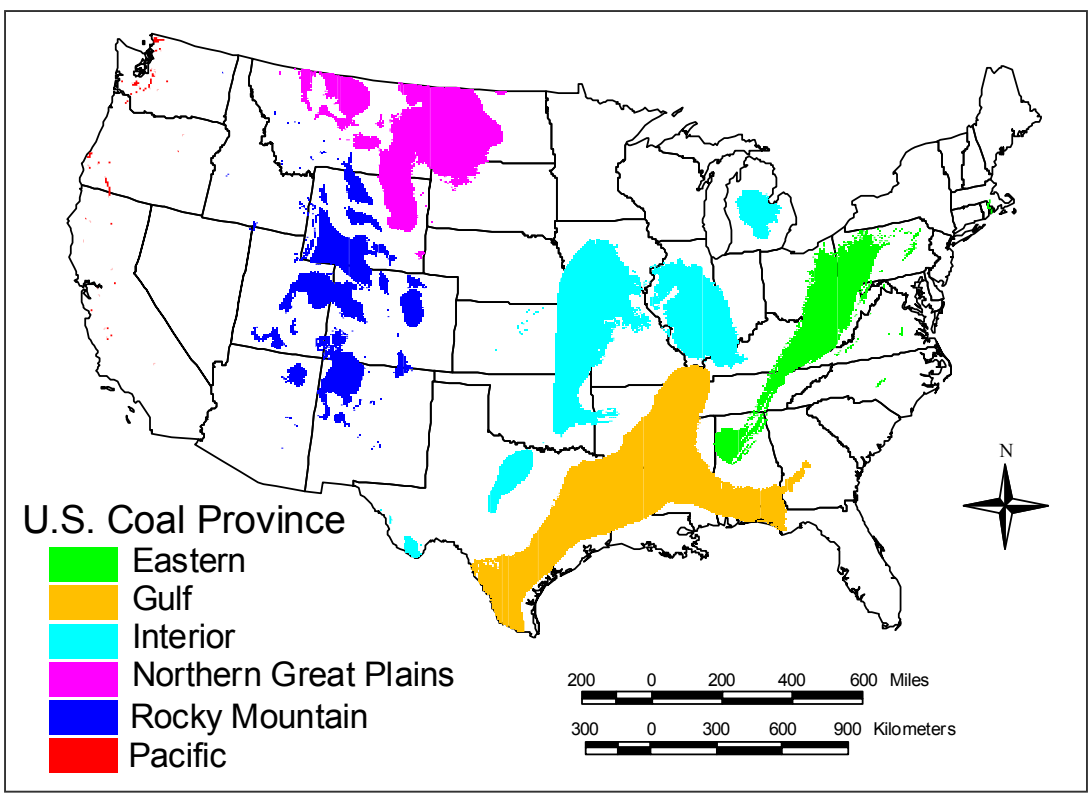

Figure 1. *Coal provinces of the contiguous United States (after Trumbell, 1960).*

Removing mercury from flue gas is a technically complex task – different technologies will be required for different coals. Maps showing the geographic variation of mercury and acid gas emission factors for U.S. coals will locate the best coals for each technology and may help to identify the best technologies for each coal.

Scope of this Report

This report describes the progress made during the first six months of this project. Results of tasks 1, 2, and 3 (figure 2) are described and discussed. Work on task 4 has begun and some initial results are discussed.

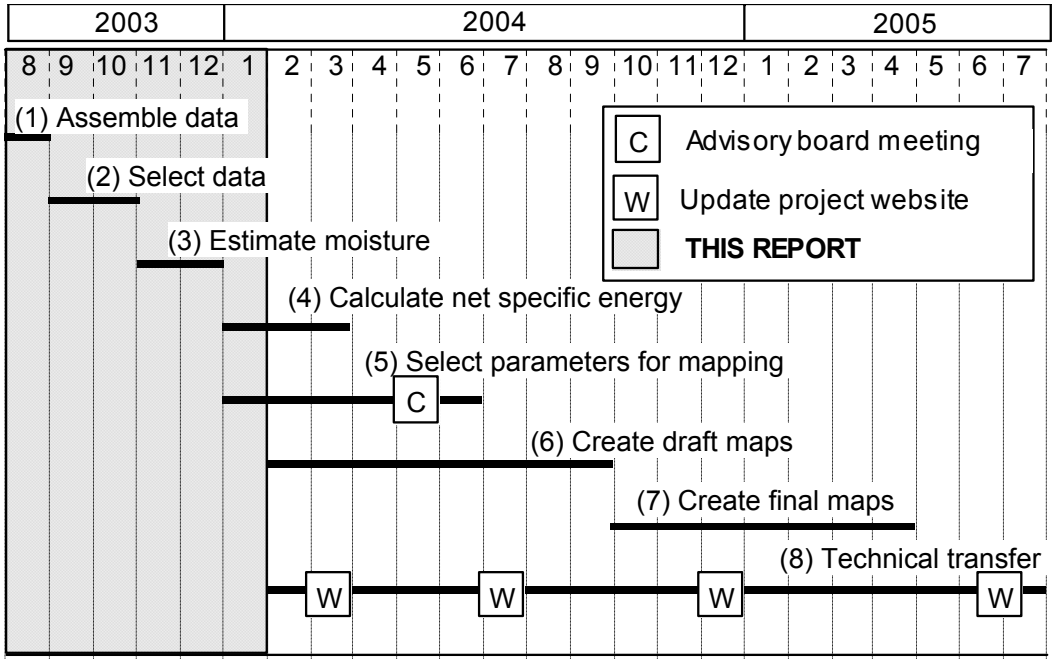

Figure 2. *Project milestone chart showing the tasks included in this reporting period.*

EXECUTIVE SUMMARY

This project will create maps showing the geographic variation of mercury and acid gas emission factors for U.S. coals. Coal assay data have been selected from public data sets for this purpose.

- 19,507 records are from the 1999, FERC 423 data set (a monthly, fuel cost and quality survey of electric utility power plants, from the EIA).

- 25,826 records are from the 1999, ICR data set (the part 2, mercury Information Collection Request, from the EPA).

- 5,823 records are from the 1992–1999, CTRDB data set (the Coal Transportation Rate Data Base, from the EIA).

- 5,059 records are from the COALQUAL data set (from the USGS).

- 73 records are from the DOE-PSU data set (from the Pennsylvania State University).

Results and observations from this project include:

- County-average moisture values are estimated for the ICR coal and verified by comparison with CTRDB coal.

- About 90% of the selected COALQUAL data records have Mott-Spooner difference values within ±250 Btu/lb.

.

- County-average moisture, Btu, ash, sulfur, chlorine, and mercury values are calculated for commercially shipped coal; the results are listed in the appendix.

Tasks to be accomplished during the next six-month reporting period include the calculation of net specific energy, the selection of parameters for mapping, and the creation of draft maps.

EXPERIMENTAL

Assembling and Selecting Data (Tasks 1 and 2)

This section describes five data sets (FERC 423, ICR, CTRDB, COALQUAL, and PSU-DOE), and how corresponding data records are selected.

FERC 423 Data

Figure 3 shows the geographic distribution of the 19,507 records selected from the 1999, Federal Energy Regulatory Commission (FERC) 423 data set (USEIA, 2003a). The FERC 423 data are from the Form 423 monthly survey of fossil-fueled electric utilities. Among other things, the records list the cost, quality, and origin of fuel shipments delivered to electric utility power plants with steam generator capacities of at least 50 MW. Data fields listed in the FERC 423 are described in table 1.

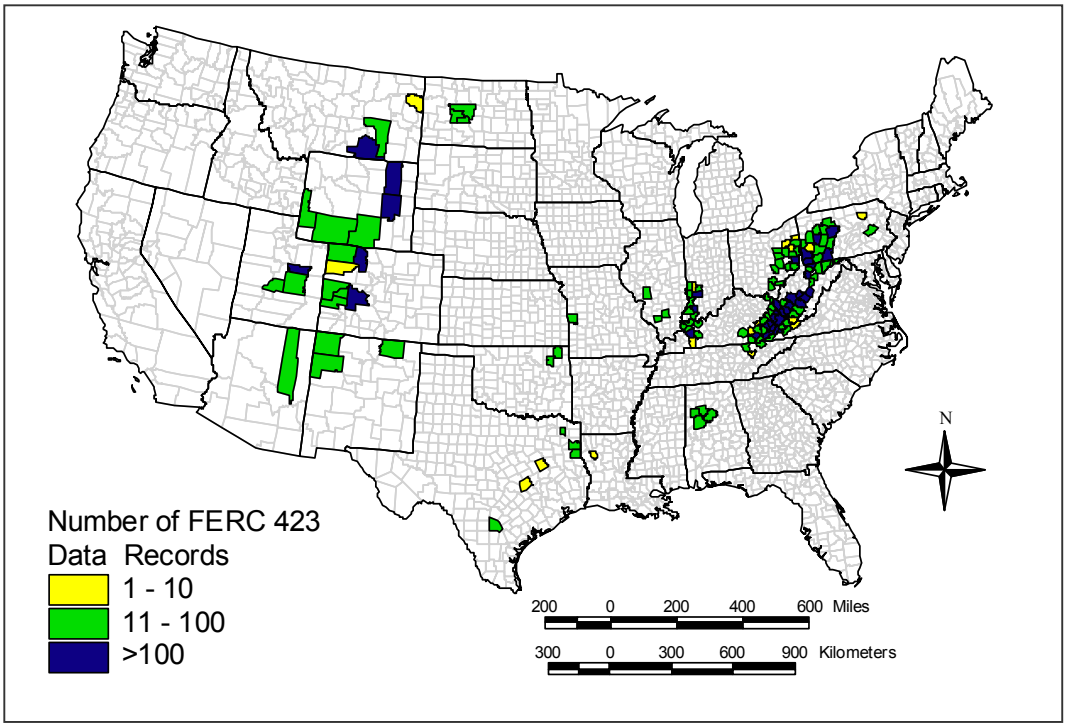

Figure 3. *Geographic distribution of selected FERC 423 data by U.S. county-of-origin.*

Table 2 shows that about half of the FERC 423 data records are selected for this project. Records for liquid, gaseous, and other non-coal fuels are ignored, as are records for imported coal and domestic coal of uncertain state or county origin. Although fuel receipts reported on the FERC Form 423 include over 99% of coal delivered to electric utility power plants, non-utility power plants (independent power producers and combined heat and power plants) do not report on FERC Form 423. These non-utility power plants consumed 56 million tons of coal during 1999, which is about five percent of the total 950 million tons burned at power plants (USEIA 2003b). Consequently, the FERC 423 data are missing about five percent of the coal tonnage shipped to U.S. power plants during 1999.

Table 1. *Summary of FERC 423 data fields.*

Company	Code for the name of utility parent company.
Plant	Code for the name of the utility power plant.
Year	Reporting year.
Month	Reporting month.
BOM District	U.S. Bureau of Mines coal producing district, country-of-origin (coal only).
State-of-origin	U.S. state-of-origin (coal).
Mine Type	Surface or underground coal mine.
Region (plant)	Regional location of the electric utility.
State (plant)	State location of the electric utility.
Generic Fuel	Type of fuel (solid, liquid, gaseous).
Specific Fuel	Bituminous, subbituminous, lignite, fuel oil, natural gas, etc.
Contract Type	Simple contract, contract with escalator, new, firm (gas), Interruptible gas, spot and off peak gas, spot coal or oil.
Contract Expire	Indicates if the contact expires within 24 months.
Quantity	Tons in coal shipment (short tons).
Btu	Heating value (gross Btu/lb, as-shipped).
Sulfur	Sulfur content (weight%, as-shipped).
Ash	Ash value (weight%, as-shipped).
Cost	Cents per million Btu (total cost, including transportation and taxes).
County	U.S. county-of-origin (mostly for coal shipments).

Table 2. *Tabulation of selected and ignored 1999, FERC 423 data records.*

35,886	ORIGINAL RECORDS		
		15,790	Liquid or gas[1]
		20,096	Solid fuel
20,096	SOLID FUEL RECORDS		
		116	Imported coal[1]
		132	Uncertain location[1]
		231	Petroleum coke[1]
		68	Refuse[1]
		42	Wood[1]
		19,507	Coal
19,507	SELECTED RECORDS		
		20	Anthracite
		15,962	Bituminous
		235	Lignite
		3,290	Subbituminous

[1] ignored

ICR Data

Figure 4 shows the geographic distribution of the 25,826 records selected from the part 2, Information Collection Request (ICR) data set (USEPA, 2003). The EPA required electric utility steam generating units of 25 MW or more to report coal origin, tonnage, and assay values for every solid fuel shipment received during 1999, and to periodically measure and report the mercury and chlorine values. The U.S. Geological Survey (USGS) added some data fields in June 2002 to indicate (where possible) consistent names for the coal bed, mine, field, and other attributes. Data fields listed in the ICR data are summarized in table 3. Notably, the ICR assay values are reported on a dry basis, and do not include coal moisture values.

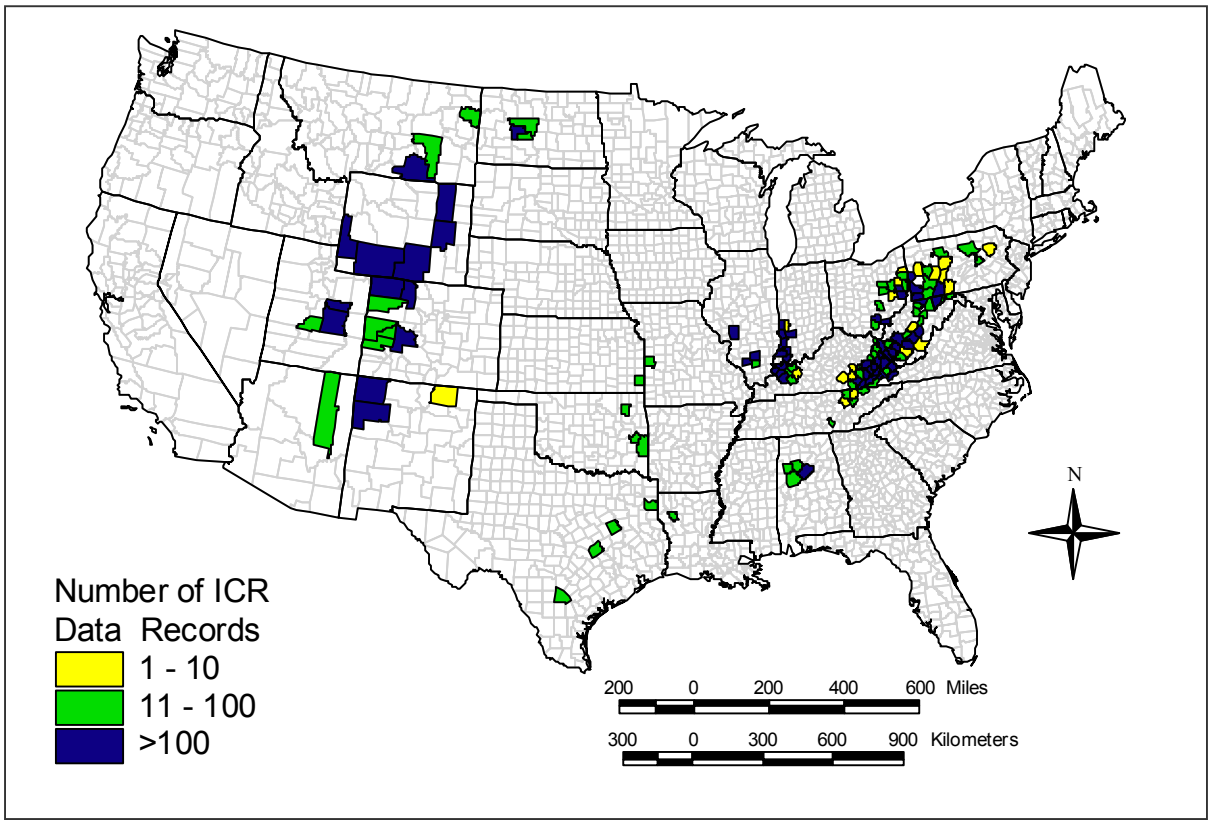

Figure 4. *Geographic distribution of selected ICR data by U.S. county-of-origin.*

Only 17% of the 152,476 ICR data records are used in this project (table 4). Most of the ignored records lack mercury assay values. Records corresponding to coal waste products, coal blends, or non-coal fuels are also ignored. Of the remaining records for single coals that include mercury values, more than 5,000 cannot be used because they lack location origins. With the exception of samples from mine-mouth power plants, records for as-fired or grab samples are also ignored; these sample collection methods tend to result in biased or non-representative assay specimens. Finally, several hundred records for samples from outside the study area are also ignored.

Table 3. *Summary of ICR data fields.*

Plant Name	The name of the power plant.
Shipment date	The date of the coal shipment.
Received	The amount of the shipment in dry tons.
State	The shipment state-of-origin.
County	The shipment county-of-origin.
Seam	The coal bed name reported by the power plant.
Method	The shipment transportation mode.
Fuel Type	The kind of fuel.
Supplier	The supplier name, location, and address.
Amount	The amount of the shipment that the assay represents in dry tons.
Sulfur	Sulfur content (weight%, dry basis).
Btu	Heating value (gross Btu/lb, dry basis).
Ash	Ash value (weight%, dry basis).
Mercury	Mercury content (ppm, dry basis) where results below the detection limit are flagged.
Chlorine	Chlorine content (ppm, dry basis) where results below the detection limit are flagged.
Assay Methods	Including reference to standard or in-house methods used to collect, prepare, and measure mercury in assay specimens, with an indication of assay accuracy and precision.
Laboratory	The name, location and address of the laboratory.
Coal Bed	USGS[1] coal bed.
Coal Group	USGS[1] coal group.
Coal Zone	USGS[1] National Coal Resource Investigations and Assessments coal bed zone.
Coal Basin	USGS[1] coal basin or field.
Coalfield	USGS[1] local coalfield name.
Coal Mine	USGS[1] coal mine name.

[1] U.S. Geological Survey, added June 2003

Quick and others (2003) used a graph of ash verses the heating value (Btu/lb) to identify erroneous ICR assay data for coal from Campbell County, Wyoming. This graphic method, when applied to each of the 163 U.S. counties represented in the ICR, shows 2,845 erroneous data records (table 4). Most (73%) of the errors are attributed to incorrect reporting bases where assay results are reported on a moist basis, or on a dry ash-free basis, rather than the dry basis specified by the ICR. In a few instances it is possible to identify mistaken location origins. No cause is known for the remaining erroneous records. Possibilities include data entry errors, mistaken location origins, unrecognized coal blends, and analytical error. Whatever the cause, these erroneous data are ignored.

Table 4. *Tabulation of selected and ignored 1999, ICR data records.*

152,476	ORIGINAL RECORDS			
		103,403	Coal without Hg or Cl values[1]	
		4,361	Coal waste[1]	
		3,283	Coal blends[1]	
		3,256	Petroleum coke[1]	
		1,045	Tire derived fuel[1]	
37,128	RECORDS FOR COAL WITH MERCURY VALUES			
		5,539	Coal without state or county locations[1]	
		1,005	As-fired samples[1]	
		763	Apparent duplicate records[1]	
		697	Apparent nominal data[1]	
		348	Foreign coal[1]	
		70	Grab samples[1]	
		35	Alaskan coal[1]	
28,671	INITIAL RECORDS			
		2,845	Data outliers[1], including:	
			1,363	on a dry, ash-free basis, rather than a dry basis[1]
			713	on a moist basis, rather than a dry basis[1]
			90	with bad origin locations[1]
			679	of undetermined cause[1]
25,826	SELECTED RECORDS			

[1] ignored

CTRDB Data

Figure 5 shows the geographic distribution of the 5,823 selected Coal Transportation Rate Data Base (CTRDB) data records. These data are from the U.S. Energy Information Administration (USEIA, 2003c) and include information on certain commercial coal shipments delivered to power plants between 1992 and 1999. The data largely originate from the FERC Form 580, biannual survey of investor-owned, interstate electric power plants. Among other things, the records list the quality and origin of contract fuels delivered to steam-electric power plants of 50 MW or more. Data fields listed in the CTRDB data set are summarized in table 5. Note that the CTRDB data fields include coal moisture values; these moisture values are used to verify moisture values estimated for ICR coal (discussed below).

About three-fourths of the records included in the CTRDB are selected for this project (table 6). Records corresponding to duplicate assays are most frequently ignored; this is done to preclude unwanted weighting effects in subsequent analyses. Records that lack coal quality values or location origins as well as those for coke or imported coal are also ignored. Finally, a few records with anomalous coal quality values (outliers on Btu vs. moisture plots) are also ignored.

COALQUAL Data

The COALQUAL data set was compiled by the U.S. Geological Survey (Bragg and others, 1997) and includes records for coal samples collected from U.S. drill holes, mines, and outcrops. Figure 6 shows the geographic distribution of the 5,059 selected COALQUAL data records. This comprehensive data set has 136 data fields, which include detailed information

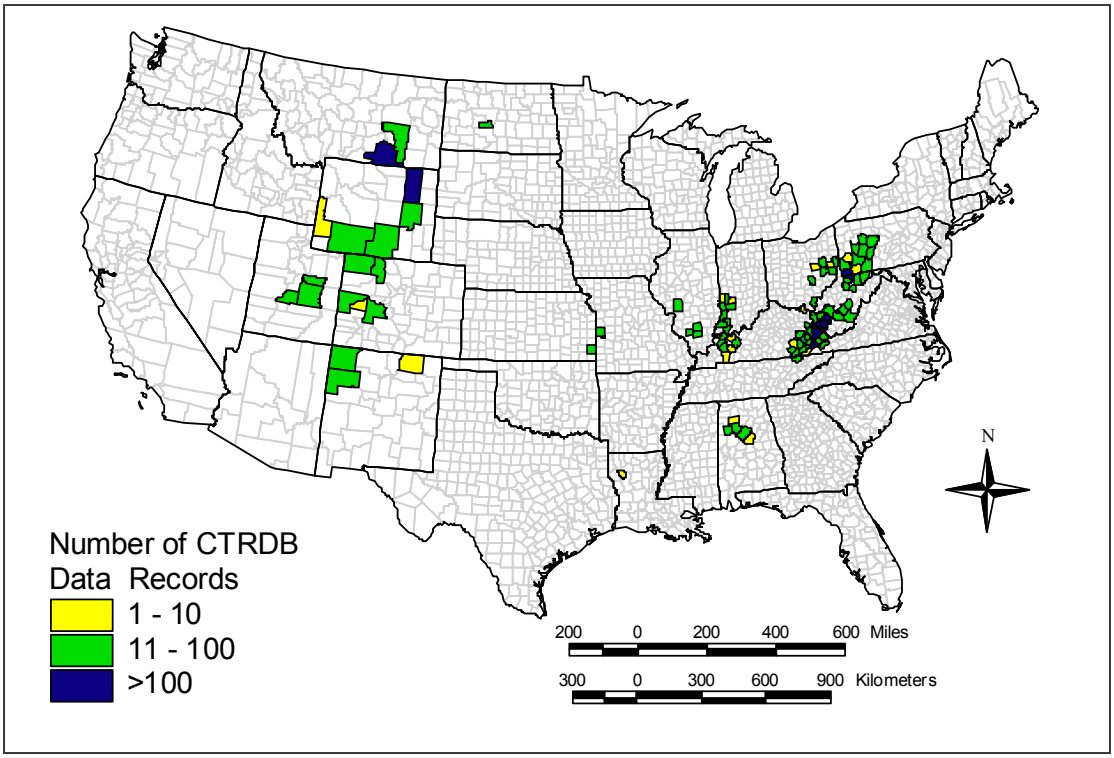

Figure 5. *Geographic distribution of selected CTRDB data by U.S. county-of-origin.*

Table 5. *Summary of CTRDB data fields.*

Utility Name	Name of the utility parent company.
Year	The year the data represent.
Contract Specifications	Including: contracted dates, tonnage, and coal quality specifications.
Contractor Name	Name of the coal supplier.
Mine Name	Name of the coal mine.
Origin State	State of the coal origin.
Origin County	County of the coal origin.
BOM District	U.S. Bureau of Mines coal-producing district of the coal origin.
Destination Plant	Power plant name.
Destination State	Location state of the power plant.
Destination County	Location county of the power plant.
Tons Shipped	Tons of coal shipped.
Mine Price	Price of the coal at the coal mine.
Delivered Price	Price of the coal at the power plant.
Btu	Coal heating value (gross Btu/lb, as-shipped).
Sulfur	Coal sulfur content (weight%, as-shipped).
Ash	Coal ash value (weight%, as-shipped).
Moisture	Coal moisture content (weight%, as-shipped).
Transportation Information	Type of transportation (train, truck, barge, etc); the number of transport modes, carriers, and transfers; transport distance.
Carrier Information	Name(s) of transport carriers, transfer locations etc.
Transport Costs	Mode rates, transfer fees, and so forth.

Table 6. Tabulation of selected and ignored 1992–1999, CTRDB data records.

7,905	ORIGINAL RECORDS	
	1,041	Duplicate assay values[1]
	868	No coal quality data[1]
	113	Foreign coals[1]
	26	No origin location[1]
	25	Coal quality outliers[1]
	9	Petroleum coke[1]
5,823	SELECTED RECORDS	

[1] ignored

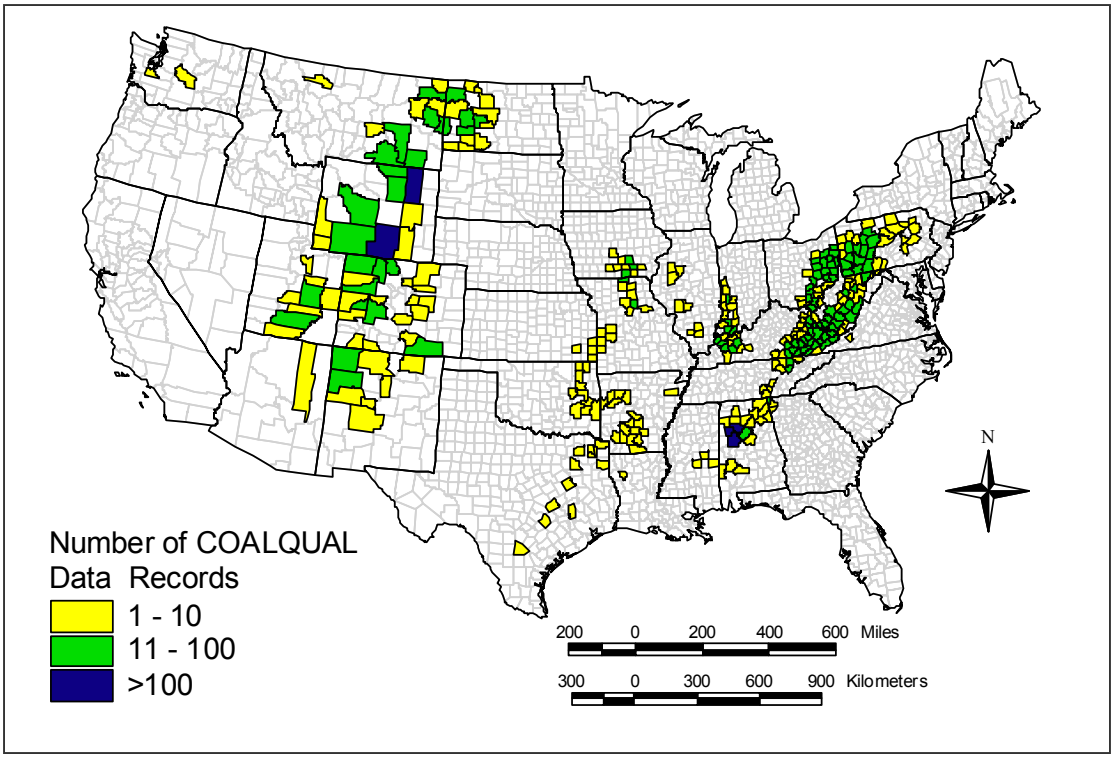

Figure 6. *Geographic distribution of selected COALQUAL data by U.S. county-of-origin.*

related to the sample type, location, collection method, and geologic setting. Nearly all records have complete proximate and ultimate assays as well as major, minor, and trace element values. Data fields listed in the COALQUAL data are summarized in table 7. Table 8 shows the tabulation of selected and ignored data records for the COALQUAL data.

Details of the sampling and assay methods used for the COALQUAL data set are fully described by Bragg and others (1997) in text accompanying the data on the CD-ROM format; several of these details are worth noting:

(1) The ASTM assays are reported on a whole-coal (moist) basis and the USGS assays are reported on a residual-moisture basis where the residual-moisture content of the analysis specimen was not measured. Using the approach of Quick and others (2003),

Table 7. *Summary of COALQUAL data fields.*

Location Information	Including: state, county, latitude, longitude, province, region, field, district, quadrangle.
Geologic Information	Including: formation, group, bed, member, zone, depth, bed thickness, system, and geologic age.
Collection Information	Collector name, drillhole/mine name, estimated rank, and laboratory submission date.
Laboratory	Assay laboratory: U.S. Bureau of Mines, Geochemical Testing Co., State agencies, USGS, Dickinson Laboratories Inc.
Sample Type	Channel, drillcore, weathered channel, or outcrop.
Data Type	Single sample assay, physical composite assay, calculated composite assay, partial composite assay, partial bed split.
ASTM Assays	(Moist, whole-coal basis) including: moisture, Btu, ash, volatile matter, CHNOS, ash fusion temperatures, free swelling index, sulfur forms, air-dry-loss, equilibrium moisture, and Hardgrove grindability.
USGS Assays	(Residual moisture basis) including: USGS ash value, 11 major and minor ash oxides, and up to 62 trace elements.

Table 8. *Tabulation of selected and ignored COALQUAL data records.*

7,432	ORIGINAL RECORDS
948	Calculated composites[1]
568	No Btu, ash, or sulfur values[1]
551	Weathered coal[1]
150	Outcrop samples[1]
105	Anomalous moisture values[1]
51	Geographically isolated, or Alaskan coal[1]
5,059	SELECTED RECORDS

[1] ignored

residual moisture of high volatile A bituminous and lower-rank coal is calculated as, $Moisture_{residual} = 3.042^{-4} \times Btu/lb_{m,mmf} - 6.156^{-8} \times Btu/lb^2_{m,mmf} + 10.32$. A minimum residual-moisture value of 0.7 is assigned where the equation gives negative values and for higher-rank coal.

(2) Hydrogen values in the COALQUAL data set include the hydrogen in moisture. This convention has significance for the calculation of flue gas volumes, the calculation of heating values from elemental composition, and the calculation of the lower (net) heating value.

(3) Qualitative values, where an assay value is above or below detection limits, are respectively listed as the maximum detection limit, or 0.7 times the minimum detection limit. Although the percentage of qualified values for each data field is reported, the status of values for single records is not.
(4) Some data records are for calculated, whole-bed composites. Such records are ignored in this study because the whole-bed values are calculated from component partial-bed assays by volume (thickness) rather than mass.

DOE-PSU Data

Figure 7 shows the geographic distribution of the 73, selected U.S. Department of Energy-Pennsylvania State University (DOE-PSU) data records. The data are for coal samples collected between 1983 and 1995 from active mines in 48 U.S. counties and 18 U.S. states. The data include 67 records for full-bed or working-section channel samples, five run-of-mine samples, and one drill hole core. Thirty-three (DOE) records are from Davis and Glick (1993) and Scaroni and others (1999). The remaining 40 (PSU) records are from Quick and Glick (2000), with additional information from the Penn State Coal Data Base (anonymous, 1990). Petrographic assays, Gieseler fluidity, as well as major, minor, and trace element assays are from the Pennsylvania State University; the other assays are from a commercial laboratory. Data fields included in the DOE-PSU data are summarized in table 9.

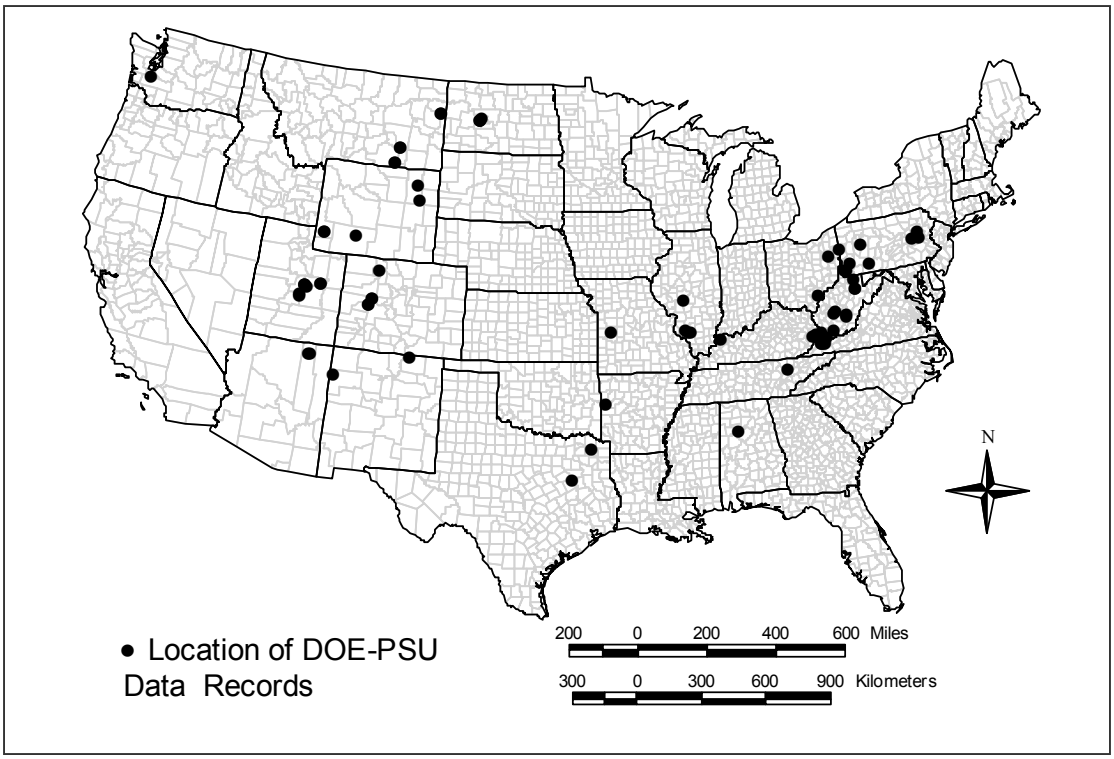

Figure 7. *Geographic distribution of selected DOE-PSU data.*

Table 9. *Summary of DOE-PSU data fields.*

Location Information	Including: state, county, coal province, region, field, quadrangle, latitude, and longitude.
Geologic Information	Including: formation, group, bed, bed thickness, lithologic description, system, and geologic age.
Collection Information	Collection date, laboratory submission date, and assay dates.
Sample Type	Channel, working section, run-of-mine, drillcore.
Assays	As received and equilibrium moisture, Btu, ash, volatile matter, CHNOS, free swelling index, sulfur forms, chlorine, carbonate CO_2, maceral composition, and vitrinite reflectance, Hardgrove grindability, Geiseler fluidity, ash fusion temperatures, major, minor, and trace elements.

Estimating Moisture (Task 3)

Table A.2 includes estimated moisture values for the ICR data. This section describes how these moisture values are estimated and verified.

Moisture Estimation Method

As noted above, the ICR data are reported on a dry basis, whereas the FERC 423 data are reported on a moist basis. Where data records are aggregated by county-of-origin, comparison of the two data sets allows moisture to be algebraically estimated (figure 8). Note that this approach is not accurate for individual coals, but as will be shown, does provide a reasonable average moisture value for coal from each of the 163 U.S. counties listed in the ICR. As shown in figure 8, the first step to estimate ICR moisture is to find the best-fit regression line for moist-basis FERC 423 data from a single U.S. county. The slope and intercept of this line (-114 and 12,300, respectively, in the figure 8 example) are then used to calculate moisture values for the dry-basis ICR data from the same county, and the county-average ICR moisture value is calculated.

The method works reasonably well for U.S. counties with abundant data. However, a statistically significant best-fit regression line is not possible where the FERC 423 data are too few, or too homogeneous. To solve this problem, the intercept value is fixed according to regionally established relationships between the ASTM (1990) rank parameter (Btu/lb on a moist, mineral-matter-free basis [Btu/lb $_{m,mmf}$]) and the required intercept value illustrated in figure 8. These relationships are made using plots of ash vs. Btu/lb values for regional subsets of the FERC 423 data that are grouped by intervals of 250 Btu/lb $_{m,mmf}$. A regression intercept value is established for each group, and a second linear regression analysis between the group-average Btu/lb $_{m,mmf}$ values and their corresponding intercepts provides a unique equation for each region (table 10).

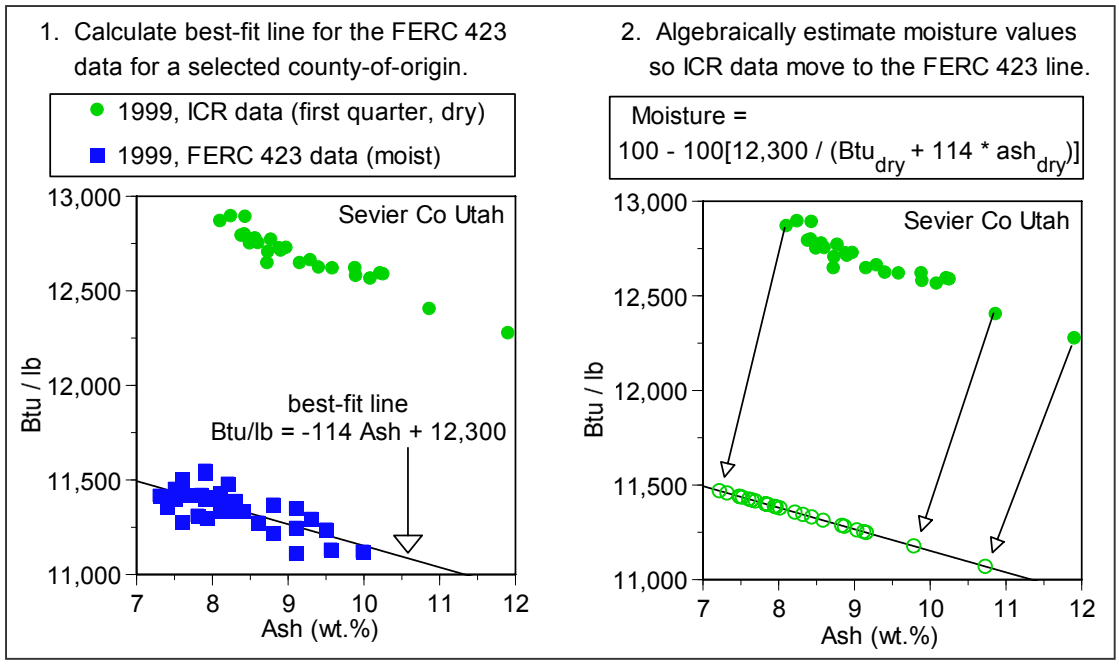

Figure 8. *Algebraic method used to estimate ICR moisture values.*

The average Btu/lb $_{m,mmf}$ value, calculated using FERC 423 data from a single U.S. county, is used with the appropriate equation listed in table 10 to obtain an intercept value. This intercept value is then fixed during the ash vs. Btu regression analysis (figure 8, part 1) to obtain the best-fit line for the FERC 423 data for that U.S. county. The slope (m) and intercept (b) of this best-fit, FERC 423 line are then used to estimate the ICR coal moisture values for ICR data from the same U.S. county using the equation, $Moisture_{ICR} = 100 - \left[\frac{100 \times b}{(Btu/lb_{ICR} - m \times Ash_{ICR})}\right]$ (as illustrated in figure 8, part 2). Finally, the county-average ICR moisture value is determined using all of the calculated ICR moisture values for that U.S. county.

Verification of Estimated Moisture Values

Figure 9 shows a cross plot of coal moisture values observed in the CTRDB data with the corresponding coal moisture values calculated for the ICR data; each data point represents a county average. The figure shows a nearly 1:1 relationship, and a standard error of about one percent moisture. The most notable outlier is from Moffat County, Colorado where the CTDRB includes a low-moisture population not observed in the ICR or FERC 423 data sets (see table A.2). The CTRDB data records for the low-moisture population list Eagle/Foidel as the mine name. Since the Foidel mine is located in Routt, rather than Moffat County, unrecognized location errors in the CTRDB data are likely responsible for this deviation and perhaps other scatter evident in figure 9.

The veracity of the estimated ICR moisture values is further illustrated in figure 10. Figure 10a shows that the relationship between the Btu/lb $_{m,mmf}$ rank parameter (ASTM, 1990) and coal moisture is essentially identical for both the ICR and CTRDB data. Perhaps more

Table 10. *Equations used to estimate regional ash vs. Btu plot intercept values for FERC 423 data.*

BOM district	Descriptive Geographic Extent	Equation
13	Eastern Province, southern Appalachian region: Alabama and southern Tennessee.	Intercept = 1.315 Btu/lb $_{m,mmf}$ – 4,541
7, 8	Eastern Province, central Appalachian region: northern Tennessee, eastern Kentucky, Virginia, and southern West Virginia.	Intercept = 1.034 Btu/lb $_{m,mmf}$ – 519
1, 2, 3, 4, 6	Eastern Province, northern Appalachian region: Ohio, northern West Virginia, and Pennsylvania.	Intercept = 0.981 Btu/lb $_{m,mmf}$ + 225
9, 10, 11	Eastern Interior Province (Illinois Basin): western Kentucky, Indiana, and Illinois.	Intercept = 0.970 Btu/lb $_{m,mmf}$ + 361
15	Western Interior Province: Kansas, Missouri, and Oklahoma.	Intercept = 1.127 Btu/lb $_{m,mmf}$ – 1,859
15	Gulf Province: Texas and Louisiana.	Intercept = 0.788 Btu/lb $_{m,mmf}$ + 1,652
17	Rocky Mountain Province: Colorado.	Intercept = 1.00 Btu/lb $_{m,mmf}$ + 111
18,19, 20	Rocky Mountain Province: southern Wyoming, Utah, New Mexico, and Arizona.	Intercept = 0.994 Btu/lb $_{m,mmf}$ + 73
19, 21, 22	Northern Great Plains Province: northeastern Wyoming, Montana, and North Dakota.	Intercept = 1.088 Btu/lb $_{m,mmf}$ – 804
1, 7, 8, 24	Eastern Province counties with medium volatile bituminous and higher rank coal: Allegany and Garret Counties Maryland; Bedford, Cambria, Clearfield, Lackawanna, Lycoming, Schuylkill, Somerset, and Sullivan Counties Pennsylvania; Tazewell Co Virginia; Grant, Greenbrier, McDowell, Mercer, Raleigh, and Wyoming Counties West Virginia.	Intercept = 0.983 Btu/lb $_{m,mmf}$ + 217

Note that the Btu/lb$_{m,mmf}$ value used in the listed equations is calculated from the county-average, FERC 423 data using the equation: $Btu / lb_{m,mmf} = \frac{100\,(Btu_{FERC423} - 50\,Sulfur_{FERC423})}{\left[100 - \left(1.08\,Ash_{FERC223} + 0.55\,Sulfur_{FERC423}\right)\right]}$.

significant is the similar provincial variation of coal moisture values for these two data sets shown in figures 10b and 10c. For example, both the ICR and CTRDB data show that U.S. Interior province coal has more moisture than Rocky Mountain province coal of the same rank (Btu/lb $_{m,mmf}$). Calculations (not shown) show that this provincial variation of moisture content is not explained by provincial variation of coal mineral abundance.

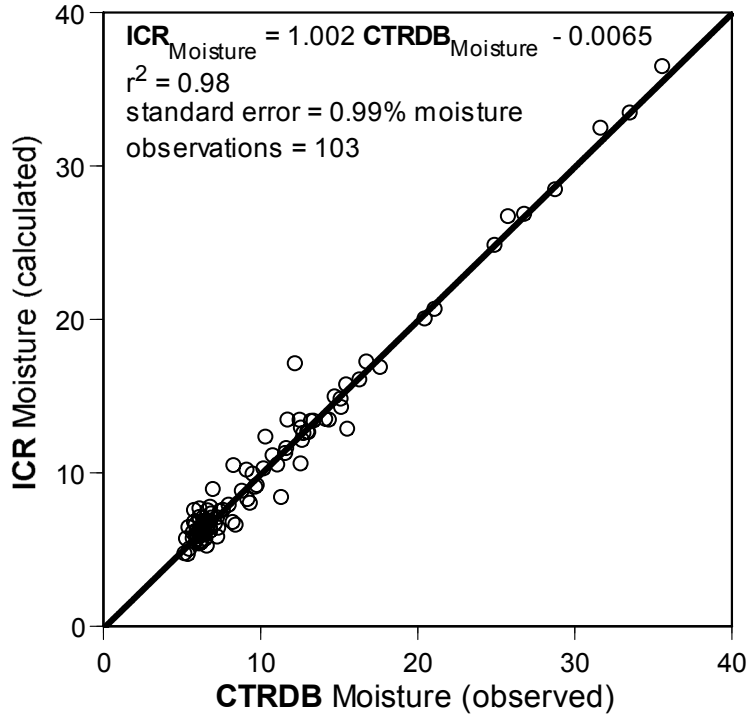

Figure 9. *The calculated ICR moisture values are nearly the same as the observed CTRDB moisture values; each data point is a U.S. county average.*

Evaluation of COALQUAL Mott-Spooner Values (Task 4)

The Mott-Spooner value is the heating value (Btu/lb) calculated from the elemental composition of the coal (Mott and Spooner, 1940). The difference between the measured and the calculated Btu/lb value ($\text{Btu/lb}_{\text{measured}} - \text{Btu/lb}_{\text{calculated}}$) is called the Mott-Spooner difference, and is useful to identify erroneous data (sources of error include data entry mistakes, assay errors, or inconsistent reporting bases). Mott-Spooner difference values are calculated to evaluate the suitability of the COALQUAL data for estimation of coal hydrogen value later in this project. Coal hydrogen values are required to calculate net specific energy (task 4).

Although numerous equations can be used to calculate the heating value from elemental composition (Neavel and others, 1986), equations listed by Mott and Spooner (1940) are used in this study. The variables in these equations are expressed on a dry, ash-free ($_{\text{daf}}$) basis, where C is percent carbon, H is percent hydrogen, S is percent total sulfur, and O is percent oxygen calculated as, $O_{daf} = 100 - C_{daf} - H_{daf} - S_{daf}$. Because hydrogen in the COALQUAL data includes the hydrogen in moisture, the contribution of moisture to the hydrogen value is stochiometrically calculated (moisture × 0.1119) and subtracted from the reported hydrogen value before calculation to a dry, ash-free basis. For higher rank coals with less than 15% oxygen $_{(\text{daf})}$, the coal heating value is calculated as,

$$Btu/lb_{daf} = 144.5 \times H_{daf} + 40.5 \times S_{daf} - 62.5 \times O_{daf}.$$

For lower rank coals with more than 15 % oxygen $_{(\text{daf})}$, the equation is,

$$Btu/lb_{daf} = 144.5 \times C_{daf} + 610.2 \times H_{daf} + 40.5 \times S_{daf} - 65.9 \times O_{daf} + 0.310 \times O_{daf}^2.$$

Using these equations, Mott-Spooner values were calculated for 98% of the 5,059 selected COALQUAL data records; values could not be calculated for 2% of the records because they lack elemental data. Mott-Spooner difference values for 15 data records exceed ±1,000 Btu/lb

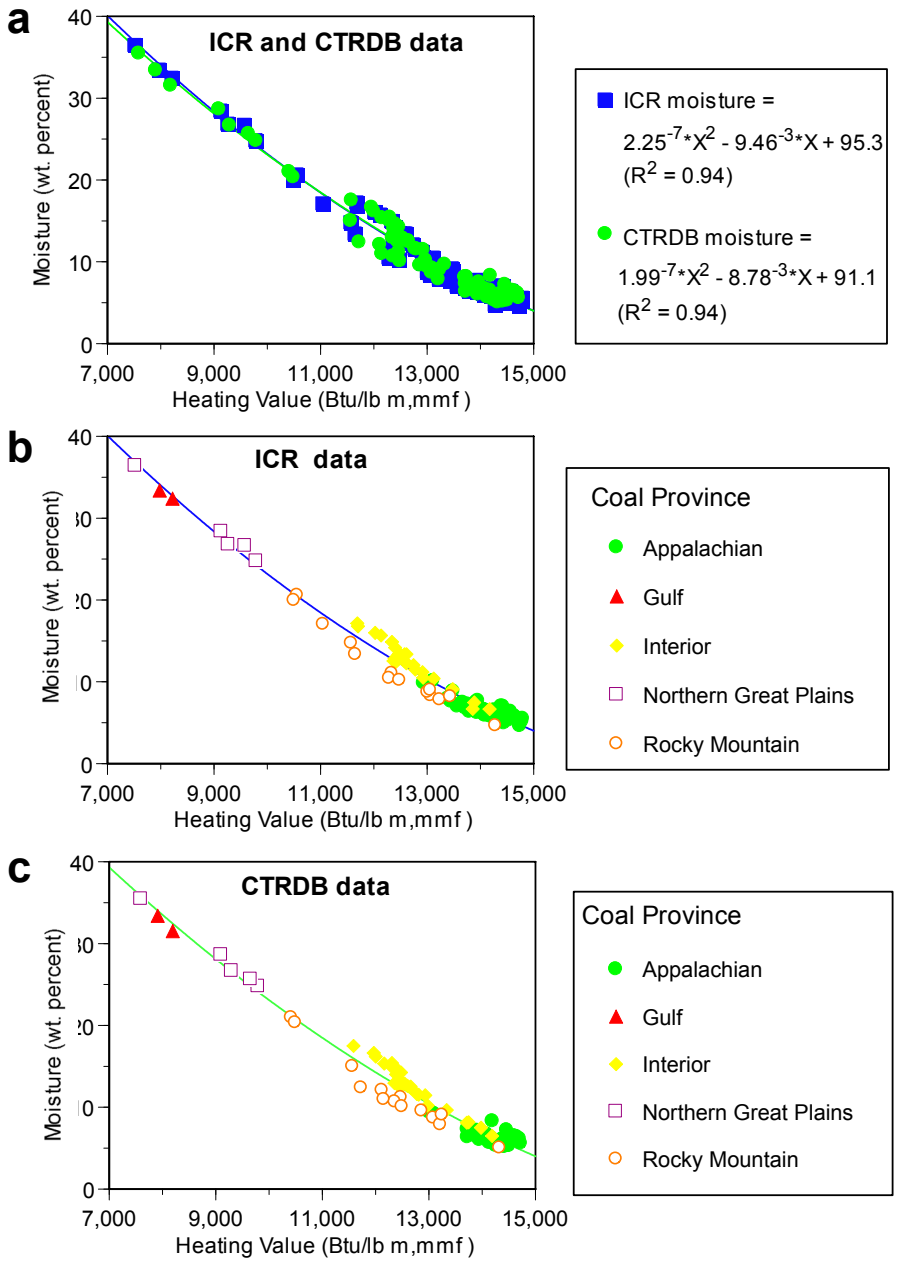

Figure 10. (**a**) *The essentially identical relationships between the coal heating value and coal moisture content for the ICR and CTRDB data verifies the estimated moisture values for the ICR data.* (**b**, **c**) *The similar provincial distribution of moisture values around each line is likewise significant. Each data point is a U.S. county population average. The standard error for both lines is 1.2% moisture.*

and are ignored, as are four records with relatively high (positive) Mott-Spooner difference values from a single laboratory. The distribution of Mott-Spooner difference values for the remaining 4,957 data records is shown in figure 11. The Mott-Spooner difference values shown in figure 11 are normally distributed about a median value of +15 Btu/lb. This trivial, positive value appears to be partly due to a difference between analytical laboratories illustrated in the figure. However, provincial variation of Mott-Spooner difference values shown in table 11 may also contribute to the slightly positive value. More remarkable, is that the mean Mott-Spooner difference for data from the U.S. Bureau of Mines laboratory is only +4 Btu/lb, which is essentially zero.

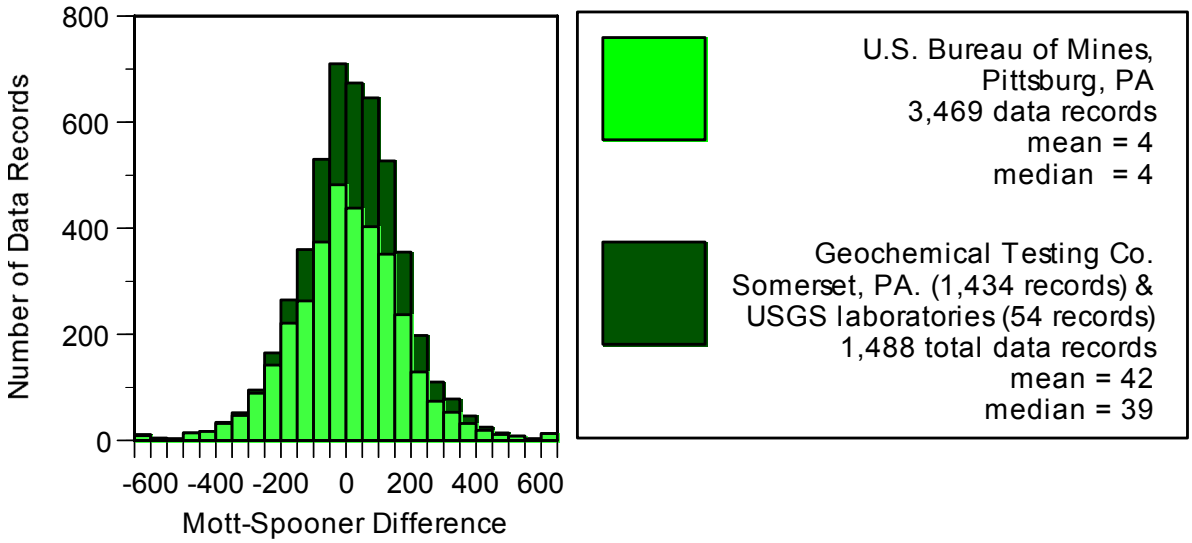

Figure 11. *The distribution of Mott-Spooner difference values for 4,957 selected COALQUAL data records is negligibly skewed about a mean near zero. A slight difference is observed between analytical laboratories.*

Table 11. *Provincial variation of Mott-Spooner difference values in the COALQUAL data.*

Province	Eastern	Interior	Gulf	Rocky Mountain	Northern Great Plains[1]
Number of Records	3,071	471	91	755	573
Average Mott-Spooner Difference	3	22	1	40	49
Median Mott-Spooner Difference	1	26	-9	54	64

[1] includes four records from the Pacific province.

RESULTS AND DISCUSSION

Average moisture, Btu/lb, ash, sulfur, chlorine, and mercury values for coal delivered to electric power plants, grouped according to U.S. county-of-origin, are provided in the appendix. The average values are calculated using selected data records from three data sets (FERC 423, ICR, and CTRBD).

1) 19,507 records are from the 1999, FERC 423 data set. These data are from a monthly fuel cost and quality survey of electric utility power plants, and include moist-basis Btu/lb, ash, and sulfur values.
2) 25,826 records are from the 1999, ICR data set. These data are from electric utility power plants, which were required to periodically report dry-basis Btu/lb, ash, sulfur, chlorine, and mercury values for coal shipments received during 1999. Moisture values are calculated for ICR data grouped by U.S. county-of-origin.
3) 5,823 records are from the 1992–1999, CTRDB data set. These data are largely from a biannual survey of investor-owned, interstate electric power plants, and include most-basis Btu/lb, ash, and sulfur values, as well as coal moisture values.

In addition to the three commercial data sets listed above, records are also selected from two geologic data sets. The geologic data sets include coal quality values for samples from coal mines and exploration drill holes.

1) 5,059 records are from the COALQUAL data set. These data are for coal samples collected by the U.S. Geological Survey and various state agencies; up to 136 assay results (including major, minor, and trace elements) are included. About 90% of the selected data have Mott-Spooner difference values within ±250 Btu/lb.
2) 73 records are from the DOE-PSU data set. These data are for coal samples collected from U.S. mines by workers from the Pennsylvania State University. Like the COALQUAL data, the DOE-PSU data include comprehensive assay results

County-average moisture values calculated for the ICR data are remarkably similar to observed moisture values for the CTRDB (figure 10). These calculated ICR moisture values are used to adjust the ICR data to a moist reporting basis, which allows a direct comparison of the ICR data with other commercial coal data sets (table A.2). Of significance to this project, the ICR moisture values are essential to calculate net energy (task 4).

The provincial variation of coal moisture values shown in figure 10 is noteworthy. For example, high volatile C bituminous rank coal from the Interior province has 3% to 4% more moisture than equivalent Rocky Mountain province coal. One possible explanation of this variation is the influence of mineral matter abundance in coal. McCutcheon and Barton (1999) show that the mineral components of coal contain less moisture than the organic components. Accordingly, we used multivariate regression analysis (where the Btu/lb $_{m,mmf}$ and the Parr mineral matter values are simultaneously used to predict moisture) to examine variation of moisture within coal provinces. Although mineral matter does show the expected negative correlation with moisture for Gulf and Eastern province coals, it does not significantly correlate with moisture variation for Interior, Rocky Mountain, or Northern Great Plains province coal. In these instances, a geographic factor possibly obscures the expected negative correlation between of coal mineral abundance and coal moisture content. Construction of maps showing the variation of coal moisture should help to clarify the possible influence of geographic location on moisture in coal.

Besides coal moisture values, calculation of ICR net energy values (task 4) also requires coal hydrogen values. Because hydrogen values are not listed for the commercial coal data, we intend to estimate hydrogen values for commercial coals based on relationships observed in the COALQUAL data. To test the suitability of the COALQUAL data for this purpose, we calculated their Mott-Spooner difference values (figure 11). Mott and Spooner (1940) state that the difference between the measured and the calculated heating value should be within ±100 Btu/lb; if not, they suggest that the results of the elemental analysis should be examined and repeated. Given and others (1986) argue that no precise limits of acceptability can be stated, but that the data are probably wrong if the difference exceeds ±250 Btu/lb. About 10% of the records shown in figure 11 exceed this threshold (230 records have Mott-Spooner difference values less than –250 Btu/lb, and 296 records have Mott-Spooner difference values greater than +250 Btu/lb). More importantly, about 90% of the COALQUAL data pass the Mott-Spooner test and can be confidently used to estimate hydrogen in commercial coal.

CONCLUSIONS

About 56,000 coal quality data records have been selected from more than 200,000 records listed in 5 public data sets. Most of the selected data (51,156 records) are for commercial coal shipments and the remaining data (5,123 records) are for geologic (in-ground) samples. Average coal quality values for the commercial coals have been calculated by U.S. county-of-origin and are listed in the appendix.

Mott-Spooner difference values show that 90% of the COALQUAL data records are suitable to estimate hydrogen values for commercial coal. Moisture values have been calculated for the ICR data and verified by comparison with CTRDB data. Both hydrogen and moisture values are required to calculate net energy values later in this project (task 4).

We observe provincial variation of moisture in commercial coal. This variation is not due simply to unequal mineral abundance. Construction of draft maps (task 6) should help to clarify any influence of geographic origin on moisture in coal. We also plan to compare moisture in commercial coal with moisture contents in geologic coal samples; similarities and differences should help us better use the geologic data to predict the composition and combustion behavior of commercial coal.

REFERENCES

Anonymous, 1990, The Penn State Coal Sample Bank and Data Base, second edition: Coal and Organic Petrology Laboratories, The Pennsylvania State University, University Park, Pennsylvania, unpaginated data sheets.

American Society for Testing and Materials, 1990, Method D 388-90 standard classification of coals by rank, Annual Book of ASTM Standards: West Conshohocken, Pennsylvania, v. 05.05, p. 193-197.

Bragg, L.J., Oman, J.K., Tewalt, S.J., Oman, C.L., Rega, N.H., Washington, P.M., and Finkelman R.B., 1997, Coal quality (COALQUAL) database – version 2.0: U.S. Geological Survey Open-File Report 97-134, CD-ROM.

Davis, A., and Glick, D.C., 1993, Establishment and maintenance of a coal sample bank and data base, final report to the U.S. Department of Energy for contract DE-RP22-87PC79997: Coal and Organic Petrology Laboratories, The Pennsylvania State University, University Park, Pennsylvania, DOE-PC-79997-1, 266 pp

Given, P.H., Weldon, D., and Zoeller, J.H., 1986, Calculation of calorific values of coals from ultimate analyses – theoretical basis and geochemical implications: Fuel, v. 65, p. 849-854.

McCutcheon, A.L., and Barton, W.A., 1999, Contribution of mineral matter to water associated with bituminous coals: Energy and Fuels, v. 13, p. 160-165.

Mott, R.A., and Spooner, C.E., 1940, The calorific value of carbon in coal – the Dulong relationship: Fuel, v. 19, p. 242-231 and 242-251.

Neavel, R.C., Smith, S.E., Hippo, E.J., and Miller, R.N., 1986, Interrelationships between coal compositional parameters: Fuel, v. 65, p. 312-320.

Quick, J.C., Brill, T.C., and Tabet, D.E., 2003, Mercury in US coal – observations using the COALQUAL and ICR data: Environmental Geology, v. 43, p. 247-259.

Quick, J.C., and Glick, D.C., 2000, Carbon dioxide from coal combustion – variation with rank of US coal: Fuel, v. 79, p. 803-812.

Scaroni, A.W., Davis, A., Glick, D.C., Hatcher, P.G., Mitchell, G.D., Carson, D., and Lei, H., 1999, Maintenance of the Coal Sample Bank and Data Base, final technical report for the U.S. Department of Energy contract DE-AC22-93PC93051: Coal and Organic Petrology Laboratories, The Pennsylvania State University, University Park, Pennsylvania, DOE-PC-93051-23, 192 pp.

Trumbell, J.V.A., 1960, Coal fields of the United States, exclusive of Alaska – sheet 1: U.S. Geological Survey Map, online, <nationalatlas.gov/coalfdm.html>, scale 1:5,000,000, accessed February 2004.

U.S. Energy Information Administration, 2003a, Form FERC 423 Database, Monthly cost and quality of fuels for electric power plants: Online, <eia.doe.gov/cneaf/electricity/page/ferc423.html>, accessed October and November 2003.

—2003b, Table 4.1, Consumption of fossil fuels for electricity generation by type of power producer, 1990 through 2001, Electric Power Annual 2001 data tables: Online, <eia.doe.gov/cneaf/electricity/epa/epa_sum.html>, accessed October and November 2003.

—2003c, The Coal Transportation Rate Database data tables: Online, <eia.doe.gov/cneaf/coal/ctrdb/database.html>, accessed October and November 2003.

U.S. Environmental Protection Agency, 2003, Unified air toxics website, Electric utility steam generating units hazardous air pollutant emission study: Online, <epa.gov/ttn/atw/combust/utiltox/utoxpg.html>, accessed October and November 2003.

LIST OF ACRONYMS AND ABBREVIATIONS

ASTM	American Society for Testing and Materials.
Btu/lb	British thermal units per pound coal on a moist, whole-coal basis (multiply by 0.002326 to convert to MJ/kg).
Btu/lb $_{m,mmf}$	British thermal units per pound coal, on a moist, mineral-matter-free basis calculated as, $Btu/lb_{m,mmf} = \frac{100\,(Btu/lb - 50\,Sulfur)}{(100 - [1.08\,Ash - 0.55\,S])}$, where the Sulfur, Ash and Btu/lb values are on a moist, whole-coal basis.
lbs S/10^6 Btu	Pounds of sulfur per million Btu (multiply by 0.430 to convert to kg S/GJ).
lbs Hg/10^{12} Btu	Pounds of mercury per trillion Btu (multiply by 0.430 to convert to kg Hg/PJ).
COALQUAL	Coal quality database from the U.S. Geological Survey.
CTRDB	Coal Transportation Rate Data Base from the U.S. Energy Information Administration.
daf	A dry, ash-free reporting basis, usually noted as a subscript associated with a coal assay value. Dry, ash-free basis values are obtained by multipling, moist, whole-coal assay values by the factor: $\frac{100}{(100 - Ash - Moisture)}$, where Ash and Moisture values are on a moist, whole-coal basis.
DOE	U.S. Department of Energy.
EIA	U.S. Energy Information Administration.
EPA	U.S. Environmental Protection Agency.
FERC	Federal Energy Regulatory Commission.
FERC 423	A monthly data set listing the cost and quality of coal delivered to U.S. power plants.
ICR	The part 2, Information Collection Request collected by the EPA. It includes mercury and chlorine values for fuels delivered to U.S. power plants.
PSU	Pennsylvania State University.
UGS	Utah Geological Survey
USGS	United States Geological Survey.

APPENDIX

Average Coal Quality Values by U.S. County-of-Origin

Average coal quality values, calculated for selected data records grouped by U.S. county-of-origin, are listed for the ICR, CTRDB, and FERC 423 data. Sometimes, multiple populations are listed for a single U.S. county. The subpopulations typically differ by several hundred Btu, or less frequently, by distinct ash or sulfur values. These subpopulations may be real or erroneous. Reasons for multiple populations within a single U.S. county include: significant intra-county variation of coal rank and quality, inconsistent reporting calculations, mistaken location origins, unrecognized coal blends, or the presence of raw and washed coal products. Consequently, the results presented here are preliminary.

Table A.1 *Average quality, including mercury and chlorine content, of commercially shipped coal indicated by selected records from the ICR data, aggregated by U.S. county-of-origin (subpopulations numerically listed where observed).*

PRELIMINARY RESULTS, February 2004

STATE County population	count	Btu (dry)	Ash (% dry)	Sulfur (% dry)	Mercury (ppm dry)	Chlorine (ppm dry)	lbs S per 10^6 Btu	lbs Hg per 10^{12} Btu
ALABAMA								
Fayette	25	12,940	13.4	1.8	0.10	360	1.4	7.6
Jefferson	113	13,120	13.6	1.4	0.22	370	1.1	16.7
1	25	13,400	10.6	0.8	0.06	140	0.5	4.4
2	51	13,050	14.3	1.9	0.32	250	1.4	24.7
3	37	12,630	14.8	1.3	0.18	700	1.0	13.9
Tuscaloosa	64	13,580	13.1	0.9	0.07	200	0.6	5.0
Walker	46	12,690	14.7	1.9	0.27	520	1.5	21.0
ARIZONA								
Navajo	98	12,310	9.9	0.6	0.04	100	0.5	3.1
COLORADO								
Delta	34	13,160	7.7	0.4	0.04	100	0.3	2.7
Gunnison	194	12,870	9.8	0.5	0.05	100	0.4	3.8
1	15	13,360	9.7	0.6	0.07	190	0.5	5.4
2	179	12,830	9.8	0.5	0.05	90	0.4	3.7
Mesa	39	12,360	14.0	0.6	0.04	570	0.5	3.2
Moffat	173	12,460	7.2	0.5	0.03	190	0.4	2.5
1	128	12,570	6.9	0.4	0.03	230	0.4	2.6
2	45	12,170	8.0	0.5	0.02	60	0.5	1.9
Montrose	46	11,450	21.1	0.9	0.06	70	0.8	5.4
Rio Blanco	53	11,690	12.9	0.5	0.04	170	0.4	3.3
Routt	238	12,490	10.2	0.5	0.04	330	0.4	3.0
1	182	12,540	10.5	0.5	0.04	250	0.4	3.1
2	56	12,330	9.1	0.5	0.04	600	0.4	2.9
ILLINOIS								
Franklin	44	13,630	6.7	1.1	0.06	4,450	0.8	4.4
Gallatin	220	13,580	9.9	3.0	0.11	1,850	2.2	8.0
Jackson	47	12,740	11.6	3.0	0.11	430	2.4	8.2
Jefferson	139	13,540	7.0	1.3	0.07	3,960	1.0	5.3
Logan	130	12,640	10.9	3.6	0.07	1,660	2.8	5.8
1	99	12,640	11.4	3.7	0.08	1,730	3.0	6.0
2	31	12,660	9.5	3.0	0.07	1,440	2.4	5.3
Macoupin	192	12,790	9.8	2.8	0.06	1,140	2.2	5.0
1	185	12,790	9.8	2.8	0.07	1,140	2.2	5.1
2	7	12,830	7.5	1.2	0.03	1,300	0.9	2.6
McDonough	3	13,730	6.5	3.2	0.19	210	2.3	14.1
Montgomery	54	12,710	10.2	1.4	0.06	1,210	1.1	4.6
Perry	187	12,670	11.1	3.2	0.06	1,190	2.5	4.9
1	18	12,820	11.3	2.8	0.09	420	2.2	6.9
2	169	12,650	11.1	3.2	0.06	1,270	2.5	4.7
Randolph	295	12,490	11.9	3.4	0.06	1,060	2.7	5.1

STATE County population	count	Btu (dry)	Ash (% dry)	Sulfur (% dry)	Mercury (ppm dry)	Chlorine (ppm dry)	lbs S per 10^6 Btu	lbs Hg per 10^{12} Btu
Saline	331	13,410	9.3	2.0	0.10	3,090	1.5	7.5
1	61	12,890	14.4	3.6	0.10	2,220	2.8	7.7
2	270	13,530	8.1	1.6	0.10	3,280	1.2	7.5
Vermilion	74	12,930	10.5	1.5	0.05	2,560	1.2	4.2
Wabash	54	12,710	12.1	1.7	0.16	1,800	1.4	12.9
Wayne	1	13,180	9.6	4.3	0.08	100	3.3	6.1
White	56	13,250	8.4	3.4	0.08	1,380	2.5	5.7
INDIANA								
Clay	4	11,970	16.9	2.5	0.08	280	2.1	6.8
Daviess	46	13,080	10.2	3.0	0.11	230	2.3	8.5
Gibson	113	12,960	10.4	2.6	0.08	350	2.0	6.4
Greene	114	13,010	10.9	2.3	0.09	420	1.8	6.5
Knox	259	13,060	10.1	1.7	0.06	420	1.3	4.7
Parke	46	13,580	7.4	2.4	0.05	460	1.8	4.0
Pike	161	12,970	10.5	3.5	0.08	230	2.7	6.5
Sullivan	205	12,930	10.9	1.7	0.05	380	1.3	4.0
1	65	12,820	11.6	2.4	0.07	430	1.9	5.1
2	140	12,980	10.6	1.4	0.04	360	1.1	3.5
Vigo	184	12,490	12.8	1.3	0.08	450	1.1	6.2
1	136	12,980	10.6	1.4	0.07	490	1.1	5.6
2	48	11,120	18.8	1.2	0.09	360	1.1	7.9
Warrick	157	12,740	11.5	3.8	0.10	260	3.0	7.7
1	46	12,710	11.6	5.0	0.08	150	4.0	6.5
2	111	12,750	11.5	3.3	0.11	300	2.6	8.3
KANSAS								
Crawford	86	12,780	14.2	3.5	0.07	1,810	2.8	5.2
Linn	38	11,760	21.0	4.4	0.12	900	3.7	10.7
KENTUCKY								
Bell	102	13,440	9.8	1.4	0.10	430	1.0	7.1
Boyd	16	13,280	11.7	0.9	0.08	750	0.7	6.1
Breathitt	200	13,140	11.2	1.3	0.10	830	1.0	7.8
1	8	13,730	10.9	1.4	0.13	540	1.0	9.7
2	192	13,120	11.2	1.3	0.10	840	1.0	7.8
Clay	22	13,410	10.6	1.6	0.22	2,800	1.2	16.4
Daviess	46	12,950	10.5	3.3	0.09	200	2.5	6.9
1	28	13,060	9.9	2.9	0.08	190	2.2	6.3
2	18	12,770	11.5	3.9	0.10	230	3.0	7.8
Estill	5	13,820	7.9	1.0	0.05	930	0.7	3.9
Floyd	233	13,090	11.7	1.1	0.09	1,290	0.8	7.1
Harlan	267	13,690	9.0	1.1	0.08	440	0.8	6.2
Henderson	108	12,130	14.9	3.9	0.14	230	3.2	11.9
Hopkins	230	12,670	13.3	3.1	0.09	530	2.5	6.9
Jackson	3	13,140	11.3	1.8	0.16	1,870	1.4	12.2
Johnson	76	13,000	11.3	1.4	0.16	1,050	1.1	12.0
Knott	412	13,580	9.3	1.2	0.09	1,260	0.9	6.9
1	33	13,720	10.2	1.2	0.07	1,160	0.9	5.2

STATE County population	count	Btu (dry)	Ash (% dry)	Sulfur (% dry)	Mercury (ppm dry)	Chlorine (ppm dry)	lbs S per 10^6 Btu	lbs Hg per 10^{12} Btu
2	359	13,600	9.2	1.2	0.10	1,280	0.9	7.0
3	20	13,040	11.0	1.0	0.09	1,140	0.8	6.6
Laurel	8	12,870	13.6	1.1	0.10	1,970	0.9	7.6
Lawrence	92	13,330	10.0	1.1	0.14	1,180	0.8	10.8
Leslie	206	13,560	9.4	1.2	0.07	1,230	0.9	5.5
Letcher	313	13,680	8.8	1.2	0.09	1,140	0.9	6.9
Magoffin	40	13,240	11.2	1.4	0.10	860	1.0	7.5
Martin	266	12,960	11.7	0.9	0.11	1,010	0.7	8.2
McLean	16	11,850	17.9	3.7	0.08	290	3.2	6.6
Muhlenberg	55	12,090	16.3	3.6	0.10	260	3.0	8.5
Ohio	3	12,500	13.5	4.0	0.11	340	3.2	8.8
Owsley	23	13,220	10.2	2.0	0.17	1,950	1.5	13.0
Perry	542	13,200	11.2	1.0	0.07	1,020	0.8	5.4
Pike	847	13,540	10.0	0.9	0.09	1,380	0.7	6.5
Pulaski	10	13,410	10.7	1.3	0.11	1,010	1.0	8.1
Union	225	13,230	10.5	2.7	0.09	1,790	2.0	7.1
1	132	13,350	10.7	2.3	0.10	2,430	1.7	7.4
2	93	13,070	10.1	3.2	0.09	870	2.5	6.6
Webster	153	13,130	11.0	2.9	0.10	1,820	2.2	7.5
Whitley	24	13,190	10.6	1.3	0.11	1,530	1.0	8.4
LOUISIANA								
DeSoto	59	10,430	18.1	1.4	0.09	160	1.3	8.9
Red River	38	10,540	18.2	1.1	0.06	160	1.0	5.6
MARYLAND								
Allegheny	29	12,200	19.5	1.8	0.20	160	1.5	16.4
Garrett	116	13,180	15.2	1.8	0.20	940	1.4	15.4
MISSOURI								
Bates	30	11,840	19.2	4.1	0.10	390	3.5	8.5
MONTANA								
Big Horn	452	12,290	6.8	0.6	0.05	80	0.5	4.2
Richland	28	10,700	12.0	0.8	0.09	200	0.7	8.6
Rosebud	35	11,910	11.1	1.0	0.07	40	0.9	5.5
NEW MEXICO								
Colfax	7	12,560	15.6	0.6	0.06	130	0.5	4.4
McKinley	206	11,300	18.2	0.7	0.06	160	0.7	5.8
San Juan	101	10,160	26.5	0.9	0.09	80	0.9	8.6
1	52	10,070	28.1	1.0	0.09	70	1.0	9.1
2	49	10,260	24.8	0.9	0.08	90	0.9	8.0
NORTH DAKOTA								
McLean	45	9,910	18.2	1.1	0.10	110	1.1	9.9
Mercer	255	10,630	12.7	1.1	0.07	120	1.0	7.0
1	26	11,010	11.0	1.1	0.08	200	1.0	7.5
2	229	10,590	12.9	1.1	0.07	110	1.0	7.0
Oliver	68	10,690	14.1	1.6	0.12	190	1.5	11.3

STATE County population	count	Btu (dry)	Ash (% dry)	Sulfur (% dry)	Mercury (ppm dry)	Chlorine (ppm dry)	lbs S per 10^6 Btu	lbs Hg per 10^{12} Btu
1	33	10,840	13.4	1.6	0.13	180	1.5	12.1
2	35	10,550	14.8	1.5	0.11	200	1.4	10.5
OHIO								
Belmont	422	13,100	11.0	4.0	0.13	490	3.1	9.7
Carroll	3	12,970	12.6	2.8	0.30	670	2.1	23.2
Columbiana	14	13,040	11.7	4.1	0.48	1,040	3.1	37.3
Coshocton	49	13,350	8.3	3.0	0.24	830	2.2	18.2
Guernsey	2	12,190	15.9	2.3	0.41	700	1.9	33.8
Harrison	192	12,980	12.0	3.0	0.29	1,220	2.3	22.2
1	168	13,050	11.9	2.9	0.29	1,320	2.2	22.0
2	24	12,520	12.8	3.8	0.29	520	3.0	23.3
Holmes	14	12,190	15.0	3.4	0.40	760	2.8	33.4
Jackson	34	12,130	14.4	4.5	0.29	240	3.7	24.3
Jefferson	36	12,870	12.5	2.5	0.16	740	1.9	12.6
Mahoning	3	10,650	23.8	3.8	0.37	750	3.6	35.2
Meigs	101	12,400	13.9	3.9	0.24	1,460	3.2	19.3
Morgan	56	12,520	13.6	4.7	0.13	610	3.8	10.5
Perry	91	12,490	12.9	3.1	0.30	270	2.5	23.8
Tuscarawas	64	12,520	13.4	3.9	0.23	810	3.1	18.8
1	52	12,580	13.4	4.0	0.19	820	3.2	15.4
2	12	12,240	13.5	3.6	0.41	790	3.0	33.4
Vinton	117	12,580	11.9	3.3	0.19	380	2.6	15.3
OKLAHOMA								
Haskell	11	12,760	16.7	3.5	0.45	560	2.7	35.3
Le Flore	28	12,710	16.8	3.5	0.46	500	2.8	36.1
Rogers	36	13,330	11.2	4.2	0.07	2,030	3.2	5.6
PENNSYLVANIA								
Armstrong	20	12,880	14.7	2.9	0.39	1,740	2.3	30.4
Beaver	260	12,890	12.9	1.8	0.24	730	1.4	18.8
Bedford	8	12,490	15.9	1.6	0.42	890	1.3	33.4
Butler	6	11,910	17.5	3.1	0.30	860	2.6	25.2
Cambria	3	13,380	13.4	2.1	0.30	1,620	1.6	22.3
Clearfield	6	12,830	16.8	1.9	0.44	1,080	1.5	34.2
Elk	49	13,370	11.6	2.1	0.46	1,570	1.6	34.2
Fayette	62	13,710	9.1	1.8	0.16	880	1.3	11.9
Greene	908	13,920	8.2	2.1	0.11	980	1.5	8.1
Indiana	4	13,080	15.3	2.4	0.48	1,710	1.8	36.9
Luzerne	2	13,160	11.2	0.6	0.13	150	0.5	9.9
Lycoming	23	11,260	24.2	0.7	0.20	900	0.6	18.1
Northumberland	50	11,820	18.3	0.7	0.13	430	0.6	11.1
Somerset	163	13,710	10.8	2.1	0.18	950	1.5	13.0
1	78	13,450	13.4	1.8	0.21	1,050	1.4	16.1
2	85	13,950	8.5	2.3	0.14	870	1.7	10.2
Washington	413	13,930	7.7	1.7	0.13	1,080	1.2	9.6
Westmoreland	27	13,870	8.8	1.7	0.22	1,380	1.2	15.7

STATE County population	count	Btu (dry)	Ash (% dry)	Sulfur (% dry)	Mercury (ppm dry)	Chlorine (ppm dry)	lbs S per 10^6 Btu	lbs Hg per 10^{12} Btu
TENNESSEE								
Anderson	12	13,390	10.0	1.3	0.15	1,030	1.0	11.5
Campbell	1	13,320	10.1	1.2	0.13	340	0.9	9.5
Claiborne	24	13,800	7.9	1.4	0.10	380	1.0	7.6
Cumberland	15	13,410	12.7	0.8	0.05	810	0.6	3.6
Morgan	1	13,320	11.6	1.9	0.27	320	1.4	20.6
Scott	19	13,210	11.6	1.5	0.13	990	1.1	9.7
Sequatchie	34	12,910	14.2	0.8	0.07	1,110	0.6	5.3
TEXAS								
Atascosa	34	7,530	34.4	2.3	0.05	900	3.1	6.7
Freestone	32	9,700	23.3	1.1	0.13	370	1.1	13.9
Harrison	48	9,790	22.8	1.9	0.30	130	1.9	30.6
Leon	12	9,590	24.8	1.5	0.14	220	1.6	14.7
Milam	28	9,680	23.5	1.7	0.09	470	1.7	9.4
Robertson	87	9,700	24.3	1.3	0.04	130	1.4	3.9
UTAH								
Carbon	126	12,820	10.6	0.6	0.05	210	0.5	3.6
1	57	12,910	10.9	0.7	0.05	310	0.5	3.7
2	69	12,740	10.4	0.6	0.04	130	0.5	3.4
Emery	226	13,110	10.4	0.5	0.06	250	0.4	4.4
Sevier	91	12,650	9.2	0.4	0.06	110	0.3	4.6
VIRGINIA								
Buchanan	240	14,100	8.9	0.9	0.09	1,130	0.6	6.8
1	103	14,840	6.0	0.7	0.08	1,460	0.5	5.5
2	137	13,550	11.1	1.0	0.10	880	0.8	7.8
Craig	18	14,780	6.3	0.7	0.08	1,130	0.5	5.6
Dickenson	69	14,090	8.8	1.0	0.08	520	0.7	5.5
1	36	14,250	8.5	1.0	0.07	520	0.7	5.2
2	33	13,910	9.1	1.0	0.08	530	0.7	5.8
Lee	56	13,750	8.6	1.2	0.06	110	0.9	4.4
Russell	136	12,990	15.3	0.7	0.06	610	0.6	5.0
Wise	846	13,710	10.4	1.1	0.09	300	0.8	6.3
WASHINGTON								
Lewis	90		20.4	1.2	0.07	100	1.2	6.4
WEST VIRGINIA								
Barbour	38	13,910	10.1	1.5	0.16	1,670	1.1	11.3
Boone	1,190	13,220	12.0	0.9	0.09	1,310	0.7	6.9
1	770	13,430	11.5	0.9	0.08	1,450	0.6	6.2
2	420	12,840	12.9	0.8	0.11	1,040	0.7	8.3
Braxton	8	13,530	11.0	0.9	0.14	1,340	0.7	10.1
Brooke	127	13,180	11.2	4.0	0.14	820	3.0	10.6
Calhoun	4	13,450	10.4	1.5	0.10	500	1.1	7.4
Clay	73	12,980	13.3	0.8	0.14	930	0.7	10.7
Fayette	166	12,930	13.9	0.9	0.10	1,040	0.7	7.5

STATE County population	count	Btu (dry)	Ash (% dry)	Sulfur (% dry)	Mercury (ppm dry)	Chlorine (ppm dry)	lbs S per 10^6 Btu	lbs Hg per 10^{12} Btu
1	18	13,720	11.0	1.1	0.12	1,010	0.8	9.0
2	141	12,820	14.5	0.9	0.09	1,060	0.7	7.3
3	7	13,140	10.7	1.3	0.13	590	1.0	9.6
Grant	113	13,210	14.3	1.8	0.23	1,150	1.4	17.6
Greenbrier	6	14,010	9.7	0.9	0.15	1,010	0.7	10.7
Harrison	19	14,050	7.3	3.1	0.09	740	2.2	6.4
Kanawha	671	12,820	14.4	0.8	0.09	970	0.6	7.4
Lincoln	24	12,290	15.5	0.9	0.09	800	0.7	7.4
Logan								
1	259	13,130	12.6	0.7	0.08	1,120	0.6	5.8
2	110	12,500	14.7	0.8	0.12	900	0.6	9.3
Marion	13	14,100	7.6	2.2	0.06	1,290	1.6	4.5
Marshall	606	12,960	13.0	4.1	0.12	440	3.2	9.6
Mingo	452	12,960	13.2	0.9	0.08	1,070	0.7	6.4
Monongalia	516	13,460	10.9	2.3	0.11	860	1.7	8.7
Nicholas	141	13,090	13.1	1.0	0.14	1,040	0.8	11.0
Preston	18	14,030	9.4	1.5	0.16	1,770	1.0	11.3
Raleigh	7	12,220	19.0	0.9	0.11	800	0.8	9.1
Upshur	92	13,650	10.3	1.8	0.25	1,000	1.4	18.4
Wayne	417	12,900	12.4	0.9	0.12	1,030	0.7	9.2
Webster	268	13,190	12.7	1.0	0.12	1,380	0.7	9.2
Wyoming	17	14,210	7.7	0.8	0.06	1,190	0.6	4.2
WYOMING								
Campbell	3,819	12,050	7.1	0.4	0.07	130	0.4	5.8
Carbon	133	12,590	7.3	0.7	0.03	60	0.6	2.1
Converse	392	11,900	7.6	0.4	0.06	170	0.3	4.8
1	328	12,000	7.2	0.4	0.06	170	0.3	4.9
2	64	11,380	9.4	0.5	0.05	150	0.4	4.6
Lincoln	105	12,550	6.5	1.0	0.05	140	0.8	4.2
Sweetwater	116	11,760	11.9	0.7	0.05	100	0.6	4.3

Table A.2 Average quality of commercially shipped coal indicated by three data sets for data aggregated by U.S. county -of-origin

PRELIMINARY RESULTS, February 2004.

ORIGIN		ICR						CTRDB						FERC 423				
STATE		calculated to a moist basis.						reported on a moist basis.						reported on a moist basis				
County Population		n	M	Btu	Ash	S	Btu m,mmf	n	M	Btu	Ash	S	Btu m,mmf	n	Btu	Ash	S	Btu m,mmf
ALABAMA																		
Fayette		25	7.1	12,030	12.5	1.7	13,950	27	6.9	12,080	12.3	1.8	13,990	35	12,000	12.6	1.7	13,940
Jefferson		113	6.6	12,260	12.7	1.3	14,240	33	8.4	12,380	11.6	0.7	14,180	98	12,300	12.9	1.1	14,340
	1	25	5.5	13,230	10	0.7	14,850	—	—	—	—	—	—	24	12,870	12.1	1.4	14,850
	2	51	6.6	12,180	13.3	1.7	14,290	—	—	—	—	—	—	62	12,200	13.2	1	14,250
	3	37	7.3	11,710	13.7	1.2	13,770	—	—	—	—	—	—	12	11,730	13.6	1.1	13,770
Shelby		—	—	—	—	—	—	4	7.4	12,520	10.8	0.7	14,190	—	—	—	—	—
Tuscaloosa		64	7.5	12,560	12.1	0.8	14,470	—	—	—	—	—	—	67	12,510	12	0.9	14,400
	1	—	—	—	—	—	—	—	—	—	—	—	—	57	12,590	11.9	0.8	14,470
	2	—	—	—	—	—	—	—	—	—	—	—	—	10	12,050	12.7	1.7	14 020
Walker		46	6.2	11,900	13.7	1.8	14,040	85	6.8	12,120	12.7	1.1	14,070	33	11,920	13.6	1.6	14,030
Winston		—	—	—	—	—	—	5	6.8	12,030	11.7	1	13,800	—	—	—	—	—
ARIZONA																		
Navajo		*98	*14.7	*10,500	*8.4	*0.5	*11,560	—	—	—	—	—	—	24	10,960	9.6	0.5	12,240
COLORADO																		
Delta		34	8.4	12,050	7.0	0.4	13,050	8	11.3	11,290	8.7	0.4	12,460	26	12,060	7.0	0.4	13,050
Gunnison		194	8.8	11,740	8.9	0.5	13,000	41	8.8	11,790	9.0	0.5	13,070	124	11,720	9.2	0.5	13,020
	1	15	6.2	12,530	9.1	0.6	13,910	10	7.6	12,080	9.6	0.5	13,490	13	12,440	9.6	0.6	13,900
	2	179	9.1	11,670	8.9	0.5	12,920	31	9.2	11,700	8.8	0.5	12,930	111	11,640	9.1	0.5	12,920
Mesa		39	9.1	11,240	12.8	0.5	13,050	11	9.7	11,130	12.3	0.6	12,850	20	11,260	12.4	0.5	13,020
Moffat		173	17.1	10,330	5.9	0.4	11,040	31	12.2	10,980	8.5	0.4	12,100	74	10,360	5.9	0.4	11,070
	1	—	—	—	—	—	—	22	10.4	11,180	9.6	0.4	12,480	—	—	—	—	—
	2	128	16.7	10,460	5.7	0.4	11,160	9	16.6	10,480	5.7	0.4	11,170	60	10,470	5.7	0.4	11,160
	3	45	18.3	9,940	6.5	0.4	10,690	—	—	—	—	—	—	14	9,910	6.7	0.4	10,690

ORIGIN		ICR						CTRDB						FERC 423				
STATE		calculated to a moist basis.						reported on a moist basis.						reported on a moist basis				
County Population		n	M	Btu	Ash	S	Btu m,mmf	n	M	Btu	Ash	S	Btu m,mmf	n	Btu	Ash	S	Btu m,mmf
Montrose		46	5.8	10,780	19.9	0.8	13,750	—	—	—	—	—	—	12	10,760	20.0	0.8	13,750
Rio,Blanco		53	13.1	10,150	11.2	0.4	11,550	—	—	—	—	—	—	9	10,190	10.9	0.4	11,560
Routt		238	11.1	11,100	9.1	0.5	12,320	24	10.8	11,130	9.1	0.5	12,350	120	11,130	9.0	0.5	12,350
	1	182	9.8	11,310	9.5	0.5	12,610	20	10.4	11,230	9.1	0.5	12,480	95	11,290	9.6	0.5	12,610
	2	56	15.4	10,440	7.7	0.4	11,390	4	12.9	10,600	8.7	0.4	11,700	25	10,520	6.9	0.4	11,380
ILLINOIS																		
Brown		—	—	—	—	—	—	6	16.5	11,460	5.3	2.8	12,210	—	—	—	—	—
Clinton		—	—	—	—	—	—	4	15.2	10,850	8.0	3.4	11,930	—	—	—	—	—
Franklin		44	13.5	11,790	5.8	0.9	12,600	16	11.7	11,550	8.5	2.3	12,760	—	—	—	—	—
Gallatin		220	6.8	12,660	9.3	2.8	14,160	5	6.6	12,660	9.3	2.8	14,170	111	12,460	10.0	2.7	14,030
	1	—	—	—	—	—	—	—	—	—	—	—	—	105	12,680	9.1	2.7	14,150
	2	—	—	—	—	—	—	—	—	—	—	—	—	6	8,530	26.2	2.6	11,940
Jackson		47	12.4	11,170	10.1	2.7	12,600	4	10.3	11,560	9.6	2.7	12,960	25	11,260	9.4	2.5	12,590
Jefferson		139	11.3	12,010	6.2	1.2	12,900	32	11.5	11,960	6.5	1.0	12,880	93	11,740	7.6	1.1	12,790
	1	—	—	—	—	—	—	—	—	—	—	—	—	87	11,970	6.6	1.0	12,900
	2	—	—	—	—	—	—	—	—	—	—	—	—	6	8,470	22.7	1.7	11,240
Logan		130	17.3	10,450	9.0	3.0	11,630	—	—	—	—	—	—	25	10,470	9.4	3.1	11,700
	1	99	17.2	10,470	9.4	3.1	11,700	—	—	—	—	—	—	—	—	—	—	—
	2	31	17.9	10,400	7.8	2.5	11,390	—	—	—	—	—	—	—	—	—	—	—
Macoupin		192	16.9	10,630	8.1	2.3	11,690	31	17.6	10,500	8.3	2.5	11,570	49	10,470	8.1	2.3	11,510
	1	185	16.9	10,630	8.2	2.4	11,700	18	16.5	10,670	8.2	3.4	11,770	23	10,640	8.1	3.5	11,720
	2	7	17.6	10,570	6.2	1.0	11,330	13	19.1	10,270	8.3	1.2	11,290	26	10,320	8.1	1.2	11,320
McDonough		3	11.7	12,130	5.7	2.8	12,990	—	—	—	—	—	—	14	10,730	8.5	2.9	11,860
Montgomery		54	16.0	10,670	8.6	1.2	11,780	—	—	—	—	—	—	12	10,710	8.3	3.4	11,820
Perry		187	12.9	11,030	9.7	2.7	12,380	28	12.6	11,170	9.1	2.8	12,440	60	11,040	9.9	2.9	12,430
	1	18	11.0	11,420	10.0	2.5	12,860	4	11.7	11,740	7.1	2.3	12,780	11	11,200	11.6	2.6	12,860
	2	169	13.2	10,990	9.7	2.8	12,320	24	12.7	11,070	9.4	2.9	12,380	49	11,000	9.5	2.9	12,330

ORIGIN		ICR						CTRDB						FERC 423				
STATE		calculated to a moist basis.						reported on a moist basis.						reported on a moist basis				
County Population		n	M	Btu	Ash	S	Btu m,mmf	n	M	Btu	Ash	S	Btu m,mmf	n	Btu	Ash	S	Btu m,mmf
Randolph		295	12.7	10,910	10.4	3.0	12,350	33	13.0	11,000	9.7	2.9	12,340	21	11,070	9.3	2.8	12,350
Saline		331	9.2	12,180	8.5	1.8	13,460	53	9.8	12,120	8.0	1.9	13,320	167	12,210	8.5	1.9	13,510
	1	61	5.0	12,250	13.7	3.4	14,490	8	6.1	12,710	9.5	2.9	14,250	40	12,470	12.1	3.2	14,460
	2	270	10.2	12,160	7.3	1.4	13,230	45	10.4	12,010	7.7	1.7	13,150	127	12,130	7.4	1.5	13,220
Vermilion		74	16.1	10,850	8.8	1.3	12,010	4	16.3	10,870	8.4	1.5	11,990	19	10,890	8.5	1.3	12,020
Wabash		54	13.4	11,010	10.5	1.5	12,450	4	13.4	10,860	11.6	1.5	12,440	22	11,070	10.1	1.5	12,460
Washington		—	—	—	—	—	—	—	—	—	—	—	—	15	10,690	10.5	2.9	12,110
Wayne		13177	11.4	11,680	8.5	3.8	12,950	—	—	—	—	—	—	—	—	—	—	—
White		56	10.9	11,810	7.5	3.0	12,920	—	—	—	—	—	—	38	11,810	7.5	2.9	12,920
Williamson		—	—	—	—	—	—	—	—	—	—	—	—	18	10,230	17.9	2.4	12,670
	1	—	—	—	—	—	—	—	—	—	—	—	—	7	8,430	26.4	2.0	11,830
	2	—	—	—	—	—	—	—	—	—	—	—	—	11	11,380	12.4	2.6	13,210
INDIANA																		
Clay		4	12.9	10,430	14.7	2.2	12,450	18	15.5	11,110	8.7	1.6	12,290	10	11,170	9.5	2.1	12,480
Daviess		46	13.5	11,320	8.8	2.6	12,560	53	14.3	11,290	8.5	1.8	12,460	99	11,310	8.3	2.3	12,470
	1	—	—	—	—	—	—	—	—	—	—	—	—	78	11,340	8.7	2.6	12,570
	2	—	—	—	—	—	—	—	—	—	—	—	—	21	11,200	6.9	1.4	12,120
Gibson		113	13.5	11,210	9.0	2.2	12,460	34	14.1	11,110	9.1	2.3	12,370	84	11,140	9.4	2.7	12,450
Greene		114	15.0	11,060	9.2	1.9	12,330	93	14.7	11,180	8.8	1.8	12,390	144	11,090	9.2	1.9	12,360
	1	—	—	—	—	—	—	88	14.8	11,160	8.8	1.8	12,370	136	11,090	9.1	1.8	12,330
	2	—	—	—	—	—	—	5	12.8	11,600	8.4	2.6	12,830	8	11,210	12.0	3.2	12,970
Knox		259	14.3	11,200	8.7	1.5	12,390	52	15.1	11,130	8.4	1.5	12,270	94	11,140	9.1	2.0	12,400
	1	—	—	—	—	—	—	—	—	—	—	—	—	87	11,110	9.2	2.1	12,390
	2	—	—	—	—	—	—	—	—	—	—	—	—	7	11,450	8.0	1.2	12,550
Owen		—	—	—	—	—	—	9	16.2	11,160	7.8	1.4	12,210	14	11,950	6.7	2.0	12,920
Parke		46	11.7	11,990	6.5	2.1	12,940	—	—	—	—	—	—	—	—	—	—	—

ORIGIN		ICR						CTRDB						FERC 423				
STATE		calculated to a moist basis.						reported on a moist basis.						reported on a moist basis				
County Population		n	M	Btu	Ash	S	Btu m,mmf	n	M	Btu	Ash	S	Btu m,mmf	n	Btu	Ash	S	Btu m,mmf
Pike		161	12.1	11,400	9.3	3.1	12,730	13	12.6	11,380	8.8	3.3	12,640	119	11,240	10.2	3.6	12,720
Sullivan		205	15.8	10,890	9.2	1.4	12,120	35	15.4	10,850	9.7	1.5	12,150	51	10,900	9.4	1.6	12,170
	1	65	13.9	11,030	10.0	2.1	12,410	21	14.9	10,910	9.7	1.9	12,230	22	11,050	9.9	2.1	12,410
	2	140	16.6	10,830	8.8	1.2	11,980	14	16.2	10,750	9.7	0.8	12,020	29	10,800	9.0	1.1	11,980
Vigo		184	17.3	10,350	10.5	1.1	11,670	10	16.7	10,830	8.6	1.2	11,950	96	10,600	9.6	1.2	11,840
	1	136	16.8	10,800	8.8	1.2	11,960	—	—	—	—	—	—	85	10,790	8.9	1.2	11,960
	2	48	18.6	9,050	15.3	1.0	10,860	—	—	—	—	—	—	11	9,110	14.9	1.0	10,870
Warrick		157	12.7	11,130	10.1	3.4	12,560	44	13.0	11,240	9.1	2.9	12,530	40	11,090	10.0	3.4	12,500
	1	46	9.8	11,460	10.4	4.5	13,030	17	11.0	11,720	8.8	3.2	13,030	11	11,510	10.1	4.5	13,030
	2	111	13.8	10,990	9.9	2.9	12,360	27	14.3	10,950	9.3	2.7	12,220	29	10,930	9.9	3.1	12,300
KANSAS																		
Crawford		86	7.6	11,820	13.1	3.3	13,870	15	7.6	12,110	11.7	3.3	13,960	—	—	—	—	—
Linn		38	6.9	10,950	19.5	4.1	14,020	—	—	—	—	—	—	23	10,940	19.6	4.1	14,020
KENTUCKY																		
Bell		102	6.0	12,640	9.2	1.3	14,070	19	6.3	12,520	10.2	1.2	14,110	77	12,730	8.7	1.3	14,080
Boyd		16	7.4	12,310	10.8	0.9	13,960	—	—	—	—	—	—	32	12,430	10.0	0.8	13,960
Breathitt		200	8.9	11,970	10.2	1.1	13,470	47	7.0	12,340	10.0	1.1	13,870	84	11,820	12.0	1.1	13,610
	1	8	7.9	12,640	10.1	1.3	14,220	32	6.6	12,490	9.8	1.1	14,000	17	12,280	12.4	0.8	14,210
	2	192	9.0	11,940	10.2	1.1	13,440	15	7.6	12,020	10.5	1.1	13,580	67	11,700	11.9	1.2	13,460
Christian		—	—	—	—	—	—	6	11.0	11,820	8.2	2.3	13,020	4	10,700	15.6	4.2	12,980
Clay		22	7.6	12,400	9.8	1.4	13,900	6	5.8	12,640	9.7	1.2	14,150	28	12,270	10.7	1.0	13,910
Daviess		46	13.4	11,210	9.1	2.8	12,490	9	13.2	11,080	9.8	3.2	12,460	39	11,150	9.1	2.9	12,430
	1	28	12.4	11,440	8.7	2.5	12,670	—	—	—	—	—	—	19	11,390	9.0	2.7	12,670
	2	18	14.9	10,870	9.8	3.3	12,210	—	—	—	—	—	—	20	10,930	9.3	3.0	12,210
Estill		5	7.5	12,780	7.3	0.9	13,900	—	—	—	—	—	—	—	—	—	—	—
Floyd		233	6.9	12,190	10.9	1.0	13,850	73	6.8	12,500	9.7	0.9	13,980	217	12,210	11.0	0.9	13,870

ORIGIN	ICR						CTRDB						FERC 423				
STATE	calculated to a moist basis.						reported on a moist basis.						reported on a moist basis				
County Population	n	M	Btu	Ash	S	Btu m,mmf	n	M	Btu	Ash	S	Btu m,mmf	n	Btu	Ash	S	Btu m,mmf
Greenup	—	—	—	—	—	—	6	7.4	11,490	14.2	2.5	13,650	12	12,370	12.2	0.9	14,280
Harlan	267	6.4	12,810	8.4	1.1	14,120	70	6.8	12,660	8.7	1.0	14,010	226	12,770	8.7	1.0	14,120
Henderson	108	12.6	10,600	13.0	3.4	12,400	24	12.7	11,310	9.0	2.8	12,580	32	10,690	12.1	3.3	12,400
1	—	—	—	—	—	—	17	13.7	11,120	9.0	2.7	12,360	—	—	—	—	—
2	—	—	—	—	—	—	7	10.4	11,770	9.0	2.8	13,110	—	—	—	—	—
Hopkins	230	9.5	11,470	12.0	2.8	13,250	38	10.1	11,680	9.9	2.9	13,150	107	11,330	13.0	3.0	13,260
Jackson	3	7.4	12,170	10.5	1.7	13,770	—	—	—	—	—	—	—	—	—	—	—
Johnson	76	6.9	12,110	10.5	1.3	13,700	23	6.5	12,010	11.3	1.3	13,710	66	11,900	12.0	1.3	13,700
Knott	412	6.6	12,690	8.7	1.1	14,040	74	6.5	12,340	10.6	1.0	13,970	263	12,500	9.9	1.1	14,030
1	33	5.1	13,030	9.6	1.1	14,580	—	—	—	—	—	—	17	12,810	11.0	1.3	14,580
2	359	6.6	12,700	8.6	1.2	14,030	—	—	—	—	—	—	232	12,530	9.7	1.1	14,030
3	20	8.9	11,870	10.0	0.9	13,340	—	—	—	—	—	—	14	11,680	11.4	1.1	13,350
Laurel	8	9.2	11,690	12.4	1.0	13,520	—	—	—	—	—	—	4	11,790	11.7	1.8	13,550
Lawrence	92	8.0	12,270	9.2	1.0	13,660	—	—	—	—	—	—	25	12,250	9.3	1.0	13,650
Leslie	206	6.8	12,640	8.8	1.1	14,000	20	5.8	12,670	9.2	1.3	14,120	52	12,560	9.3	1.1	13,990
Letcher	313	6.2	12,830	8.2	1.2	14,120	38	6.1	12,890	8.1	1.0	14,150	179	12,840	8.3	1.2	14,130
Magoffin	40	7.4	12,270	10.4	1.3	13,860	19	7.0	12,000	12.3	1.3	13,880	42	12,200	10.8	1.2	13,860
Martin	266	6.4	12,130	11.0	0.9	13,780	119	6.6	12,390	9.6	0.8	13,850	287	12,060	11.3	1.0	13,760
1	—	—	—	—	—	—	—	—	—	—	—	—	278	12,110	11.2	0.9	13,800
2	—	—	—	—	—	—	—	—	—	—	—	—	9	10,380	15.4	3.8	12,550
McLean	16	12.4	10,380	15.7	3.3	12,570	—	—	—	—	—	—	—	—	—	—	—
Muhlenberg	55	10.6	10,800	14.6	3.2	12,910	9	12.5	11,410	8.6	2.6	12,630	15	10,240	14.0	2.9	12,160
1	—	—	—	—	—	—	—	—	—	—	—	—	9	10,540	15.8	3.2	12,820
2	—	—	—	—	—	—	—	—	—	—	—	—	6	9,780	11.3	2.5	11,160
Ohio	3	11.6	11,040	12.0	3.5	12,760	11	11.6	11,500	8.9	3.1	12,790	—	—	—	—	—
Owsley	23	6.4	12,370	9.6	1.8	13,850	—	—	—	—	—	—	9	12,610	8.1	1.7	13,870

ORIGIN	ICR						CTRDB						FERC 423				
STATE	calculated to a moist basis.						reported on a moist basis.						reported on a moist basis				
County Population	n	M	Btu	Ash	S	Btu m,mmf	n	M	Btu	Ash	S	Btu m,mmf	n	Btu	Ash	S	Btu m,mmf
Perry	542	6.6	12,320	10.4	0.9	13,910	95	6.3	12,730	8.6	1.0	14,060	387	12,270	10.8	1.0	13,910
1	—	—	—	—	—	—	—	—	—	—	—	—	377	12,300	10.7	1.0	13,940
2	—	—	—	—	—	—	—	—	—	—	—	—	10	10,990	13.3	1.0	12,860
Pike	847	6.5	12,650	9.3	0.8	14,100	495	6.3	12,750	9.1	1.0	14,170	1,007	12,600	9.7	0.9	14,100
Pulaski	10	6.8	12,500	10.0	1.3	14,050	—	—	—	—	—	—	36	12,610	9.3	1.3	14,050
Union	225	8.9	12,060	9.5	2.5	13,510	—	—	—	—	—	—	76	11,860	9.1	2.7	13,220
1	132	7.1	12,400	10.0	2.2	13,960	—	—	—	—	—	—	24	12,450	9.7	2.4	13,970
2	93	11.4	11,580	8.9	2.9	12,880	—	—	—	—	—	—	52	11,580	8.9	2.9	12,880
Webster	153	6.8	12,240	10.3	2.7	13,840	25	8.2	12,230	9.5	2.7	13,700	90	11,940	12.2	3.0	13,840
Whitley	24	7.6	12,190	9.8	1.2	13,670	—	—	—	—	—	—	17	12,450	8.0	1.1	13,660
LOUISIANA																	
DeSoto	59	33.5	6,936	12.0	0.9	7,970	8	33.5	6,850	12.3	1.0	7,890	11	6,920	12.3	1.0	7,970
Red,River	38	32.5	7,117	12.3	0.7	8,210	8	31.6	6,940	14.0	0.7	8,180	10	7,050	13.1	0.7	8,210
MARYLAND																	
Allegheny	29	4.9	11,608	18.5	1.7	14,580	—	—	—	—	—	—	18	12,111	14.0	1.3	14,310
1	—	—	—	—	—	—	—	—	—	—	—	—	7	11,739	17.7	1.7	14,574
2	—	—	—	—	—	—	—	—	—	—	—	—	11	12,349	11.6	1.0	14,142
Garrett	116	5.6	12,440	14.3	1.7	14,780	38	6.2	12,820	11.5	1.6	14,690	52	12,200	14.8	2.2	14,600
1	—	—	—	—	—	—	—	—	—	—	—	—	43	12,300	15.2	1.9	14,790
2	—	—	—	—	—	—	—	—	—	—	—	—	9	11,730	12.7	3.2	13,690
MISSOURI																	
Bates	30	10.5	10,598	17.2	3.7	13,108	16	8.3	10,993	17.7	4.2	13,727	11	10,610	17.0	3.6	13,098
1	—	—	—	—	—	—	5	11.3	10,687	15.6	3.5	12,955	—	—	—	—	—
2	—	—	—	—	—	—	11	6.9	11,132	18.6	4.4	14,077	—	—	—	—	—
MONTANA																	
Big,Horn	452	24.9	9,230	5.1	0.4	9,780	149	24.9	9,230	5.2	0.4	9,780	210	9,200	5.5	0.4	9,780

ORIGIN	ICR						CTRDB						FERC 423				
STATE	calculated to a moist basis.						reported on a moist basis.						reported on a moist basis				
County Population	n	M	Btu	Ash	S	Btu m,mmf	n	M	Btu	Ash	S	Btu m,mmf	n	Btu	Ash	S	Btu m,mmf
Richland	28	36.7	6,770	7.6	0.5	7,370	—	—	—	—	—	—	10	6,750	8.0	0.5	7,380
Rosebud	35	26.7	8,730	8.1	0.7	9,570	40	25.7	8,800	8.1	0.7	9,640	51	8,640	9.0	0.7	9,570
NEW MEXICO																	
Colfax	7	4.7	11,960	14.9	0.6	14,270	8	5.2	12,280	13.0	0.5	14,310	15	11,600	15.9	0.6	14,020
McKinley	206	14.8	9,620	15.5	0.6	11,560	20	15.1	9,740	14.5	0.5	11,550	78	9,600	15.7	0.6	11,570
San,Juan	101	10.5	9,090	23.8	0.8	12,270	16	11.1	9,090	23.1	0.8	12,140	23	9,170	23.6	0.8	12,350
1	52	7.5	9,310	26.0	0.9	12,980	8	8.6	9,360	24.3	0.9	12,710	13	9,390	25.5	0.8	12,980
2	49	13.7	8,850	21.4	0.8	11,530	8	13.5	8,820	21.9	0.8	11,570	10	8,890	21.1	0.8	11,530
NORTH DAKOTA																	
McLean	*45	*37.6	*6,180	*11.4	*0.7	*7,040	—	—	—	—	—	—	12	6,180	11.4	0.7	7,040
Mercer	255	37.0	6,700	8.0	0.7	7,330	—	—	—	—	—	—	59	6,800	8.4	0.8	7,480
1	26	35.8	7,070	7.0	0.7	7,650	—	—	—	—	—	—	28	6,970	8.6	0.9	7,680
2	229	37.1	6,660	8.1	0.7	7,290	—	—	—	—	—	—	31	6,650	8.3	0.7	7,300
Oliver	68	36.5	6,790	9.0	1.0	7,510	20	35.6	6,940	7.9	1.0	7,580	48	6,830	8.4	0.9	7,500
1	33	35.7	6,970	8.6	1.1	7,680	15	35.4	6,700	8.0	1.0	7,640	24	7,020	7.8	0.9	7,660
2	35	37.3	6,620	9.3	0.9	7,350	5	36.1	6,760	7.9	0.9	7,380	24	6,640	9.0	0.9	7,340
OHIO																	
Belmont	422	6.3	12,270	10.3	3.8	13,920	61	6.3	12,230	10.8	3.2	13,940	119	12,320	10.1	3.7	13,930
Carroll	3	6.0	12,190	11.8	2.6	14,060	—	—	—	—	—	—	8	12,070	12.6	3.5	14,080
Columbiana	14	6.6	12,180	10.9	3.8	13,920	—	—	—	—	—	—	71	12,340	9.1	2.6	13,760
1	—	—	—	—	—	—	—	—	—	—	—	—	59	12,410	9.4	2.6	13,890
2	—	—	—	—	—	—	—	—	—	—	—	—	12	11,980	7.5	2.7	13,100
Coshocton	49	10.2	11,990	7.4	2.7	13,100	9	9.1	11,480	10.9	4.1	13,110	12	11,070	11.9	2.8	12,760
Gallia	—	—	—	—	—	—	15	9.9	11,210	11.7	3.1	12,910	—	—	—	—	—
Guernsey	2	7.7	11,250	14.7	2.1	13,430	12	6.1	12,050	12.1	2.5	13,940	—	—	—	—	—

ORIGIN	ICR						CTRDB						FERC 423				
STATE	calculated to a moist basis.						reported on a moist basis.						reported on a moist basis				
County / Population	n	M	Btu	Ash	S	Btu m,mmf	n	M	Btu	Ash	S	Btu m,mmf	n	Btu	Ash	S	Btu m,mmf
Harrison	192	7.3	12,030	11.1	2.8	13,750	8	6.8	12,220	10.7	3.4	13,910	70	11,940	11.5	3.0	13,730
1	168	7.1	12,120	11.0	2.7	13,840	—	—	—	—	—	—	59	12,060	11.4	2.9	13,840
2	24	8.9	11,400	11.7	3.4	13,140	—	—	—	—	—	—	11	11,300	12.4	3.4	13,140
Holmes	14	9.2	11,070	13.6	3.1	13,060	—	—	—	—	—	—	16	11,390	11.5	3.5	13,090
Jackson	34	10.2	10,890	13.0	4.1	12,760	—	—	—	—	—	—	24	10,950	12.6	3.4	12,740
Jefferson	36	7.6	11,890	11.6	2.3	13,660	23	6.6	12,060	11.7	3.0	13,900	12	11,900	11.5	2.3	13,660
Mahoning	3	8.5	9,740	21.8	3.4	12,830	—	—	—	—	—	—	7	10,000	19.9	3.5	12,830
Meigs	101	9.8	11,190	12.5	3.6	13,040	—	—	—	—	—	—	12	11,230	12.3	3.5	13,040
Monroe	—	—	—	—	—	—	—	—	—	—	—	—	23	12,190	10.2	4.3	13,830
Morgan	56	7.2	11,620	12.6	4.4	13,570	6	7.9	11,530	12.3	4.7	13,430	—	—	—	—	—
Muskingum	—	—	—	—	—	—	—	—	—	—	—	—	12	11,550	12.7	4.5	13,510
Noble	—	—	—	—	—	—	—	—	—	—	—	—	24	11,560	13.9	4.6	13,750
1	—	—	—	—	—	—	—	—	—	—	—	—	12	11,550	12.7	4.5	13,510
2	—	—	—	—	—	—	—	—	—	—	—	—	12	11,580	15.1	4.7	13,980
Perry	91	9.9	11,250	11.6	2.8	12,920	18	9.5	11,200	12.4	2.7	12,990	25	11,280	11.3	2.8	12,910
Stark	—	—	—	—	—	—	—	—	—	—	—	—	4	12,670	7.7	2.2	13,880
Tuscarawas	64	8.0	11,510	12.3	3.6	13,380	19	9.3	11,510	10.5	3.6	13,080	57	11,640	11.0	3.4	13,290
1	52	7.9	11,590	12.3	3.7	13,480	7	8.3	11,870	9.6	3.4	13,330	37	11,670	11.8	3.5	13,460
2	12	8.8	11,160	12.3	3.3	12,950	12	9.9	11,310	11.1	3.7	12,940	20	11,580	9.5	3.1	12,970
Vinton	117	10.5	11,260	10.7	3.0	12,800	—	—	—	—	—	—	29	11,260	10.7	3.0	12,800
OKLAHOMA																	
Craig	—	—	—	—	—	—	—	—	—	—	—	—	13	12,310	12.8	3.3	14,400
Haskell	11	3.6	12,300	16.1	3.3	15,030	—	—	—	—	—	—	—	—	—	—	—
Le,Flore	28	3.8	12,220	16.2	3.4	14,940	—	—	—	—	—	—	—	—	—	—	—
Rogers	36	4.2	12,760	10.7	4.0	14,570	—	—	—	—	—	—	12	13,010	9.1	3.9	14,570

ORIGIN	ICR						CTRDB						FERC 423				
STATE	calculated to a moist basis.						reported on a moist basis.						reported on a moist basis				
County Population	n	M	Btu	Ash	S	Btu m,mmf	n	M	Btu	Ash	S	Btu m,mmf	n	Btu	Ash	S	Btu m,mmf
PENNSYLVANIA																	
Allegheny	—	—	—	—	—	—	9	6.2	12,280	11.3	2.1	14,040	5	12,010	8.9	1.5	13,330
Armstrong	20	5.5	12,170	13.9	2.7	14,420	53	6.2	12,360	12.5	2.1	14,370	221	12,340	12.6	2.1	14,360
Beaver	260	6.8	12,010	12.0	1.6	13,850	—	—	—	—	—	—	14	11,980	12.2	1.6	13,850
Bedford	8	6.9	11,630	14.8	1.5	13,900	—	—	—	—	—	—	—	—	—	—	—
Butler	6	7.4	11,030	16.2	2.9	13,450	—	—	—	—	—	—	18	11,750	13.5	3.0	13,840
1	—	—	—	—	—	—	—	—	—	—	—	—	14	12,020	13.0	3.2	14,080
2	—	—	—	—	—	—	—	—	—	—	—	—	4	10,790	15.4	2.4	13,000
Cambria	3	5.2	12,680	12.7	2.0	14,770	16	6.6	12,510	12.8	1.9	14,590	47	12,460	13.1	2.1	14,600
1	—	—	—	—	—	—	—	—	—	—	—	—	43	12,470	13.4	2.2	14,660
2	—	—	—	—	—	—	—	—	—	—	—	—	4	12,380	9.7	1.1	13,860
Clarion	—	—	—	—	—	—	4	6.8	12,690	8.8	2.6	14,100	35	12,730	9.0	2.0	14,220
Clearfield	6	5.7	12,100	15.8	1.8	14,660	51	6.5	12,570	12.7	1.9	14,640	519	12,520	13.0	1.8	14,620
1	—	—	—	—	—	—	—	—	—	—	—	—	154	12,610	13.5	1.8	14,830
2	—	—	—	—	—	—	—	—	—	—	—	—	242	12,500	13.2	1.8	14,650
3	—	—	—	—	—	—	—	—	—	—	—	—	123	12,430	11.8	1.7	14,290
Elk	49	6.2	12,550	10.9	1.9	14,290	—	—	—	—	—	—	26	12,610	10.5	1.7	14,270
Fayette	62	7.8	12,640	8.4	1.6	13,940	6	6.8	12,570	9.5	1.1	14,030	25	12,340	10.4	1.5	13,940
Greene	908	6.0	13,090	7.7	2.0	14,350	184	5.9	13,110	7.7	1.7	14,350	598	13,080	7.8	1.9	14,340
Indiana	4	5.5	12,370	14.4	2.2	14,730	48	6.2	12,350	13.8	1.9	14,580	97	12,340	14.4	2.2	14,680
1	—	—	—	—	—	—	—	—	—	—	—	—	92	12,350	14.5	2.3	14,730
2	—	—	—	—	—	—	—	—	—	—	—	—	5	12,170	11.6	0.7	13,930
Jefferson	—	—	—	—	—	—	12	6.6	12,660	10.5	1.5	14,330	46	12,460	11.8	1.6	14,340
1	—	—	—	—	—	—	—	—	—	—	—	—	41	12,510	11.9	1.7	14,410
2	—	—	—	—	—	—	—	—	—	—	—	—	5	12,010	11.3	1.1	13,710
Lackawanna	—	—	—	—	—	—	—	—	—	—	—	—	16	11,160	20.0	0.9	14,260

ORIGIN	ICR						CTRDB						FERC 423				
STATE	calculated to a moist basis.						reported on a moist basis.						reported on a moist basis				
County Population	n	M	Btu	Ash	S	Btu m,mmf	n	M	Btu	Ash	S	Btu m,mmf	n	Btu	Ash	S	Btu m,mmf
Luzerne	2	7.8	12,130	10.3	0.6	13,670	—	—	—	—	—	—	—	—	—	—	—
Lycoming	23	4.9	10,710	23.0	0.7	14,280	—	—	—	—	—	—	—	—	—	—	—
Northumberland	50	7.9	10,880	16.8	0.6	13,310	—	—	—	—	—	—	—	—	—	—	—
Schuylkill	—	—	—	—	—	—	—	—	—	—	—	—	13	8,330	32.8	0.6	12,900
Somerset	163	5.7	12,920	10.2	2.0	14,600	49	5.7	12,500	13.5	1.9	14,710	155	12,440	13.8	1.9	14,690
1	78	5.4	12,720	12.7	1.7	14,800	—	—	—	—	—	—	112	12,510	14.0	2.0	14,810
2	85	6.0	13,110	8.0	2.2	14,410	—	—	—	—	—	—	43	12,250	13.5	1.5	14,390
Sullivan	—	—	—	—	—	—	—	—	—	—	—	—	5	8,230	34.4	0.5	13,080
Washington	413	6.0	13,100	7.3	1.6	14,260	47	6.0	13,120	7.4	1.7	14,310	183	13,060	7.8	1.6	14,310
1	—	—	—	—	—	—	—	—	—	—	—	—	170	13,060	7.6	1.6	14,280
2	—	—	—	—	—	—	—	—	—	—	—	—	13	13,100	10.2	1.6	14,770
Westmoreland	27	6.3	13,010	8.3	1.6	14,340	23	6.1	12,690	10.6	1.9	14,390	51	12,500	11.9	2.0	14,420
1	—	—	—	—	—	—	—	—	—	—	—	—	44	12,500	11.5	2.1	14,340
2	—	—	—	—	—	—	—	—	—	—	—	—	7	12,530	14.4	1.8	14,900
TENNESSEE																	
Anderson	12	7.3	12,420	9.2	1.2	13,830	—	—	—	—	—	—	4	12,380	9.5	1.3	13,830
Campbell	1	7.8	12,280	9.3	1.1	13,680	—	—	—	—	—	—	—	—	—	—	—
Claiborne	24	6.6	12,890	7.4	1.3	14,050	12	5.8	12,790	8.3	1.4	14,100	36	12,820	8.2	1.3	14,110
1	—	—	—	—	—	—	—	—	—	—	—	—	6	12,620	11.1	1.0	14,370
2	—	—	—	—	—	—	—	—	—	—	—	—	30	12,860	7.6	1.4	14,050
Cumberland	15	6.7	12,510	11.8	0.7	14,360	—	—	—	—	—	—	—	—	—	—	—
Morgan	1	6.6	12,430	10.8	1.7	14,130	—	—	—	—	—	—	—	—	—	—	—
Scott	19	6.0	12,420	10.9	1.4	14,120	—	—	—	—	—	—	12	12,300	11.6	1.4	14,110
Sequatchie	34	6.7	12,040	13.2	0.8	14,070	—	—	—	—	—	—	—	—	—	—	—
TEXAS																	

ORIGIN	ICR						CTRDB						FERC 423				
STATE	calculated to a moist basis.						reported on a moist basis.						reported on a moist basis				
County Population	n	M	Btu	Ash	S	Btu m,mmf	n	M	Btu	Ash	S	Btu m,mmf	n	Btu	Ash	S	Btu m,mmf
Atascosa	*34	*27.8	*5,440	*24.9	*1.7	*7,410	—	—	—	—	—	—	11	5,270	26.8	1.8	7,400
Freestone	*32	*32	*6,600	*15.8	*0.7	*7,950	—	—	—	—	—	—	10	6,610	15.7	0.7	7,950
Harrison	*48	*33.5	*6,510	*15.2	*1.2	*7,780	—	—	—	—	—	—	12	6,600	14.1	1.2	7,780
Leon	12	26.8	7,020	18.2	1.1	8,730	—	—	—	—	—	—	—	—	—	—	—
Milam	*28	*30.6	*6,720	*16.3	*1.2	*8,140	—	—	—	—	—	—	9	6,690	16.5	1.2	8,140
Panola	—	—	—	—	—	—	—	—	—	—	—	—	12	6,500	13.4	1.1	7,590
Robertson	87	30.4	6,750	16.9	0.9	8,250	—	—	—	—	—	—	11	6,760	16.8	0.9	8,250
Titus	—	—	—	—	—	—	—	—	—	—	—	—	11	5,880	19.1	0.5	7,400
UTAH																	
Carbon	126	7.9	11,810	9.8	0.6	13,220	52	8.0	11,840	9.4	0.5	13,200	121	11,920	9.1	0.5	13,230
1	57	6.3	12,100	10.2	0.6	13,630	32	7.3	11,940	9.9	0.5	13,390	56	12,220	9.5	0.6	13,630
2	69	9.3	11,560	9.4	0.5	12,890	20	9.0	11,690	8.6	0.5	12,890	65	11,660	8.7	0.5	12,880
Emery	226	8.3	12,030	9.5	0.4	13,420	12	9.2	11,670	10.9	0.5	13,230	97	12,010	9.8	0.5	13,440
Sevier	91	10.3	11,350	8.3	0.4	12,470	14	10.2	11,350	8.3	0.4	12,480	36	11,360	8.2	0.4	12,480
VIRGINIA																	
Buchanan	240	7.1	13,110	8.3	0.8	14,410	55	6.3	13,120	8.9	1.0	14,550	92	13,290	7.8	0.9	14,530
1	103	7.0	13,800	5.5	0.7	14,700	32	5.9	13,350	8.3	1.0	14,690	60	13,580	7.0	0.8	14,700
2	137	7.1	12,580	10.4	1.0	14,200	23	6.9	12,810	9.7	1.0	14,350	32	12,750	9.3	1.2	14,210
Craig	18	5.5	13,970	5.9	0.7	14,950	—	—	—	—	—	—	—	—	—	—	—
Dickenson	69	7.1	13,090	8.1	0.9	14,380	46	6.1	12,980	8.9	1.1	14,390	76	13,080	8.8	1.1	14,490
1	36	5.9	13,410	8.0	0.9	14,710	23	5.5	13,090	9.1	1.1	14,550	51	13,230	9.1	1.1	14,710
2	33	8.4	12,740	8.3	0.9	14,020	23	6.7	12,860	8.7	1.2	14,230	25	12,760	8.2	1.1	14,030
Lee	56	6.1	12,910	8.1	1.1	14,180	9	7.2	12,450	9.5	0.7	13,890	77	12,780	9.0	0.9	14,180
Russell	136	4.7	12,380	14.6	0.7	14,730	15	5.4	12,570	12.1	0.8	14,490	92	12,520	13.7	0.7	14,720
Tazewell	—	—	—	—	—	—	—	—	—	—	—	—	9	12,880	10.0	0.7	14,460

ORIGIN	ICR						CTRDB						FERC 423				
STATE	calculated to a moist basis.						reported on a moist basis.						reported on a moist basis				
County Population	n	M	Btu	Ash	S	Btu m,mmf	n	M	Btu	Ash	S	Btu m,mmf	n	Btu	Ash	S	Btu m,mmf
Wise	846	6.3	12,850	9.7	1.0	14,400	205	5.9	12,910	9.7	1.2	14,450	399	12,820	9.9	1.1	14,390
WASHINGTON																	
Lewis	90	25.4	7,790	15.2	0.9	9,320	—	—	—	—	—	—	12	7,780	15.1	0.9	9,320
WEST VIRGINIA																	
Barbour	38	5.9	13,080	9.5	1.4	14,630	25	6.1	13,020	9.1	1.6	14,490	32	13,110	9.3	1.5	14,640
Berkeley	—	—	—	—	—	—	10	5.8	12,290	12.6	0.9	14,260	—	—	—	—	—
Boone	1,190	6.3	12,400	11.3	0.8	14,140	333	6.3	12,420	11.0	0.8	14,120	654	12,440	10.9	0.8	14,120
1	770	6.1	12,620	10.8	0.8	14,310	202	6.0	12,580	10.7	0.9	14,240	388	12,750	10.0	0.8	14,320
2	420	6.6	11,990	12.1	0.8	13,820	131	6.6	12,190	11.4	0.8	13,920	266	11,980	12.2	0.8	13,820
Braxton	8	6.6	12,640	10.3	0.8	14,240	—	—	—	—	—	—	—	—	—	—	—
Brooke	127	6.7	12,300	10.4	3.7	13,970	11	7.1	12,300	10.1	3.2	13,900	48	12,310	10.4	3.7	13,970
Calhoun	4	7.0	12,510	9.7	1.4	14,010	—	—	—	—	—	—	—	—	—	—	—
Clay	73	5.4	12,290	12.6	0.8	14,250	—	—	—	—	—	—	119	12,290	12.5	0.9	14,230
1	—	—	—	—	—	—	—	—	—	—	—	—	112	12,330	12.4	0.9	14,250
2	—	—	—	—	—	—	—	—	—	—	—	—	7	11,700	14.0	1.3	13,810
Fayette	166	6.6	12,080	13.0	0.9	14,080	52	5.9	12,590	10.7	0.9	14,270	184	12,220	12.3	1.1	14,130
1	18	6.1	12,890	10.3	1.0	14,540	40	5.7	12,700	10.5	0.9	14,350	37	12,850	10.6	1.0	14,550
2	141	6.5	11,990	13.5	0.9	14,060	12	6.4	12,230	11.4	0.7	13,980	137	12,110	12.7	1.1	14,080
3	7	10.2	11,800	9.6	1.2	13,200	—	—	—	—	—	—	10	11,380	12.6	2.5	13,240
Grant	113	6.1	12,400	13.5	1.7	14,570	18	6.4	12,460	13.1	1.6	14,570	42	12,420	13.4	1.7	14,580
Greenbrier	6	6.5	13,100	9.1	0.9	14,550	27	5.4	12,450	11.5	0.8	14,240	—	—	—	—	—
Harrison	19	5.7	13,240	6.9	2.9	14,400	34	5.3	12,640	10.7	3.2	14,410	105	12,710	10.2	3.1	14,380
Kanawha	671	6.0	12,050	13.5	0.8	14,140	57	6.4	12,360	11.5	0.9	14,140	495	12,090	13.3	0.8	14,140
Lincoln	24	7.1	11,420	14.4	0.8	13,550	18	7.2	12,100	11.1	0.7	13,780	20	11,650	12.9	0.8	13,550
Logan	369	6.0	12,170	12.4	0.7	14,070	130	6.1	12,280	11.8	0.8	14,100	152	12,120	12.7	0.7	14,070

ORIGIN	ICR						CTRDB						FERC 423				
STATE	calculated to a moist basis.						reported on a moist basis.						reported on a moist basis				
County Population	n	M	Btu	Ash	S	Btu m,mmf	n	M	Btu	Ash	S	Btu m,mmf	n	Btu	Ash	S	Btu m,mmf
1	259	5.7	12,380	11.8	0.7	14,220	97	5.8	12,340	11.8	0.8	14,180	104	12,300	12.4	0.7	14,220
2	110	6.7	11,670	13.7	0.8	13,710	33	7.0	12,100	11.6	0.8	13,860	48	11,730	13.5	0.8	13,740
Marion	13	5.4	13,340	7.1	2.1	14,520	16	6.1	12,790	9.6	2.5	14,360	43	12,840	10.2	3.0	14,520
Marshall	606	6.7	12,090	12.1	3.9	14,030	22	6.5	12,150	11.8	3.5	14,040	161	12,210	11.3	3.6	14,020
McDowell	—	—	—	—	—	—	—	—	—	—	—	—	9	13,780	5.9	0.7	14,740
Mineral	—	—	—	—	—	—	6	5.8	12,330	14.8	1.7	14,730	—	—	—	—	—
Mingo	452	6.5	12,120	12.4	0.9	14,020	225	6.4	12,670	9.3	0.8	14,100	515	12,350	11.0	0.7	14,040
Monongalia	516	5.6	12,710	10.3	2.1	14,360	103	5.9	12,860	9.1	2.2	14,330	295	12,920	8.9	2.2	14,360
1	—	—	—	—	—	—	—	—	—	—	—	—	279	12,960	8.8	2.1	14,390
2	—	—	—	—	—	—	—	—	—	—	—	—	16	12,180	10.9	2.8	13,890
Nicholas	141	6.1	12,290	12.3	0.9	14,200	57	5.7	12,820	9.4	0.9	14,300	129	12,340	12.0	1.0	14,210
Preston	18	6.4	13,130	8.8	1.4	14,540	35	7.3	12,910	9.6	1.5	14,450	68	12,990	9.8	1.4	14,580
Raleigh	7	7.2	11,340	17.7	0.9	14,040	—	—	—	—	—	—	25	11,520	19.5	1.0	14,650
1	—	—	—	—	—	—	—	—	—	—	—	—	6	12,540	10.5	0.7	14,150
2	—	—	—	—	—	—	—	—	—	—	—	—	19	11,200	22.4	1.1	14,810
Upshur	92	4.9	12,980	9.7	1.7	14,570	—	—	—	—	—	—	81	12,830	10.6	1.8	14,560
Wayne	417	7.5	11,940	11.5	0.8	13,650	51	7.4	12,030	11.2	0.9	13,710	183	12,040	10.8	0.8	13,660
Webster	268	5.0	12,530	12.0	0.9	14,430	34	5.5	12,830	10.1	0.8	14,440	145	12,600	11.6	0.9	14,430
Wyoming	17	5.2	13,470	7.3	0.8	14,650	—	—	—	—	—	—	24	13,560	6.8	0.7	14,650
WYOMING																	
Campbell	3,819	28.5	8,620	5.1	0.3	9,120	785	28.7	8,580	5.1	0.3	9,080	2,154	8,600	5.2	0.3	9,110
1	2,286	27.6	8,720	5.4	0.4	9,260	397	27.5	8,760	5.0	0.3	9,260	1,206	8,760	5.0	0.3	9,260
2	1,533	29.8	8,460	4.6	0.3	8,910	388	30.0	8,390	5.3	0.4	8,900	948	8,400	5.3	0.3	8,910
Carbon	133	13.5	10,890	6.3	0.6	11,690	29	12.5	10,770	7.4	0.6	11,710	49	10,810	6.3	0.6	11,340
1	—	—	—	—	—	—	15	12.2	11,100	6.9	0.6	12,000	39	10,920	6.1	0.6	11,700
2	—	—	—	—	—	—	14	12.8	10,410	8.0	0.5	11,410	10	10,410	6.8	0.7	11,250

ORIGIN	ICR						CTRDB						FERC 423				
STATE	calculated to a moist basis.						reported on a moist basis.						reported on a moist basis				
County Population	n	M	Btu	Ash	S	Btu m,mmf	n	M	Btu	Ash	S	Btu m,mmf	n	Btu	Ash	S	Btu m,mmf
Converse	392	26.9	8,700	5.5	0.3	9,250	48	26.8	8,710	5.7	0.3	9,280	203	8,760	5.5	0.3	9,310
1	328	26.5	8,820	5.3	0.3	9,360	44	26.8	8,800	5.2	0.2	9,330	188	8,820	5.3	0.2	9,360
2	64	29.0	8,080	6.7	0.3	8,700	4	26.9	7,750	10.8	0.5	8,770	15	7,910	8.6	0.5	8,720
Lincoln	105	20.7	9,960	5.1	0.8	10,550	4	21.1	9,800	5.3	0.7	10,400	12	9,990	4.9	0.7	10,550
Sweetwater	116	20.1	9,400	9.5	0.5	10,490	17	20.4	9,560	8.1	0.5	10,480	23	9,390	9.6	0.5	10,480

Notes to table:

Asterisks (*) designate as-fired, rather than as-shipped, coal samples.
em-dashes (—) designate no data or **CTRDB** and **FERC 423** populations that contain less than four data records.
n is the number of selected data records.
M is the weight percent moisture (as-received, whole-coal basis). M is a calculated value for the ICR data and an observed value for the CTRDB data.
Btu are the British thermal units per pound (as-received, whole-coal basis).
Ash is the weight percent ash (as-received, whole-coal basis).
S is the weight percent sulfur (as-received, whole-coal basis).
Btu m,mmf are the British thermal units per pound expressed on a moist, mineral-matter-free basis (ASTM, 1990).
ICR data are selected from the 1999, EPA Information Collection Request (USEPA, 2003).
CTRDB data are selected from the 1990 to 1999, EIA Coal Transportation Rate Data Base (USEIA, 2003c).
FERC 423 data are selected from the 1999, Federal Energy Regulatory Commission, form 423 data set (USEIA, 2003a).