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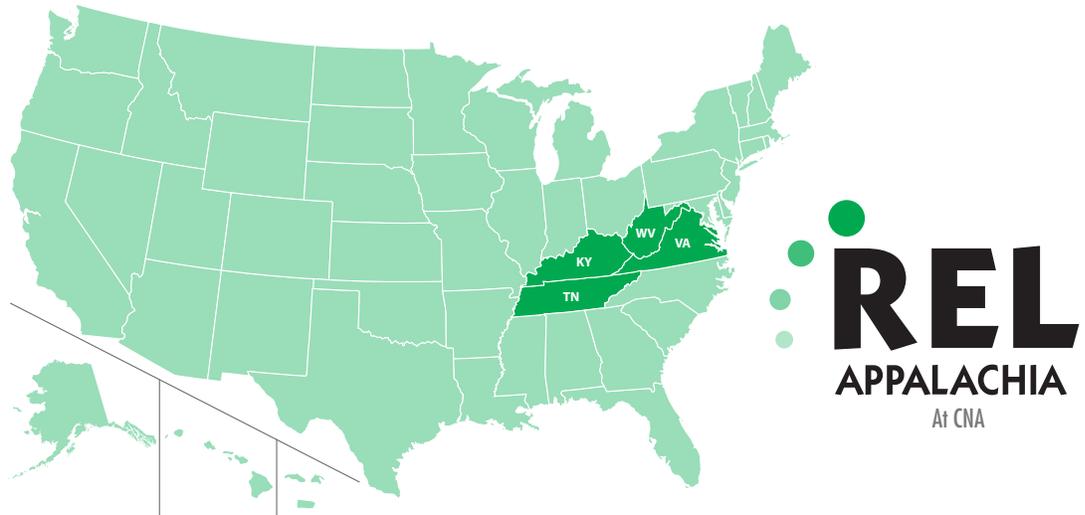
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Changes in the cost of energy in one state's school districts

To support the work of Tennessee's Energy Efficient Schools Initiative (EESI) Council, this report describes data on energy expenditures in school districts for 2002/03–2007/08. Energy expenditures rose from about 2.6 percent to about 3.0 percent of total expenditures over the period, with some differences in the mix of energy types and expenditures per student by district characteristics. An index of fiscal stress can be used to establish priority districts for EESI Council funding. Simulation of the impact of future energy inflation by district characteristics finds that the variation within districts grouped by characteristics is just as large as that across district characteristics, suggesting that the EESI Council should investigate individual district circumstances in allocating state funds rather than create allocation rules based on district characteristics.

Energy prices have received considerable public attention in recent years, especially the run-up in crude oil prices to $140 a barrel in summer 2008. But the prices of other forms of energy, such as electricity and natural gas, have also risen dramatically. These price increases have affected energy expenditures by local education agencies. Facing unexpected increases in energy bills for which no budget

allowance had been made, school districts have considered such drastic actions as reducing the school week to four days. Yet, despite the substantial public attention to the implications of rising energy prices for school districts, little research has examined the issue.

The Tennessee legislature addressed school district budget concerns through the statewide Energy Efficient Schools Initiative (EESI) of 2008, creating a 12-member EESI Council with a mandate to issue grants to school systems for capital outlays on energy-use projects. This report responds to a request to improve the council's understanding of energy use in Tennessee school districts by examining district energy expenditure data. The report addresses three main questions:

- What proportion of school district budgets was spent on energy, and how did this change over time?

- Did the increase in energy expenditure disproportionately affect districts with certain characteristics?

- What might happen to district energy costs if real energy prices continue to rise?

The study finds that in 2007/08, energy expenditures accounted for about 3 percent of

Tennessee school districts' total expenditures of $6,231 million. From 2002/03 to 2007/08 energy expenditures rose $82 million (from $164 million to $246 million), while total expenditures rose $2,050 million. However, the increase in aggregate energy expenditures likely reflected some changes in energy expenditures that were independent of changes in energy prices. For example, student population growth might have necessitated purchasing additional units of energy to run buildings. An alternative approach is to assume that energy is a fixed proportion of the budget. Using the difference between actual energy expenditure each year and a hypothetical level based on energy's 2.6 percent share of expenditures in 2002/03 yields an increase in energy's share of total expenditures of less than 0.4 percentage points, which could account for some $29 million of the overall increase in expenditures.

The mix of energy (electricity, natural gas, and oil-based products) and expenditures per student vary by district characteristics—region, size (number of students), and locale. By region, districts with the highest percentage of electricity use as a source of energy had the lowest cost per student. A similar pattern holds for district size: districts with larger student populations, which have the highest percentage of electricity use, also had a lower cost per student. But for locales, this pattern holds only for towns. City, suburban, and rural districts all had roughly the same percentage of electricity use, but the cost per student was 5 percent or more lower in suburban districts. Thus, factors other than energy prices seem to drive differences across locales. Without data on additional factors, such as the age of the buildings or the heating and air conditioning

plants, it was not possible to identify the sources of these differences.

Not all districts had the same cost structure. Two measures of district spending on energy were used to investigate fiscal stress caused by the rise in energy costs. The ending rate, or operations and maintenance expenditures on energy per student in 2007/08, identifies districts that spent a relatively high proportion of their funds on energy for operations and maintenance. High energy expenditures could cause fiscal stress by crowding out other expenditures. The growth rate, or the rate of increase in energy expenditures on operations and maintenance over 2002/03–2007/08, identifies districts facing the largest change in circumstances over the past six years as a result of high energy price inflation. Districts with the highest growth rates have to make the greatest adjustments to higher energy costs.

Districts were ranked and grouped into quartiles on each of these measures. On average, the most energy-expenditure-efficient districts in 2007/08 spent $173 per student on energy, while the least energy-efficient-expenditure districts spent $295 per student. To support the EESI Council's decisions on funding requests, the study created an index of the fiscal stress resulting from the expenditure increases for each district. The distribution of stress scores, calculated by adding the quartile rankings for the two criteria, shows that more districts fall into the three middle scores than into the four extreme scores (see table). In other words, the stress scores identify a few districts under the most and least stress and then larger numbers in the middle. Use of this indicator could enable the EESI Council to

Distribution of Tennessee school districts by stress scores

Stress score[a]	Number of districts
2	8
3	19
4	30
5	30
6	19
7	17
8	13

a. Calculated by adding the quartile rankings for energy operations and maintenance (O&M) expenditures in 2007/08 and rate of increase in energy O&M expenditures for 2002/03–2007/08.

Source: Authors' calculations based on data from Tennessee Department of Education, *Annual Statistical Report.*

concentrate more support on a few districts and less on a larger number of districts.

These stress scores were used to examine whether district characteristics affect the increase in energy expenditures. The average stress scores follow a pattern similar to the expenditures per student calculations. Even though the stress metric includes the growth rate along with expenditures, the effect of the growth rate variable is too weak to change the underlying pattern in most cases. Thus, West Tennessee districts, districts with large student populations, and suburban districts are under less stress than are other districts. Population standard deviations of the stress scores were also calculated across all districts for each district characteristic. The standard deviations are uniformly larger than the differences in average stress scores, so the differences are not statistically significant. The magnitude and lack of statistical significance of these differences mean that district characteristics are not a reliable indicator of stress. Not all districts with the same characteristics have the same or even similar stress scores. As a result, the EESI

Council might not want to use these district characteristics in establishing criteria for allocating state funds.

The final question asks whether certain types of districts face more difficult challenges than others if real energy prices continue to rise, given current expenditure patterns. For this analysis, a real increase in the price of energy means an increase relative to other prices (the overall inflation rate) or an increase in energy expenditures holding total expenditures constant. Actual increases in expenditures might be smaller than the simulated increases because if energy prices rise, districts would try to reduce energy consumption.

To simulate the impact of increased energy prices, the analysis was conducted backwards by first calculating the overall increase in energy prices that would raise the energy expenditure rate 0.43 percentage points—reflecting the largest increase in energy expenditures as a proportion of total expenditures (16 percent) over 2002/03–2007/08, from 2.62 percent to 3.05 percent. With 2007/08 as the base year, the effect of a 16 percent increase in expenditures for each district was simulated by increasing the price of all three types of energy separately and then together.

The simulated increases in the percentage of total expenditures devoted to energy show, for example, that if electricity prices rise 16 percent and other energy prices are stable, energy expenditures in East Tennessee districts would rise 0.36 percentage points, but if all energy prices rise 16 percent, energy expenditures would rise 0.44 percentage points. However, the differences in the averages for each characteristic and energy type are smaller than the

standard deviations, which means that they are not statistically significant. The variation by characteristics is not nearly as large as the variation across school districts.

Because the limited data available for this analysis precluded analysis of such important factors as the age of buildings or heating and air conditioning plants, the EESI Council will need to look at districts on a case by case basis when allocating resources, using the district stress scores for guidance, rather than predetermining allocations based on district characteristics.

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To support the work of Tennessee's Energy Efficient Schools Initiative (EESI) Council, this report describes data on energy expenditures in school districts for 2002/03–2007/08. Energy expenditures rose from about 2.6 percent to about 3.0 percent of total expenditures over the period, with some differences in the mix of energy types and expenditures per student by district characteristics. An index of fiscal stress can be used to establish priority districts for EESI Council funding. Simulation of the impact of future energy inflation by district characteristics finds that the variation within districts grouped by characteristics is just as large as that across district characteristics, suggesting that the EESI Council should investigate individual district circumstances in allocating state funds rather than create allocation rules based on district characteristics.

WHY THIS STUDY?

Energy prices have received considerable public attention in recent years, especially the run-up in crude oil prices to $140 a barrel in summer 2008. But the prices of other forms of energy, such as electricity and natural gas, have also risen dramatically. These price increases have affected energy expenditures by local education agencies. Facing unexpected increases in energy bills for which no budget allowance had been made, school districts have considered such drastic actions as reducing the school week to four days (Aarons 2008; Kingsbury 2008).

The Tennessee legislature addressed the school district budget concerns by enacting the statewide Energy Efficient Schools Initiative (EESI) of 2008 (Tennessee Code 49-17), creating a 12-member EESI Council with four key mandates: to approve guidelines on design and technology, to make grants to school systems for capital outlays for energy-use projects, to verify the achievement of energy efficiencies, and to establish and support energy management programs. An ex-officio member of the council, Tennessee Commissioner of Education Dr. Timothy Webb, asked Regional Educational Laboratory Appalachia to improve the council's understanding of energy use in Tennessee school districts.

Despite the substantial public attention to the implications of increasing energy prices for school districts, little research has addressed the issue. A report by the National Center for Education Statistics (2003), *Effects of Energy Needs and Expenditures on U.S. Public Schools*, describes how school districts were adjusting to price increases and reduced energy consumption. The report lists several actions districts were taking: improving the energy efficiency of existing infrastructure, locking in rates with energy vendors, joining consortia to negotiate prices with energy vendors, increasing facility usage charges, and shutting schools or dismissing students early for at least one day a week. Despite its useful recommendations, that report does not address the questions specific to

BOX 1
Data sources

The data for this study are from 2002/03–2007/08 reports on the 136 school districts in Tennessee. The main source of district-level data is the Tennessee Department of Education's *Annual Statistical Reports*, available on the department's web site (www.tennessee.gov/education/reports_data.shtml). The database includes four broad categories of data: student demographics, expenditures by budget category, transportation, and funding.

The Tennessee Department of Education provided district-level energy expenditure data by energy type (electricity, fuel oil, natural gas, gasoline, and diesel) and by budget category.[1] Thirty school districts

have either fully or partially outsourced their school bus services, and information about these outsourced costs does not include a breakout of energy costs. Thus, no transportation-related energy cost information was available for those 30 districts. The analysis of energy expenditures reported here shows data for 136 districts even though the data include transportation-related costs only for the 106 districts with complete information on transportation energy costs. These data were supplemented with data on regional designations (East Tennessee, Middle Tennessee, or West Tennessee) using the Tennessee Department of Education classification scheme; district size by number of students, based on a definition provided by Dr. Webb (small, fewer than 3,500; medium, 3,500–5,000; and large, more than

5,000); and a locale variable (urban, suburban, town, rural) from the Common Core of Data (U.S. Department of Education 2008).

Note

1. The detailed energy data reside in Tennessee's eReporting Energy Costs system. Although not available online, the data are publicly available on request from the Tennessee Department of Education. The data are a part of the *Annual Financial Report* submitted by districts to the Tennessee Department of Education. The Tennessee Department of Education *Annual Statistical Report*, submitted by the department to the state legislature, contains most of the data in the *Annual Financial Report*, though in aggregated form in some cases, and is available publicly on the department's web site. The Local Finance office of the Tennessee Department of Education supports the collection and reporting of these data.

Tennessee's EESI Council, which formed the basis of this study:

- What proportion of school district budgets was spent on energy, and how did this change over time?

- Did the increase in energy expenditure disproportionately affect districts with certain characteristics?

- What might happen to district energy costs if real energy prices continue to rise?

During its initial meetings, the EESI Council decided to focus its funding exclusively on projects to reduce energy use for building operations and maintenance (O&M), even though districts also spent money on energy for transportation. The first research question considered both total and O&M expenditures; the second and third considered only O&M expenditures (see box 1 for data sources).

Before considering these questions, the study examined the prices of energy in Tennessee compared with the national average and the rate of increase in prices (the inflation rate) over the study period of 2002–08.

THE OVERALL COST OF ENERGY

This section provides background information on energy prices in Tennessee relative to the national average and on the rate of increase in prices (the inflation rate) over the study period of 2002–08 (figures 1–3). Tennessee school districts used three main sources of energy: electricity, natural gas, and oil-based products (primarily gasoline and diesel).

The prices of electricity and gasoline in Tennessee were below the national average (see figures 1 and 3), and the price of natural gas ran at about the national average until it spiked in 2007 and 2008

FIGURE 1

Comparison of the price of electricity in Tennessee and nationally, 2002–08

Cents per kilowatt hour

Source: www.eia.doe.gov/cneaf/electricity/epa/average_price_state.xls.

FIGURE 3

Comparison of the price of regular gasoline per gallon in the Midwest region and nationally, 2002–08

Dollars per gallon

Source: www.eia.doe.gov/oil_gas/petroleum/data_publications/wrgp/mogas_history.html.

FIGURE 2

Comparison of the price of natural gas in Tennessee and nationally, 2002–08

Dollars per 1,000 cubic feet

Note: Price to commercial consumers.

Source: http://tonto.eia.doe.gov/dnav/ng/ng_pri_sum_a_EPGO_PCS_DMcf_m.html.

(see figure 2).[1] The price of a kilowatt hour of electricity rose 25 percent in Tennessee and 26 percent nationally over 2002–08, higher than the 20 percent Consumer Price Index inflation rate (Bureau of Labor Statistics 2009). Prices of gasoline in the Midwest region rose 172 percent over the period compared with 182 percent nationally.[2] While the U.S. Department of Energy data sources provide no time series of gasoline prices for Tennessee specifically, the American Automobile Association (2009), which reports prices by state daily, showed that Tennessee was among a dozen states with the lowest prices in February 2009.

Natural gas prices in Tennessee started out in 2002 at 30 percent above the national average, matched the national average price for several years, and then spiked to about 11 percent above the national average at the end of the period. Overall, natural gas prices doubled in Tennessee and rose 133 percent nationally. For districts that rely heavily on natural gas, this rate of increase seems likely to pose a significant problem.

In sum, the prices of electricity and gasoline in Tennessee were at or below the national average, with price increases comparable to national trends; energy prices trended upward over 2002–08 at rates that were higher than overall increases in the Consumer Price Index; and gasoline prices increased faster than natural gas prices, which increased faster than electricity prices.

These findings suggest that the challenges of rising energy prices in many states are similar to those found in Tennessee.

WHAT PROPORTION OF THE BUDGET WAS SPENT ON ENERGY?

Spending on energy as a proportion of total district budgets grew over the period 2002–08, and the proportion was highest in 2005/06, not in 2007/08 when oil prices were highest (table 1).[3] The changes in these proportions result from changes in overall expenditures and in energy expenditures. The peak in 2005/06 corresponds to the year with the slowest growth in total expenditures (3.6 percent compared with a 5.9 percent average for the period) and the fastest growth in energy expenditures (18.4 percent compared with 8.5 percent for the period).[4] Although energy expenditures continued to rise in the following two years, total expenditures increased faster, so that the proportion devoted to energy fell.

> **Spending on energy as a proportion of total district budgets grew over 2002 08, and the proportion was highest in 2005/06, not in 2007/08 when oil prices were highest**

With energy expenditures consuming a growing proportion of school district budgets, policymakers might want to know how much of the increase resulted from the faster pace of energy inflation. One approach is to look at the difference in energy expenditures between 2002/03 and 2007/08. Over those six years energy expenditures rose $82 million (from $164 million to $246 million). The problem with this approach is that the increase in aggregate energy expenditures likely reflected some changes in energy expenditures that were independent of changes in energy prices. For example, growth in the student population could have resulted in the need to purchase more units of energy to run buildings. An alternative approach is to assume that energy is a fixed proportion of the budget. Table 2 shows the difference between actual energy expenditure each year and a hypothetical level of expenditure using energy's 2.62 percent share of expenditures for 2002/03. This approach yields an estimated increase in the cost of energy across all districts of roughly $29 million in 2007/08. This estimate implies that if Tennessee had provided an additional $29 million in district funding for 2007/08, that would have been sufficient to cover the additional cost of energy.

TABLE 1

Energy and total expenditures in 136 Tennessee school districts, 2002/03–2007/08 (millions of dollars)

Expenditure	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08
Total expenditures	6,231	6,608	6,983	7,233	7,688	8,281
Energy expenditures	164	174	186	220	224	246
Energy as percent of total	2.62	2.63	2.67	3.05	2.91	2.97

Source: Authors' calculations based on data from Tennessee Department of Education, *Annual Statistical Reports.*

TABLE 2

Actual and hypothetical increase in school district energy costs in Tennessee, by school year, 2002/03–2007/08 (millions of dollars)

Cost	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08
Actual	164	174	186	220	224	246
Hypothetical[a]	164	174	183	190	202	217
Difference	0	0	2	30	22	29

a. Assumes that the proportion of expenditures for energy is fixed at the 2002/03 level of 2.62 percent.

Source: Authors' calculations based on data from Tennessee Department of Education, *Annual Statistical Reports.*

This estimate, however, is a lower bound because districts might have taken measures to deal with the rising energy costs, such as deferring scheduled maintenance, that artificially reduced energy use for a time. (The districts will presumably be forced to incur these deferred costs later.) Whatever the dollar amount, many districts faced the difficulty that these increased energy costs were not included in their annual budgets. Reallocating resources to cover budget shortfalls is easier over the long run than in the short run because more options are available over time to adjust existing contracts and other budgetary constraints.

It is illuminating to show energy expenditures by budget category at the beginning and end of the study period (table 3). In 2007/08 Tennessee school districts had total expenditures of about $8.3 billion. Of that total, they spent nearly $700 million (8 percent) on energy for operations and maintenance (O&M) and about $310 million (4 percent) on energy for transportation. The 8 percent spent on O&M is about 1 percentage point below estimates of the national average (Agron 2009). In 2002/03 energy consumed a much larger share of the O&M budget (29 percent) than of the transportation budget (5 percent).[5] Over the six-year period the proportion of the O&M budget devoted to energy increased by less than 10 percent (from 29 percent to 31 percent), but the proportion of the transportation budget doubled (from 5 percent to

10 percent). Despite this rapid increase, transportation energy expenditures still represented well under 1 percent of total expenditures ($32 million of $8.3 billion).

Although news accounts often focus on the cost of energy for school buses, O&M expenditures account for a much larger share of energy spending (figure 4). At the beginning of the period studied (2002/03), O&M accounted for about 94 percent of energy spending; by the end of the period

FIGURE 4
Distribution of school district energy expenditures in Tennessee, by budget category, 2003/04 and 2007/08

Source: Authors' calculations based on data from Tennessee Department of Education, *Annual Statistical Reports.*

TABLE 3
School district total expenditures and energy expenditures by budget category in Tennessee, 2002/03 and 2007/08 (millions of dollars and percentages)

Category	2002/03				2007/08			
	Total expenditure		Energy expenditure		Total expenditure		Energy expenditure	
	Amount	Percent of total	Amount	Percent of category	Amount	Percent of total	Amount	Percent of category
Operations and maintenance	536	9	154	29	682	8	213	31
Transportation	217	3	10	5	310	4	32	10
Total expenditure	6,231	100	164	3	8,281	100	246	3

Note: Components of energy expenditures may not sum to totals or correspond precisely to data in tables 1 and 2 because of rounding.

Source: Authors' calculations based on data from Tennessee Department of Education, *Annual Statistical Reports.*

FIGURE 5
Distribution of energy expenditures in Tennessee school districts, by fuel type

Source: Authors' calculations based on data from Tennessee Department of Education, *Annual Statistical Reports.*

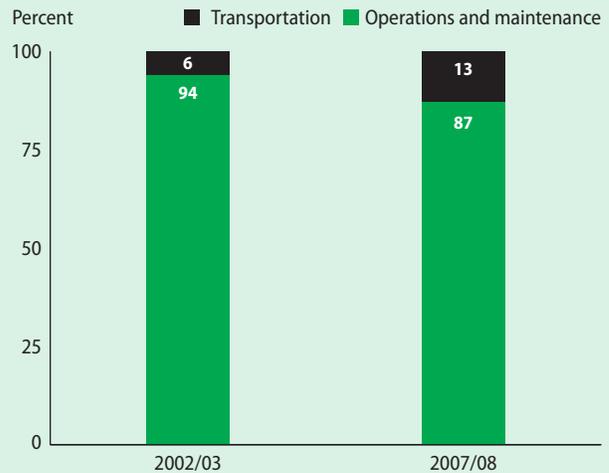(2007/08), the proportion had fallen to about 87 percent.
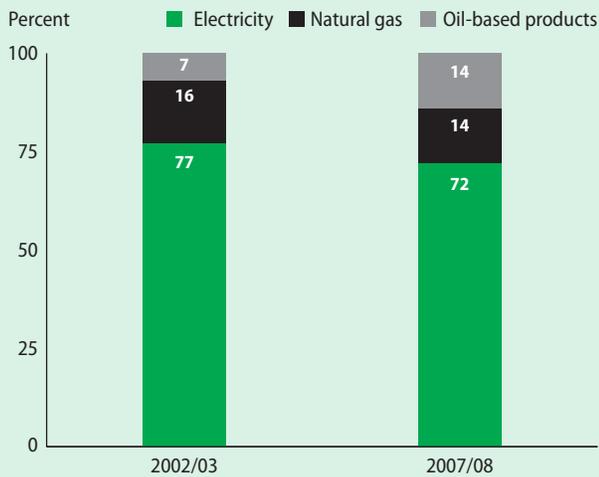
A breakdown of the distribution of energy expenditures by fuel type offers further insights into the shifting expenditure patterns (figure 5). The share of expenditures devoted to oil-based products more than doubled (from 7 percent to 14 percent), while the shares devoted to the other fuel types declined roughly proportionately. All transportation energy expenditures are for oil-based products, whereas the majority of O&M expenditures are for electricity.

As noted, natural gas prices increased faster than gasoline prices after the spike in 2008. That spike does not appear to be reflected in these energy-expenditure data. One possible explanation is that school districts locked in lower prices before the spike. In that case the proportion spent on natural gas would be expected to increase during the 2008/09 school year or later. Over the long run, if the price of oil increases at a faster rate than other energy prices, districts would be expected to shift their consumption pattern away from oil-based products to other forms of energy (such as natural-gas-powered buses).

DO DISTRICT CHARACTERISTICS MATTER?

The study examined three district characteristics: region, size (number of students), and locale. The analysis begins by examining energy expenditure rates for districts grouped by these characteristics and then looks at two factors that could cause a disproportionate impact on some districts: the mix of energy types and expenditures per student. Energy mix was useful because, as already shown, the price of different types of energy did not rise proportionately. Expenditures per student might provide useful insights because, according to the technical experts on the EESI Council, expenditures per student would be a good proxy for energy demand. Districts with high energy expenditures per student might have more space to light, heat, and cool or might have older, less efficient infrastructure or power special equipment with high energy demands. This section uses data from individual districts to examine the fiscal stress caused by the rise in energy costs.

Energy expenditure rates

On average, districts devoted 2.6 percent of their total expenditures ($8.3 million) in 2007/08 on energy for O&M ($213 million). This proportion varied by district characteristics (table 4); all categories of districts other than city and suburban districts, which were fairly small, included at least 30 districts. In particular, the rates are lower for West Tennessee, large districts, and city and suburban locales. The rest of this section examines possible reasons for these differences in expenditure rates.

Differences by type of energy

Examination of the allocation of O&M energy expenditures by district characteristics shows that the largest departure from the average energy mix was West Tennessee districts' more intensive use of electricity. Variations in consumption patterns by other characteristics were more muted: large districts used a slightly higher percentage

TABLE 4

Number of districts and energy expenditure rates for operations and maintenance in Tennessee, by district characteristics, 2007/08

District characteristic	Number of districts	Energy expenditure rate[a] (percent)
Total	136	2.6
Region		
East	53	2.6
Middle	46	2.7
West	37	2.3
Student population		
Small	59	2.9
Medium	37	2.9
Large	40	2.5
Locale		
City	12	2.3
Suburban	13	2.6
Town	34	2.9
Rural	77	2.8

a. Calculated as operations and maintenance energy expenditures divided by total expenditures.

Source: Authors' calculations based on data from Tennessee Department of Education, *Annual Statistical Reports*.

TABLE 5

Allocation of operations and maintenance energy expenditures in Tennessee, by district characteristics, 2007/08 (percent)

District characteristic	Electricity	Natural gas	Oil based products
Region			
East	81	17	2
Middle	80	19	1
West	89	10	2
Student population			
Small	80	19	1
Medium	80	20	0
Large	83	15	2
Locale			
City	84	14	2
Suburban	83	15	2
Town	78	22	0
Rural	82	17	1

Source: Authors' calculations based on data from Tennessee Department of Education, *Annual Statistical Reports*.

of electricity, and towns used a slightly higher percentage of natural gas. Across all characteristics, oil-based products represented only a small fraction of O&M energy expenditures.

Differences by expenditure rate per student

O&M energy expenditure per student also varied by district characteristics in 2007/08. By region, districts with the highest percentage of electricity usage had the lowest cost per student. For example, in West Tennessee, where the average energy mix for districts includes 8–9 percentage points more electricity than in districts in the other two regions (table 5), energy expenditure per student is lower (figure 6). Although the differences in the energy mix are smaller across district size, districts with large student populations, which have the highest percentage of electricity use, also have lower per student costs (figure 7).

This pattern did not hold across all locales (figure 8). Towns followed the pattern, with the lowest percentage of electricity use (see table 5) and the highest cost per student. The other locales did not. City, suburban, and rural districts all had roughly the same percentage of electricity use, but the cost per student was lower in suburban districts by 5 percent or more.

Factors other than energy prices seemed to drive the differences across locales. Without data on additional factors, such as the age of the buildings or the heating and air conditioning plants, it was not possible to identify specific source of these differences.

Identifying differences in fiscal stress from energy inflation

The EESI Council planned to allocate its limited resources to help districts mitigate the effects of increases in O&M energy expenditures. Although several factors seemed likely to influence this effort, such as the return on investment for particular projects, the council's decisions would

FIGURE 6

Operations and maintenance energy expenditure per student in Tennessee school districts, by region, 2007/08

Dollars

Source: Authors' calculations based on data from Tennessee Department of Education, *Annual Statistical Reports.*

FIGURE 8

Operations and maintenance energy expenditure per student in Tennessee school districts, by locale, 2007/08

Dollars

Source: Authors' calculations based on data from Tennessee Department of Education, *Annual Statistical Reports.*

FIGURE 7

Operations and maintenance energy expenditure per student in Tennessee school districts, by student population, 2007/08

Dollars

Source: Authors' calculations based on data from Tennessee Department of Education, *Annual Statistical Reports.*

Two measures of district spending on energy were used to investigate the concept of stress:

- *Ending rate,* or O&M expenditures on energy per student in 2007/08, identifies districts that spent a relatively high proportion of their funds on O&M energy. High energy expenditures could cause fiscal stress by crowding out other expenditures.

- *Growth rate,* or the rate of increase of energy expenditures on O&M over the six-year study period, identifies districts facing the largest change in circumstances over 2002/03–2007/08 as a result of high energy inflation. Districts with the highest growth rates must make the greatest adjustments to higher energy costs.

For each of these measures, the 136 districts were ranked and divided into quartiles of 34 districts. One concern with this approach is that the ending rate and growth rate could be describing similar underlying trends so that most districts would be high or low across both measures. The correlation between the quartile ranks was .12, which suggests

benefit from some indication of which districts were under the greatest fiscal stress as a result of unbudgeted energy costs. Not all districts had the same cost structure.[6]

TABLE 6
Average values of ending energy rates, by Tennessee school district quartiles, 2007/08

Ending energy rate quartile[a]	Quartile average (dollars)
First	173
Second	213
Third	246
Fourth	295

a. Operations and maintenance expenditures on energy per student in 2007/08.

Source: Authors' calculations based on data from Tennessee Department of Education, *Annual Statistical Report.*

TABLE 7
Average values of energy growth rates, by Tennessee school district quartiles, 2007/08

Energy growth rate quartile[a]	Quartile average (percent)
First	20
Second	30
Third	39
Fourth	63

a. Rate of increase of operations and maintenance expenditures on energy over 2002/03–2007/08.

Source: Authors' calculations based on data from Tennessee Department of Education, *Annual Statistical Report.*

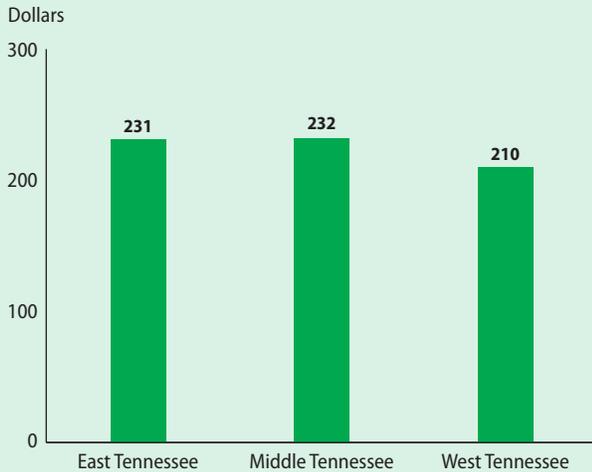that the two measures are not capturing the same phenomena.[7]

On average, the most energy-expenditure-efficient districts (first quartile) in 2007/08 spent $173 per student on energy, while the least energy-efficient-expenditure districts (fourth quartile) spent $295 per student (table 6).

On average, energy expenditures increased 20 percent in districts with the smallest growth in energy expenditures and 63 percent in districts with the greatest increase in energy expenditures (table 7).

A matrix of the number of districts in the ending energy rate and energy growth rate quartiles provides an indication of the fiscal stress caused

TABLE 8
Number of Tennessee school districts in each quartile for energy growth rate and ending energy rate

Ending energy rate quartiles, 2007/08[a]	Energy growth rate quartiles, 2002/03 2007/08[b]			
	First	Second	Third	Fourth
First	8	8	10	8
Second	11	11	9	3
Third	9	7	8	10
Fourth	6	8	7	13

a. Operations and maintenance (O&M) expenditures on energy per student in 2007/08.
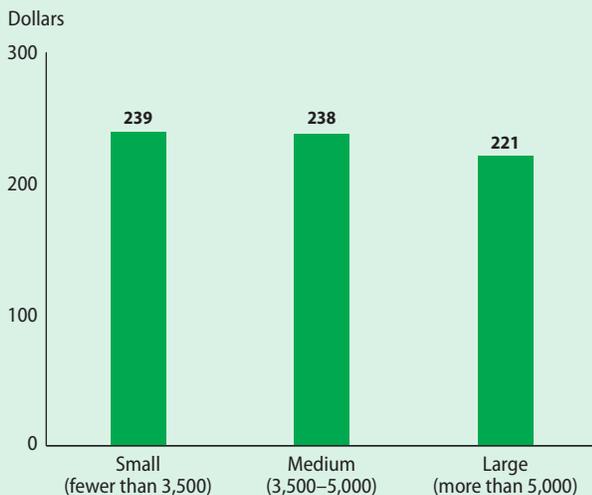
b. Rate of increase of O&M expenditures on energy over 2002/03–2007/08.

Source: Authors' calculations based on data from Tennessee Department of Education, *Annual Statistical Report.*

by the increase in the price of energy and the cost of energy per student. Districts in the lower-right corner of table 8 (fourth quartile for both measures) are under the most stress, with both the highest ending rates and the highest growth rates. The level of stress goes down in moving to the upper left corner (first quartile for both measures).

The distribution of stress scores, calculated by adding the quartile rankings for the two criteria, shows that more districts fall into the three middle scores than into the four extreme scores (table 9). (The stress scores for each district are shown in table D1 in appendix D.) In other words, the stress scores identify a few districts under the most and least stress and then larger numbers in the middle. This indicator could be useful to the EESI Council and other policymakers by allowing them to concentrate greater support on a few districts and less on a larger number of districts.

These stress scores can be used to examine in more detail whether district characteristics affect the increase in energy expenditures (table 10). The analysis has already shown that the composition of districts' energy bundles and their costs varied by characteristics: districts in West Tennessee, with large student populations, and in suburban locales

TABLE 9
Distribution of Tennessee school districts by stress scores

Stress score[a]	Number of districts
2	8
3	19
4	30
5	30
6	19
7	17
8	13

a. Calculated by adding the quartile rankings for operations and maintenance (O&M) expenditures in 2007/08 and rate of increase in O&M expenditures for 2002/03–2007/08; see table 8.

Source: Authors' calculations based on data from Tennessee Department of Education, *Annual Statistical Report.*

TABLE 10
Average stress scores, by Tennessee school district characteristics

District characteristic	Stress scores[a]	
	Average	Standard deviation
Region		
East	4.9	1.8
Middle	5.3	1.6
West	4.7	1.6
Student population		
Small	5.1	1.7
Medium	5.1	1.7
Large	4.9	1.7
Locale		
City	4.9	1.6
Suburban	4.5	1.7
Town	5.1	1.9
Rural	5.1	1.6

a. Calculated by adding the quartile rankings for operations and maintenance (O&M) expenditures in 2007/08 and rate of increase in O&M expenditures for 2002/03–2007/08; see table 8.

Source: Authors' calculations based on data from Tennessee Department of Education, *Annual Statistical Report.*

had lower per student energy expenditure rates than did other districts.

The average stress scores follow a pattern similar to that for the expenditures per student calculations shown in figures 6–8. Even though the stress metric includes the growth rate along with expenditures, the effect of the growth rate variable is too weak to change the underlying pattern in most cases. Thus, West Tennessee districts, districts with large student populations, and suburban districts, are under less stress than are other districts.

Population standard deviations of the stress scores were also calculated across all districts for each district characteristic (see table 10). These standard deviations are uniformly larger than the differences in average stress scores, so the differences are not statistically significant. The magnitude and lack of statistical significance of these differences mean that district characteristics are not a reliable indicator of stress scores (see tables D2–D4 in appendix D for t-statistics for the test of differences in mean stress scores by district characteristic). Not all districts with the same characteristics have the same or even similar stress scores. As a result, these district characteristics might not be appropriate for establishing criteria for allocating state funds.

WHAT MIGHT HAPPEN TO DISTRICT ENERGY COSTS IF REAL ENERGY PRICES CONTINUE TO RISE?

Given current energy expenditure patterns, will certain types of districts face more difficult challenges than others if real energy prices continue to rise? For this analysis, a real increase in the price of energy means an increase relative to other prices (the overall inflation rate) or an increase in energy expenditures holding total expenditures constant.[8] This assumption about prices provides an upper-bound estimate of the impact on energy expenditures because if energy prices rise, districts would try to reduce energy consumption, so actual increases in expenditures might be smaller than simulated increases.

To simulate the impact of increased energy prices, the analysis was conducted backwards by first calculating the overall increase in energy prices

that would raise the energy expenditure rate 0.43 percentage points—reflecting the largest increase in energy expenditures as a proportion of total expenditures over 2002/03–2007/08 (16 percent), from 2.62 percent to 3.05 percent (see table 1). With 2007/08 as the base year, the effect of a 16 percent increase in expenditures for each district was simulated in two steps: increasing the price of all three types of energy separately and then together. Calculations were done for each district separately and then added across all districts to determine the rate of change. Because expenditures were added for each district, districts with higher expenditure levels will carry more weight in the simulations than those with lower levels.

The following example illustrates the simulation methodology. Suppose a district's energy expenditure is 80 percent electricity, 15 percent natural gas, and 5 percent oil-based products and that energy expenditures are 3 percent of the district's total expenditures of $20 million, or $600,000. In that case, the district spends $480,000 on electricity. For that district:

- A 16 percent increase in electricity prices while total expenditures and other energy expenditures remain unchanged would raise electricity expenditures to $556,800 and total energy costs to $676,800, and energy expenditures would rise to 3.38 percent of total expenditures.

- A 16 percent increase in natural gas prices while all other prices remain unchanged would raise natural gas expenditures from $90,000 to $104,400, and energy expenditures would rise to 3.07 percent of total expenditures.

- A 16 percent increase in oil-based product prices while all other prices remain unchanged would raise oil-based product expenditure from $30,000 to $34,800, and energy expenditures would rise to 3.02 percent of total expenditures.

- If all energy prices increase 16 percent, energy expenditures would rise from $600,000 to

TABLE 11

Simulated increases in energy expenditures in Tennessee school districts as a proportion of total expenditures resulting from a 16 percent real increase in energy prices, by district characteristics (percentage points)

District characteristic	Impact of a 16 percent increase in prices of			
	Electricity	Natural gas	Oil based products	Total
Region				
East	0.36	0.07	0.00	0.44
Middle	0.39	0.09	0.00	0.49
West	0.33	0.10	0.00	0.43
Student population				
Small	0.37	0.09	0.00	0.47
Medium	0.37	0.09	0.00	0.46
Large	0.35	0.08	0.01	0.43
Locale				
Urban	0.33	0.08	0.00	0.41
Suburban	0.34	0.08	0.01	0.42
Town	0.37	0.09	0.00	0.47
Rural	0.36	0.09	0.00	0.45

Note: In the baseline case, 3.05 percent of total expenditures are devoted to energy expenditure.

Source: Authors' calculations based on data from Tennessee Department of Education, *Annual Statistical Report.*

$696,000, and energy expenditures would rise to 3.48 percent of total expenditures.

These simulated increases in the percentage of total expenditures devoted to energy are shown in table 11 by energy type for districts grouped by characteristics. For example, if electricity prices rise 16 percent and other prices are stable, energy expenditures in East Tennessee districts would rise 0.36 percentage points, but if all energy prices rise 16 percent, energy expenditures would rise 0.44 percentage points. The results in table 11 show what would happen for a specific set of price increases. The results for a different price increase would vary proportionately by category.

The differences in the averages for each characteristic and energy type are smaller than the standard deviations, which means that they are not statistically significant. (The standard deviations by characteristic are shown in table E2 in appendix E.) The variation by characteristics is not nearly as large as the variation across individual school districts. For example, the 16 percent increase in overall energy prices causes energy expenditure increases at the district level of 0.24–0.78 percentage points. (See table E1 in appendix E for individual district values.)

As with the stress scores, these simulation results suggest that the EESI Council might not want to use these district characteristics in establishing criteria for allocating state funds since the simulations did not produce statistically significant different outcomes by district characteristics.[9] Had the simulated impact of projected energy price increases been statistically larger for districts with small student populations, for example, the council might have chosen to target small districts for funding. Instead, the council will need to examine the circumstances (such as level and rate of increase in energy expenditures), determine the significance of

> **The simulation results suggest that the EESI Council might not want to use these district characteristics in establishing criteria for allocating state funds since the simulations did not produce statistically significant different outcomes by district characteristics**

other characteristics, or collect additional data to identify districts to target for program funding.

LIMITATIONS OF THE STUDY

This analysis has two important limitations. First, the analysis is based on energy expenditure rather than energy consumption data because Tennessee does not collect energy consumption data from districts. As a result, changes in energy expenditures observed in the data could have resulted from price increases, capital improvements (in heating systems, for example), or a change in building infrastructure. Furthermore, the Tennessee Department of Education has no information about the characteristics of school district buildings. Thus, the analysis of the changes in energy expenditures was limited to such generic characteristics as region and locale.

Information about building characteristics could provide useful insights into the differences across school districts. For example, suburban districts might spend less per student than other districts because they have newer, more energy-efficient school buildings.[10] In addition, more detailed information would allow the building of a richer simulation model, which might yield greater distinctions based on district characteristics. Given the limited number of variables available for describing districts, it appears that the EESI Council would be better off examining funding requests on a case by case basis using the district stress scores for guidance (see table D1 in appendix D), rather than developing broad guidelines using district characteristics.

Second, much of the analysis focused on the O&M portion of energy expenditures and largely ignored transportation. This approach was selected both because the EESI Council chose to focus on O&M-related projects and because the transportation data were incomplete. There is evidence, however, that the rapid increase in oil prices in 2007/08 caused transportation energy costs to rise more rapidly than O&M energy costs because most

transportation expenditures were for oil-based products while most O&M expenditures were for electricity. As a result, the measure of fiscal stress lacks one potential source of stress. Nonetheless, transportation energy expenditures were only a small proportion of total energy expenditures.

APPENDIX A
ENERGY PRICES NATIONALLY AND
IN TENNESSEE, 2002–08

Table A1 shows the prices per unit of energy that were used to construct figures 1–3.

TABLE A1

The price of energy in Tennessee and national average, by energy type, 2002–08

Year	Electricity (cents per kilowatt hour)		Natural gas (dollars per thousand cubic feet)		Gasoline (cents per gallon)	
	National	Tennessee	National	Tennessee	National	Midwest
2002	7.13	5.72	6.62	8.60	111.7	113.6
2003	7.38	5.84	8.73	9.25	150.7	141.3
2004	7.55	6.14	9.65	9.83	154.7	149.5
2005	8.05	6.31	10.58	11.17	184.8	171.5
2006	8.77	6.97	10.98	11.02	224.2	225.8
2007	8.98	7.07	11.61	12.45	241.4	225.9
2008	8.99	7.14	15.45	17.11	315.4	309.3
Percent difference, 2002–08	26	25	133	99	182	172

Source: Authors' calculations based on data from Tennessee Department of Education, *Annual Statistical Report.*

APPENDIX B
ENERGY AND TOTAL EXPENDITURES FOR 106 TENNESSEE SCHOOL DISTRICTS, 2002/03–2007/08

Table B1 shows the costs for the 106 districts for which complete transportation data were available. Although the percentages for energy expenditures are higher than for the set with all 136 districts, they follow a similar pattern (see table 1 in the main text). Therefore, data from all 136 districts rather than this subset for 106 districts are used in the analysis.

TABLE B1

Energy and total expenditures in 106 Tennessee school districts with complete transportation data, 2002/03–2007/08 (millions of dollars)

Expenditure	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08
Total expenditures	4,574	4,912	5,174	5,297	5,665	6,081
Energy expenditures	126	134	143	170	173	190
Energy as percent of total	2.76	2.72	2.77	3.21	3.05	3.13

Source: Authors' calculations based on data from Tennessee Department of Education, *Annual Statistical Report.*

APPENDIX C
TOTAL EXPENDITURES, ENERGY
EXPENDITURES, AND OPERATIONS AND
MAINTENANCE ENERGY EXPENDITURES,
BY DISTRICT, SCHOOL YEAR 2007/08

Table C1 shows total, energy, and operations and maintenance (O&M) energy expenditures for 2007/08 for each school district in Tennessee.

The source for these data is the publicly available *Annual Statistical Reports* issued by the Tennessee Department of Education. The table also shows these energy expenditures as a percentage of total expenditures. Districts that have outsourced their transportation services show identical numbers for total energy expenditures and O&M expenditures because data on their transportation energy expenditures are not available.

TABLE C1
Total expenditures, energy expenditures, and operations and maintenance energy expenditures for Tennessee school districts, by district, 2007/08

District	Total expenditures ($)	Energy expenditures ($)	Energy as percent of total	Operations and maintenance energy expenditures ($)	Operations and maintenance energy expenditures as percent of total energy
Alamo	4,502,988	84,539	1.88	84,539	1.88
Alcoa	15,051,876	489,086	3.25	489,086	3.25
Anderson County	62,221,256	1,916,510	3.08	1,904,510	3.06
Athens	15,796,386	445,899	2.82	412,173	2.61
Bedford County	68,459,670	2,214,002	3.23	1,901,072	2.78
Bells	3,133,784	72,513	2.31	72,513	2.31
Benton County	20,308,486	638,394	3.14	616,171	3.03
Bledsoe County	16,032,811	619,413	3.86	421,920	2.63
Blount County	86,944,625	2,647,784	3.05	2,647,784	3.05
Bradford	4,760,406	126,133	2.65	93,031	1.95
Bradley County	73,128,789	1,985,073	2.71	1,917,301	2.62
Bristol	35,389,726	1,105,042	3.12	1,043,281	2.95
Campbell County	45,446,140	1,333,432	2.93	1,304,788	2.87
Cannon County	16,475,259	578,420	3.51	478,945	2.91
Carroll County	3,693,979	367,137	9.94	70,810	1.92
Carter County	46,189,746	1,638,295	3.55	1,267,588	2.74
Cheatham County	52,627,544	1,700,838	3.23	1,389,193	2.64
Chester County	18,514,776	680,594	3.68	525,226	2.84
Claiborne County	42,238,144	1,432,012	3.39	1,262,873	2.99
Clay County	10,124,588	522,142	5.16	398,179	3.93
Cleveland	39,577,113	1,485,733	3.75	1,307,869	3.30
Clinton	7,623,222	165,055	2.17	165,055	2.17
Cocke County	37,362,961	1,406,537	3.76	1,092,307	2.92
Coffee County	34,236,727	1,048,046	3.06	830,571	2.43
Crockett County	13,009,759	645,290	4.96	524,645	4.03
Cumberland County	51,223,380	2,086,542	4.07	1,762,610	3.44
Davidson County	851,927,475	22,557,289	2.65	18,969,950	2.23
Dayton	4,965,113	113,063	2.28	113,063	2.28

TABLE C1 (CONTINUED)

Total expenditures, energy expenditures, and operations and maintenance energy expenditures for Tennessee school districts, by district, 2007/08

District	Total expenditures ($)	Energy expenditures ($)	Energy as percent of total	Operations and maintenance energy expenditures ($)	Operations and maintenance energy expenditures as percent of total energy
Decatur County	12,607,034	494,006	3.92	383,206	3.04
Dekalb County	19,377,229	773,836	3.99	585,411	3.02
Dickson County	60,433,791	2,414,320	3.99	1,977,633	3.27
Dyer County	27,172,728	1,188,207	4.37	866,629	3.19
Dyersburg	27,072,738	946,711	3.50	946,711	3.50
Elizabethton	17,035,463	550,245	3.23	503,838	2.96
Etowah	2,944,583	94,950	3.22	89,185	3.03
Fayette County	32,361,715	1,339,119	4.14	733,016	2.27
Fayetteville	7,900,698	256,784	3.25	234,563	2.97
Fentress County	18,790,653	796,709	4.24	621,366	3.31
Franklin	50,872,603	1,091,167	2.14	968,070	1.90
Franklin County	46,314,725	1,648,567	3.56	1,587,710	3.43
Gibson Co. Spec.	22,887,842	695,617	3.04	482,499	2.11
Giles County	34,271,712	1,567,880	4.57	1,246,276	3.64
Grainger County	40,518,558	752,075	1.86	667,156	1.65
Greene County	52,982,249	1,817,823	3.43	1,366,660	2.58
Greeneville	27,547,802	856,939	3.11	764,435	2.77
Grundy County	19,462,052	709,246	3.64	536,375	2.76
Hamblen County	89,119,344	2,482,597	2.79	2,082,950	2.34
Hamilton County	342,767,714	8,732,362	2.55	8,730,998	2.55
Hancock County	9,624,445	401,306	4.17	292,740	3.04
Hardeman County	35,471,271	1,172,470	3.31	803,524	2.27
Hardin County	29,481,117	1,149,841	3.90	937,014	3.18
Hawkins County	58,124,519	2,523,608	4.34	1,734,073	2.98
Haywood County	27,340,497	926,770	3.39	657,239	2.40
Henderson County	24,582,016	855,584	3.48	756,806	3.08
Henry County	26,062,247	1,000,673	3.84	682,294	2.62
Hickman County	31,538,865	1,364,041	4.32	1,108,306	3.51
Hollow Rock-Br	5,023,815	116,508	2.32	116,508	2.32
Houston County	11,016,682	475,516	4.32	386,693	3.51
Humboldt	11,883,814	333,650	2.81	303,942	2.56
Humphreys County	22,019,024	921,701	4.19	697,579	3.17
Huntingdon	9,555,696	279,651	2.93	279,651	2.93
Jackson County	14,024,401	508,082	3.62	409,421	2.92
Jackson-Madison Co	113,287,970	4,252,542	3.75	3,289,695	2.90
Jefferson County	52,562,543	1,618,586	3.08	1,273,321	2.42
Johnson City	65,967,193	2,264,562	3.43	2,201,882	3.34
Johnson County	22,165,751	926,828	4.18	755,244	3.41

(CONTINUED)

TABLE C1 (CONTINUED)
Total expenditures, energy expenditures, and operations and maintenance energy expenditures for Tennessee school districts, by district, 2007/08

District	Total expenditures ($)	Energy expenditures ($)	Energy as percent of total	Operations and maintenance energy expenditures ($)	Operations and maintenance energy expenditures as percent of total energy
Kingsport	67,114,891	1,150,569	1.71	1,150,569	1.71
Knox County	485,714,548	14,079,626	2.90	14,063,200	2.90
Lake County	8,064,691	446,110	5.53	393,776	4.88
Lauderdale County	35,585,896	1,076,343	3.02	766,253	2.15
Lawrence County	47,200,387	1,818,035	3.85	1,454,641	3.08
Lebanon	25,880,098	739,303	2.86	653,126	2.52
Lenoir City	19,816,097	678,412	3.42	635,301	3.21
Lewis County	13,424,866	448,475	3.34	357,659	2.66
Lexington	8,924,003	291,727	3.27	291,727	3.27
Lincoln County	28,190,330	1,491,755	5.29	1,194,889	4.24
Loudon County	41,890,193	850,684	2.03	850,684	2.03
Macon County	25,655,647	1,077,178	4.20	808,229	3.15
Manchester	11,658,639	316,171	2.71	309,791	2.66
Marion County	45,762,995	1,236,903	2.70	1,116,758	2.44
Marshall County	37,192,038	1,628,260	4.38	1,296,549	3.49
Maryville	45,683,214	912,262	2.00	912,262	2.00
Maury County	86,336,720	3,101,385	3.59	2,500,859	2.90
McKenzie	11,170,600	245,192	2.19	245,192	2.19
McMinn County	42,318,301	1,659,045	3.92	1,285,879	3.04
McNairy County	31,461,421	1,042,284	3.31	781,624	2.48
Meigs County	13,865,618	465,679	3.36	322,593	2.33
Memphis	1,143,086,717	25,055,575	2.19	25,054,818	2.19
Milan	16,851,202	463,561	2.75	410,354	2.44
Monroe County	47,173,418	872,234	1.85	872,234	1.85
Montgomery County	244,537,248	6,128,272	2.51	4,999,582	2.04
Moore County	7,591,809	322,084	4.24	255,492	3.37
Morgan County	25,546,347	1,001,631	3.92	794,989	3.11
Murfreesboro	59,487,902	2,330,116	3.92	2,167,945	3.64
Newport	6,002,001	210,232	3.50	208,247	3.47
Oak Ridge	51,315,161	1,858,449	3.62	1,699,731	3.31
Obion County	29,473,401	1,313,722	4.46	1,011,585	3.43
Oneida	10,246,708	287,349	2.80	257,534	2.51
Overton County	25,889,353	971,774	3.75	764,064	2.95
Paris	14,719,555	365,093	2.48	305,254	2.07
Perry County	9,228,175	381,411	4.13	288,715	3.13
Pickett County	5,911,343	227,679	3.85	180,012	3.05
Polk County	21,041,391	774,569	3.68	594,827	2.83
Putnam County	81,688,819	3,431,655	4.20	3,040,036	3.72

(CONTINUED)

TABLE C1 (CONTINUED)

Total expenditures, energy expenditures, and operations and maintenance energy expenditures for Tennessee school districts, by district, 2007/08

District	Total expenditures ($)	Energy expenditures ($)	Energy as percent of total	Operations and maintenance energy expenditures ($)	Operations and maintenance energy expenditures as percent of total energy
Rhea County	30,053,122	1,285,666	4.28	1,050,441	3.50
Richard City	2,765,989	96,813	3.50	96,813	3.50
Roane County	58,393,565	2,317,273	3.97	1,830,850	3.14
Robertson County	72,868,802	2,623,722	3.60	2,106,473	2.89
Rogersville	5,389,088	132,939	2.47	132,939	2.47
Rutherford County	307,215,310	8,710,120	2.84	8,710,120	2.84
Scott County	20,852,323	766,211	3.67	580,568	2.78
Sequatchie County	16,939,321	557,114	3.29	474,025	2.80
Sevier County	124,038,782	3,817,370	3.08	3,044,776	2.45
Shelby County	383,923,570	9,085,791	2.37	7,335,182	1.91
Smith County	25,164,937	1,066,288	4.24	860,096	3.42
South Carroll	3,086,998	47,387	1.54	47,008	1.52
Stewart County	16,653,835	939,324	5.64	687,002	4.13
Sullivan County	94,879,195	2,515,495	2.65	2,416,333	2.55
Sumner County	187,000,597	5,479,800	2.93	4,548,513	2.43
Sweetwater	12,475,595	326,989	2.62	318,904	2.56
Tipton County	94,580,178	2,576,863	2.72	1,840,379	1.95
Trenton	11,194,289	418,260	3.74	374,370	3.34
Trousdale County	9,653,947	395,833	4.10	322,680	3.34
Tullahoma	31,590,779	1,046,878	3.31	1,008,850	3.19
Unicoi County	21,159,664	650,703	3.08	534,950	2.53
Union City	11,997,041	407,608	3.40	370,450	3.09
Union County	24,545,651	828,942	3.38	817,338	3.33
Van Buren County	6,613,085	251,822	3.81	192,496	2.91
Warren County	45,856,469	1,930,055	4.21	1,525,116	3.33
Washington County	61,335,562	2,193,400	3.58	1,568,259	2.56
Wayne County	21,504,437	922,504	4.29	729,999	3.39
Weakley County	34,384,085	1,406,264	4.09	1,098,716	3.20
West Carroll	7,677,207	196,341	2.56	196,341	2.56
White County	27,612,465	948,762	3.44	753,762	2.73
Williamson County	238,592,023	6,870,804	2.88	5,417,368	2.27
Wilson County	134,807,506	3,573,695	2.65	2,690,229	2.00

Source: Authors' calculations based on data from Tennessee Department of Education, *Annual Statistical Report.*

APPENDIX D
STRESS SCORES FOR 136 TENNESSEE
SCHOOL DISTRICTS AND TESTS FOR
DIFFERENCES IN THE MEANS OF STRESS
SCORES BY DISTRICT CHARACTERISTICS

Table D1 shows the stress scores for each district
in the state.

TABLE D1
Stress scores for Tennessee school districts

District	Ending energy rate, 2007/08[a]	Energy growth rate, 2003/04 2007/08[b]	Composite stress score[c]	District	Ending energy rate, 2007/08[a]	Energy growth rate, 2003/04 2007/08[b]	Composite stress score[c]
Alamo	1	3	4	Dekalb County	2	1	3
Alcoa	4	1	5	Dickson County	3	1	4
Anderson County	4	3	7	Dyer County	3	4	7
Athens	3	3	6	Dyersburg	4	2	6
Bedford County	3	2	5	Elizabethton	3	1	4
Bells	1	4	5	Etowah	3	4	7
Benton County	3	2	5	Fayette County	2	2	4
Bledsoe County	2	3	5	Fayetteville	3	1	4
Blount County	3	3	6	Fentress County	3	4	7
Bradford	1	3	4	Franklin	3	1	4
Bradley County	1	1	2	Franklin County	4	4	8
Bristol	4	1	5	Gibson Co. Spec.	1	3	4
Campbell County	2	3	5	Giles County	4	4	8
Cannon County	2	2	4	Grainger County	1	4	5
Carroll County[c]	1	4	5	Greene County	1	3	4
Carter County	2	2	4	Greeneville	4	2	6
Cheatham County	2	1	3	Grundy County	3	3	6
Chester County	2	2	4	Hamblen County	2	2	4
Claiborne County	4	3	7	Hamilton County	2	1	3
Clay County	4	4	8	Hancock County	4	3	7
Cleveland	4	2	6	Hardeman County	1	4	5
Clinton	1	2	3	Hardin County	3	2	5
Cocke County	2	4	6	Hawkins County	2	4	6
Coffee County	1	2	3	Haywood County	2	2	4
Crockett County	4	4	8	Henderson County	2	1	3
Cumberland County	3	4	7	Henry County	2	2	4
Davidson County	3	2	5	Hickman County	4	4	8
Dayton	1	1	2	Hollow Rock-Br	1	2	3
Decatur County	3	3	6	Houston County	4	1	5

TABLE D1 (CONTINUED)
Stress scores for Tennessee school districts

District	Ending energy rate, 2007/08[a]	Energy growth rate, 2003/04 2007/08[b]	Composite stress score[c]
Humboldt	2	1	3
Humphreys County	3	2	5
Huntingdon	2	2	4
Jackson County	3	1	4
Jackson-Madison Co	3	2	5
Jefferson County	1	1	2
Johnson City	4	2	6
Johnson County	4	4	8
Kingsport	1	1	2
Knox County	3	4	7
Lake County	4	4	8
Lauderdale County	1	1	2
Lawrence County	2	1	3
Lebanon	2	3	5
Lenoir City	4	2	6
Lewis County	1	2	3
Lexington	4	4	8
Lincoln County	4	1	5
Loudon County	1	3	4
Macon County	2	3	5
Manchester	3	4	7
Marion County	4	2	6
Marshall County	3	1	4
Maryville	1	1	2
Maury County	2	2	4
McKenzie	1	3	4
McMinn County	2	2	4
McNairy County	1	2	3
Meigs County	1	3	4
Memphis	3	3	6
Milan	2	3	5
Monroe County	1	1	2
Montgomery County	1	4	5
Moore County	3	1	4
Morgan County	3	2	5
Murfreesboro	4	4	8
Newport	4	1	5
Oak Ridge	4	4	8
Obion County	3	3	6
Oneida	2	1	3
Overton County	2	1	3
Paris	1	3	4
Perry County	3	1	4
Pickett County	4	2	6
Polk County	2	3	5
Putnam County	4	4	8
Rhea County	3	4	7
Richard City	4	4	8
Roane County	3	4	7
Robertson County	2	3	5
Rogersville	2	1	3
Rutherford County	3	4	7
Scott County	2	1	3
Sequatchie County	2	3	5
Sevier County	2	3	5
Shelby County	1	3	4
Smith County	4	3	7
South Carroll	1	1	2
Stewart County	4	3	7
Sullivan County	2	1	3
Sumner County	1	3	4
Sweetwater	2	4	6
Tipton County	1	4	5
Trenton	4	4	8
Trousdale County	3	4	7
Tullahoma	4	3	7
Unicoi County	2	2	4
Union City	4	1	5
Union County	4	3	7
Van Buren County	3	3	6
Warren County	3	3	6
Washington County	1	2	3
Wayne County	4	2	6
Weakley County	3	1	4

TABLE D1 (CONTINUED)
Stress scores for Tennessee school districts

District	Ending energy rate, 2007/08[a]	Energy growth rate, 2003/04 2007/08[b]	Composite stress score[c]
West Carroll	1	2	3
White County	1	2	3
Williamson County	1	4	5
Wilson County	1	4	5

a. Operations and maintenance (O&M) expenditures on energy per student in 2007/08.

b. Rate of increase of O&M expenditures on energy over 2002/03–2007/08.

c. Calculated by adding the quartile rankings for O&M expenditures in 2007/08 and rate of increase in O&M expenditures for 2002/03–2007/08.

c. Carroll County school district provides support services and resources to the city and special school districts in the county but does not maintain a student population as reflected in its student numbers. Thus, student numbers and per student calculations for the Carroll County school district were modified using an estimated student number from the average of other city and special school districts in Carroll County. This modification allowed Carroll County school district to be included in the stress score calculations and comparisons.

Source: Authors' calculations based on data from Tennessee Department of Education, *Annual Statistical Report.*

Tables D2–D4 show the t-statistics for tests of differences in means in the stress scores by district characteristics. These statistics were calculated using a procedure in Excel® that tests for differences in means assuming an unequal variance in the two populations under study (such as all districts in East Tennessee and all districts in Middle Tennessee).[11]

For example, the mean stress score is 4.9 for districts in East Tennessee and 5.3 for districts in Middle Tennessee. The t-statistic for this pair of stress scores is .99 (see table D2), which is below the minimum for statistical significance at the 95 percent confidence level using a one-tail test. Thus, the 4.9 and 5.3 average stress scores are considered essentially the same—there are no differences between stress scores in East Tennessee and Middle Tennessee.

Tables D2–D4 show that none of the pairwise comparisons for differences are statistically significant.

TABLE D2
T-statistics of pairwise tests of differences in mean for pairwise comparisons of stress scores for Tennessee school districts, by region

Region	East	Middle	West
East	—	0.99	0.60
Middle	0.99	—	1.55
West	0.60	1.55	—

Note: Stress scores are calculated by adding the quartile rankings for operations and maintenance (O&M) expenditures in 2007/08 and rate of increase in O&M expenditures for 2002/03–2007/08.

Source: Authors' calculations based on data from Tennessee Department of Education, *Annual Statistical Report.*

TABLE D3
T-statistics of pairwise tests of differences in mean for pairwise comparisons of stress scores for Tennessee school districts, by student population size

Size[a]	Small	Medium	Large
Small	—	0.05	0.57
Medium	0.05	—	0.60
Large	0.57	0.60	—

Note: Stress scores are calculated by adding the quartile rankings for operations and maintenance (O&M) expenditures in 2007/08 and rate of increase in O&M expenditures for 2002/03–2007/08.

a. Small is fewer than 3,500 students, medium is 3500–5,000 students, and large is more than 5,000 students.

Source: Authors' calculations based on data from Tennessee Department of Education, *Annual Statistical Report.*

TABLE D4
T-statistics of pairwise tests of differences in mean for pairwise comparisons of stress scores for Tennessee school districts, by locale

Locale	City	Suburb	Town	Rural
City	—	0.70	0.31	0.30
Suburb	0.70	—	1.10	1.22
Town	0.31	1.10	—	0.06
Rural	0.30	1.22	0.06	—

Note: Stress scores are calculated by adding the quartile rankings for operations and maintenance (O&M) expenditures in 2007/08 and rate of increase in O&M expenditures for 2002/03–2007/08.

Source: Authors' calculations based on data from Tennessee Department of Education, *Annual Statistical Report.*

APPENDIX E
SIMULATION RESULTS, BY DISTRICT

Table E1 identifies the categorization of districts by characteristics and the results of simulations of a 16 percent increase in energy prices. Using 2007/08 as the base year, the effect of a 16 percent increase in energy expenditures was simulated for each district in two steps: increasing the prices of

each type of energy separately, and then together. The increases were calculated separately for each district and then summed across districts to estimate the rate of change in energy expenditures as a percentage of total expenditures. This means that districts with higher levels of expenditure will carry more weight in the simulations than those with lower levels of expenditure. An example of these calculations is provided in the main text.

TABLE E1

Percentage point increases for Tennessee school districts in the percent of total expenditures devoted to energy resulting from a 16 percent real increase in energy prices, by district

District	Locale	District size[a] (student population)	Region	Electricity	Natural gas	Oil based products	Total
Alamo	Rural	Small	West	0.23	0.07	0.00	0.30
Alcoa	Suburb	Small	East	0.44	0.08	0.00	0.52
Anderson County	Rural	Large	East	0.40	0.08	0.01	0.49
Athens	Town	Small	East	0.35	0.06	0.01	0.42
Bedford County	Rural	Large	Middle	0.36	0.07	0.01	0.44
Bells	Rural	Small	West	0.34	0.03	0.00	0.37
Benton County	Rural	Small	West	0.36	0.12	0.01	0.49
Bledsoe County	Rural	Small	East	0.36	0.06	0.00	0.42
Blount County	Rural	Large	East	0.43	0.04	0.02	0.49
Bradford	Rural	Small	West	0.25	0.07	0.00	0.31
Bradley County	Suburb	Large	East	0.33	0.07	0.02	0.42
Bristol	City	Medium	East	0.35	0.12	0.00	0.47
Campbell County	Rural	Large	East	0.37	0.08	0.00	0.46
Cannon County	Rural	Small	Middle	0.39	0.07	0.00	0.47
Carroll County	Rural	Small	West	0.21	0.09	0.00	0.31
Carter County	Suburb	Large	East	0.33	0.11	0.00	0.44
Cheatham County	Rural	Large	Middle	0.36	0.05	0.01	0.42
Chester County	Rural	Small	West	0.33	0.12	0.00	0.45
Claiborne County	Rural	Medium	East	0.42	0.04	0.01	0.48
Clay County	Rural	Small	Middle	0.59	0.00	0.04	0.63
Cleveland	City	Medium	East	0.46	0.07	0.00	0.53
Clinton	Town	Small	East	0.30	0.04	0.00	0.35
Cocke County	Rural	Medium	East	0.32	0.14	0.00	0.47
Coffee County	Rural	Medium	Middle	0.34	0.05	0.00	0.39
Crockett County	Rural	Small	West	0.49	0.16	0.00	0.65
Cumberland County	Rural	Large	East	0.46	0.09	0.00	0.55
Dayton	Town	Small	East	0.28	0.08	0.00	0.36
Decatur County	Rural	Small	West	0.33	0.15	0.00	0.49

(CONTINUED)

TABLE E1 (CONTINUED)

Percentage point increases for Tennessee school districts in the percent of total expenditures devoted to energy resulting from a 16 percent real increase in energy prices, by district

District	Locale	District size[a] (student population)	Region	Electricity	Natural gas	Oil based products	Total
Dekalb County	Rural	Small	Middle	0.36	0.12	0.00	0.48
Dickson County	Town	Large	Middle	0.40	0.13	0.00	0.52
Dyer County	Rural	Medium	West	0.39	0.10	0.01	0.51
Dyersburg	Town	Medium	West	0.42	0.14	0.00	0.56
Elizabethton	Suburb	Small	East	0.34	0.13	0.00	0.47
Etowah	Town	Small	East	0.35	0.14	0.00	0.48
Fayette County	Rural	Medium	West	0.26	0.10	0.00	0.36
Fayetteville	Town	Small	Middle	0.38	0.10	0.00	0.48
Fentress County	Rural	Small	Middle	0.39	0.14	0.00	0.53
Franklin	City	Medium	Middle	0.26	0.04	0.01	0.30
Franklin County	Rural	Large	Middle	0.48	0.06	0.01	0.55
Gibson Co. Spec.	Rural	Small	West	0.26	0.08	0.00	0.34
Giles County	Rural	Medium	Middle	0.47	0.10	0.01	0.58
Grainger County	Rural	Medium	East	0.25	0.02	0.00	0.26
Greene County	Rural	Large	East	0.36	0.06	0.00	0.41
Greeneville	Town	Small	East	0.41	0.04	0.00	0.44
Grundy County	Rural	Small	Middle	0.33	0.11	0.00	0.44
Hamblen County	City	Large	East	0.30	0.08	0.00	0.37
Hamilton County	City	Large	East	0.31	0.09	0.01	0.41
Hancock County	Rural	Small	East	0.45	0.04	0.00	0.49
Hardeman County	Town	Medium	West	0.26	0.10	0.00	0.36
Hardin County	Rural	Medium	West	0.40	0.11	0.00	0.51
Hawkins County	Suburb	Large	East	0.32	0.14	0.01	0.48
Haywood County	Town	Medium	West	0.29	0.10	0.00	0.38
Henderson County	Rural	Medium	West	0.39	0.11	0.00	0.49
Henry County	Rural	Medium	West	0.32	0.10	0.00	0.42
Hickman County	Rural	Medium	Middle	0.50	0.06	0.00	0.56
Hollow Rock-Br	Rural	Small	West	0.29	0.08	0.00	0.37
Houston County	Rural	Small	Middle	0.45	0.11	0.00	0.56
Humboldt	Town	Small	West	0.28	0.13	0.00	0.41
Humphreys County	Rural	Medium	Middle	0.40	0.10	0.00	0.51
Huntingdon	Rural	Small	West	0.36	0.11	0.00	0.47
Jackson County	Rural	Small	Middle	0.40	0.02	0.05	0.47
Jackson-Madison	City	Large	West	0.35	0.11	0.00	0.46
Jefferson County	Rural	Large	East	0.32	0.07	0.00	0.39
Johnson City	City	Large	East	0.46	0.08	0.00	0.53
Johnson County	Town	Small	East	0.41	0.13	0.00	0.55
Kingsport	City	Large	East	0.25	0.02	0.00	0.27

(CONTINUED)

TABLE E1 (CONTINUED)

Percentage point increases for Tennessee school districts in the percent of total expenditures devoted to energy resulting from a 16 percent real increase in energy prices, by district

District	Locale	District size[a] (student population)	Region	Electricity	Natural gas	Oil based products	Total
Knox County	Suburb	Large	East	0.37	0.08	0.01	0.46
Lake County	Rural	Small	West	0.42	0.36	0.00	0.78
Lauderdale County	Town	Medium	West	0.22	0.12	0.00	0.34
Lawrence County	Rural	Large	Middle	0.40	0.10	0.00	0.49
Lebanon	Town	Medium	Middle	0.34	0.06	0.00	0.40
Lenoir City	Suburb	Small	East	0.39	0.13	0.00	0.51
Lewis County	Town	Small	Middle	0.32	0.11	0.00	0.43
Lexington	Town	Small	West	0.45	0.07	0.00	0.52
Lincoln County	Rural	Medium	Middle	0.55	0.12	0.00	0.68
Loudon County	Suburb	Medium	East	0.28	0.04	0.00	0.32
Macon County	Rural	Medium	Middle	0.38	0.10	0.02	0.50
Manchester	Town	Small	Middle	0.38	0.04	0.01	0.43
Marion County	Rural	Medium	East	0.31	0.09	0.00	0.39
Marshall County	Rural	Medium	Middle	0.49	0.07	0.00	0.56
Maryville	Suburb	Medium	East	0.27	0.05	0.00	0.32
Maury County	Town	Large	Middle	0.34	0.12	0.00	0.46
McKenzie	Town	Small	West	0.27	0.07	0.01	0.35
McMinn County	Rural	Large	East	0.41	0.07	0.00	0.49
McNairy County	Rural	Medium	West	0.30	0.10	0.00	0.40
Meigs County	Rural	Small	East	0.36	0.02	0.00	0.37
Memphis	City	Large	West	0.34	0.00	0.01	0.35
Milan	Rural	Small	West	0.32	0.07	0.00	0.39
Monroe County	Rural	Large	East	0.24	0.06	0.00	0.30
Montgomery County	City	Large	Middle	0.26	0.05	0.01	0.33
Moore County	Rural	Small	Middle	0.44	0.10	0.00	0.54
Morgan County	Rural	Medium	East	0.44	0.06	0.00	0.50
Murfreesboro	City	Large	Middle	0.41	0.18	0.00	0.58
Nashville-Davidson	City	Large	Middle	0.27	0.08	0.01	0.36
Newport	Town	Small	East	0.51	0.05	0.00	0.56
Oak Ridge	Town	Medium	East	0.45	0.08	0.00	0.53
Obion County	Rural	Medium	West	0.42	0.13	0.00	0.55
Oneida	Town	Small	East	0.34	0.06	0.00	0.40
Overton County	Rural	Medium	Middle	0.39	0.08	0.00	0.47
Paris	Town	Small	West	0.28	0.05	0.00	0.33
Perry County	Rural	Small	Middle	0.36	0.14	0.00	0.50
Pickett County	Rural	Small	Middle	0.36	0.13	0.00	0.49
Polk County	Rural	Small	East	0.39	0.00	0.06	0.45
Putnam County	Town	Large	Middle	0.43	0.17	0.00	0.60

(CONTINUED)

TABLE E1 (CONTINUED)

Percentage point increases for Tennessee school districts in the percent of total expenditures devoted to energy resulting from a 16 percent real increase in energy prices, by district

District	Locale	District size[a] (student population)	Region	Electricity	Natural gas	Oil based products	Total
Rhea County	Rural	Medium	East	0.41	0.15	0.00	0.56
Richard City	Town	Small	East	0.45	0.10	0.01	0.56
Roane County	Town	Large	East	0.41	0.09	0.00	0.50
Robertson County	Rural	Large	Middle	0.37	0.09	0.00	0.46
Rogersville	Town	Small	East	0.31	0.09	0.00	0.39
Rutherford County	Suburb	Large	Middle	0.36	0.09	0.00	0.45
Scott County	Rural	Small	East	0.38	0.06	0.00	0.45
Sequatchie County	Rural	Small	East	0.40	0.04	0.00	0.45
Sevier County	Town	Large	East	0.33	0.06	0.00	0.39
Shelby County	Suburb	Large	West	0.31	0.00	0.00	0.31
Smith County	Rural	Medium	Middle	0.48	0.07	0.00	0.55
South Carroll	Rural	Small	West	0.17	0.07	0.00	0.24
Stewart County	Rural	Small	Middle	0.55	0.11	0.00	0.66
Sullivan County	Suburb	Large	East	0.31	0.05	0.05	0.41
Sumner County	Suburb	Large	Middle	0.33	0.05	0.01	0.39
Sweetwater	Rural	Small	East	0.33	0.07	0.01	0.41
Tipton County	Rural	Large	West	0.26	0.05	0.00	0.31
Trenton	Town	Small	West	0.41	0.13	0.00	0.54
Trousdale County	Rural	Small	Middle	0.40	0.14	0.00	0.53
Tullahoma	Town	Medium	Middle	0.38	0.13	0.00	0.51
Unicoi County	Town	Small	East	0.31	0.09	0.00	0.40
Union City	Town	Small	West	0.39	0.10	0.00	0.49
Union County	Rural	Medium	East	0.41	0.13	0.00	0.53
Van Buren County	Rural	Small	Middle	0.37	0.10	0.00	0.47
Warren County	Rural	Large	Middle	0.42	0.10	0.01	0.53
Washington County	Rural	Large	East	0.38	0.03	0.00	0.41
Wayne County	Rural	Small	Middle	0.43	0.12	0.00	0.54
Weakley County	Rural	Medium	West	0.37	0.14	0.00	0.51
West Carroll	Rural	Small	West	0.30	0.10	0.01	0.41
White County	Town	Medium	Middle	0.33	0.11	0.00	0.44
Williamson County	Rural	Large	Middle	0.32	0.04	0.00	0.36
Wilson County	Rural	Large	Middle	0.27	0.05	0.00	0.32

a. Small is fewer than 3,500 students, medium is 3500–5,000 students, and large is more than 5,000 students.

Note: In the baseline case, Alamo, for example, devoted 1.88 percent of total expenditures to energy. With a 16 percent increase in energy prices across the board, energy prices would rise 0.30 percentage points, which means that expenditures devoted to energy would rise from 1.88 percent to 2.18 percent of total expenditures.

Source: Authors' calculations based on data from Tennessee Department of Education, Annual Statistical Report.

Table E2 shows the standard deviation of the increase in energy expenditures as a percentage of total expenditures from table E1 for districts grouped by characteristics.

TABLE E2

Standard deviation of the percentage point increases in the percent of total expenditures devoted to energy as a result of a 16 percent real increase in energy prices, by district characteristics

District characteristic	Electricity	Natural gas	Oil based products	Total
Region				
East	0.06	0.04	0.01	0.07
Middle	0.07	0.04	0.01	0.08
West	0.07	0.05	0.00	0.10
Size				
Large	0.06	0.04	0.01	0.08
Medium	0.08	0.03	0.00	0.09
Small	0.08	0.05	0.01	0.10
Locale				
Urban	0.07	0.05	0.01	0.10
Suburban	0.05	0.04	0.01	0.07
Town	0.07	0.03	0.00	0.08
Rural	0.08	0.05	0.01	0.10

Source: Authors' calculations based on data from Tennessee Department of Education, *Annual Statistical Report.*

NOTES

1. See appendix A for prices of each type of energy in each year over 2002–08 and for the percentage increase in these prices.

2. The price of a gallon of gasoline varies by grade as well as within each state. The U.S. Department of Energy reports retail gasoline prices by region, with Tennessee designated as part of the Midwest region.

3. Recall that there are no transportation energy data for 30 school districts, so the numbers on energy expenditure are understated. To see whether these missing data had a material effect on the results, the percentage of the budget spent on energy was calculated separately for the 106 districts for which full data were available. These results, shown in appendix B, follow a pattern similar to the data in table 1 that include all 136 districts, suggesting that these missing data did not materially influence the results.

4. The growth rate for the period was calculated by determining the constant rate at which expenditures would have to increase starting with the 2002/03 level to reach the 2007/08 expenditure level. Thus, $246 = \$164 \times (1.059)^5$, where .059 (5.9 percent) is the growth rate.

5. As noted, the data on energy expenditures for transportation are incomplete. In the 106 districts for which complete data are available, energy expenditures represent 33 percent of the O&M budget and 12 percent of the transportation budget.

6. For example, the energy efficiency of school buildings likely varies from district to district based on the age, design, and size of the building. Neither the EESI Council nor this study's authors had access to such detailed information about buildings because the state of Tennessee does not collect such data.

7. A correlation is a statistical measure of the tendency of two measures to vary together. Correlations range in value from –1 to +1 depending on whether the measures move together (greater than zero) or move in opposite directions (less than zero). The magnitude of the correlation coefficient is an indicator of the strength of the correlation. A coefficient of .12 indicates that the two measures are not capturing the same basic phenomena.

8. Expenditures equal price times quantity or

    $$E_E = P_E {}^\star Q_E \text{ and}$$
    $$E_T = P_T {}^\star Q_T$$

    where E is expenditure, P is price, and Q is quantity, and the subscripts represent energy and total. The simulations assume that Q_E and P_T remain the same, P_E increases to reflect energy inflation, and the other components of Q_T are adjusted downward to accommodate the increase in energy costs.

9. Had more detailed data been available on district characteristics such as the number, size, and age of buildings, the analysis might have found statistically significant differences by district characteristics, thereby justifying the setting of funding policy based on district characteristics.

10. The EESI Council recognized this limitation for its own deliberations and was seeking either a source of such data or a commitment from the state to collect these data in the future.

11. This procedure is found under the tools/data analysis menu in Excel. The formula for the t-statistic is below, with $\overline{X}$ and $\overline{Y}$ representing the sample means, S_x and S_y the corresponding sample standard deviations, and n_1 and n_2 the respective sample sizes.

    $$T = \frac{\overline{X} - \overline{Y}}{\sqrt{\dfrac{S_X^2}{n_1} + \dfrac{S_Y^2}{n_2}}}$$

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