Energy Accounting: A Policy Maker's Guide

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ABSTRACT

This paper will discuss an array of energy accounting methods. Energy accounting is defined in this paper as a method to compare different fuel types. For example, how should electricity be compared to natural gas? Should such a comparison take place along economic or environmental lines? In this context, various energy accounting methods are compared and contrasted against one another. In addition, three commonly utilized energy accounting methods are discussed: site energy, source energy, and green power. The implications of a CO2-based energy accounting method is also presented within the context of energy consumption patterns for commercial buildings, published by the Energy Information Administration.

It is concluded that choosing the most applicable energy accounting method as part of an energy code or incentive program requires policy makers to answer just two key questions. Site energy is shown to be a less meaningful choice for an energy accounting method in light of the many options available.

Introduction

Policy makers responsible for the development of energy efficiency codes and incentive programs must choose an energy accounting method as part of the code or incentive program. In this paper, an energy accounting method is a stated method to compare different fuel types on the basis of price or environmental impacts. The process of establishing an energy accounting method is not, however, always simple. To better understand the difficulties, consider three examples.

In 1999, three new energy efficiency initiatives for commercial buildings were released nationally in the United States. The American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) released a 1999 version of its energy guideline known as ASHRAE 90.1-1999. ENERGY STAR® released a rating system for commercial building energy performance and the U.S. Green Building Council released a version of its LEED rating system.

Each initiative employs a unique energy accounting method. ASHRAE effectively adopted an accounting method commonly known as "site energy" (ASHRAE Journal 1999).[1] As an energy accounting method, site energy essentially assigns a relative value of 1.0 for each Btu of electricity, natural gas, heating oil and other fuel types. Thus, site energy does not differentiate fuel types on the basis of price or environmental impact. ENERGY STAR adopted an energy accounting method known as "source energy" (US Environmental Protection Agency 1999). Source energy, as practiced by ENERGY STAR, assigns a relative

[1] The prescriptive option of 90.1-1999 does not, for example, recommend levels of wall insulation as a function of heating fuel type. For this reason, the prescriptive option of 90.1-1999 treats all fuel types as equal, thus effectively adopts a site energy accounting method.

value of 3.0 for electricity and roughly 1.0 for other fuel types. The relative factor of 3.0 for electricity takes into account that electric generation is about 33 percent efficient on a U.S. national average. The U.S. Green Building Council adopted two energy accounting methods (U.S. Green Building Council 2000). The first method compares fuel types on a price basis, used to award points for energy efficient design. In California for example, the LEED system would assign a relative value of about 3.4 for each Btu of electricity and a relative value of 1.0 for each Btu of natural gas.[2] This is due to the fact that in California, the average price of electricity is 3.4 time higher than the average price of natural gas. The U.S. Green Building Council employs a second energy accounting method known as "green power" used to reward points for the purchase of electricity derived free of fossil fuel or nuclear power.

All three initiatives unfortunately share inconsistency on the issue of choosing an energy accounting method. ASHRAE originally proposed to differentiate fuel types within its recommended insulation levels, and ultimately switched to site energy in the final release (ASHRAE Journal 1999). While ENERGY STAR utilizes source energy for its commercial building initiative, site energy is utilized for its residential building initiative.[3] The U.S. Green Building Council too switched energy accounting methods from source energy to its current price basis accounting method. Green power has been consistent as part of the LEED rating system. These examples show how difficult choosing energy accounting methods has proven in the past. Also, without documenting the economic or environmental purpose of an energy accounting method (a possibility with site energy and source energy), future policy makers are left in the dark about future decisions. This paper hopes to assist present and future policy makers facing such decisions.

A Few Energy Accounting Methods

The first questions for policy makers in choosing an energy accounting method is whether the goal is to reduce energy costs or reduce environmental damage as caused by energy consumption. A second question is whether energy prices and environmental impacts should be assessed at the national level, regional level, or supplier level. Green power for example assesses environmental impacts at the supplier level. Specifically, green power assesses the fuel mix used by an electric supplier in generating electric power for the grid. The two questions above form a convenient framework for policy makers faced with establishing an energy accounting method.

> *Question #1:* Will the basis of the energy accounting method be a price comparison, an environmental comparison, or a weighted average of both?

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[2] Energy efficient design is determined by comparison to ASHRAE 90.1-1999 using the Energy Cost Budget Method option. The Energy Cost Budget Method utilizes computer simulations to compare the design of a building against that of a reference building on the basis of simulated annual energy costs. Thus, in its adoption of the performance option of 90.1-1999, LEED utilizes an energy accounting method that reflects the price differences between various fuel types.

[3] The rating system for ENERGY STAR Homes is based on the Model Energy Code. The Model Energy Code does not recommend varying component energy efficiency levels or varying insulation levels as a function of fuel type. Thus, the Model Energy Code, and ENERGY STAR Homes, have adopted a site energy accounting method.

Question #2: Will the basis of the energy accounting method compare fuel types at the national level, regional level, or supplier level.

Unique answers to each question may be combined to essentially form unique energy accounting methods. It is the task of policy makers to unlock the most applicable energy accounting method by answering the two questions. In the hopes of reflecting the interests of most readers, a few such energy accounting methods have been identified and are discussed below.

National Price Accounting Method

Consider a policy maker who chooses to compare fuel types on a price basis: Question #1. Also consider this same policy maker chooses to compare energy prices at the U.S. national level: Question #2. The resulting energy accounting method could be described as a National Price Accounting Method. Information available from the Energy Information Administration shows in this case, the relative price of electricity is 3.7 times greater than natural gas (Energy Information Administration 1998).[4] If this accounting method were used to compare the energy use of residential homes or commercial buildings, this method would allow natural gas consumption 3.7 times higher compared to electricity. Compared to heating oil, electricity is found to be 4.6 times more expensive at the U.S. national level.

National CO2 Accounting Method

Let us now consider a policy maker who instead wants to compare fuel types based on national CO2 emission rates. In this case, the CO2 emissions of electricity are found to be 3.5 times higher than natural gas. Compared to heating oil, the CO2 emissions of electricity are 2.6 times higher (US DOE 1994). If this energy accounting method were applied to a national code or incentive program, each fuel type would be treated differently in terms of allowable consumption levels, only on the basis of CO2.

National Mixed Price and CO2 Accounting Method

In this case, a policy maker might want to compare fuel types on both a price basis and CO2 basis simultaneously. Political forces or a genuine interest to balance both economic policy and environmental policy might explain this desire. If the relative price and relative CO2 emissions for each fuel type are averaged together, it is found that electricity would have 3.6 times greater impact compared to natural gas, and by coincidence also 3.6 times greater impact than heating oil. It just so happens for example that the relative price of electricity are 2.6 times higher than heating oil, and the relative CO2 emissions of electricity are 4.6 times higher than heating oil at the national level. Thus, the mixed average of prices and CO2 emissions for electricity are 3.6 times [(2.6 + 4.6)/2] higher than heating oil.

It is interesting to note that the National Price Accounting Method, National CO2 Accounting Method, and National Mixed Price and CO2 Accounting method are similar. For example, electricity is 3.7 times more expensive than natural gas, emits 3.5 times more CO2,

[4] Unless otherwise noted comparisons of electricity, natural gas, and heating oil are based on data available from the U.S. Energy Information Administration, as seen in the References.

and has a mixed impact that is 3.6 times higher. From the perspective of a policy maker, these findings show that at the national level good economic policy makes for good environmental policy and vice versa. This is true at least for electricity, natural gas, and heating oil.

State Price Accounting Method

Some policy makers might desire to account for energy prices at the state level. The U.S. Green Building Council uses this accounting method as mentioned earlier. While we saw electricity is 3.7 times more expensive than natural gas at the national level, the range at the state level is as low as 2.2 (Kentucky) to a high of 11.2 (Alaska). Thus in Kentucky, electricity and natural gas are more equally priced, while in Alaska electricity is 11.2 times more expensive than natural gas.

For residential or commercial building energy codes, a State Price Accounting Method may have applicability since homes and buildings are usually constructed regionally. Under this scenario, allowable energy consumption levels or stringency levels for component efficiency would be a function of the price for each fuel type in question. In contrast, a national incentive program to encourage the purchase of energy efficient refrigerators might want to use a National Price Accounting Method since refrigerators are manufactured centrally, and distributed nationally. The lesson here is there can never be one perfect energy accounting method that works best for all codes or incentives programs.

State CO2 Accounting Method

Here, a policy maker might want to compare fuel types based on CO2 emissions at the state level. Because electric power is derived from different fuel mixes within each state or region, the comparisons of electricity, natural gas, and heating oil vary widely. Policy makers are warned for example that CO2 emissions of electricity range from a high of 7.4 times that of natural gas (Indiana) to a low of 0.20 times (Vermont). Unlike the national level, at the state level it is not necessarily the case that good economic policy makes for good environmental policy and vice versa. Policy makers who choose to adopt a State CO2 Accounting Method must be sure they are willing to make the trade-offs between economics and environmentalism.

Supplier CO2 Accounting Method

This energy accounting method differentiates between fuel types on a CO2 basis at the supplier level. For heating oil and natural gas, the CO2 emissions are fairly constant from one supplier to another. For electricity however, the CO2 emissions vary greatly from one supplier to another by at least that found for the State CO2 Accounting Method. Thus even more so than the State CO2 Accounting Method, this accounting method will not necessarily make for good economic policy.

Green power is a special case of the Supplier CO2 Accounting Method. Rather than simply differentiate on a CO2 basis, green power requires CO2 emissions to be zero by virtue of the fact no fossil fuels may be involved in the production of electricity. The lesson here is that one energy accounting method may be special case of another.

Other Energy Accounting Methods

As mentioned, these energy accounting methods are just a few examples. Although not discussed, policy makers may desire to fold heath-related issues, such as asthma-related costs into the definition of economic impacts. Other policy makers may choose to define environmental comparisons based on fish stock degradation caused by hydropower damming. Where the discussion above revolved around average energy prices, policy makers may want to compare marginal energy prices due to time of use rates and demand charges. The point being that nearly any energy accounting method is possible depending on how the two questions are answered. As seen in the discussions, once the two questions are answered it is possible to quantify the resulting energy accounting method. This paper quantifies relative comparisons (e.g., electricity is 4.6 times more expensive than heating oil at the U.S. national average) because it will lend itself well to further discussion below. Generally speaking however, policy makers will want to quantify absolute values (e.g., 1 kWh of electricity emits 1.6 lbs. CO2) such that these values may be inserted into any necessary engineering process as part of the code or incentive program development process.

Site Energy, Source Energy, and Green Power

With an understanding of the energy accounting methods above, it is possible to discuss the three energy accounting methods employed by ASHRAE, ENERGY STAR, and the U.S. Green Building Council: site energy, source energy, and green power.

Site Energy

Site energy essentially assigns a relative value of 1.0 for all fuel types. In contrast however, we have seen that different fuel types vary as much as 4.6 to one on a price basis, and 3.5 to one on a CO2 basis, at the national level. Therefor site energy potentially underestimates relative prices and CO2 emissions of different fuel types by as much as 4.6 to one, or 460 percent. By considering all fuel types equal, site energy lacks a stated economic or environmental purpose. For these reasons, site energy is concluded to be a less meaningful energy accounting method. The use of site energy as accounting method results in energy codes and incentive programs that neither promotes the economic interests nor the environmental interests of end users.

Source Energy

Source energy assigns a relative value of 3.0 for electricity, and roughly 1.0 for other fuel types. In addition to ENERGY STAR criteria for commercial buildings, California's Title 24 is the only known initiative that utilizes source energy as an energy accounting method. Although the relative value of 3.0 for electricity compares well to the National Mixed Price and CO2 Accounting Method discussed earlier, source energy too lacks a stated economic or environmental purpose. This is due to the fact that a source energy accounting method is derived from engineering units (Btus) at the power plant rather than economic units (Dollars), or environmental units (CO2).

In practice, ENERGY STAR chose a source energy accounting method because it mimics very well the National Mixed Price and CO2 Method. Having participated in the decision making process, in hindsight the National Mixed Price and CO2 Accounting Method would have been a wiser choice for ENERGY STAR. The advantage over source energy would include a logical process of updating the accounting method by simply referencing changes in national energy prices and CO2 emissions over time. Another advantage is the discipline imposed by documenting on record the economic and environmental intentions for future policy makers.

If the original goal of the accounting method were economic, the added promotion of green power for example would work against the original goal since green power has a higher retail price compared to conventional electric generation. If the original goal of the accounting method were environmental, the added promotion of green power would match the original goal. Without knowledge of the original intention, future policy makers are forced to guess those intentions. By imposing the discipline of answering the two key questions, policy makers effectively go on record with their intentions thus avoiding future confusion.

Green Power

Green power has already been discussed as a special case of Supplier CO2 Accounting Method. How the U.S. Green Building Council utilizes green power exemplifies the potential power of answering the two key questions as a means of establishing an energy accounting method. For discussion's sake, it is assumed the LEED rating system is primarily designed to reduce CO2 emissions within the context of energy. Because the use of green power has been adopted as part of the LEED rating system, it is also assumed that supplier level CO2 emissions are of interest, in contrast to the national level or state level. Thus, if the designers of the LEED rating system were to answer the two questions presented earlier, it is assumed a Supplier CO2 Accounting Method might be an applicable choice of energy accounting method.

In this hypothetical example, the LEED rating system could utilize one energy accounting method rather than the current two. Generally speaking the adoption of one energy accounting method rather than two affords the advantage of simplicity. In this scenario, a LEED qualified building would document lower CO2 emissions compared to a prototypical building. Compliance in this case could be a function of the efficient use of energy and/or the purchase of low CO2 emitting power. In this case, the purchase of power derived from advanced combined cycle natural gas power plants would be rewarded[5]. Under the current LEED system, such a purchase is not rewarded since green power only recognizes electric production with zero CO2 emissions.

The point raised in this hypothetical example is not to imply needed change on the part of the U.S. Green Building Council, but to instead show how answering the two key questions and adopting the resulting energy accounting method may potentially alter and simplify the scope of any one initiative. When these two questions are not answered, we have seen through the examples of ENERGY STAR and the U.S. Green Building Council how

[5] Advanced combined cycle natural gas power plants use a hybrid of technologies that increase the efficiency of electric power generation, thus reducing CO2 emissions compared to more traditional power plants. The added use of natural gas compared to coal also results in lower CO2 emissions.

potential confusion may be introduced. Although any energy accounting method will fall under scrutiny, clearly documenting the economic or environmental goal at either the national, state, or supplier level avoids misinterpretation. This paper therefore recommends policy makers answer the two key questions as a means of adopting the most applicable energy accounting method as part of any energy code or incentive program.

Investigation of a National CO2 Accounting Method for Commercial Buildings

Referring to data available from the Energy Information Administration, it is possible to explore the ramifications of a National CO2 Accounting Method as applied to U.S. commercial buildings. The question posed is whether or not a CO2 accounting method would favor or disfavor any one fuel type. Because the National CO2 Accounting Method would allow 3.5 times more natural gas consumption than electricity based on the inherent CO2 emissions of both, one might think all-electric buildings would be disfavored over those which utilize natural gas for primary heating and hot water. This initial belief was found to be untrue.

Every three years, the Energy Information Administration surveys approximately 6,000 commercial buildings as part of the Commercial Building Energy Consumption and Expenditures Survey (CBECS). For office buildings alone and for all 12 building types included in the CBECS survey, the annual CO2 emissions per floor were calculated. Since electricity and natural gas are the two prominent fuel types in commercial buildings, CO2 emissions were calculated for all-electric buildings and for buildings denoted as using natural gas for primary heating and hot water.

Figure 1 shows that CO2 emissions per floor area are essentially the same for all-electric buildings and those using natural gas for heating and hot water. This holds true for office buildings as well as all buildings reported in CBECS. It should be noted these values represent averages across the entire U.S. For commercial buildings, these findings indicate that a National CO2 Accounting Method would not favor or disfavor electric or natural gas. This observation is believed to be explained by the fact electricity and natural gas already have price signals that have been shown to mirror the CO2 emissions. In other words, all-electric buildings appear to be operated more efficiently as a means of controlling energy costs. As a result these all-electric building buildings emit similar amounts of CO2 compared to their natural gas counterparts.

	Source of Primary Heating and Hot Water			
	All Buildings		Office Buildings	
	Electric	Natural Gas	Electric	Natural Gas
Fuel Types Consumed	lb CO2/sf-yr	lb CO2/sf-yr	lb CO2/sf-yr	lb CO2/sf-yr
Electric	23.9	22.6	28.2	28.2
Gas	0.4	6.6	0.2	3.9
Fuel Oil	0.1	0.2	0.1	0.1
District Steam	0.3	0.1	0.3	0.1
Total	**24.6**	**29.4**	**28.8**	**32.3**

Figure 1. Annual CO2 Emissions Per Floor Area, Broken by Primary Heating and Hot Water Fuel Type, For U.S. Office Buildings and All U.S. Commercial Buildings

The ramifications of a National CO2 Account Method were also investigated using the first ninety office buildings that qualified as ENERGY STAR. Of these ninety, 30 percent were all-electric compared to the national average of 32 percent (Hicks 2000). Because source energy closely mimics a National CO2 Account Method, these findings show that all-electric office buildings are just a likely to qualify as ENERGY STAR under a National CO2 Accounting Method.

For policy makers, it has been shown that at least for commercial buildings the application of an energy accounting method sensitive to fuel type does not necessarily favor or disfavor any one fuel type. Earlier it was discussed that both site energy and source energy lack any stated economic or environmental goal. It is also the case that site energy and source energy have political connotations associated with each. Specifically, pro-electric advocates favor site energy while pro-natural gas advocates favor source energy. Such political connotations may not only be unproductive, but fail to address the key questions. Rather than discuss the pros and cons of one fuel type as is sometimes the case with site energy and source energy, policy makers are encouraged to define economic or environmental goals at the national, state, or supplier level. If the advice of this paper is taken in full, site energy and source energy should never enter the decision making process. Instead, policy makers are encouraged to answer the two questions, arrive at the desired energy accounting method, and investigate the ramifications. In this way, a resulting energy accounting method may be documented for future policy makers, and the ramifications objectively understood.

Conclusion

Policy makers face a range of options when choosing an energy accounting method. Based on the experiences of ASHRAE, ENERGY STAR, and the U.S. Green Building Council, the choice of energy accounting methods may be difficult. For this reason, it is helpful for policy makers to answer two key questions to first assess the intentions of a code or incentive program.

Once these two questions are answered, a resulting energy accounting method may be quantified for various fuel types and the ramifications investigated. Although there can never be a perfect energy accounting method, failure to answer the two key questions may lead to confusion or misinterpretation by future policy makers.

Policy makers are encouraged to avoid the adoption of site energy and source energy as energy accounting methods since neither has a stated environmental or economic goal. While source energy is more meaningful than site energy, source energy was found to have an even more meaningful alternative identified as National Mixed Price and CO2 Accounting Method.

References

[ASHRAE] American Society of Heating, Refrigeration and Air Conditioning Engineers, Inc. 1999. "Industry News: 90.1 Draft Near Final Approval." *ASHRAE Journal* March: www.ashrae.org.

Energy Information Administration. 1999. *Natural Gas Annual 1998*: Tables 23-28.

Energy Information Administration. 1999. *Annual Electric Power 1998: Volume II*, Table 7.

Energy Information Administration. 1997. *State Energy Profiles 1996*: Table A1.

Energy Information Administration. 1999. *Petroleum Marketing Annual 1998:* Table 39.

Energy Information Administration. 1995. *Commercial Buildings Energy Consumption and Expenditures 1992*: Micro-data files .

Hicks, T. (U.S. Environmental Protection Agency). 2000. Personal communication. May 2000.

U.S. Department of Energy. 1994. *Emissions of Greenhouse Gases in the United States 1987-1992*. DOE/EIA-0573. October, page 79.

U.S. Environmental Protection Agency. 1999. ENERGY STAR Label for Buildings: Technical Description, March 1999. www.epa.gov/buildings.

U.S. Green Building Council. 2000. LEED Green Building Rating System, Version 2.0. March 2000.