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Making Buildings Part of the Climate Solution by Overcoming Information Gaps through Benchmarking

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ABSTRACT

This paper focuses on the impact of benchmarking the energy performance of U.S. commercial buildings by requiring utilities to submit energy data to a uniform database accessible to building owners and tenants. Understanding how a commercial building uses energy has many benefits; in particular, it helps building owners and tenants focus on poor-performing buildings and subsystems, and enables high-performing buildings to participate in various certification programs that can lead to higher occupancy rates, rents, and property values. Through analysis chiefly utilizing the Georgia Tech version of the National Energy Modeling System (GT-NEMS), updating input discount rates and the impact of benchmarking shows a reduction in energy consumption of 5.6% in 2035 relative to the Reference case projection of the *Annual Energy Outlook 2011*. It is estimated that the benefits of a national benchmarking policy would outweigh the costs, both to the private sector and society broadly. However, its geographical impact would vary substantially, with the South Atlantic and New England regions benefiting the most. By reducing the discount rates used to evaluate energy-efficiency investments, benchmarking would increase the purchase of energy-efficient equipment thereby reducing energy bills, CO_2 emissions, and conventional air pollution.

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1. Introduction

Understanding how a commercial building is using energy has many benefits; in particular, it helps building owners and tenants focus on poor-performing buildings and subsystems, and it enables high-performing buildings to participate in various certification programs that can lead to higher occupancy rates, rents, and property values. However, in many cases, the recipient of energy information does not have the incentive or the ability to improve energy performance, such as the relationship between tenants and building owners.

Partly because building performance information is largely unavailable, building owners and occupants have forgone cost-effective investments in energy efficiency that could significantly reduce energy consumption and utility bills. That is, a large gap exists between the most cost-effective use of energy in commercial buildings and the consumption of energy in practice (Granade et al., 2009; Hirst and Brown, 1990). Assessing the energy consumption of a building is the first step in establishing "baseline" energy use and benchmarking efforts. After all, "You can't manage what you don't measure."

The commercial building sector suffers from two main information problems. First, there is a large principal-agent problem in the sector, which occurs when one party (the agent) makes decisions in a given market, and a different party (the principal) bears the consequences of those decisions. Such market failures were found by Prindle (2007) to be significant and widespread in many end-use markets in both the U.S. and other International Energy Agency (IEA) member countries. In many commercial buildings, architects, engineers, and builders select equipment, duct systems, windows, and lighting for future building occupants who will be responsible for paying the energy bills. Once occupied, landlords maintain appliances and equipment for tenants who then pay the energy bill. Second, a decades-long research effort has identified discount rates related to equipment purchases that are far higher than anticipated, resulting in fewer purchases of high-efficiency equipment (Frederick, Loewenstein, and O'Donoghue, 2002; Train, 1985).

This policy option focuses on giving building owners in the country access to baseline information on their building's energy consumption. This could be accomplished by requiring utilities to submit energy data in a standard format to a widely used database, such as Portfolio Manager, which currently maintains information on hundreds of thousands of buildings in the U.S., submitted by building owners and managers. Using existing software packages, combining the meter data from utilities with that from the building owner could provide a "virtual building meter," allowing for building-wide analysis.[1] The data would then be available to the building owner and the utility and maintained by the Environmental Protection Agency (EPA).

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[1] Certain utilities, like Consolidated Edison and Austin Energy, have developed meter aggregating tools to collect whole-building energy consumption data.

According to a report sponsored by the U.S. Green Building Council, Real Estate Roundtable, Natural Resources Defense Council, and others (Carbonell, Fidler, and Douglas, 2010), the EPA may have the authority to require utilities to submit building energy data under Section 114 of the Clean Air Act. This utility data must be connected to individual buildings to be useful in providing building owners with baseline energy performance information. A uniform national building identification system, similar to the VIN system for cars, could facilitate this connection regardless of where a building is located, how it is used, or whether it has multiple street addresses – all currently issues in energy benchmarking.

In this paper, we discuss an approach to benchmarking that involves two features:

- Require utilities to submit whole building aggregated energy consumption data for all tenants in electronic form to EPA Portfolio Manager
- Develop a national registry of commercial buildings, with each building receiving a unique Building Identification (BID) number, analogous to the VIN number for automobiles

If implemented, better building energy data would become available to owners, tenants, and utilities. In turn, benchmarking efforts could be accelerated; demand-side management programs could become more feasible; municipal governments would have a uniform system for building codes and mandated disclosure reporting; and the federal government would gain valuable data to inform the ENERGY STAR® building certification standards and the Commercial Building Energy Consumption Survey. The real estate sector would be able to provide better information to clients as well, and energy performance could be better incorporated into property assessments.

This policy option would address some of the information barriers that currently hinder energy efficiency in commercial buildings. Many building owners lack a fundamental understanding of the quantity and places where energy is actually being consumed. Benchmarking also prepares building owners and utilities for implementation of smart grid and demand response programs. There is also a noted lack of information about the location of buildings, another issue that this policy option would address. In addition, better energy management would result from giving benchmarking data to building owners. Lastly, this policy would lay the groundwork for future information, financial and regulatory policy options, such as mandated disclosure and on-bill financing.

2. Background

2.1 Policy Experience

Benchmarking creates an energy consumption baseline in a specific building. If benchmarking is completed for a large set of buildings and stored in a shared database, a comparison of one building with the data of similar buildings is possible. Benchmarking also helps to set priorities for limited staff time and investment capital. EPA and the American Council for an Energy-Efficient Economy (ACEEE) both suggest that savings up to 10% can be made at little or no cost to building owners, but these savings frequently go overlooked (Dunn, 2011; Nadel, 2011).

The U.S. and Canada recently announced that they would collaborate on a common platform for benchmarking commercial building energy consumption (EPA, 2011). The federal government also benchmarks its buildings as a result of Section 432 of the Energy Independence and Security Act of 2007. However, policy experience with benchmarking in the U.S. is largely tied to mandated disclosure policies at the state and local level (Figure 1). Most of these policies emphasize the residential sector or are under consideration, but six cities and two states (California and Washington) have adopted mandated disclosure, which necessitates benchmarking as a prerequisite. Benchmarking requires an expenditure of time and effort, but in many cases the bulk of the effort is in gathering energy data, which this policy option could address. In fact, every one of the existing programs, including the international effort between the U.S. and Canada, uses Portfolio Manager as the benchmarking tool.

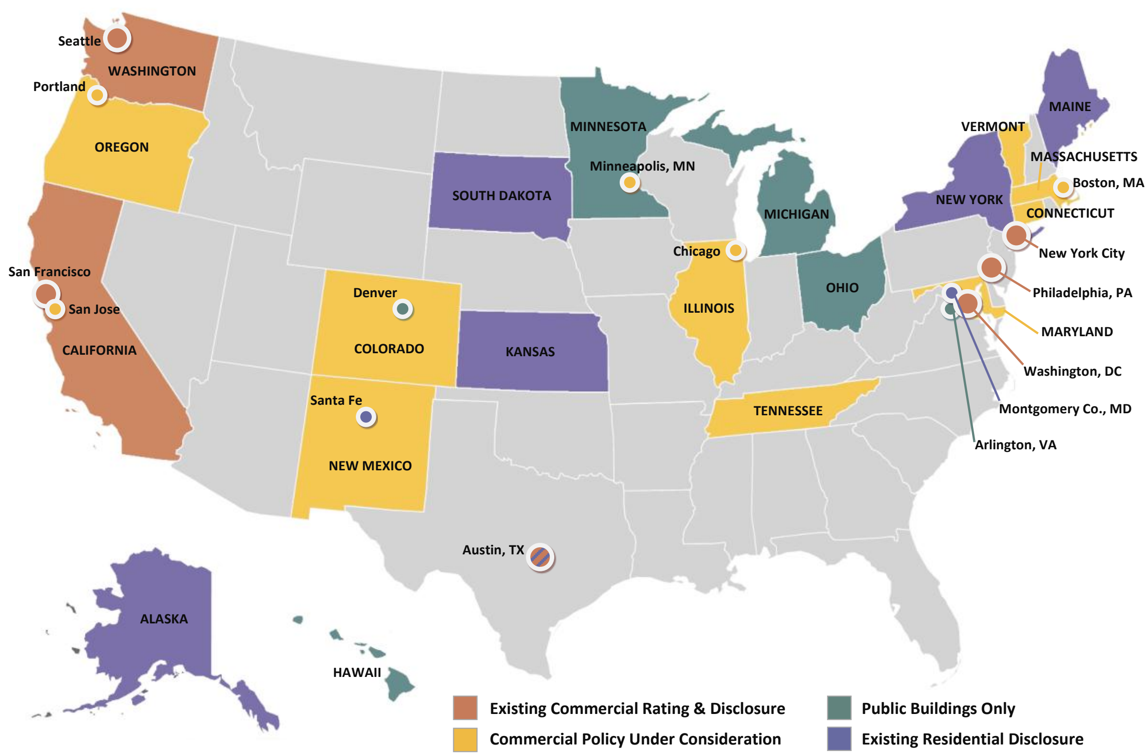


Figure 1. Mandated Disclosure and Benchmarking Efforts in the United States
Source: www.IMT.org

As of 2012, Portfolio Manager includes data on the current and past performance of more than 300,000 buildings in the U.S., submitted by building owners or managers. Many building types can be analyzed, including: banks/financial institutions; courthouses; data centers; dormitories; hospitals; hotels; houses of worship; K-12 schools; medical offices; office buildings; senior care; retail stores; supermarkets; warehouses; and wastewater treatment plants. For these building types, Portfolio Manager can provide a normalized, statistically significant score out of 100, qualify those buildings for ENERGY STAR certification, and help achieve Leadership in Energy and Environmental Design (LEED) certification. Other building types can be tracked by Portfolio Manager, but they cannot be scored out of 100 or qualified for an ENERGY STAR or LEED rating.

The Institute for Market Transformation (IMT) summarized the recent experiences of nine current U.S. programs (Burr, Keicher, and Leipziger, 2011). As a result of program reviews and in-depth stakeholder discussions, a series of best practices were recommended for outreach and education, benchmarking, compliance, data quality, energy consumption data, and disclosure. For benchmarking, the main recommendation is to follow EPA guidelines surrounding the use of Portfolio Manager. This recommendation largely enables jurisdictions to avoid debates over building use and building type classifications, but there are other benefits as well, including easy integration of building data into the Portfolio Manager format. IMT also suggests that:

- Compliance should be established from existing tax records
- Data quality should be linked to a responsible party at the property via a signature
- Utilities should receive support for any new incurred costs of compliance
- The development of leases that include data access language should be encouraged.

2.2 Results from Implementing Governments[2]

While Europe has used mandated disclosure and benchmarking programs for many years, the U.S. is just beginning to implement these programs. Currently, the governments of New York City, Seattle, Washington, D.C., and Austin, Texas are taking leadership roles, with San Francisco and Chicago following close behind. Key program managers from each of the leading cities responded to questions during short telephone interviews. Even though individual contexts vary, there are a number of consistent findings across these programs that can be informative for policymakers.

First, Portfolio Manager has found broad acceptance as the principal benchmarking tool. The time-series and cross-sectional comparison capabilities of the tool make it extremely attractive. The upcoming Portfolio Manager update and the Department of Energy (DOE) Building Technology Program Commercial Building Asset Rating tool are highly anticipated. The Sustainable Energy Efficiency Data Platform that DOE provides has also been well received because it helps the local governments share best practices and avoid replication. However, the multi-agency approach has led to confusion about federal roles, and some cities have suggested that clarifying leadership positions would be helpful.

Second, all of the program managers believe a large information gap related to building energy consumption existed in their jurisdictions prior to the benchmarking and mandated disclosure

[2] Program managers from New York City, Seattle, Austin, Washington, D.C., and DOE's Building Technology Program were interviewed.

laws. While benchmarking efforts have assisted in reducing this gap by informing building owners about total building performance, this effort has not eliminated the gap altogether; a number of stories detailed building owners who failed to understand the meaning of their building score.

Third, tenant authorization is required for building owners to access energy consumption data in many jurisdictions. Working through the legal privacy issues is time consuming, and requires collaboration with utilities, local governments, the real estate market, and occasionally state governments. Rules and support for utilities to facilitate easy access and release of aggregated building data are particularly important as a legal issue. One manager stated that this is missing in his jurisdiction, and if he were starting over, aggregated building data would be the first thing they would emphasize.

Fourth, every program experienced delays in implementation, largely due to aggressive rollout schedules and budgeting issues related to the economic downturn in 2008. Frequently, these ordinances and laws had to be amended after the program began in earnest. Lastly, a commonly noted issue was the lack of a qualified workforce. A government certification program that indicated the quality of various contractors who could improve a building's energy performance was strongly requested. Benchmarking and mandated disclosure efforts have the potential to create and expand markets for energy contractors, and some means to differentiate between the contractors would reduce other information barriers for building owners.

Box 1: Main Conclusions from Program Managers

Core Lessons From Program Managers	Key Areas for Assistance
• Portfolio Manager and the SEED database are great tools • Programs are reducing information gaps • Implementation is more difficult than anticipated • Building aggregation capacity is crucial	• Clarifying leadership roles at the federal level • Workforce certification programs • Defining confidential data • Funding or rules for utilities to aggregate building data and facilitate release and access

2.3 Policy Rationale

"Policy actions…could, in principle, correct for the excessive present-mindedness of ordinary people" – Solow, 1991

Benchmarking has the potential to reduce or eliminate information asymmetries in the marketplace and to reduce the discount rates used by consumers in the sector. A few scholars question the extent and evidence of such problems (Alcott and Greenstone, 2012; Gillingham, Newell, and Palmer, 2009; Jaffe and Stavins, 1994). However, this skepticism stems from the information assumptions of neoclassical economic theory. Policy tools based on such theory are unable to modify discount rates and provide no policy relevant advice for information-based gaps (Stern, 1986). In contrast, empirical research has found that information can modify discount rates in use; providing information may address a barrier to the deployment of energy-efficient technologies that mainstream economic tools cannot.

Theoretically, discount rates are determined by combining the market interest rate and, potentially, some level of uncertainty or risk; such a discount rate should be the same for all goods across time. Hausman (1979), in his study of air conditioner purchases, described the potential for ‘internal arbitrage’, where a consumer “trades” first costs for energy savings and benefits as a result. Hausman claimed that rational actors would equate the potential stream of energy savings from more efficient technologies with the monetary savings from buying less-expensive equipment. His findings on observed discount rates, however, did not match the theory; consumers used discount rates that were much higher than the market. “Other factors such as uncertainty and the possibility of technological change do not seem sufficient to explain the high discount rate which we found.” (Hausman, 1979) Later research would find many instances where empirically observed discount rates deviated strongly from theory, finding that future gains receive higher discounting than future losses (Thaler, 1981), that smaller anticipated results (either positive or negative) receive higher discount rates than larger anticipated results (Benzion, Rapoport, and Yagil, 1989), and that consumers prefer improving sequences of outcomes (Frederick and Loewenstein, 2002; Varey and Kahneman, 1992). Furthermore, Sultan and Winer (1993) found no evidence of consumers using market-based discount rates across a number of appliances.

Research specific to equipment purchasing decisions found numerous discount rates in use across the population. These discount rates vary over time and appliances (Train, 1985; Koomey, 1990). Frederick et al. (2002), in a review of the theoretical and empirical history of discount rates, found:

> The implicit discount rate was 17-20% for air conditioners (Hausman, 1979); 102% for gas water heaters, 138% for freezers, 243% for electric water heaters (Ruderman, Levine, and McMahon, 1987); and from 45% to 300% for refrigerators, depending on assumptions made about the cost of electricity (Gately, 1980).

Disparate findings in discount rates across the population pose theoretical difficulties, but open the door for different policy approaches and rationales. A series of tools in regulatory, financial, and information areas may help to address discount rate issues: for example, standards can address high discount rates by eliminating low-efficiency choices, and subsidies and tax rebates can change the consumer discount rate calculation and result in better choices. However, information-based policies have the unique ability to modify the discount rate in use. Studies have found that providing information can reduce discount rates anywhere from 3% to 22% (Coller and Williams, 1999; Goett, 1983). Coller and Williams suggest that information about energy consumption will result in a 5% decline in discount rates for energy decisions made by the median population. Depending on the discount rate in use, an adjustment of this size could dramatically impact equipment decisions. Table 1 summarizes the findings of the literature by end use.

Table 1: Discount Rates by End Use

End Use	Avg Discount	Studies
Lighting	36%	Koomey 1990, Metcalf 1995
A/C	17%	Hausman 1979; Goett 1983; Kooreman 1995
Space Heating	17%	Lin, Hirst, and Cohn 1976; Goett 1978; Goett and McFadden 1982; Dubin 1982; Berkovec, Hausman, and Rust 1983; Goett 1983; Dubin and McFadden 1984
Refrigerators	63%	Gately 1980; McRae 1980; Cole and Fuller 1980; Meier and Whitier 1983; Metcalf 1995
Water Heating	40%	Goett and McFadden 1982; Dubin 1982; Berkovec, Hausman, and Rust 1983; Goett 1983
Cooking	31%	Lin, Hirst, and Cohn 1976; Goett 1983
Ventilation	--	N/A

The discount rates empirically observed and discussed above are quite high. Solow (1991), in his famous presentation at Woods Hole, suggested that the market provided discount rates of 5% or 6%, and those were higher than should be used by society to meet obligations to future generations. Pigou (1952) argued that government should be a trustee for the future, and as such, has a valid role in encouraging investment towards preservation. While benchmarking does not seem to have the ability on its own to reduce the social discount rates to a level envisioned by Solow, it shows the potential to move in that direction.

This policy option would improve the functioning of the marketplace by providing information on commercial building energy performance and would make it easier to track building performance by connecting performance over time to the building's BID number. Numerous studies (Christmas, 2011; Campbell, 2011; Miller, Spivey, and Florance, 2008; Jackson, 2009; Das, Tidwell, and Ziobrowski, 2011, and others) show higher occupancy rates, higher rents, and higher property values for high-efficiency buildings. Benchmarking could increase the market demand for these buildings. Portfolio Manager itself has the potential to address many information gaps through its use of time-series data and cross-sectional comparisons. This may lead to more efficient technology choices, reduced uncertainty in maintenance costs, and lower fuel costs and ease the attainment of building certifications like ENERGY STAR. The ties between Portfolio Manager and ENERGY STAR certification also reduce transaction costs for renters desiring high-performance space. This could reduce the size of the principal-agent problem by creating market and social pressure for building owners to consider energy in purchasing decisions, particularly when combined with mandated disclosure.

Benchmarking spurs energy-efficiency investments (NMR Group, Inc. and Optimal Energy, Inc., 2012), one of the fastest and most direct means of reducing greenhouse gas emissions that is also cost-effective (Ciochetti and McGowan, 2010). The emission of greenhouse gases is causing climate change, the "greatest and widest-ranging market failure ever seen," (Stern, 2007). To the extent that benchmarking limits the emission of greenhouse gases, it helps to correct this negative externality and mitigates the threat posed by climate change.

The Committee on Climate Change Science and Technology Integration compiled a list of barriers to the deployment of technologies with the ability to reduce greenhouse gas emissions (CCCSTI, 2009). As a policy option, benchmarking has the potential to address a number of these barriers: it provides better information about energy use and performance; it addresses general gaps in information, where neither building owners nor tenants are aware of building performance; it addresses information asymmetries, where either the owner or tenant is unaware of building performance, especially when coupled with mandated disclosure laws; and it reduces discount rates and the size of the principal-agent problem. This policy option has the potential to be a step towards better consumer choices without resorting to price signals or regulation. At the same time, its success depends on the cooperation of a diverse set of stakeholders.

2.4 Policy Evaluation

Appropriateness of the Federal Role

Many have argued that it is an appropriate role of government to address the high discount rates observed among consumers. Policy actions utilizing high discount rates may be viewed as consuming today at the expense of future generations. While there is no agreement on the appropriate government discount rate, the Office of Management and Budget suggests using 7% generally (OMB Circular A-4, 2003). Prominent economists, such as Solow and Weitzman have suggested values below a 6% average may be preferred; if consumers have a discount rate higher than 6%, then the government could correct through policies and procurement practices with lower discount rates to maintain a 6% average. Regardless of the exact percentage governments should use, it is clear that mainstream positions hold that government has a role in protecting the rights and opportunities of future generations, and part of this role involves managing the societal discount rate. Since information can affect the discount rate, overcoming barriers to information have the potential to reduce the discrepancy between the consumer and government rates.

The federal government has historically taken a lead in overcoming information barriers in the market for building energy efficiency by providing national data on building characteristics, energy use and standardized benchmark metrics through the Energy Information Administration (EIA), ENERGY STAR, and other programs. This policy could be an appropriate next step to improve the information available to building owners, lower transaction costs, and enable cost-effective energy-efficient upgrades on a wide scale. This policy would also allow for building performance to be tracked over time, with the understanding that all public data would be reported without identifiers. This feature would also ensure the integrity of different building labeling systems like ENERGY STAR and LEED.

Benchmarking also provides a way to reduce the greenhouse gas emissions driving climate change that traditional economic tools cannot. In this way, it is a complementary policy tool to economically efficient approaches like carbon pricing policies, guiding behavioral changes by energy managers and users. With the commercial sector representing 19% of U.S. CO_2 emissions (over 3% of global emissions), and that percentage expected to grow (DOE, 2012), managing the emissions of the sector is critical to “preventing dangerous interference with the climate system” (UNFCCC, 1992).

Broad Applicability

Private interests and state and local governments have typically pursued the energy benchmarking of commercial buildings. However, the federal government is also benchmarking its own sizeable building stock through the Federal Energy Management Program. Economy-wide participation may enable broad understanding of building performance by building owners and lead to improved sectoral performance. Benchmarking for all commercial buildings exists only in three states; national requirements would have broad applicability without being duplicative. At the same time, a federal program would need to be able to coexist with pre-established state and local benchmarking programs, and avoid preemption of more stringent state and local efforts.

Significant Potential Benefits

Benchmarking studies have shown the potential to reduce energy consumption through modifying discount rates by 3% to 22% (Coller and Williams, 1999; Goett, 1983). By decreasing discount rates, benchmarking is increasing the importance of the energy savings in consumer choices, improving the likelihood that consumers will purchase more efficient equipment, and use existing equipment more wisely. This in turn should allow consumers to capture a portion of the potential energy savings that are overlooked, estimated at up to 10% (Dunn, 2011; Nadel, 2011).

The first major analysis of mandated benchmarking in the United States was conducted by researchers at the University of Pennsylvania and New York University reported by New York City in August of 2012. While this assessment only covered the first year of reported data, it found that if low performing buildings could be brought up to the median energy use intensities for their class, the city would reduce energy consumption in large building by 18% and reduce greenhouse gases by 20% (PlaNYC, 2012).

Administrative Feasibility

The Portfolio Manager software framework already exists and an update is about to be released. More administrative resources would be needed to operate Portfolio Manager at the anticipated increased rate of use and to add the BID number to the database. Utilities may need to develop new forms or reformat existing templates to prepare data for entry into Portfolio Manager. These are not anticipated to be administratively difficult tasks.

Additionality

Benchmarking provides some benefits on its own, but it also enables other policies, like mandated disclosure, and reduces a gap in decision-making that few other policy approaches are able to assist with. As such, it is a good candidate to provide policy synergies as part of a comprehensive policy package for the building sector.

Timing of Results

Benchmarking would spur the purchase of high efficiency equipment very rapidly, as has been shown. It appears that it may take time for the energy savings to offset the equipment investment, but the investment is cost-effective for the sector as a whole. Benchmarking has the potential for immediate changes in decision-making for the commercial sector, but may take time to yield positive social benefits, particularly if the emissions projections for the East North Central division are borne out. However, in the end, the policy option presents an opportunity for tens of billions in social benefits over the modeled period.

3. Stakeholders and Constituencies

Energy efficiency can work in a polarized world. This option enables widespread access to standardized benchmarking data on a building basis. Benchmarking is a fundamental activity for energy management, and as such, enables many other efficiency efforts. Key stakeholders for this policy are expected to be building owners and operators, tenants, utilities, real estate agents, building contractors, various national-level associations (like the Building Owners and Managers Association (BOMA), the National Association of Realtors, the National Association of Energy Service Companies, etc.), state and local governments, and the federal government.

Building owners will largely be the recipients of information that utilities collect and submit into Portfolio Manager on their behalf. Most building owners will be able to make use of the information through the Portfolio Manager interface, identify problem buildings, and take appropriate action. Portfolio Manager ratings will also simplify the process of legitimizing claims of building performance and improve the earnings potential for these building owners. Some small percentage, as revealed in the interviews with program managers, is likely to ignore or misunderstand the Portfolio Manager rating. In general though, building owners and operators are expected to oppose mandated benchmarking efforts. BOMA has launched its own benchmarking effort utilizing Portfolio Manager, called BOMA STARS, and currently has more than 690 million square feet covered by the program. However, one of the BOMA arguments for this program is to demonstrate that government mandates are unnecessary; thus, while BOMA supports benchmarking in general, it may believe that mandated benchmarking efforts are not the proper role of the Federal government (BOMA, 2012). BOMA is not supportive of the DOE Asset Rating Tool being developed by DOE's Building Technology Program.

Building operators, managers, and real estate investment trusts, tasked with maximizing return and minimizing operating costs, are expected to be supportive of benchmarking efforts. The International Facilities Management Association's Energy Challenge program operates similarly to BOMA STARS, but does not suggest any opposition to benchmarking efforts required by governments (IFMA, 2012). Discussions with stakeholders also suggest that this constituency regularly utilizes benchmarking in managing building portfolios and views benchmarking as a best practice.

Tenants are another critical constituency of this policy option. Depending on the language used to create the obligation by utilities to report energy consumption data, tenant privacy rights may need to be addressed. Current efforts underway across the nation have required different means of coding data so a specific tenant's energy consumption could not be determined; in some jurisdictions, the interpretation of legal language by utilities has stopped the release of data for certain buildings. Explicit language detailing the privacy rights of tenants and the reporting requirements by utilities is necessary for successful national implementation of this policy option. Tenants may reserve support for the policy option if privacy concerns are not addressed. However, if building owners begin promoting their buildings based on their Portfolio Manager ratings, or at least make these results public, tenants benefit from increased information and the ability to identify buildings where utility costs will be lower. In total, tenants are expected to be supportive of this policy option, but that is dependent on the ability of the approach to successfully protect their privacy.

Many utilities already provide data for Portfolio Manager or can do so with relatively minor adjustments, but others may face a higher burden. Support may be found for utilities that are able to leverage the benchmarking information towards their demand response programs, which have been found to be increasingly cost-effective, particularly in regions with wholesale markets that can pay attractive rates for shedding electric loads (Pande et al., 2010; Spees and Lave, 2007). Demand response and energy efficiency are at the top of the loading order of electric resources in California (Faruqui and Mitarotonda, 2011). Experience with existing programs has shown mixed support for benchmarking, with uncertainty surrounding legal privacy obligations the largest concern. If such questions were clearly answered, utilities would have clear guidance on acceptable ways of reporting energy consumption data. It may also be the case that utilities will experience greater costs in establishing such reporting and building aggregation programs: ConEdison in New York City charges building owners $102.50 to aggregate consumption to the building level, for example (Burr et al., 2011). This cost was determined by ConEdison and approved by the New York State Public Service Commission.

Utilities in states with decoupling may be more supportive of this policy option. Traditionally, utilities recover fixed costs from consumption charges. When sales fall, utilities may not recover all their fixed costs; thus, in states that are not yet decoupled, benchmarking may cause a loss of utility revenues. When sales increase, utilities may collect more than their authorized fixed costs and reasonable return. This creates an incentive for "throughput" and a disincentive for energy efficiency programs. One option for regulators is to eliminate the throughput incentive by implementing decoupling mechanisms through rate structures. Of the five cities that have implemented benchmarking programs, all but one (Austin) are located in states where decoupling is either adopted or pending. Utilities deploy benchmarking efforts to identify existing opportunities; developing measurement and verification protocols for utilities to claim credit for some of the energy savings from benchmarking efforts would likely increase support for this policy option.

Building contractors and construction firms are a stakeholder who may be indirectly impacted, depending on the success of a national benchmarking program in transforming the marketplace for commercial building retrofits and new construction. To the extent that this policy option generates more jobs and projects for this sector, they may be supportive. Groups like the National Association of Energy Service Companies (NAESCO) have supported mandatory benchmarking and mandated disclosure laws in the past (NAESCO, 2011). However, if benchmarking becomes viewed as a move towards a national building code by the broader community of contractors, these stakeholders may become more suspicious, and consequently, less supportive. The key national advocacy organizations for this stakeholder say relatively little about benchmarking and related policy options, aside from general support for energy efficiency (Associated Builders and Contractors, 2008, for example).

Other national associations that emphasize energy and environmental policy have taken positions on benchmarking efforts. The National Resource Defense Council's Center for Market Innovation supports energy benchmarking language in lease agreements as a way to partially address principal-agent problems and information asymmetries in the commercial sector (Center for Market Innovation, 2011). The American Council for an Energy-Efficient Economy has also recommended benchmarking as a way to begin transforming the efficiency marketplace and shift towards more performance-based assessments (Mackres and Hayes, 2012).

The real estate industry largely favors subsidization as a way to make progress toward energy-efficiency goals, and does not support mandates. For example, the NAIOP (a large commercial real estate development association) suggests raising the existing tax credits from \$1.80/ft^2 to \$3.00/ft^2, as a way to increase commercial building efficiency. As an empirical matter, financial incentives seem to be ineffective at driving green-building designations, including ENERGY STAR, unlike regulatory approaches (Choi, 2010). NAIOP opposes national-level building codes, which are viewed as insensitive to local contexts, and generally, energy-efficiency requirements for buildings (NAIOP, 2012). While this position does not explicitly eliminate support for this policy option, it seems that the general outlook of the real estate industry would be negative. Since better energy performance increases the value of properties and benchmarking has been shown to improve energy performance, it appears that the economic interest of the industry may initially favor this type of benchmarking. However, if buildings began to seriously promote their energy scores, the buildings with lower scores may lose market share. Since ENEGY STAR limits its certifications to the top 25% (roughly), the economic interests of the industry may then switch and opposition may be the dominant position.

Lastly, state and local governments are stakeholders. States like Washington, Massachusetts, and California have already taken action for commercial buildings (Burr et al., 2011), and many other states have required benchmarking for government buildings (such as Michigan and Ohio) (Buonicore, 2010). Local governments across the country have also involved themselves directly in benchmarking efforts, almost entirely through mandated disclosure laws, as discussed earlier in this paper. Such efforts have greatly increased Energy Service Companies (ESCO) projects (Burr, 2012). Increased property values may also lead to increased property tax revenues. None of these state and local approaches has attempted this particular policy option, however. In general, governments may find this policy option amenable because it would likely make compliance with a mandated disclosure law much easier to achieve, perhaps lowering resistance from other stakeholders and addressing information issues.

Table 2 summarizes this stakeholder analysis of mandated benchmarking as a policy option, highlighting the numerous favorable views but also acknowledging the presence of mixed assessments and the likely unfavorable view of the real estate industry.

Table 2: Stakeholder Assessment of Benchmarking

Stakeholder	Pros	Cons	Dominant Position
Building Owners	Could reduce energy costs, increase rent receipts, and increase number of tenants	Mandatory compliance requires coordination and effort with utilities	**Mixed**
Building Managers and REITs	Reduced energy costs and improved building value	Effort required for managed properties	**Favorable**
Tenants	Better information about buildings would enable selection of better performing floorspace	Data privacy concerns	**Favorable**
Utilities	May lessen demand, especially at peak hours, and could increase demand-response program participation	Required reporting of energy data imposes a new cost; in states without decoupling, could erode utility revenues	**Mixed**
Building Contractors	Increases retrofit projects	May change building practices	**Favorable**
Energy/Environmental Groups	Reduces energy consumption and improves service	None	**Favorable**
Real Estate	Increases property values for those buildings that achieve certification	May negatively impact building value for those not achieving certification	**Unfavorable**
Governments	Regions cultivating "green" images can reduce energy consumption and emissions, move the market, and reduce information barriers	Managing the compliance effort can be complicated and time consuming	**Favorable**

4. Methodology

Our analysis of the potential of benchmarking in the commercial sector utilizes the Georgia Tech version (GT-NEMS) of the Energy Information Administration's (EIA) 2011 National Energy Modeling System (NEMS). GT-NEMS uses a combination of discount rates and the rate for U.S. government ten-year Treasury notes to calculate consumer hurdle rates used in making equipment-purchasing decisions. While the macroeconomic module of GT-NEMS determines the rate for ten-year Treasury notes endogenously, the discount rates are inputs to the model. Modifying these inputs is the primary means of estimating the impact of benchmarking for the commercial sector in this analysis. This is done in two steps: first, by updating the discount rates to reflect a broader selection of the literature; and second, by adjusting the updated discount rates to account for the effects of a national benchmarking policy.

The GT-NEMS inputs for discount rates are separated by end use, including space heating, space cooling, ventilation, lighting, water heating, cooking, and refrigeration, and broken into seven population segments for each end use. Each population segment is capable of using a different discount rate with regard to the end use in question each year. In the *Annual Energy Outlook 2011* (EIA, 2011a) Reference case, these discount rates are quite high; for example, more than half of the consumer choices made surrounding lighting and space heating use discount rates greater than 100% and less than 3% of the population uses discount rates under 15% (EIA, 2011b).

While it is well known that consumers utilize high discount rates as discussed earlier, such high discount rates are not reflected by the bulk of the existing research. An extensive literature review spanning four decades uncovered more than two-dozen studies estimating implicit discount rates for commercial consumers across the GT-NEMS series of appliances. The mean discount rates in this literature ranged from 17% (space heating and space cooling both) to 63% (refrigerators). The Simulation and Econometrics To Analyze Risk (SIMETAR) tool was used to develop continuous probability distribution functions for each end use. GRKS distributions were used for space cooling, lighting, cooking, and water heating. SIMETAR matched Weibull distributions as a better fit for space heating and refrigeration, so these two do not use a GRKS distribution. Ventilation was the sole end use to have no specific studies, so the space heating distribution was used to represent it (Figure 2).

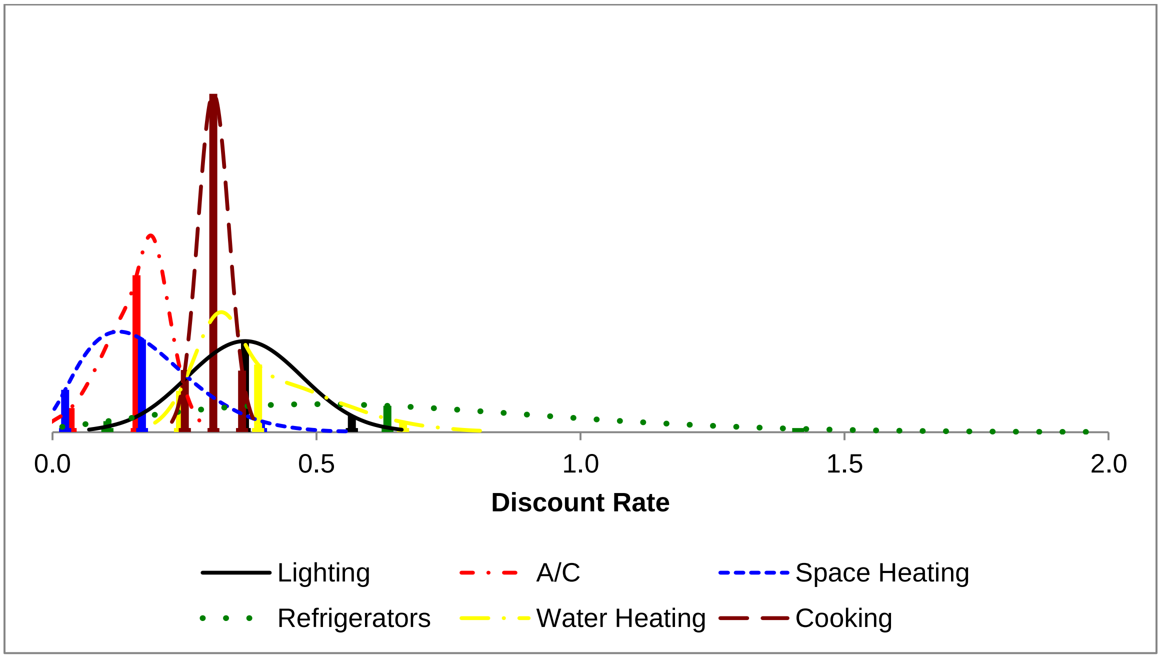


Figure 2. Probability Distribution Functions by End Use

The probability density functions were then divided into seven segments containing an equal area under the curve for each end use. The median value of each of these seven segments was used as an input into GT-NEMS in the Updated Discount Rates scenario (UDR). To estimate the impact of benchmarking, it was assumed that the findings of Coller and Williams (1999) would hold, and that the median discount rate would decline by five percentage points. Therefore, for the true median of each end use, the discount rate was lowered by five percentage points. The quotient of this "benchmarked" median discount rate and the updated median discount rate was calculated and used as an adjustment factor to the other six population segment medians. In this way, the findings of Coller and Williams are carried throughout the consumer population, since each population segment reduces by the same proportion as the median.

If these benchmarked discount rates were all GT-NEMS utilized in determining the hurdle rates of consumers, this method should estimate the impact of benchmarking, given the Coller and William (1999) findings. However, GT-NEMS adds the rate of ten-year Treasury notes to these values, which vary by year according to macroeconomic conditions. The model results of the Reference case Treasury note rates were compared to the same in the updated discount rates scenario described above. The difference in Treasury note rates was insignificant. This finding enabled the Reference case Treasury note rates to be subtracted from the updated discount rates so that final hurdle rate calculated by GT-NEMS matches the values suggested by the literature. These modifications generate the main policy case (referred to as "Benchmarking"). All policy scenarios begin in 2015. Table 3 presents the 2015 hurdle rates used in GT-NEMS across scenarios for two major end-uses in the commercial sector, space heating and lighting (these values represent the sum of the Treasury bill rates and the discount rates).

Table 3: Discount Rates Across Scenarios for Space Heating and Lighting in 2015

% of Population			Discount Rate*		
Reference	**UDR**	**Benchmarking**	**Reference**	**UDR**	**Benchmarking**
Space Heating					
27	14.2	14.2	1005.75	56.7	40.4
23	14.3	14.3	**105.75**	27.5	19.6
19	14.3	14.3	50.75	21.6	15.4
18.6	14.3	14.3	30.75	**17.4**	**12.4**
10.7	14.3	14.3	20.75	13.8	9.8
1.5	14.3	14.3	12.25	10.4	7.4
0.2	14.3	14.3	5.75	6.7	4.8
Lighting					
27	14.2	14.2	1005.75	66	57.3
23	14.3	14.3	**105.75**	47	40.8
18.6	14.3	14.3	50.75	42	36.5
18.6	14.3	14.3	30.75	**38**	**33**
8.8	14.3	14.3	20.75	35	30.4
1.5	14.3	14.3	12.25	31	26.9
2.5	14.3	14.3	5.75	25	21.7

*****Discount rates presented include the projected Treasury bill rate for 2015. **Bold** numbers represent the median estimate for the specific scenario.

Lastly, a sensitivity is estimated, where benchmarking is modeled as transformative and brings new, highly efficient technologies to the marketplace. This sensitivity (referred to as "Benchmarking +") utilizes the EIA High Tech technology suite for the commercial sector and represents a scenario in which benchmarking efforts result in the development of new, more efficient technology to meet market demands. This sensitivity is consistent with the "announcement effect" that has been documented in financial and product markets where the declaration of new regulations, financial policies, or future products causes a market response.

5. Results

5.1 Impacts on Commercial Energy Consumption

The impact of all of these scenarios on energy consumption can be seen in Figure 3. The Update Discount Rate shows savings of 2.75% in 2020 and 5.1% in 2035; Benchmarking is responsible additional savings of 0.25% in 2020 and 0.5% in 2035.

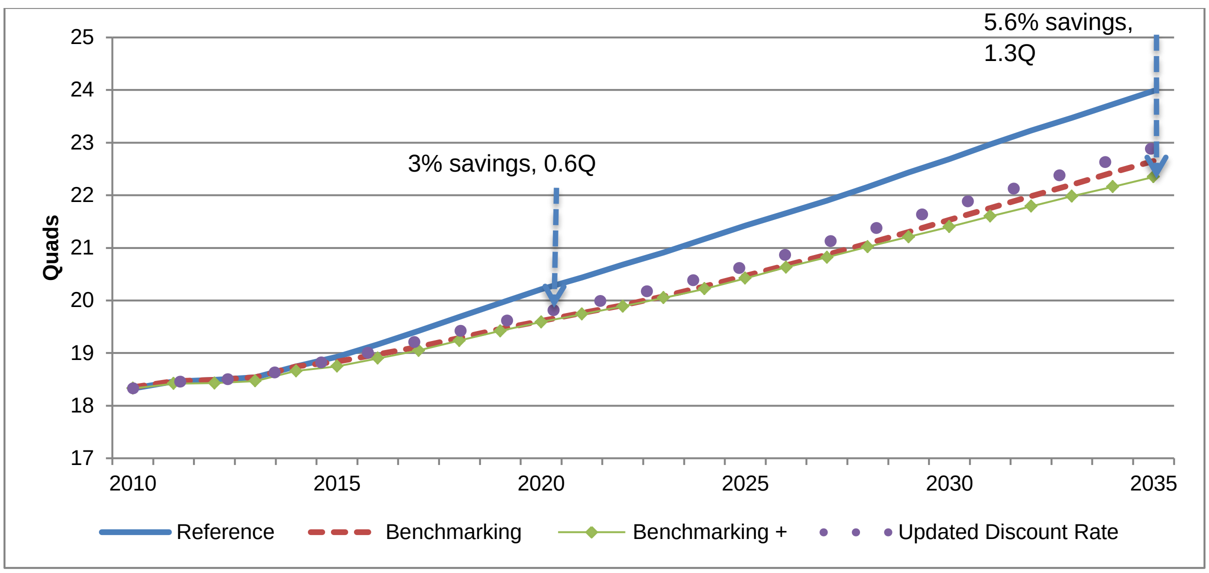


Figure 3. Commercial Sector Energy Consumption

Benchmarking reduces energy consumption without reducing the commercial sector's growing spatial footprint. As a result, energy intensity, measured in Btu per ft^2, declines, as does the nation's energy intensity as a whole (Figure 4). In 2020, Benchmarking results in a 3% improvement in energy intensity, relative to the Reference case. While significant, this improvement is 17% short of the Better Buildings Initiative goal of a 20% improvement over 2020 energy intensities in the commercial building sector. Thus, a benchmarking policy is unlikely to meet the Better Buildings Initiative alone.

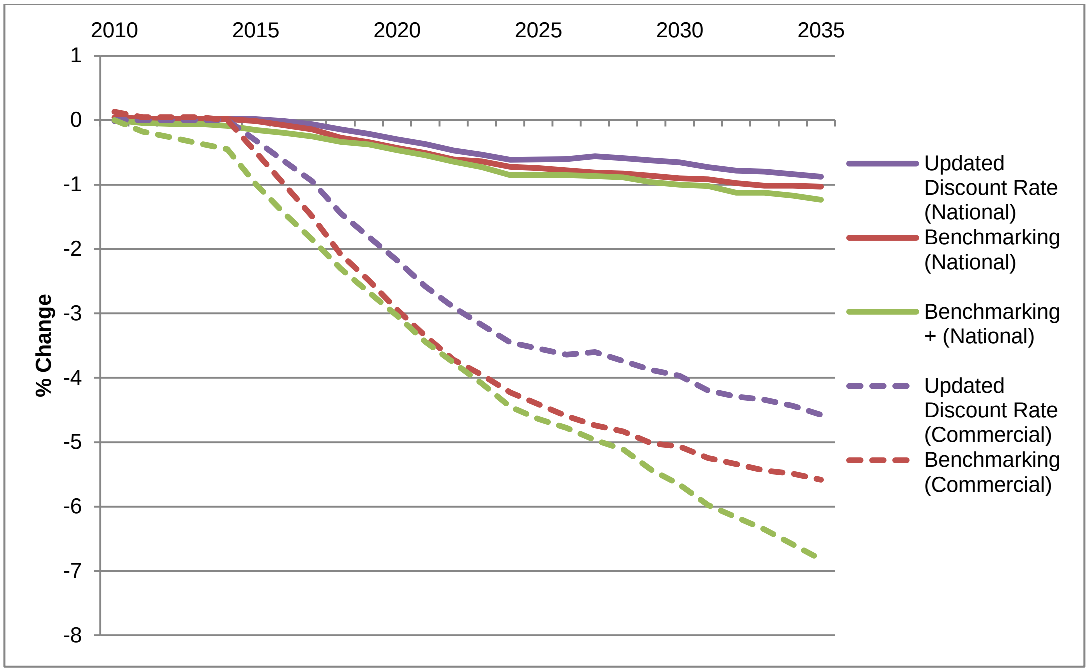


Figure 4. Change in Energy Intensity from Reference

Table 4 presents a cost-benefit analysis of the benchmarking policy option from the private sector perspective, including energy savings and new investment costs. Benchmarking shows the potential to save 600 TBtus in 2020, increasing to 1,330 TBtus by 2035, representing approximately 3% and 5.6% of commercial energy consumption, respectively. In total, the commercial sector would see savings of over 30,000 TBtus over the lifetime of the equipment chosen in the Benchmarking scenario. Equipment expenditures decline in total, with a present value $30 billion, and result in savings of more than $95 billion (2009-$), when evaluated with a 7% discount rate. From the perspective of the private sector as a whole, benchmarking offers large benefits. As noted earlier, even with such benefits, certain interests may not find such results compelling.

Relative to the UDR case, Benchmarking induces an additional savings of 40 TBtus in 2020 and 110 TBtus in 2035. Benchmarking shows the potential to save 2,800 TBtus beyond the UDR result, with a present value slightly more than $13 billion. Investment costs continue to represent additional savings.

Table 4. Benchmarking Policy Option from the Private Sector Perspective

Year	BAU Energy Consumption	Annual Energy Savings*			Cumulative Energy Savings**		Annual Private Cost*	Cumulative Private Cost
	Trillion Btu	Trillion Btu	%***	$M	Trillion Btu	$M	$M	$M
2015	18,900 (18,800)	90 (0)	0.5 (0)	1,820 (620)	90 (0)	1,820 (620)	-2,030 (-1,100)	-2,030 (-1,100)
2020	20,200 (19,700)	600 (40)	3.0 (0.20)	4,050 (900)	2,100 (120)	18,900 (5,050)	-1,580 (-760)	-11,800 (-5,230)
2035	24,000 (22,800)	1,330 (110)	5.6 (0.5)	3,190 (390)	18,000 (1,750)	75,504 (10,700)	-1,130 (-230)	-30,200 (-11,800)
2055	--	--	--	--	30,600 (2,800)	95,200 (13,100)	--	-30,200 (-11,800)

Top numbers represent Benchmarking compared to the Reference case. Numbers in parentheses are Benchmarking compared to the UDR case.

*Annual values are shown with no discounting to reflect the magnitude of savings in each given year

**Cumulative values are net present values discounted at 7%. Investments stimulated from the policy occur through 2035. Energy savings degrade at an annual rate of 5%, such that all policy effects have ended by 2055.

***Percent of annual commercial energy consumption.

Reductions in investment costs may seem counterintuitive, because reducing the discount rate should encourage investment in more efficient technologies, which are typically more expensive. All investment costs were directly calculable except ventilation; to estimate ventilation costs, the average $/MMBtu saved for space cooling was calculated annually from the GT-NEMS projection, and applied to the reduction in ventilation energy consumption to serve as a proxy. In most end-uses studied, the investment costs do increase, to the tune of several hundred million dollars a year. However, such increases in investment costs are offset by the reductions coming from one technology class – lighting.

More advanced lighting technologies are frequently higher quality, with longer lifetimes. This results in lower operations and management (O&M) costs. An advantage of using GT-NEMS is the ability to learn what technologies are being selected, down to a Census division and building type resolution (a more complete discussion of building types and regions is in the following section). When comparing Benchmarking and the Reference case, two technologies are primarily responsible for the reduction in investment – F32T8 Super fixtures and CFLs. F32T8 Supers are displacing F32T8 High Efficiency standard fixtures. The HE fixtures, while having lower initial costs, are slightly more expensive to maintain and lower efficiency than the Supers. Healthcare, offices (both large and small) and mercantile buildings are the biggest F32T8 Super adopters by building type, and particularly those in the South Atlantic, Mid Atlantic, and Pacific Census divisions. CFLs are pulling service demand away from LED and PAR-38 bulbs; CFLs have slightly higher first costs than PAR-38s, but lower O&M costs and much-improved energy performance. CFLs also have lower O&M costs than LEDs in the GT-NEMS technology profile. As a result, two-thirds of the increase in CFL service demand comes from PAR-38s and one-third from LEDs. These changes are taking place nationally in lodging, mercantile, and large office buildings, mostly in the South Atlantic, East North Central, and West South Central Census divisions.

The F32T8 Supers become more dominant when Benchmarking is compared to the UDR case, as the operating costs become more important in the decisions made by consumers. Adoption increases significantly in healthcare, large and small office, and mercantile buildings in the South Atlantic, Mid Atlantic, and East North Central Census divisions. However, CFLs lose service demand to LEDs after 2020. While CFLs have significantly lower first costs and slightly lower O&M costs than LEDs, the ascendant LED is 2.1x more efficient than the CFL, and has an expected lifetime that is ten years longer. The improved lifetime and performance of LEDs leads to increased rates of adoption when comparing Benchmarking and the UDR case.

5.2 Variations across Building Types and Regions

The potential benefits are not uniformly distributed; there are significant variations across the building types in the sector. Benchmarking seems to offer savings that are sustained over time, but have a bigger impact early in the modeled period. The energy savings range from 1% (Small Office) to 6% (Assembly) in 2020, averaging 3% across all building types. By 2035, the range is 2% (Small Office) to 11% (Assembly), averaging 5% across all building types relative to the Reference case (Figure 5). These numbers show that the relative divergence from the Reference case occurs most rapidly in the first five years; it takes the next 15 years to achieve roughly the same percentage gain. This finding is generally true for all building types. Mercantile buildings are responsible for the largest reduction in energy consumption from any single building type, saving 60 TBtus in 2020 and 133 TBtus in 2035. However, mercantile buildings are relatively average performers; the energy savings for these buildings are larger because mercantile buildings represent roughly 25% of commercial building energy consumption. Savings for particular building types may be slightly overestimated for large office and warehouse building types, where managers and real estate investment trusts frequently benchmark these properties.

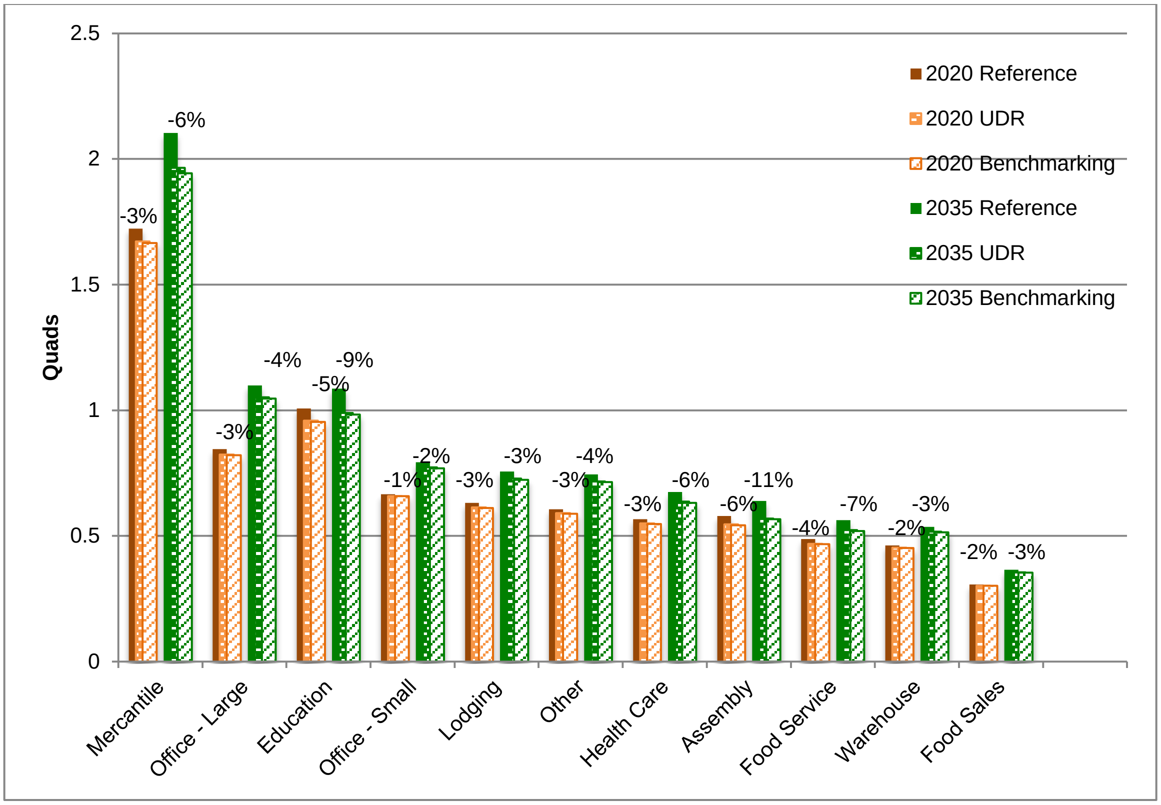


Figure 5. Delivered Energy Consumption by Building Type

The potential benefits also vary geographically by region over time, comparing the Reference case and the Benchmarking scenario (Figure 6). In 2020, the energy savings as a result of the benchmarking policy range from an increase of 1.9% in the East North Central division to 5.6% savings in the Mid Atlantic division when compared to the Reference case. CO_2 emissions in 2020 range from an increase of 5.8%, again in the East North Central division, to a reduction of 5.8% in the South Atlantic division. Electricity rates decrease most in the New England division with lagging energy savings, perhaps as a result of the rebound effect and price elasticities.

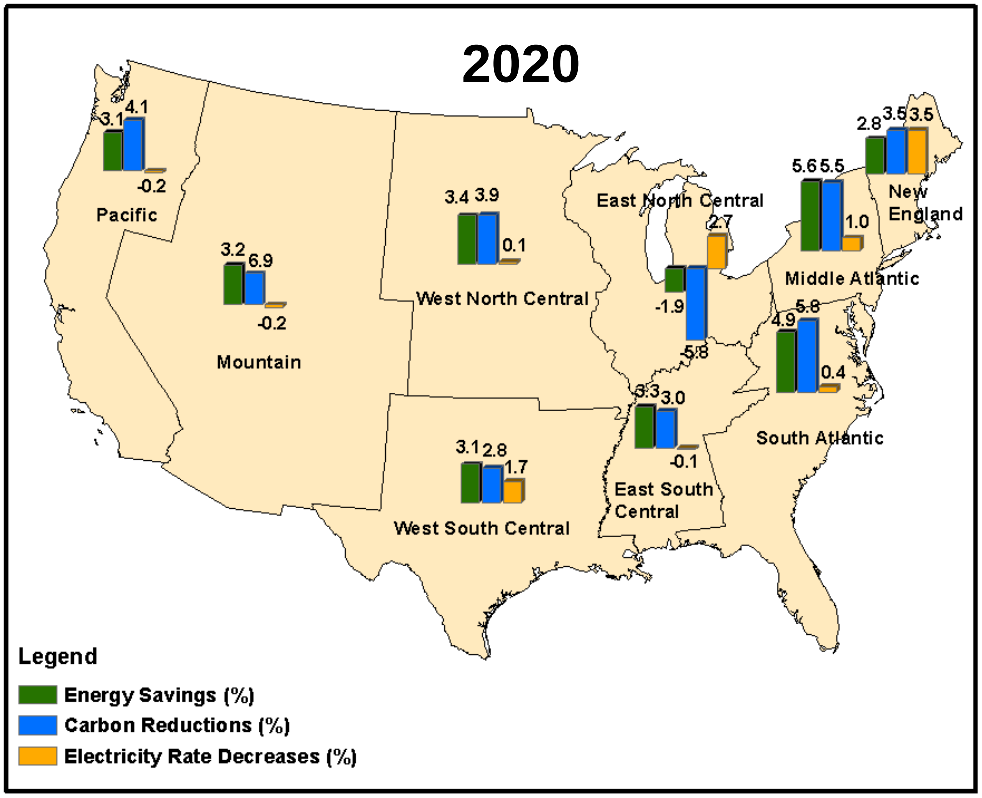
By 2021 all of the divisions would reduce their energy consumption as the result of benchmarking; by 2035, the energy savings range from 4.7% in the West South Central region to 6.9% in the Mountain region. CO_2 emissions reductions in 2035 range from from 4.2% in the West South Central region to 6.3% in New England. Over the entire time frame, the South Atlantic achieves the highest average reductions in consumption and CO_2 emissions, opposed to the East North Central, which, while still averaging reductions, trails in both categories. On electricity prices, New England receives the highest average reduction in price at 2.5%, while East South Central sees the least impact, averaging no change from the Reference case.

The effect of the UDR case is pronounced, although the regional 'cast' is much the same. East North Central increases energy consumption by 3.6% and Mid Atlantic decreases consumption by 2.6% (to reiterate a previous point, national energy consumption in 2020 is 0.2% lower in 2020 in the Benchmarking scenario than in the UDR case). CO_2 emissions range from an increase of 6.4% in East North Central to a decrease of 2.9% in West North Central. Electricity rates decline in 8 of 9 Census divisions, led by New England at 3.3%.

Looking further into the projection, East North Central begins to show energy reductions after 2022, similar to the comparison with the Reference case. However, New England and East South Central show a net increase in energy consumption from 2022 through 2035. In 2035, energy consumption ranges from an increase of 0.5% in East South Central to a decrease of 1.9% in the Mid Atlantic. Not surprisingly then, the impact on CO_2 emissions also diverges from the comparison of Benchmarking to the Reference case, with 2035 results ranging from an increase of 1.04% in West North Central to a decrease of 1.1% in the Pacific. Electricity prices in this comparison range from an increase of 0.9% in the Mid Atlantic to a decrease of 1.7% in New England in 2035. While the national trend is to decline in all three of these metrics (electricity price, energy consumption, and CO_2 emissions) relative to the UDR case, the regional results are not unidirectional, nor do they scale proportionally from the Reference case.

Figure 6 highlights that the effect of benchmarking in the East North Central Division is complex and unique. Demand for electricity would be reduced as a direct impact of the policy. As a result, coal and electricity prices would decline almost 3%. Many regions see similar reductions in the price of electricity, but the East North Central division derives the vast majority of its electricity from coal – consuming more coal than any other division in the nation. The response of this division to the national downward pressure in prices is to increase consumption. In 2020, coal supplies 40 billion kWh more than in the Reference case. While the East North Central division is the only division in the country to increase demand for coal in the electric power sector in 2020 (seven others reduce their demand, and one sees no difference) relative to the Reference case, its increase is large enough that national coal demand exceeds that of the Reference case in 2020. As a result of these interactions, carbon intensity, energy consumption, and a variety of emissions all increase in 2020 for the East North Central division; no other census division experiences these effects. Coal consumption is consistently higher than in the Reference case through 2035 for this division.

However, the commercial sector for this region experiences another series of dramatic changes after 2020. GT-NEMS introduces a set of newly available technologies in 2020, many of which see increased levels of adoption compared to the Reference case (i.e., air-source heat pumps). As old equipment is retired, much higher efficiency equipment replaces it. The price of electricity also increases relative to the 2010's. Thus, while East North Central experiences electricity prices that averaged 2.4% lower than the Reference case between 2015 and 2020, prices are only 0.13% lower than the Reference case between 2025 and 2030. This level of savings is below the national average for these out years. Energy consumption would also fall during this later period, due to strong and consistent reductions in natural gas consumption. The end result is that the East North Central division looks similar to neighboring regions by 2035.



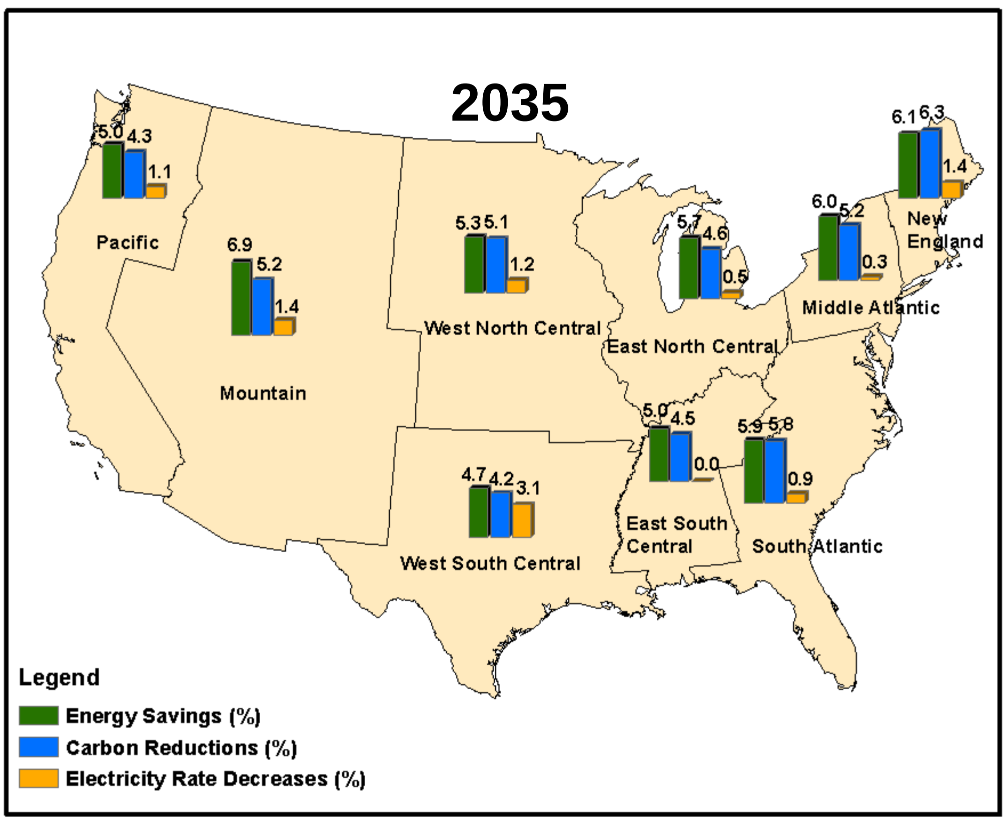


Figure 6. Change from the Reference Case in Commercial Energy Consumption, Carbon Emissions and Electricity Rates by Census Division in 2020 and 2035

In general, these projections show that CO_2 reductions are and remain closely tied to energy savings. This indicates that while benchmarking has the potential to reduce energy consumption, it will not motivate major changes in energy production – either from centralized sources or from major increases in the deployment of renewables within the commercial sector. With few exceptions, carbon intensity marginally increases; this is due to decreases in natural gas consumption for electricity generation in all regions of the country. Coal consumption for electricity generation, while generally declining, decreases less than natural gas, and slightly increases in three census divisions (East North Central, East South Central, and West South Central). Commercial buildings tend to be operating at highest capacity during regular business hours, so the gains in efficiency from benchmarking reduce the need for natural gas peakers while having little impact on baseload power production like coal. Such findings have implications for multiple stakeholders, particularly utilities with demand response programs.

5.2 Technology Readiness

Benchmarking, as a policy option, emphasizes better decision-making. In the analysis performed here, the available technologies are the same as the Reference case of the EIA *Annual Energy Outlook 2011* (EIA, 2011a). As a result, the savings described in this scenario are the result of deploying currently available technologies and technologies anticipated to become available with no changes from the current policy landscape. Table 5 shows the change in energy consumption by end-use for the two major fuels used in the sector (natural gas and electricity). In both 2020 and 2035, the greatest savings are from ventilation, followed by natural gas space heating and electric space cooling. Electric space heating experiences an increase in consumption after 2029, following a shift towards more heat pumps in those years. Excluding ventilation, the average saving for an end-use is 3.5% in 2020 and 5.5% in 2035.

Table 5. Changes in End-Use Consumption

End-Use	Energy (Quads)	2010	2020			2035		
		Ref	Ref (UDR)	Benchmarking	Change	Ref (UDR)	Benchmarking	Change
Space Heating	Purchased Electricity	0.2	0.2 (0.2)	0.2	-2%	0.2 (0.2)	0.2	**+5%**
	Natural Gas	1.6	1.8 (1.7)	1.7	**-5%**	1.8 (1.6)	1.6	**-10%**
	Delivered Energy	1.9	2.1 (2.0)	2.0	-5%	2.0 (1.9)	1.9	-8%
	Primary Energy	2.3	2.4 (2.3)	2.3	-4%	2.4 (2.3)	2.3	-6%
Space Cooling	Purchased Electricity	0.6	0.5 (0.5)	0.5	-4%	0.6 (0.6)	0.6	-8%
	Primary Energy	1.9	1.7 (1.7)	1.6	-4%	1.9 (1.8)	1.7	**-8%**
Ventilation	Purchased Electricity	0.5	0.6 (0.5)	0.5	-19%	0.7 (0.4)	0.4	-41%
	Primary Energy	1.6	1.8 (1.5)	1.5	**-19%**	2.2 (1.3)	1.3	**-41%**
Lighting	Purchased Electricity	1.0	1.1 (1.1)	1.1	-2%	1.2 (1.2)	1.2	-4%
	Primary Energy	3.2	3.3 (3.3)	3.3	-2%	3.8 (3.6)	3.6	-4%
Sector	Purchased Electricity	4.6	5.2 (5.0)	5.0	-3%	6.4 (6.1)	6.0	-6%
	Natural Gas	3.2	3.6 (3.5)	3.5	-3%	3.9 (3.8)	3.7	-5%
	Delivered Energy	8.5	9.5 (9.3)	9.2	-3%	11.1 (10.5)	10.5	-5%
	Primary Energy	18.3	20.2 (19.7)	19.6	-3%	24.0 (22.8)	22.7	-6%

Top numbers represent Benchmarking compared to the Reference case. Numbers in parentheses are Benchmarking compared to the UDR case.

Benchmarking results in a series of technology shifts across the major end uses, summarized in Table 6. Low efficiency boilers, furnaces, and water heaters see ongoing reductions in service demand. In every technology class, the shift is consistently towards more efficient equipment. To be clear, Table 6 shows technologies gaining and losing the most service demand in the comparison between scenarios and as such, does not reflect the level of service demand met by these technologies. A dominant, well-deployed technology that experienced no change in service demand would not appear in the analysis represented by Table 6 because there was not a shift in its usage between scenarios.

Table 6. Technology Shifts: Benchmarking versus Reference Case

End Use	2010-2020	2020-2035
Electric Space Heating		
– Ascendent Technologies	Typical air source heat pump (COP 3.3)	Typical air source heat pumps (COP 3.3)
– Declining Technologies	Typical electric boiler (COP 0.94); *Packaged space heat (COP 0.93)	Typical electric boiler (COP 0.94); *Packaged space heat (COP 0.93)
Natural Gas Space Heating		
– Ascendent Technologies	High efficiency furnaces (88%) and boilers (95%)	High efficiency gas boilers (95%)
– Declining Technologies	2007 Standard furnace (78%); *2007 High efficiency furnace (80%)	Typical gas furnaces (80%)
Electric Cooling		
– Ascendent Technologies	High efficiency reciprocating chillers (COP 3.5)	High efficiency centrifugal chillers (COP 7.0)
– Declining Technologies	Low efficiency reciprocating chillers (COP 2.3)	Low efficiency centrifugal chillers (COP 4.7)
Electric Water Heating		
– Ascendent Technologies	Solar water heaters (COP 2.5)	Typical heat pump water heater (COP 2.3); *Solar water heaters
– Declining Technologies	2007 Standard electric water heater (COP 0.97)	2007 Standard electric water heater (COP 0.97)
Natural Gas Water Heating		
– Ascendent Technologies	High efficiency gas water heater (COP 0.93)	High efficiency gas water heater (COP 0.93)
– Declining Technologies	2007 Standard gas water heater (COP 0.78)	2007 Standard gas water heater (COP 0.78)
Lighting		
– Ascendent Technologies	#26W CFL; F32T8 Supers	#26W CFL; *Typical LED; F32T8 Supers
– Declining Technologies	F32T8 HE – standard; PAR-38	F32T8 HE – standard; PAR-38

Unless noted, comparisons to the Reference and UDR selected the same technologies.
*Technology selected in the UDR comparison but not the Reference comparison.
#Technology selected in the Reference comparison but not in the UDR comparison.

For space heating, Benchmarking projected a fuel shift from natural gas to electric technologies. In 2020, the move is from typical natural gas furnaces to high efficiency natural gas furnaces. However, in 2035, a 135 TBtu drop in service demand for a typical natural gas furnace is met by a 143 TBtu increase in service demand for an air-source heat pump, representing a change in the fuels and technologies selected by consumers to meet demand. In total, there is a 105 TBtu increase in service demand for electric space heating and a 98 TBtu decline in service demand from natural gas space heating in 2035, relative to the Reference case.

In comparing Benchmarking to the UDR case, the story is largely the same. While there is quite a bit of service demand shifting within each fuel type, there is a net loss of 4 TBtu in service demand for natural gas space heating, and a net gain of 4 TBtu in electric space heating. By 2035, this service demand trading increases to 18 TBtus, demonstrating a small shift towards electric heat pumps.

5.3 Cost Effectiveness

The Benchmarking projections reduce energy demand, as has been shown earlier in this paper. Natural gas consumption is down an average of 3.5%, and 4.2% for electricity compared to the Reference case. The result is a reduction in price for both natural gas and electricity of 0.83% and 0.85%, respectively. When the Benchmarking projections are compared to the UDR case, natural gas and electricity consumption decline an average of 0.6% and 0.4%, respectively, with a corresponding 0.2% and 0.3% average reduction in price for each fuel. This reduction helps to suppress the growth in prices in both fuels (Figure 7).

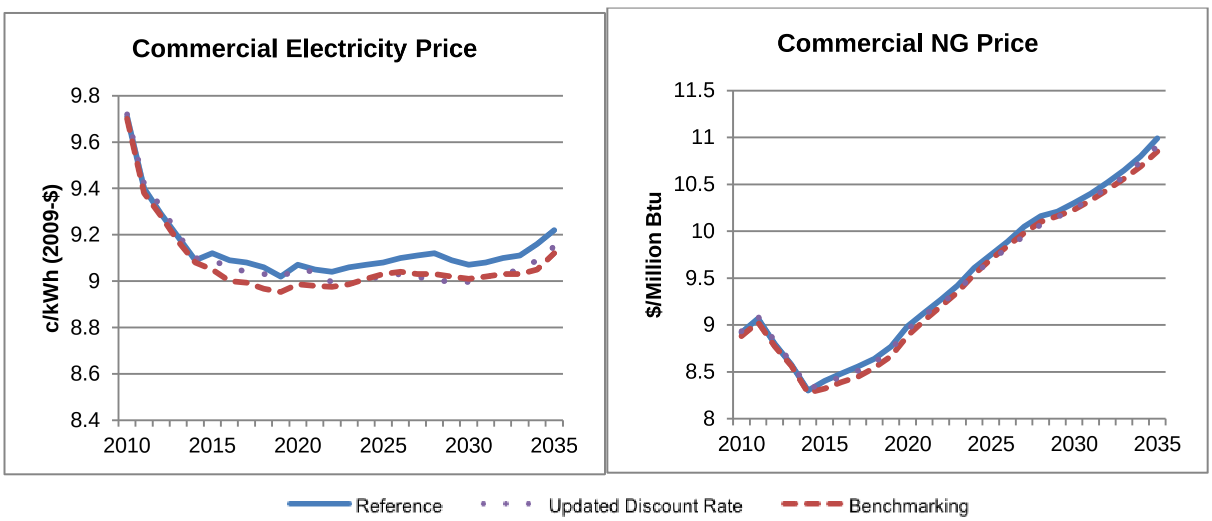


Figure 7. Effect of Benchmarking on Energy Prices

Decreased demand compounded by declining energy prices would result in a reduction in energy expenditures by the owners of commercial buildings. Compared with the Reference case, 2020 expenditures would decline by 3%, a savings of $7 billion; in 2035, expenditures would decline 6.5% with savings worth $15 billion (Figure 8). On average, annual energy expenditures decline by 5% and are valued at $9.5 billion. These savings represent $115 billion through 2035, and $146 billion over the lifetime of the installed equipment, that can be put to productive use elsewhere in the economy (evaluated with a 7% discount rate). Compared with the UDR case, 2020 expenditures decline by 0.8%, worth $1.5 billion; 2035 expenditures decline 0.9% and are worth $1.9 billion. Average expenditures decline by 0.6%, valued at $1.1 billion. Savings through 2035 have a net present value of $10.7 billion, increasing to $13.1 billion over the lifetime of the equipment (also evaluated with a 7% discount rate).

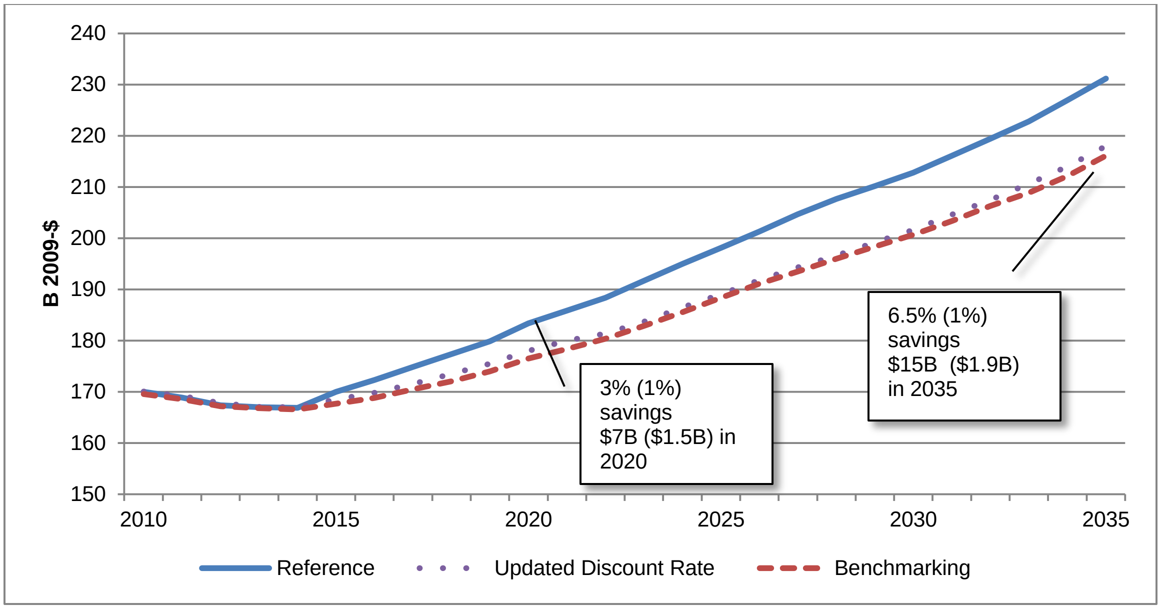


Figure 8. Commercial Sector Energy Expenditures

The national GDP impacts of the benchmarking policy modeled in this policy are minor. GT-NEMS projects that national GDP will reach $19.1 trillion (2009-$) by 2020 in the reference case. Benchmarking is projected to increase national GDP by $5 billion, equivalent to an additional 2.3 hours of productivity. In 2035, the national GDP is projected to hit $28.2 trillion (2009-$) in the reference case; the benchmarking projection of GDP is exactly the same in 2035.

Aside from the benefits that would pass to the private sector from reduced energy expenditures, there are additional social benefits from fewer emissions of pollutants. These are broken into criteria pollutant (SO_2, NO_x, and $PM_{2.5}$ and PM_{10}) benefits and CO_2 benefits. Changing the regulatory framework for these pollutants and other changes (lower prices or new discoveries, for example) that result in dramatic departures from projected ways of meeting energy demand would lead to different estimates of the costs and benefits associated with these pollutants.

Criteria pollutant benefits are calculated based on values from the National Research Council (2010), and take into account public health effects, damages to crops and timber, buildings, and recreation. Such damages tend to vary substantially depending on meteorological conditions, proximity of populations to emitters, and sources and means of electricity generation (Fann and Wesson, 2011). The National Research Council estimates exclude damages from mercury pollution, climate change, ecosystem impacts, and other areas where damages are difficult to monetize. Even with this incompleteness, damages from coal power plants are estimated to exceed $62 billion annually, and new analysis of this sort suggests that the damages from coal power plants exceeds the value-added to the economy (Muller, Mendelsohn, and Nordhaus, 2011). The average values provided for electricity generation and on-site use of energy sources are used to analyze the emissions benefits of benchmarking.

Carbon dioxide emissions are outputs of GT-NEMS and are the result of fuels used for energy on-site and in the electricity sector. Thus, they are dynamic and change annually based on the mix of fuels used to meet commercial sector energy demand. The economic value of reductions in CO_2 is estimated by multiplying the annual decrement in emissions by the "social cost of carbon" (SCC). The SCC is an estimate of the marginal damage caused by a ton of CO_2. In this analysis, the central values of the U.S. Government Interagency Working Group on the Social Cost of Carbon (EPA, 2010) are used, ranging from $25 per metric ton of CO_2 in 2015 to $47 per metric ton of CO_2 in 2050 (in 2009-$).

When compared to the Reference case, the net value of avoided emissions is estimated at $470 million in 2020, improving to $5.45 billion in 2035. In 2020, criteria pollutant increases would be responsible for $360 million in damages due to regional changes in the electricity generation profile, but CO_2 reductions would add benefits of $830 million. By 2035, criteria pollutants and CO_2 would provide social benefits valued at $1.14 billion and $4.31 billion, respectively. Cumulatively, the net present value of these emissions reductions would be $21.7 billion through 2035 and $35.8 billion in 2055 when evaluated with a 3% discount rate, the bulk of which are derived from reductions in CO_2 emissions (Figure 9).

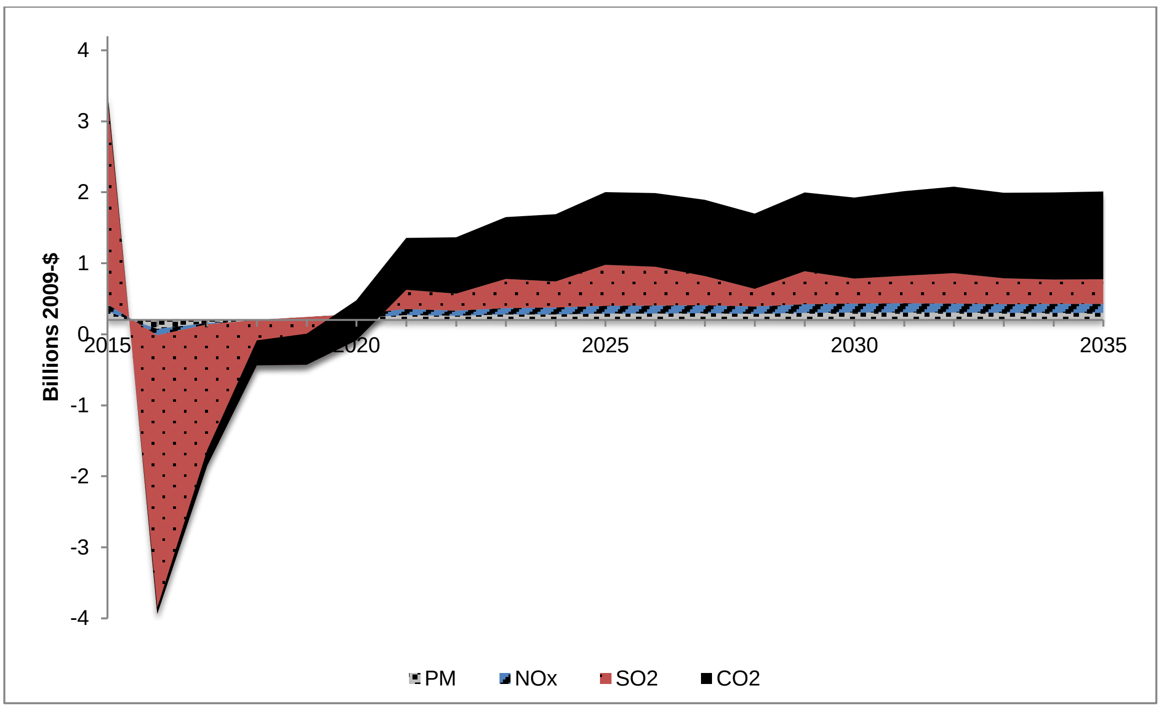


Figure 9: Emissions Benefits of Benchmarking

When compared to the UDR case, Benchmarking results in $60 million in net benefits in 2020, with $190 million in benefits from criteria pollutant reductions countering an increase in CO_2 emissions that represent damages of $130 million. In 2035, these roles have reversed; criteria pollutant emissions are higher than in the UDR case, representing $450 million in damages, while CO_2 emissions are slightly lower, worth an estimated $130 million. Cumulatively, the net present value of emissions reductions is $1.9 billion through 2035 and $400 million through

2055 (using a 3% discount rate). This reduction in cumulative net benefit is the result of an increase in coal consumption during the last five years of the modeled period and its long-lasting effect on the projection to 2055.

While the benchmarking policy option is modeled as ceasing in 2035, the benefits of the policy would extend into the future due to the lifetime of energy-saving technologies installed as a result of the policy. Energy-efficient technologies have varying lifetimes, both less and more than 20 years (for example, natural gas water heaters do not last 20 years, but chillers and boilers last longer).[3] This analysis, consistent with the literature, assumes that energy savings degrade at 5% annually (Brown et al., 1996). Therefore, technologies installed in 2035 provide the greatest savings in that year, with a linear decline in savings out to 2055, when energy savings are no longer expected. The same rationale is applied to emissions benefits.

Buildings with multiple tenants will require aggregation services in order to determine the energy footprint of an entire building. The additional cost incurred by this service is referred to in this analysis as the compliance costs. These costs were determined using the 2003 Commercial Building Energy Consumption Survey (CBECS) data (EIA, 2007), which provides the number of multi-tenant buildings with electric and natural gas service. The average square footage of a multi-tenant building from CBECS is used in conjunction with GT-NEMS projections of commercial floorspace to produce estimates of the number of multi-tenant buildings that will exist between 2004 and 2035. Burr (2012) estimates that existing mandated disclosure laws will require 60,000 buildings to undergo benchmarking regardless of this policy option, so these buildings are subtracted from the total. It is assumed that the cost of compliance will be the same for each building, following the ConEdison model in New York City, and is set at $102.50 (2011-$) for electricity and natural gas, such that a building needing aggregation for both fuels would incur costs of $205. The end-result is an initial cost of $141 million (2009-$) in 2015. Costs for new buildings after 2015 are also included, and range from $2.7 million in 2016 to $3.2 million in 2035 (2009-$).

These costs are modeled as public costs due to concerns about the distributional impacts and policy viability. If these costs were directed to utilities, opposition to the policy would likely grow substantially. The costs of accounting upgrades and software development are probably minor, but the cost of benchmarking every building would not be. Even though some cities have adopted a utility-pays model (Seattle and Austin), it is not recommended for national implementation efforts. If costs were directed toward building owners, building owners would be incentivized to avoid complying with the policy. As the purpose of the policy is to identify and benchmark the energy consumption of as many buildings as possible in the U.S., this approach is not complementary to the goals of the policy. Given these potential effects of policy implementation choices, it is recommended that the federal government finance compliance. Such an approach would alleviate increased utility opposition and foster a cooperative environment. The federal government's initial expenditure on the program would be considerable, but one-time at that magnitude; additional year's costs would be roughly 2% that

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[3] See Tables 5.3.9, 5.6.9, and 5.7.15 in the DOE *Buildings Energy Data Book* http://buildingsdatabook.eren.doe.gov/).

of the first. Other policy designs may include some form of cost-sharing between the public and private sectors, or phased-in benchmarking requirements based on the square footage of (i.e., buildings over 50,000 ft^2 the first year, 40,000 ft^2 the second year, etc.), as has been seen in local jurisdictions.

Having tallied the benefits and costs of benchmarking to both the private and public sector, it is worthwhile to see how these compare from the perspective of society. Table 7 shows all of this information. In the first five years of the policy, compliance costs and the increases in criteria pollutant emissions are significant costs, but the commercial sector is showing net benefits of $6.1 billion compared to the Reference case. By 2035, cumulative energy savings, combined with the benefits of reduced emissions, exceed cumulative equipment and compliance costs by more than $100 billion. By 2055, all new equipment has been retired and net benefits have grown to $175 billion. This yields a social benefit/cost ratio of 4.6 using a 3% discount rate. The result of comparing Benchmarking to the UDR case presents smaller net benefits but a higher benefit/cost ratio, as can also be seen Table 7.

Expanding the view to the national level adds in energy savings and expenditures for the nation, as well as the effects on pollutant emissions and the equipment investment costs of the residential sector. The value of energy savings show large increases here, largely as a spillover effect of lower energy prices following the changes in demand from the commercial sector. Changes in the electricity generation profile increase pollutant emissions early in the modeled period. The persistence of negative emissions benefits varies, depending on whether the Reference case or the UDR case is used as a baseline for comparison. The consistency of higher pollutants as a result of the Benchmarking approach suggests that complementary policies will be necessary to ensure that there is no backslide in public health and welfare, such as the Mercury and Air Toxics Standard rule recently released by the EPA. Using a 3% discount rate, net social benefits increase to $260 billion with a benefit/cost ratio of 6.4 when compared to the Reference case. Using the UDR case as the baseline increases the benefit/cost ratio to 9.3 with social benefits of $63 billion (Table 7).

Table 7. Commercial Sector Social Benefit/Cost Analysis of Benchmarking*

Year	Cumulative Social Benefits				Cumulative Social Costs			Benefit/Cost Analysis	
	Energy Expenditure Savings	Value of Avoided CO_2	Value of Avoided Criteria Pollutants	Total Benefits	Higher Equipment Outlays	Compliance Costs	Total Costs	Social B/C Ratio	Net Social Benefits
Commercial Sector									
2020	23.7 (6.3)	1.6 (-0.4)	-4.5 (0.7)	20.8 (6.5)	14.6 (-6.4)	0.1 (0.1)	14.7 (-6.3)		
2035	127.8 (16.5)	17.4 (0.6)	4.3 (1.3)	149.5 (18.4)	48.5 (-18.0)	0.1 (0.1)	48.7 (-17.9)		
Total Impact**	187.4 (23.8)	27.0 (0.9)	8.8 (-0.4)	223.3 (24.3)	48.5 (-18.0)	0.1 (0.1)	48.7 (-17.9)	4.6 (76.7)	175 (42)
National Economy									
2020	42.8 (18)	-1.0 (-2.1)	-5.1 (-4.5)	36.7 (11.4)	14.6 (-6.4)	0.1 (0.1)	14.7 (-6.3)		
2035	190.4 (40.7)	10.7 (-1.9)	2.5 (-3.8)	203.6 (35)	48.3 (-18.1)	0.1 (0.1)	48.5 (-17.9)		
Total Impact**	283.8 (53.4)	18.6 (-2.7)	6.1 (-5.2)	308.4 (45.5)	48.3 (-18.1)	0.1 (0.1)	48.5 (-17.9)	6.4 (9.3)	260 (63)

*Present value of costs and benefits were analyzed using a 3% discount rate. Numbers in parentheses are Benchmarking compared to the UDR case.
**The total impact accounts for the energy savings and its related benefits occurred throughout the lifetime the commercial equipment, assuming an average lifetime of 20 years.

As is always the case with a benefit/cost analysis, there are important costs and benefits that were unable to be characterized, so it is crucial to recognize this effort as a best guess (Krutilla, 1967). For example, the costs of utilities in developing new aggregation software packages and adjusting accounting methods so data can be easily input into Portfolio Manager have not been successfully estimated here. Also, the benefits of improved asset values for building owners and local governments, as well as numerous unpriced environmental benefits, are lacking from this analysis. Many benefits of having a data set that included all commercial buildings would be present for researchers and could improve policy decisions at the federal level, but these benefits are also lacking from this analysis. Lastly, a major benefit of benchmarking is the reduced transaction costs necessary to learn about building energy performance. Reducing these transaction costs are likely to be a large part of the policy rationale behind pursuing a policy like benchmarking, but methods to estimate the value of reduced transaction costs are currently lacking. Such costs could be further reduced through mandated disclosure efforts.

6. Summary

Many improvements in commercial building energy efficiency could be spurred by requiring utilities to submit building energy data to a uniform database accessible to building owners and tenants. Numerous other advantages would also present themselves as a result of the proposed BID system.

If the marketplace shifted as a result of benchmarking and other related policy efforts, the market may see an opportunity for good energy performance, spurring an end-user-driven marketplace shift and further increasing the information available to the marketplace. Building owners would have motivation to seek highly energy-efficient tenants, perhaps presenting such tenants additional incentives and inducements. Private organizations or government could grant recognition of quality energy management to specific tenants, further reducing transaction costs between tenants and building owners. This could enable market-based rewards for good energy management by tenants, representing something similar to an ENERGY STAR program for tenants that allowed them to signal their quality.

It is estimated that the benefits of a national benchmarking policy outweigh the costs, both to the private sector and society broadly. Overcoming some of the information barriers in the sector looks to be a worthy investment, mostly on the basis of the potential for energy savings. Opposition to benchmarking is likely to be grounded in concerns over tenant privacy, incurred costs (depending on policy design), and fear of the impact on the value of poor-performing buildings. Clarity from the federal government in policy design could substantially reduce some of this opposition and improve the functionality of the marketplace.

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