SOUTHERN APPALACHIAN MOUNTAINS INITIATIVE

Demand Management Incentive Strategy Evaluation

Final Report

Submitted by ICF Consulting

September 6, 2001

Contents

• Introduction

The Southern Appalachian Mountains Initiative (SAMI) needs to develop and evaluate demand management strategies to reduce air emissions. SAMI is particularly interested in emissions reduction strategies that take advantage of the benefits of incentives, but will examine a broad range of policies and strategies that offer substantial opportunity to reduce emissions in the SAMI region.

SAMI is developing an *integrated assessment* of emissions reduction options. To that end, SAMI needs to understand the relative emissions reduction benefits of strategies and policies that alter the economic behavior of consumers, and of organizations when they behave like consumers.

SAMI wishes to examine the potential benefits primarily of programs that operate through incentives, or otherwise have the following characteristics:

- They affect purchase decisions and other behavior by individual consumers (including organizations when they behave like consumers).
- They provide feedback that guides these groups toward behaviors that generate fewer emissions.
- They prompt early adoption of promising technologies and early fleet turnover.
- They have potential to alter the underlying economics such that they become self-perpetuating over time, without the ongoing use of incentives.
- They are administratively and politically feasible.

Through this project, ICF Consulting sought to help SAMI improve its understanding of potential benefits of two groups of policies and strategies with the above characteristics: those affecting transportation in the Southeast, and those affecting consumer and commercial energy use in the Southeast. We found that several policies and approaches in each category could contribute substantial reductions in demand and emissions in the SAMI region.

The report discusses transportation first, and then energy. The calculations and appendices for each sector's discussion follow the section for that sector, for ease of those focusing on a particular section.

- **Transportation Demand Management**

The second portion of the study examined transportation demand management and related policies and strategies.

Transportation demand has been growing, and is projected to continue growing, rapidly in the Southeast. Increased demand is driven by a combination of increasing population, mixed economic signals sent through imperfect transportation markets, and regional growth characterized by low-density, automobile-dependent land uses. Policymakers can affect the resulting emissions through policies addressing technology and behavior. ICF examined strategies that reduce emissions by focusing on technology and on two drivers of behavior: transportation incentives, broadly defined, and land use management programs.

In "transportation incentives, broadly defined," ICF and the SAMI Policy Advisory Committee (PAC) included programs to change the relative price of transportation options. For example, employer-based rideshare programs do not change the financial cost of transit or driving. Rather, they lower the barrier to ridesharing by providing information and guaranteed rides home. Similarly, "Parking Cash Out" offers employees the cash value of their parking spaces. The offer does not increase the financial cost of driving, but rather the opportunity cost of driving. Both policies affect incentives. We thus include in our pool of potential policies many often grouped as Transportation Demand Management. Although some TDM policies have been badly implemented and thus performed poorly, TDM remains promising because it can affect the transportation system as it now operates, affecting the incentives of large portions of the public without requiring them to invest in new technology or move.

ICF and the PAC also saw certain "land use management programs" as incentive policies in that they induce, or facilitate, behavior change by individuals and companies. Research from around the country demonstrates that many—although certainly not all—homebuyers and renters seek to live in more compact, mixed-use development. In many cases, the kind of traditional neighborhood they seek cannot be built under prevailing zoning codes, or willing builders find banks reluctant to finance mixed-use development. These and other hurdles can be removed through concerted action on the part of the stakeholders who make up SAMI, and so these policies are properly part of the evaluation pool.

- **POTENTIAL TRANSPORTATION TECHNOLOGIES AND POLICIES**

ICF Consulting identified fourteen potential transportation strategies, in four broad categories. We selected the strategies based on our experience analyzing transportation and related land use strategies nationally and a review of the available literature. These strategies were identified using the following criteria:

Demand-oriented: Each strategy affects the demand for vehicle travel and/or motor vehicle technologies.
Incentive-based: Each strategy can be implemented by creating incentives for travelers to change their behavior voluntarily. However, as we discussed on the kick-off call, the implementation strategy for most is flexible. Regulation can be used in many cases as well.

Technical feasibility: Each strategy was judged to be technically feasible; that is, there are no intractable barriers associated with implementation for technical reasons. Some of the measures, however, may have significant costs or political implementation issues.

Likely to affect emissions: Each strategy is likely to reduce emissions if implemented.

Market-based Incentives

1. **Road pricing** – Convert major bridges, tunnels, and limited access highways into toll roads; implement tolls on new limited access highways.

2. **Increase parking pricing / aggressively implement Commuter Choice and Parking Cash Out** – A variety of mechanisms for increasing parking costs, and for making existing fixed parking costs variable.

3. **Increase gas tax** – Increase the tax on motor vehicle gasoline and diesel fuel.

4. **VMT-based (or pay-at-the-pump) auto insurance** – Implement a program to partially or fully charge vehicle insurance on a per-mile basis, thus converting one of the largest fixed costs of vehicles into a variable cost.

Investments to Encourage Alternative Modes/Reduced Traffic Congestion

5. **Improve transit service, speeds and/or reliability** – Increase bus (and rail, where applicable) transit service coverage and frequency. Introduce exclusive bus lanes. Improve transit service using technologies such as signal prioritization, queue jumping, and ITS elements, such as vehicle tracking for headway control.

6. **Reduce transit fares** – Lower transit fares and/or provide free transit service routes. Restructure fares to maximize mode shift from Single Occupant Vehicles (SOVs), especially for congested periods and corridors.

7. **Improve bicycle/pedestrian infrastructure** – Conduct intersection improvements and retrofit existing facilities during major rehabilitations, in accordance with recent American Association of State Highway and Transportation Officials (AASHTO) guidelines. Increase investments in sidewalks, bicycle lanes, signage, bicycle parking, and off-road walking/biking trails.

8. **Increase ridesharing-oriented infrastructure (HOV lanes, park-and-ride)** – Increase number of high-occupancy vehicle (HOV) lanes, especially through conversion of existing lanes. Increase the number of associated park-and-ride facilities.

9. **Coordination/Information/Marketing for SOV Alternatives** – Develop a comprehensive program to promote alternatives to driving alone, including marketing to promote transportation alternatives, information to facilitate ridesharing, guaranteed ride home programs, flexible hours, telework, etc.

10. **Aggressive employer-provided TDM programs -** Provide tax incentives and/or matching funds for employers who implement commute benefit programs (provision of transit benefits, parking cash-out, ridesharing services, etc.).

Land Use / Development-Focused Strategies

11. **Transit-oriented/center-and-corridor focused development** – Focus growth near transit stations, and pursue a "town center-and-corridor" structure for new growth.

Incentives to Purchase Cleaner Vehicles:

12. **Vehicle efficiency taxes / feebates** – Implement a tax on vehicles that have high emission rates/low fuel-economy, or implement a feebate program that taxes high-emission vehicles and offers rebates that lower the purchase price of fuel-efficient vehicles; substantial rebates could be implemented to encourage purchase of alternative fueled vehicles (AFVs) / low-emission vehicles.

13. **Vehicle retirement / buyback programs** – Implement a program that offers a financial incentive to voluntarily remove a high-emissions vehicle from use.

14. **Provide alternative fuel vehicle (AFV) infrastructure** – Develop fueling stations for AFVs to facilitate increased use; a substantial barrier to purchasing an AFV is that facilities are not widely available to refuel vehicles that do not run on gasoline or diesel fuel.

- **DESCRIPTION OF POTENTIAL TECHNOLOGIES/POLICIES**

This section discusses each technology or policy above, including

1. a brief description of the strategy,

2. a qualitative analysis of potential effectiveness at reducing emissions, drawing from available literature, and

3. a brief discussion of implementation issues, such as institutional barriers, costs, and political feasibility.

- **Roadway Pricing**[1]

Description

Roadway pricing is the use of fees to increase the price of driving on specific facilities (e.g., tunnels, bridges, roadways), in certain regions, or at certain times. Drivers with more flexibility in trip choices (and who therefore place a lower value on a specific route or time) will switch to less expensive options, which may include other non-priced roads or alternates modes (e.g., transit, high-occupancy vehicles, or bicycling). When the pricing varies with time-of-day or congestion, it is commonly known as value pricing or congestion pricing.

There are several general categories of roadway pricing:

- **Facility pricing**, which is a charge for the use of a bridge, tunnel, or small and easily controlled section of road. This is the most commonly implemented strategy.

- **Road pricing**, or toll roads, is where drivers are charged for the use of a road at specific points (e.g., toll booths). While manned booths have traditionally been used to collect fees in this type of pricing strategy, booths are increasingly being replaced by automated fare collection systems.

- **Cordon pricing**, which is typically used to charge for travel in wider regions. A specific area is cordoned off and drivers are charged upon entering this area.

- **Value pricing** is a special type of roadway pricing where the toll varies by the time of day, based on changes in the demand for travel and resulting congestion. Also known as congestion pricing, this encourages drivers to switch their travel to less congested times, resulting in a more even distribution of traffic throughout the day. While usually the toll

[1] See: U.S. EPA. *Opportunities to Improve Air Quality through Transportation Pricing Programs.* September 1997.
U.S. DOT/FHWA. *Transportation and Global Climate Change: A Review and Analysis of the Literature.* DOT-T-97-03. June 1998.
Hagler Bailly. *Strategies to Reduce GHG Emissions from Passenger Transportation in Urban Canada*. Draft Final Report. May 1999.

structure is fixed, some localities now have the toll vary in real-time based on current congestion levels; this is called dynamic congestion pricing.

Effectiveness

Road pricing is a particularly effective potential transportation control measure because it impacts the entire fleet of vehicles rather than only new vehicles. The effectiveness of road pricing is determined by a number of factors including:

1. The fee that is charged;

2. Current cost of driving per mile;

3. The responsiveness of travelers to the price of travel (measured in terms of price elasticity); and

4. The nature and extent of the pricing strategy.

Congestion pricing directly affects the timing of vehicle trips, and can also affect mode choice and vehicle occupancy. The improved flow of traffic results in lower emissions and increased fuel efficiency.

Most of the congestion pricing programs operating in the U.S. are relatively recent, and the monitoring and evaluation to determine emissions reductions have not yet been undertaken. International experience shows that roadway pricing can be successful in reducing emissions.

The first U.S. highway congestion pricing project was implemented on SR-91 in California. The 10-mile facility was built as a two-way, four-lane HOV road in the median of an existing freeway linking Riverside County and downtown Los Angeles. Ridesharing was encouraged by charging SOVs and HOV-2s up to $2.50 to access the lanes (price varies by time of day), but allowing HOV-3+ to ride free. After 10 months of operation, 70,000 people had accounts with the California Private Transportation Corporation (CPTC), the private company that planned, constructed, and runs the program. Although it is too early to evaluate air quality improvements, CPTC claims that congestion has been mitigated in the corridor as evidenced by data that indicate 20 to 25 percent of daily trips on the new part of the freeway are HOV-3+.[2] Another study conducted by the Southern California Association of Governments determined that a fee of $0.15 to $0.25 applied during a four-hour peak morning period increased speeds by 10 to 20 percent and decreased vehicle miles traveled by 8 to 12 percent.

Road pricing measures are only as effective as the extent to which they are implemented. Road pricing strategies can be readily applied to controlled access roads (e.g., interstates), which carry 20 percent of the VMT in the Southern Appalachian region on just 2.6 percent of the road network. Road pricing is likely to be most effective where there are alternative modes of transportation and where carpooling is easy—that is, in and around metropolitan areas.

Implementation

Currently, twenty states have a form of roadway pricing in effect with costs averaging between $0.02 and $0.10 per mile.[3] Some localities have been disinclined to implement pricing strategies,

---

[2] U.S. EPA. *Congestion Pricing*. EPA420-S-98- 004. July 1998.

[3] Deakin, Elizabeth and Greig Harvey, "Transportation Pricing Strategies for California: An Assessment of Congestion, Emission, Energy and Equity Impacts." Technical Report prepared for the California Air Resources Board. 1995.

however, because of institutional barriers and the lack of political acceptance. Critical political and institutional issues include public opposition to new taxes or fees, geographic and economic equity concerns, lack of regional transportation coordination, and the lack of alternatives to driving alone during peak periods.

This public opposition has been reversing recently. New tolls, especially those involving HOT lanes and/or congestion pricing, have been implemented and are being studied across the country. A recent poll in the Washington, D.C. metropolitan area found that the public ranked tolls first among means to pay for transportation facilities, followed by gas taxes, income taxes, and sales taxes (in order of preference). Public opposition to new fees can be overcome when the benefits of roadway pricing are clearly explained through outreach and education campaigns. Equity issues can be addressed by ensuring that sufficient transit options are available, or if alternate transit is not available, by providing rebates or free trips to low-income drivers.

Typically, pricing measures are set up to be self-financing and may even provide additional revenue for other transportation improvements, or allow the locality to reduce property or income taxes. In addition, new information technologies have reduced the complexities of implementing pricing policies. These technologies presently are being used to estimate traffic levels, calculate the fees associated with such traffic levels and time of day, and charge vehicles the corresponding fee (through the use of transponders) without having them stop.

- **Fuel Tax**[4]

Description

While the use of federal and/or state fuel taxes to recover road construction and maintenance costs is an established practice, the use of these taxes to reflect externalities or reduce vehicle miles traveled (VMT) is a new strategy, at least in the United States. American gas prices are a fraction of those in other industrialized nations, where a gallon of gas typically costs $4 to $5 per gallon. Advocates of this strategy point out that higher fuel taxes can better reflect congestion and environmental externalities, and affect primarily single-occupancy vehicle trips. As people see the real cost of driving, they change travel modes, as well as decrease the frequency and duration of SOV trips.

Effectiveness

The effectiveness of fuel taxes as a method to reduce VMT is dependent on consumer reaction to the increased cost of fuel. Estimates of the elasticity of fuel demand to fuel price range from –0.21 to –0.81, meaning that a 10 percent increase in the cost of fuel produces a 2 to 8 percent decrease in fuel consumption. –0.21 reflects short-run elasticities, and –0.81 a fairly long-run elasticity.

Implementation

There have traditionally been significant political obstacles to using increased fuel taxes as a means to capture more of the social costs of driving (e.g., congestion and pollution costs). Most estimates suggest that prices would have to be raised by more than $1 per gallon to significantly influence driving behavior. To make an increased tax publicly palatable, a very thorough public education campaign would have to be undertaken. Such an increase would likely also need to be phased in over an extended period.

[4] See: U.S. EPA. *Opportunities to Improve Air Quality through Transportation Pricing Programs.* September 1997.
U.S. DOT/FHWA. *Transportation and Global Climate Change: A Review and Analysis of the Literature.* DOT-T-97-03. June 1998.

While fuel taxes are relatively easy to implement and collect, there are concerns that it places an unfair burden on low-income drivers, drivers with no alternative modes of transportation, and those who must do a significant amount of travel by auto. Adverse impacts on rural residents have been especially noted, as they typically drive further, have fewer options, and have more legitimate needs for trucks and less fuel-efficient vehicles. A tax rebate program could be developed to address these concerns.

Boundary issues are also a significant concern. Drivers may choose to purchase fuel in neighboring jurisdictions without the tax. Regional cooperation would be necessary to address this concern, the sort of cooperation available through SAMI.

- **Transit Fare Reductions**

Description

By reducing transit fares across the board or by providing specific routes or travel times with reduced or eliminated fares, transit usage can be significantly increased. Although transit demand is moderately price inelastic, some fare policies such as reduced or free fares, monthly or weekly passes and fare simplification (i.e., multiple operators accepting one fare medium) may encourage more ridership.[5] Free fares are frequently associated with downtown circulator systems and certain shuttle services, and are often tied in with a specific branding image for the free service.

Effectiveness

Recent research suggests that on the average, bus fare elasticity is roughly –0.4. "Transit riders in small cities are more responsive to fare increases than those in large cities. The fare elasticity for bus service is -0.36 for systems in urbanized areas of 1 million or more population. In urbanized areas with less than 1 million people, the elasticity is -0.43."[6] When introduced on selected routes or services, ridership response can be significantly greater.

Implementation

While fare reductions will certainly increase ridership, transit agencies must be prepared for the decrease in revenue. One key to the successful implementation of transit fare reductions is a strong publicity campaign to encourage ridership. Also important is the coordination of jurisdictions and transit agencies to ensure seamless fare integration.

- **Parking pricing / aggressively implement Commuter Choice and Parking Cash Out[7]**

Description

Parking price increases can be easily implemented by the government at municipal lots and meters. Local governments can also add meters to previously unregulated parking spaces. Prices and enforcement policies can be changed based on time of day and use patterns (e.g., by commuters). Local governments may also choose to impose surcharges for SOVs or long-term parkers in public

[5] U.S. EPA. *Improved Public Transit.* EPA 420-S-98-010. July 1998.

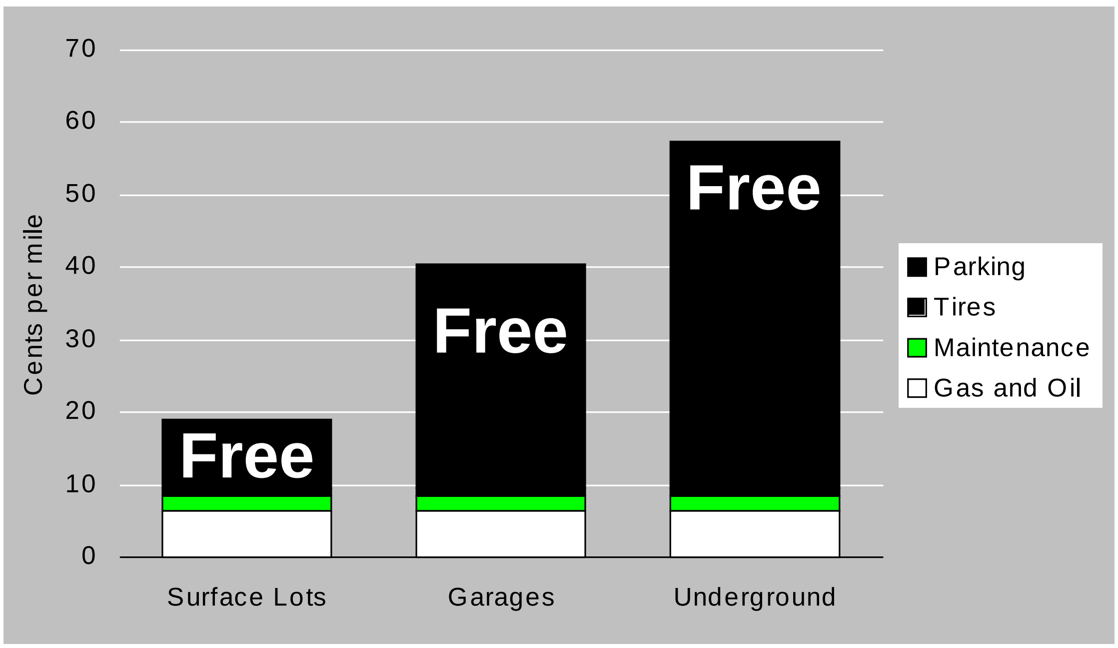
[6] American Public Transit Association, "Fare Elasticity and its Application to Forecasting Transit Demand," 1991.

[7] See: U.S. DOT/FHWA. *Transportation and Global Climate Change: A Review and Analysis of the Literature.* DOT-T-97-03. June 1998.
Hagler Bailly. *Strategies to Reduce GHG Emissions from Passenger Transportation in Urban Canada*. Draft Final Report. May 1999.

parking facilities or give price preferences to car- and van-pools. Surcharges and taxes on commercial parking have been effectively used in a number of localities.

Parking pricing programs affect air quality primarily by discouraging auto trips, thereby reducing vehicle miles traveled (VMT). "Reducing commuter trips not only reduces emissions associated with VMT, but those associated with 'cold starts,' when commuters set out in the morning and 'hot soaks,' when vehicles are parked at work and continue to produce evaporative emissions even after the engines are turned off."[8] A benefit of limiting parking space may be the freeing for potential higher economic use of land that would otherwise be used for parking, with corresponding benefits to density, increased property tax revenues, etc.

A particularly powerful and easy-to-implement form of parking price increase is called Parking Cash Out. About 95 percent of all commuters who drive to work receive free parking, and most auto commuters park free even in the central business districts of large cities. In almost all cases, the cost of the free parking space exceeds the marginal cost of driving to work.



Parking Cash Out offers the value of that parking to employees in cash, turning a subsidy to driving into an incentive not to drive, at essentially no change in cost. Tax barriers to Cash Out have recently been removed. The Taxpayer Relief Act of 1997 amended the federal tax code to allow employers to offer taxable cash instead of a tax-exempt parking space. Since the act went into effect in 1998, the option of Parking Cash Out has been available to employers nationwide.

Effectiveness

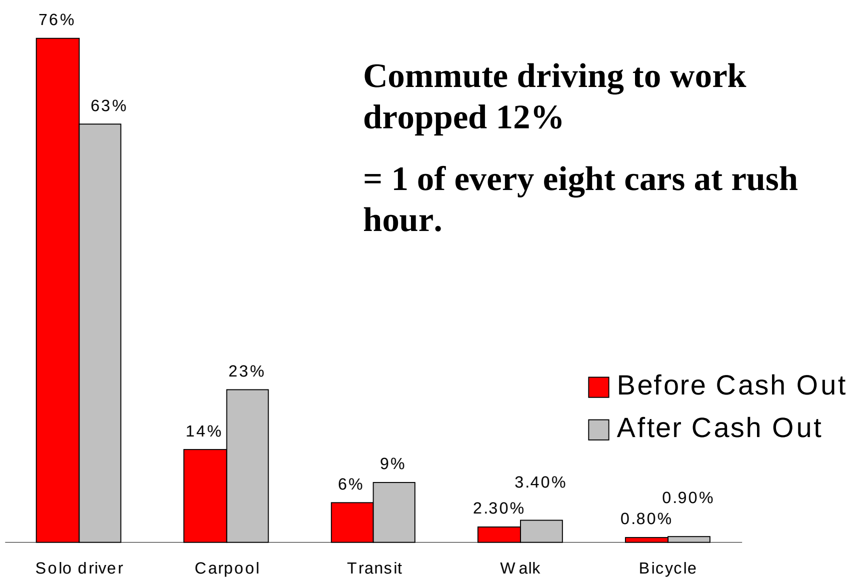
Parking price increases generally can have a large effect on driving because it is imposed and perceived as a variable (trip-by-trip) cost. A $2-$4 price increase can result in a 10-25% decrease in vehicle miles traveled. Public parking price increases are likely to be most effective in areas with established transit systems (allowing people to easily shift modes) and where people depend on public parking. Increases may also encourage ridesharing. It may also be more effective when implemented by employers because employee parking is often subsidized.

[8] U.S. EPA. *Parking Pricing*. EPA420-S-98-009. July 1998.

The effectiveness of parking pricing programs depends on several factors:

1. The change in price, particularly relative to the original price and the total trip cost.
2. The proportion of commuters whose employers pay for parking.
3. The availability of transit and other alternatives to SOV driving.
4. The availability of uncontrolled parking supplies (e.g., neighborhood streets, vacant lots, etc.) to which commuters may be diverted under pricing strategies.[9]

At eight Southern California employers who implemented Parking Cash Out, commute VMT dropped by 12%, equivalent to taking one out of eight cars off the road at rush hour.[10] At these employers, Cashing Out also reduced vehicle emissions by 12%, and at the time of day most critical to preventing ozone formation.



Outside California, it appears that a Parking Cash Out program reduces driving to work alone by roughly 20%, or more.[11]

Implementation

Parking price increases are easily implemented and are generally low cost. It is important that increases are done in a sufficiently large area to prevent people from switching to alternate no-cost parking places. Parking price increases will also provide revenue that can be used for a variety of purposes, including to provide alternatives. It is generally more difficult to impose prices where public or private parking is free.[12]

"In a downtown or suburban setting, where the public sector controls a considerable amount of parking, pricing policies may be effective in reducing both local and regional trip making. However, in localities where private parking dominates, changes in public parking pricing may reduce local trips to and from public facilities, but have little effect on the locality taken as a whole.

[9] U.S. EPA. *Parking Pricing*. EPA420-S-98-009. July 1998.

[10] Shoup, Donald, "Evaluating the Effects of Parking Cash Out: Eight Case Studies," final report to the California Air Resources Board, draft, February 7, 1997.

[11] ICF Consulting, "Parking Cash Out: Briefing Paper for the Commuter Choice Leadership Initiative," 1/26/01.

[12] U.S. EPA. *Parking Pricing*. EPA420-S-98-009. July 1998.

In such settings, parking policies must address the commercial and private sector."[13] This can be accomplished by introducing surcharges or special taxes on commercial parking.

Parking Cash Out gives employees choice, and everyone likes choice. In the study of California Cash Out employers, employers described their programs as effective employee recruitment and retention incentives. Program Administrators characterized the program as "a really good experience", "recommended", "fairer", and "loved by employees."

Employees interviewed for the study consistently remarked that the Cash Out option is an added fringe benefit that helps to recruit and retain employees. As one employee commented, "Employees are grateful and thankful and more motivated. So that's a plus for the company."[14]

- **VMT-Based Fees or Pay-at-the Pump Auto Insurance[15]**

Description

Vehicle miles traveled-based (VMT-based) fees are levied as a surcharge on every mile of travel and generally fall into one of several categories depending on where and when they are collected. If the fees are charged at the pump as additions to the price of gasoline (assuming that each gallon represents a certain number of miles traveled), they are viewed as pay-at-the pump (PATP) charges. When they are collected as per-mile tolls for the use of specific facilities, they are considered roadway pricing. VMT-based fees may also be linked to registration or emissions fees, in the form of per-mile surcharges that may vary by the emissions class that a vehicle falls into or measured emissions.

VMT-based and PATP auto insurance premiums are another method of converting a large fixed cost to a variable, more immediate cost. Under this strategy, drivers are charged premiums based on the mileage that they drive (may be self-reported or audited yearly) or are charged based on their fuel consumption (measured by the amount of fuel they purchase at the pump).

Effectiveness

VMT fees can cause reductions in congestion and pollution. In contrast to gasoline taxes, where the costs can be reduced with more efficient engines, the only way to reduce one's costs under this measure is to drive less, thus reducing emissions and traffic. Although VMT fees can impact both pollution and congestion, they are less likely to affect either than a fee designed specifically to reduce vehicle emissions or traffic congestion individually. This is primarily because VMT fees charge a flat fee for every mile driven, whereas a more specialized fee would vary based on the emissions characteristics of the vehicle, the air quality conditions during the time of travel, or the traffic conditions during the time of travel. The effect of a VMT fee will depend on the size of the fee, the types of vehicles currently driven, how the program is administered, and the availability of travel alternatives in a particular area.

---

[13] U.S. EPA. *Parking Pricing*. EPA420-S-98-009. July 1998.
[14] Donald Shoup, *Evaluating the Effects of California's Parking Cash-Out Law: Eight Case Studies*. University of California. May 22, 1997.
[15] Todd Litman, "Distance-Based Vehicle Insurance As A TDM Strategy", Victoria Transport Policy Institute, May 22, 2001.
See also: U.S. EPA. *Opportunities to Improve Air Quality through Transportation Pricing Programs.* September 1997.
U.S. DOT/FHWA. *Transportation and Global Climate Change: A Review and Analysis of the Literature.* DOT-T-97-03. June 1998.
Hagler Bailly. *Strategies to Reduce GHG Emissions from Passenger Transportation in Urban Canada*. Draft Final Report. May 1999.

There is little quantitative data available, but it is estimated that a 10 percent increase in fuel prices from PATP charges is estimated to create a 2-2.5 percent reduction in VMT.

Implementation

There are actuarial, regulatory, political, and technical issues that complicate implementation of VMT-based or PATP strategies. PATP auto insurance programs can be complex because they require the government to collect fees from gas stations and reimburse insurance companies. Public acceptance for additional fuel fees may be hard to gain. A recent pilot project by Progressive Insurance in Dallas, which charged customers insurance premiums by the mile, as tracked by GPS units, suggests that this approach may have great potential. The pilot was extremely popular with customers, and also produced a 10-20 percent reduction in driving.[16]

- **Transit Service Improvement**[17]

Description

Transit services can be improved through a number of ways. System or service expansion involves the extension of the geographic service area or the addition of routes to an existing service area. The addition of express bus services can be a particularly effective alternative to single occupancy driving because they can provide fast routes between suburban communities and downtown areas.[18]

Operational improvements can be made by splitting routes, improving transfers, improving coordination between modes (e.g., bus and rail), increasing the frequency of vehicles, and improving passenger amenities (e.g., shelters, stations, vehicle comfort, signage, and handicap/elderly access). Because reliability is important to many commuters, improving the maintenance of buses and rail services may result in increased ridership.

Transit service can also be improved by implementing transit management systems, which include hardware/software components on buses, dispatching centers, radio communications, operator training, and maintenance to increase mass transit ridership and productivity.[19] For example, dispatch centers can receive real-time Automatic Vehicle Location information derived from sign-post or Global Positioning System equipment. Electronic fare payment is expanding from magnetic strip farecards in use in the Washington, D.C. METRO and San Francisco BART rail systems to systems that accept multi-purpose magnetic strip cards, commercial credit cards, and remote electronic transaction devices.[20]

Effectiveness

In Houston, San Diego, and Atlanta, daily vehicle miles of travel on major freeways decreased 17.8 percent, 47.8 percent, and 55 percent respectively after mass transit improvements were made in the mid 1980s. In terms of air quality, the MetroLink program, an 18- mile light rail transit line that

---

[16] Anne Eisenberg, "GPS system may mean paying for car insurance by the mile," *New York Times*, Thursday, April 27, 2000.
[17] See: U.S. DOT/FHWA. *Transportation and Global Climate Change: A Review and Analysis of the Literature.* DOT-T-97-03. June 1998.
Hagler Bailly. *Strategies to Reduce GHG Emissions from Passenger Transportation in Urban Canada*. Draft Final Report. May 1999.
[18] U.S. EPA. *Improved Public Transit.* EPA 420-S-98-010. July 1998.
[19] U.S. EPA. *Improved Public Transit.* EPA 420-S-98-010. July 1998.
[20] U.S. EPA. *Intelligent Transportation Systems.* EPA 420-S-98-007. July 1998.

connects suburban communities with downtown St. Louis is estimated to reduce daily VMT and emissions considerably. Projections are 64,700 miles per day and 4,500 metric tons per year.[21]

Air quality improvements from transit improvements are not difficult to estimate because the number of people utilizing the improved transit system is easy to quantify. The number of vehicles, miles traveled, and air emissions can then be estimated based on this information.[22]

Implementation

Transit service improvements depend on stable long-term funding. Transit projects can be very expensive if they are capital intensive (e.g., building rail lines) and rely on infrastructure changes; farebox revenues often do not cover the cost of capital improvements. However, improvements involving transit schedules and public awareness programs are much cheaper. Improving bus shelters, instituting regional fare structures, and better signage are also examples of effective improvements that cost much less than the capital-intensive examples mentioned above.[23]

- **Bicycle/Pedestrian Infrastructure Improvement**[24]

Description

Infrastructure improvements such as sidewalks, trails, bicycle lanes, and bicycle racks can improve the overall bicycle and pedestrian environment enough to encourage mode shifts to bicycling and walking. Traffic calming measures, such as speed bumps, traffic circles, median barriers, and curb extensions, can also be implemented to improve the non-motorized environment.

Because bicycling and walking do not create greenhouse gas emissions, they provide an immediately clean alternative to single-occupancy vehicles. In addition, the infrastructure improvements can contribute to a community's livability and economic well-being.

Effectiveness

Bicycling and walking will generally be viable alternative modes of transportation for relatively short trips which make up approximately 60 percent of all trips (i.e., generally less than five miles in length).[25] The effect on commuting trips will likely be minimal except in mixed-use districts.

The choice of bicycling or walking as a transportation mode is influenced by the length of trip, connectivity to transit, land use pattern, topography, weather, safety concerns, and individual health and fitness. The reduction in vehicle miles traveled from bicycle improvements has been estimated to be 0.01-3%. Pedestrian improvements are most suitable for higher density, mixed-use areas. It has been shown that pedestrian improvements can lead to a 5-10% reduction in intra-district trips resulting in a 0.8-1.6% decrease in greenhouse gas emissions.

Most studies estimate low reductions of vehicle miles traveled and greenhouse gas emissions from bicycle and pedestrian-oriented projects. While vehicle miles traveled reductions from mode shifts

[21] U.S. EPA. *Improved Public Transit.* EPA 420-S-98-010. July 1998.
[22] U.S. EPA. *Improved Public Transit.* EPA 420-S-98-010. July 1998.
[23] U.S. EPA. *Improved Public Transit.* EPA 420-S-98-010. July 1998.
[24] U.S. DOT/FHWA. *Transportation and Global Climate Change: A Review and Analysis of the Literature.* DOT-T-97-03. June 1998.
[25] *Bicycle and Pedestrian Programs.* EPA420-S-98-002. July 1998.

to bicycling and walking will be low, the air emissions benefits can be quite large because cold start and hot soak emissions comprise a large proportion of emissions from a vehicle trip.[26]

"Many cities and states have calculated the air quality impacts of a shift in auto trips to bicycle trips. Oklahoma's State Implementation Plan estimated that a 25-mile network of bicycle facilities would result in a 1 percent modal shift to bicycles and a corresponding 0.4 percent reduction in air pollutants."[27]

Implementation

"A major barrier to implementation are missing links in routes such as non-continuous bike routes. Other factors that have limited bicycling include lack of safe routes to work destinations, conflicts with traffic laws that give preference to autos, and lack of facilities to accommodate these activities (e.g., bike racks or access to showers)."[28]

Funding, safety, maintenance, and climate issues can also affect how successful bicycle and pedestrian infrastructure improvements are in encouraging mode shifts. The increased vitality of commercial areas and increased transit revenues can help increase the political viability of these infrastructure improvements."
Land use decisions and implementation of traffic calming measures are generally implemented at the local level. Fairfax, Virginia, and Charlotte, North Carolina are examples of SAMI cities that have institutionalized traffic calming policies.

- **Ridesharing-oriented Infrastructure Increases[29]**

Description

Ridesharing, by reducing per person vehicle miles traveled, can reduce overall emissions. The public sector can encourage ridesharing by providing infrastructure improvements such as building or designating high-occupancy vehicle (HOV) lanes on highways and building park-and-ride lots. HOV lanes, by increasing the number of people per vehicle, can reduce travel time, the number of vehicles on the road, and per person emissions. However, the increased capacity on non-HOV roads may induce demand and reduce net benefits.
Park-and-ride lots provide central collection points for individuals participating in carpools, vanpools, and shuttle services. Park-and-ride lots are often established in conjunction with bus or rail service but may also provide direct access to HOV lanes.

Effectiveness

HOV lanes are effective mainly during peak travel times on heavily congested freeways and arterials. HOV restrictions on one corridor may cause shift in traffic to other corridors. It has been estimated that HOV restrictions may create 1.4% reductions in vehicle miles traveled in major metropolitan areas. HOV lanes may also divert passengers from using transit.

Park-and-ride lots have limited emissions reduction potential because they reduce the length of trips but not the number of trips. The effectiveness of park-and-ride lots is particularly tied to the available transit and ridesharing options. They are most appropriate in urban areas where long-

[26] Hagler Bailly. *Strategies to Reduce GHG Emissions from Passenger Transportation in Urban Canada*. Draft Final Report. May 1999.
[27] *Bicycle and Pedestrian Programs.* EPA420-S-98-002. July 1998.
[28] *Bicycle and Pedestrian Programs.* EPA420-S-98-002. July 1998.
[29] U.S. DOT/FHWA. *Transportation and Global Climate Change: A Review and Analysis of the Literature.* DOT-T-97-03. June 1998.

distance commutes are common. Increases in carpool availability also may negatively impact transit ridership. In addition, the increased capacity may create induced demand.

Implementation

There are financial and environmental considerations in establishing both HOV lanes and park-and-ride lots. These include capital construction costs, right-of-way waivers, noise barriers, and planning and design factors. Public concerns may include the right number of passengers to require in HOV lanes and the loss of access to certain corridors. Publicity campaigns will be needed to explain the role of HOV lanes in reducing congestion and alleviating air quality concerns. A strong enforcement program will also be needed to ensure that the vehicles in the HOV lanes have the right number of passengers.

- **Coordination/Information/Marketing for SOV Alternatives**[30]

Description

The public sector can encourage the use of single-occupancy vehicle alternatives through information and marketing campaigns. The public sector can also work to coordinate private and public programs to ensure that people have the widest range of choices possible.

Single-occupancy vehicle incentives are used to encourage commuters and other drivers to use alternatives to driving alone. By providing alternatives to single occupant vehicle drivers, vehicle miles of travel and congestion (and congestion-related emissions) can be reduced. Incentives can include direct subsidies for transit use or ridesharing, parking pricing systems that favor high occupancy vehicles, and guaranteed ride home programs.

Effectiveness

The costs and benefits of regional, state, and local rideshare incentive programs are difficult to measure because it is difficult to determine the relationship between promotional efforts and vehicle miles traveled and emission impacts. These efforts tend to be in support of in-house employer programs. There appears to be no evaluation that has estimated the impact of promotional programs above and beyond that attributable to the employer programs. While these efforts improve the effectiveness of employer-based ridesharing programs, produce results among unaffiliated commuters, and serve to maintain existing levels of shared ride modes, it is difficult to quantify these results.[31] Given this, we would analyze these impacts as part of a package. Typically these packages show substantial reductions, from 1.5% to 3.5% of regional VMT. [32]

- **Incentives for Infill and Transit-oriented Development**

Strategy Description

This strategy involves providing incentives for developers to increase the amount and density of development in areas that are already established, particularly in areas near transit stations. Incentives could include a reduction in regulatory requirements or zoning restrictions, or increased flexibility in zoning, such as increased density allowances. Incentives can also include monetary incentives, such as support in securing a loan, tax increment financing, or provision of additional public services.

---

[30] *Commute Alternative Incentives.* EPA420-S-98-003. July 1998.

[31] Commute Alternative Incentives. EPA420-S-98-003. July 1998.

[32] ICF Consulting, Evaluation of Transportation and Land Use Alternatives for the Atlanta Region," for the Georgia Regional Transportation Authority, April 4, 2000.

Public infrastructure spending can also be used to increase the attractiveness of older urban areas and spur increased private sector development. Localities throughout the U.S. have used public support for libraries, post offices, sports facilities, and parks to increase the attractiveness of older urban areas. Some states have also implemented broader land use strategies to target development to established areas by targeting public infrastructure investments, such as investments in school renovations/modernizations, to older areas.

In addition to incentives for infill, this strategy includes use of disincentives for greenfield development. Disincentives include developer impact fees that raise the cost of development in areas with limited infrastructure and public services.

Effectiveness

A recent analysis of infill development in Atlanta using transportation modeling tools suggests that additional development in the Atlantic Steel site in Midtown Atlanta would result in 12 to 34 percent less vehicle miles of travel than placing the same type of development in more suburban parts of the region. Good TOD site design would reduce VMT by another 5 percent.[33]

The effectiveness of incentives for infill development depends on:

1. **Existing transportation and land use patterns** – In order to be transit-oriented, development must be focused around a transit station or lines with frequent service. Typically, transit-oriented development is proposed in the areas surrounding fixed rail transit stations, such as light-rail or heavy-rail. Infill development, however, can be encouraged in many places and TOD can also be focused around bus routes.

2. **Rates of growth in development** – These incentives only affect new development; as a result, they are most effective in fast growing metropolitan areas.

3. **The extent to which developers respond to the incentives** – Developer responses depend on the level of incentives and disincentives that are offered, as well as market characteristics, such as land costs and demand for different types of developments (e.g., single-family homes, townhouses, multi-unit housing).

4. **Effects on vehicle travel and transportation system performance** – A number of regional analyses of alternative development patterns suggest that more compact, transit-focused development patterns result in less vehicle travel and fewer air pollutant emissions from transportation than more dispersed development patterns, even if localized traffic increases in some areas.[34]

Implementation Issues

Land use planning is a local issue largely under local control, which makes broader state-level or regional approaches difficult to implement. Still, a number of states have had success in targeting development toward established areas, including Washington, Oregon, and Maryland. These states use a variety of regulatory and state funding mechanisms to manage growth. The Georgia Regional Transportation Authority has the ability to declare local jurisdictions “non-cooperating” on transportation and land use planning, and withhold state funds.

[33] U.S. Environmental Protection Agency. “EPA and Atlantic Steel: Supporting Environmental Excellence and Smart Growth.” EPA 500-F-98-264, August 1999. p. 5.

[34] Hagler Bailly. *The Effects of Urban Form and Travel and Emissions: A Review of the Literature.* Prepared for U.S. Environmental Protection Agency. 1999.

Infill development proposals often suffer from a not-in-my-backyard (NIMBY) resistance, with the addition of mixed use developments and higher densities often opposed by home-owners in established neighborhoods, who fear that multi-family housing will have an adverse effect on property values. On the other hand, some communities support infill development strategies as a means to preserve the vitality of older communities, reduce vehicle dependency, and improve quality of life.

- **Incentives for Employer-Provided TDM Programs**

Strategy Description

State and local governments can provide tax incentives and/or matching funds for employers to implement transportation demand management (TDM) programs. Employer TDM programs include a wide variety of measures focused on reducing single occupant vehicle use for commuting. The most common elements of employer-based TDM programs include commute benefit programs that cover some of the cost of commuting by transit, vanpool, carpool, or bicycle or walking (e.g., such as providing a transit benefit or providing free parking for carpools). Employer-based TDM programs can also include preferential parking, telecommuting programs, and ridesharing services.

Employer-based transportation management programs principally serve home-to-work trips in urban areas with populations of 50,000 or more. The commuter market represents the strongest potential of any set of trips for increasing carpooling, reducing vehicle trips, and reducing VMT, particularly in larger metropolitan areas.

Effectiveness

A number of states and localities have implemented incentive programs to encourage employers to offer their employees commute benefits. Effectiveness varies widely with employer commitment. Most employers see excellent results with moderate commitment. The following examples suggest the potential with high employer commitment:

> Kaiser Permanente's KaiserRide (California): One-third of healthcare provider KP's work force uses transportation alternatives an average of three days per week, eliminating 48 million miles of driving per year.
>
> University of Washington U-PASS discount transit pass & parking pricing: Between 1990 and 1999 (a time of declining transit ridership generally), UW-Seattle transit ridership grew 68%. Only 25% of commuters to campus drive alone.
>
> Minor & James Medical Clinic, Seattle, Washington: All 340 employees receive an Annual Flex Pass, good for free transit in King County, 24/7/365. (The pass retails for $1,746) No parking is provided at the clinic, except for employees who are required to work late nights. Guaranteed ride home program paid for. 80 percent of the employees take transit to work daily.

When moderately aggressive assumptions about implementation are analyzed in a regional travel model, these employer-based TDM packages typically show substantial reductions, from 1.5% to 3.5% of regional VMT. [35]

[35] ICF Consulting, Evaluation of Transportation and Land Use Alternatives for the Atlanta Region," for the Georgia Regional Transportation Authority, April 4, 2000.

Implementation Issues

Incentives generally require public funding through subsidies or tax credits that reduce government revenues.
There are a number of reasons that employers may be hesitant to participate in commute programs. Some common concerns by employers are that the subsidies will disappear and that they will be burdened with additional costs or will need to eliminate a commute benefit program.

Commute benefit programs can help businesses attract and retain employees and improve productivity. Telecommuting programs, in particular, potentially can improve productivity and worker morale and help to attract employees who may live far from the workplace. They also can reduce costs for office space.

Typically the positive aspects outweigh the negative. US EPA launched in October 2000 its Commuter Choice Leadership Initiative, with a goal of recruiting firms across the nation to commit to providing a variety of employer-based commute options. At the October launch, four state and local governments and seven major corporations including Nike and Intel committed to the program. EPA anticipates signing up 1,000 employers over the next two years.[36] EPA anticipates success in part because such programs help recruit staff in a tight employment environment, and because they save firms and institutions money.[37] For example, faced with traffic jams around campus and demand for 2,500 new parking spaces, Cornell University, a large university in rural upstate New York, developed a program that reduces the number of vehicles brought to campus each day by 26%. In doing so, Cornell preserved 13 acres of campus green space, averted the need for a 1,200-space parking structure, and saves $3 million a year in parking space construction, debt service, and maintenance costs.

- **Incentives to Encourage Purchasing Low Emission Vehicles**

Strategy Description

This strategy involves providing a pricing incentive to encourage people to purchase low emission vehicles. Two major types of incentives/disincentives serve this purpose: 1) implementing a subsidy for the purchase of low emission vehicles; or 2) implementing a feebate program that taxes high-emission vehicles and offers rebates to lower the purchase price of low-emission vehicles.

These vehicle pricing programs can be designed to target the broad consumer market or different segments of the market. For example, New York State Energy & Research Administration (NYSERA) implemented a subsidy program to encourage taxi cab operators to convert their vehicle fleets to alternative fuels. Programs can similarly be targeted to fleet operators, such as rental car companies.

Vehicle tax and feebate programs have typically been discussed in the context of fuel economy rather than emissions. All new vehicles are required to meet an emissions standard, whereas the fuel economy standard (CAFE) is a fleetwide average. Federal taxes on vehicles with very low fuel economy – “gas guzzler” taxes – are currently being imposed and affect a small percentage of vehicle sales.

[36] John J. Fialka. “Environmental Agency Plans to Offer Incentives to Curb ‘Sprawl’ Pollution,” *The Wall Street Journal*, October 18, 2000.
[37] US EPA, “Commuter Choice Benefits: The Environment, the Community, the Bottom Line,” October 2000, EPA 420-F-00-029.

Effectiveness

The effectiveness of subsidies and feebates on air pollutant emissions depends on:

1. **Rate of turnover in the vehicle fleet** – Since these incentives only affect new vehicle purchases, they only affect the fleet of new vehicles that are purchased each year and a number of years are required for the full impact to be observed.

2. **The level of subsidy / feebates set -** The level of the incentive affects the degree to which consumers respond to the program. A large enough incentive would need to be provided to make low emission vehicles cost competitive with standard vehicles. (the vehicles also need to be comparable in terms of features that customers desire).

3. **Responsiveness of consumers and manufacturers to the tax/feebate –** In addition to costs of vehicles, consumers care about vehicle features, including vehicle size, comfort, and attractiveness. The responsiveness of consumers to the incentive depends in part upon the range of low-emission vehicles available to them and the features of those vehicles.

Lawrence Berkeley Laboratory (LBL) estimated that a relatively moderate feebate (one with a $500 differential between a 20 mpg and 25 mpg vehicle) could achieve a 15 percent improvement in new car fuel economy by 2010 over levels expected without feebates.

Since all new vehicles must meet an emissions standard, there is limited variation in emission rates among vehicles in a particular vehicle category (e.g., automobiles, light trucks). A subsidy or differential tax could be formulated to encourage a shift from light trucks to automobiles or to encourage a movement toward low-emission vehicles.

Implementation Issues

Feebates can be structured to be revenue-neutral or revenue-generating for governments. Subsidies for the purchase of low-emission vehicles require government support.

- **Vehicle Retirement / Buyback Programs**[38]

Strategy Description

Vehicle retirement programs, also called scrappage programs, involve offering a financial incentive to voluntarily remove a high-emissions vehicle from use. They operate by paying a fee to owners of older vehicles who volunteer their vehicles to be scrapped, thus removing them from use. Vehicle retirement/ buyback strategies are founded on the fact that a small portion of older vehicles produces a disproportionate share of emissions. This imbalance is largely because older vehicles were subject to less stringent emission standards than newer vehicles and emissions tend to increase with vehicle age due to wear on the vehicle and emission control technology. The fee or "bounty" can be a fixed price per scrapped vehicle or the program could offer different prices for different model years based on their individual emission characteristics.

Vehicle retirement / buyback programs have been implemented on a sporadic basis in a number of regions. Unocal operated a program called SCRAP that retired nearly 8,400 pre-1971 vehicles in the Los Angeles area in 1990. The U.S. Generating Company purchased 125 pre-1980 vehicles in Delaware in 1992. The Illinois Cash for Clunkers Project was conducted in 1992 by the Illinois Environmental Protection Agency, with help from seven corporate sponsors. The project, which

[38] U.S. Environmental Protection Agency. "Accelerated Retirement of Vehicles." *Transportation and Air Quality TCM Technical Overviews.* (EPA420-S-98-001), July 1998.

retired 207 vehicles from model-years 1968 to 1979, was unique in that it offered a variable bounty depending on model-year. Overall, bounties ranged from $647 for a 1968 vehicle to $902 for a 1979 vehicle.

A more ambitious and longer lasting program is included in the California SIP. The program calls for the accelerated retirement of large numbers of older, higher-emitting vehicles in the South Coast Air Basin from 1999 through 2010 through the activities of privately operated voluntary accelerated vehicle retirement enterprises. The SIP commits the program to achieving a 25 ton per day reduction in emissions of reactive organic gases and oxides of nitrogen in 2010.

Effectiveness

The effectiveness of vehicle retirement programs largely depends on:

1. the number of vehicles retired due to the program (which depends in large part on the fee provided for scrappage and the organization of the program),

2. the use and characteristics of scrapped vehicles, and

3. the use and characteristics of replacement vehicles.

The amount of the bounty is a critical variable in a scrappage program. If the bounty is too low, the program will not attract enough vehicles to have a measurable impact on air quality. If the bounty is too high, the program will tend to attract vehicles that are newer and cleaner, which would reduce the program's overall cost-effectiveness. For the most part, actual scrappage programs have offered somewhere between $500 and $1,000 per scrapped vehicle.

Unlike many other emission reduction programs, scrappage programs may be more effective if they are limited in duration because a long-lasting program is less likely to encourage early retirement. Under a continuous or long-running program, vehicles with no remaining lifetime may end up being purchased by scrappage programs rather than being "naturally retired," as they would have been in the absence of these programs. In addition, the cost-effectiveness of a scrappage program is likely to decline over time as the pool of dirty vehicles is reduced.

Programs should be designed to ensure that scrapped vehicles actually are contributing to air quality problems in the region. Eligible vehicles should also be required to be driven to the scrap site and should have fully functional components to ensure that bounties are not paid on previously retired vehicles. Eligibility should also be linked to a vehicle's registration in the program area to prevent the scrappage of a vehicle imported into the region.

The net emission reductions for a particular scrapped vehicle depends on the total emissions the vehicle would have emitted over its estimated remaining lifetime minus the emissions from a replacement vehicle (if any) driven over the same time period. Given that typical bounties are low compared to the price of a new vehicle, this suggests that many participants either did not use the vehicle very often, were going to replace the vehicle anyway, or will replace their scrapped vehicles with used vehicles. Emission reductions are limited when high-polluting vehicles are replaced by similar vehicles. Emission benefits are also limited if vehicle owners drive the replacement vehicle significantly more than the original vehicle. Vehicle use tends to decline with vehicle age, with a new vehicle typically drive about twice as many miles as an automobile 10 years or older.

Implementation Issues

Implementing a scrappage program requires a source of money to pay the bounty. If the administrator of the program is a public agency, obtaining the necessary funds may be difficult. Programs operated by private companies have largely been implemented to offset emissions elsewhere in the company. While the flexibility to implement such programs may lower the cost of air pollution, it does not result in additional emission reductions if they simply offset other emissions.

The effectiveness of scrappage programs can be improved by linking them to programs that are designed to measure the emissions of individual vehicles, such as inspection and maintenance (I/M) programs and remote sensing programs. These programs can be used to help ensure that only dirty vehicles are scrapped.

Vehicle eligibility for scrappage programs must be well-defined. A simple eligibility criterion is vehicle age (or model year).

- **Provide Alternative Fuel Vehicle (AFV) Infrastructure**

Strategy Description

A barrier to purchasing an alternative fueled vehicles (AFVs) is that facilities are not widely available to refuel vehicles that do not run on gasoline or diesel fuel. This strategy involves developing fueling stations for AFVs and programs to encourage conversion of vehicles to alternative fuels.

Effectiveness

The effectiveness of this strategy depends on:

1. the extent to which infrastructure is a barrier to the purchase and use of AFVs

2. rate of turn-over in the vehicle fleet

There is a wide range of estimates of effectiveness that require further discussion to narrow down.

Implementation Issues

Providing infrastructure is expensive, and the first question would be the distribution of costs.

- **Clean Diesel Fuel Technology**[39]

Strategy Description

Diesel fuel, like all petroleum-based fuel, can be formulated in a number of ways. A clean diesel program would seek to accelerate the adoption of a “clean” diesel fuel, i.e., a fuel low in density, high in cetane, and low in both monoaromatics and polyaromatics. US EPA is currently examining diesel fuel standards. A SAMI strategy would want to take account of the federal strategy, but while that strategy is being formulated, this analysis gives a sense of the magnitude of potential reductions available from clean diesel.

[39] See US EPA, Draft Regulatory Impact Analysis: Control of Emissions of Air Pollution from Highway Heavy-Duty Engines, DRAFT, U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Mobile Sources, August, 1999.

Effectiveness[40]

The following chart, from an EPA study, suggests the potential reductions available. The Table summarizes percent changes in predicted results for two fuels, a blend representative of current U.S. diesel fuel (based on national fuel surveys for 1994 and 1995), and a "clean" diesel fuel.

Combined Effects Fuel Properties on Predicted Emissions from Phase 2 Testing of the Heavy-duty Engine Working Group Project (Reference values for NOx, HC, and HC+NOx of 2.57 g/hp-hr, 0.13 g/bhp-hr, and 2.7 g/bhp-hr respectively were used. Negative percentages represent a decrease in emissions)

	Fuel Property				Predicted Emission Change		
	Density kg/m^3	Cetane Number	Mono-aromatics %	Poly-aromatics %	% Change in NOx vs. "Light" at 2.57g/bhp-hr level	% Change in HC vs. "Light" at 0.13 g/bhp-hr level	% Change in HC+NOx vs. "Light" at 2.70g/bhp-hr level
Average U.S. Diesel Fuel	845	45	25	9			
"Light", High Cetane, Low Aromatic Fuel	830	52	10	2.5	-7.2	-25.8	-8.4

We used a conservative 5% emissions reduction assumption.

Implementation Issues

Clean Diesel implies a variety of changes to both fuel production and engine manufacture, the costs of which are beyond the scope of this document to review. The EPA Regulatory Impact analysis for EPA's proposed new diesel standards suggests that the costs per truck could be in the low hundreds of dollars.[41]

[40] *Ibid.*, Table 3-6, p. 35.
[41] *Ibid.*, Table 5-7, p. 95.

Summary of Incremental Costs to Meet the Proposed Otto-cycle Vehicle Emission Standards

	Chassis-based Standards	Engine-based Standards
Catalyst	$160	$150
On-board Diagnostics	$80	$45
ORVR	$7	--
Other Emissions Hardware	$50	$53
Total Hardware	**$297**	**$248**
Fixed Costs	$5	$39
Operating Costs (ORVR)	-$6	--
Total Incremental Cost	**$296**	**$287**

- **TECHNOLOGIES/POLICIES CHOSEN FOR ANALYSIS**

ICF presented the 14 policy approaches and technologies to the SAMI Public Advisory Committee at a June 2000 meeting in Atlanta. The policy committee asked ICF to model 10 of these:

1. Increase parking pricing
2. Gas tax
3. VMT-based pricing
4. Transit, Bicycle, and Pedestrian-Oriented Development
5. Employer-based TDM
6. Lower Transit Fares and Improve Service
7. Aggressive AFV program
8. Increase Rideshare-Oriented Infrastructure
9. Clean Diesel-Fuel Technology
10. Inspection and Maintenance

Thus, the Committee directed ICF eliminate AFV infrastructure, Vehicle retirement, Road pricing, and Marketing for SOV Alternatives. The Committee directed ICF to add one measure for analysis, the Clean Diesel Fuel Technology. The Committee based its deliberations on a combination of potential impact and potential political acceptability; those deliberations were not shared with ICF.

- **ANALYSIS OF TRANSPORTATION MEASURES**

- **General Assumptions**

The transportation sector emissions baseline was developed based on the emissions inventories already developed by SAMI for highway vehicles as part of its integrated assessment. The existing SAMI emissions inventory is extremely detailed, and includes estimates of vehicle miles of travel (VMT) and emissions at the county level, for each vehicle class (e.g., LDGV, LDGT1, LDGT2, HDGV, MC, LDDV, LDDT, HDDV),[*] for each of 12 road types (rural interstates, rural other principal arterials, rural minor arterials, rural major collectors, rural minor collectors, rural local roads, urban interstates, urban other freeways and expressways, urban other principal arterials, urban minor arterials, urban collectors, urban local roads). Emission estimates were developed based on emission rates developed for each month (based on temperature, vehicle type, and vehicle speed on each road type) and then weighted to achieve annual average emission rates for 2010 and 2020 for each vehicle type and road type.

Because the great level of detail and complexity in these inventories, our approach used a simplified version of this detailed inventory. The eight individual vehicle classes were aggregated into two classes: light-duty vehicles (which account for LDGV, LDGT1, LDGT2, MC, LDDV, and LDDT) and heavy-duty vehicles (which account for HDGV and HDDV). Also, road types were collapsed into three classes: urban interstates and other freeways and expressways, other urban roads, and rural roads.

- **Vehicle Activity Assumptions**

VMT growth was estimated as follows:

1. Growth from 1990 to 1995 was based on VMT data from the Federal Highway Administration's Highway Statistics publication.

2. Growth factors for 1995 to 2010 were developed for each Metropolitan Statistical Area (MSA) and rest-of-state area by vehicle class by multiplying national VMT growth factors for each vehicle type (from EPA's MOBILE4.1 Fuel Consumption Model (FCM)) by the ratio of MSA population growth to national population growth.

3. Annual growth rates for 2010 to 2040 were assumed to be the same as those indicated in the FCM for 2010 to 2020.

4. Georgia provided its own 2010 VMT database based on the State's VMT projections, and 2040 VMT for Georgia was then calculated using the growth factors discussed above.

- **Vehicle Emission Rate Assumptions**

1. The emission rates used for the baseline were those from SAMI's "On the Way" inventory, which accounts for all emission control measures that have been promulgated (including the 1990 Clean Air Act Amendments, the 1 hour ozone standard, and several mobile source reductions), as well as recent federal regulatory actions that are expected to be implemented in the near future but that had not yet been promulgated. These include EPA's call for regional NO_x reductions and the Tier 2 and low sulfur fuel rules for mobile sources.

2. VOC, NO_x, and CO emission rates were developed from EPA's MOBILE5b model.

- **ANALYSIS APPROACH**

ICF began with the baseline VMT and emissions database prepared by E.H. Pechan. For each of the policies, we developed a spreadsheet model that selected the affected VMT, allowed us to input relevant costs or other factors, and allowed us to input a response elasticity. The model then calculated the estimated VMT reductions.

[*] LDGV = Light Duty Gas Vehicle, HDGV = Heavy Duty Gas Vehicle; D = Diesel, and T = Truck. MC = Motorcycle.

Affected VMT: the descriptions of the policies/approaches described what kind of VMT would be affected by each policy or approach. The model allowed us to select VMT according to the following criteria, for each modeled policy/approach:

1. Urban area type
2. Rural area type
3. Highway road type
4. Other road type
5. Light Duty vehicle type
6. Heavy Duty vehicle type

Response rates and other assumptions: The efficacy of each policy or approach depends on the response of the affected drivers and/or vehicle purchasers. Response rates were selected from the ranges given in the descriptions of each policy/approach, above. Those rates, in turn, had been selected from the literature.

Other adjustments were made as necessitated by the nature of the policy or approach. For example, although ridesharing incentives are technically applicable to all urban VMT, in practice more than half of all urban VMT is probably not amenable to ridesharing given the spatial distribution of trips, and trip purposes that are not easily shared. Thus, we adjusted the “affected VMT” down before applying a response rate.

Detailed inputs and calculations are shown in the section following: Transportation Inputs and Calculations.

The assumptions used were near the high end of reasonable ranges for key variables. That is, given the Policy Advisory Committee’s desire to know what transportation policies *could* contribute, we erred on the side of over-estimating the impacts of these policies. If results show that a policy has potential to contribute to regional emissions reductions, then it may be worth further analysis that is beyond the scope of this work.

- **RESULTS**

- **VMT Results**

Policy	***Brief description of assumed stringency***	***2010 VMT reduction***	***2040 VMT reduction*** *(or equivalent for fuels policies)*
Increase parking pricing	$3/day increase	3.4%	4.2%
Gas tax	$0.50/gallon increase	5.3%	6.6%
VMT-based pricing	$0.10/mile (doubles the marginal cost of driving)	17.5%	26.2%
Transit, Bicycle, and Pedestrian-Oriented Development	10% of urban areas affected by 2010, 40% by 2040	1.5%	6.0%
Employer-based TDM	Cuts average commuting by 12% by 2010, by 20% by 2040	1.8%	3.0%
Lower Transit Fares and Improve Service	Fares decrease 50%, service improves 25%	2.4%	2.4%
Aggressive AFV program	♦ By 2010: 10% of travel converted to LEV, 5% to ZEV ♦ By 2040: 50% of travel converted to LEV, 25% to ZEV. ♦ 40% VMT-equivalency of LEV II to conventional vehicles in 2010. ♦ 20% VMT-equivalency of LEV II to conventional vehicles in 2040.	5.6%	32.7%
Increase Rideshare-Oriented Infrastructure	Ridesharing attracts 20% of urban highway trips	1.0%	1.0%
Clean Diesel-Fuel Technology	♦ By 2010: 50% of public sector heavy duty VMT penetrated by clean diesel vehicles, 5% of private sector heavy duty VMT ♦ By 2040: 100% of public sector heavy duty VMT penetrated by clean diesel vehicles, 20% of private sector heavy duty VMT (See note below)	.8%	10%
Inspection and Maintenance	EPA-estimated benefits of IM240 applied to all SAMI VMT	6.2%	?%

We have not summed the potential reductions because doing so would produce substantial double-counting. While in general the elasticities chosen are optimistic, any single policy could probably achieve near the high end of its estimated benefits with a comprehensive effort. However, reductions of 40% in region-wide VMT are clearly unreachable, certainly in the 2010 timeframe.

- **Emissions results**

SAMI is ultimately interested in emissions reductions, not VMT reductions. ICF is conducting the analysis in VMT terms because the requested product is a VMT database. That database is then used by E.H. Pechan to perform emissions modeling. Thus we are performing even the analysis of alternative-fuel and clean-diesel policies—policies which aim to reduce emissions, not VMT—in VMT terms.

For this stage of the analysis, however, SAMI needs to know whether various strategies will have a large enough impact on regional emissions to merit further analysis. Thus we have converted the VMT reductions above into estimated emissions reductions. We have applied the VMT reductions to the baseline mobile-source NOx inventory for 2010 and 2040.

Policy	***2010 emission reduction, tons NO_x***	***2040 emission reduction, tons NO_x***
Increase parking pricing	37,483	65,412
Gas tax	58,429	102,791
VMT-based pricing	192,925	408,048
Transit, Bicycle, and Pedestrian-Oriented Development	16,536	93,446
Employer-based TDM	19,844	46,723
Lower Transit Fares and Improve Service	26,458	37,378
Aggressive AFV program	61,736	510,060
Increase Rideshare-Oriented Infrastructure	11,024	15,574
Clean Diesel-Fuel Technology	8,819	155,744
Inspection and Maintenance	68,902	n.a.

Notes:

1. Rideshare Infrastructure stands out as offering relatively minor benefits in either timeframe.

2. While Clean Diesel Technology looks promising in 2040, it may be appropriate to incorporate these benefits into the baseline, given the new diesel heavy-duty diesel emission standards and low sulfur diesel fuel rule proposed by EPA on May 17, 2000.

3. Expanding IM240 to the entire region may offer substantial benefits in the 2010 timeframe. There is very little basis for estimating benefits from I&M in the 2040 timeframe.

- **Transportation inputs and calculations**

Strategy 1: Increase Parking Pricing

Approach: Implement a variety of mechanisms to increase average perceived daily parking costs by $3.00.

Target: Reduce light-duty VMT in urbanized areas.

Limitations: Most employers subsidize employee parking or own their parking.

Procedures, Assumptions, and Calculations:

1	Urban	Include Urban area type (Urban=yes, blank=no)
2		Include Rural area type (Rural=yes, blank=no)
3	Highway	Include Highway road type (Highway=yes, blank=no)
4	Other	Include Other road type (Other=yes, blank=no)
5	Light Duty	Include Light Duty vehicle type (Light Duty=yes, blank=no)
6		Include Heavy Duty vehicle type (Heavy Duty=yes, blank=no)
7	30%	Multiply VMT by the percent of travel that is associated with commuting
8	$0.10	Average marginal cost of commute trips ($/vmt)
9	22	Average daily vmt (two-way) for commute trips
10	$0.50	Average (baseline) per-trip costs commute trips (parking, tolls)
11	$2.70	Calculate total out-of-pocket per-trip cost
12	$3.00	Parking price increase (daily)
13	$5.70	Calculate average (after) per-trip costs commute trips (parking, tolls)
14	111%	Calculate percentage increase in marginal cost per daily commute
15	0.2	Elasticity of daily commute VMT wrt price (through 2010)
16	0.25	Elasticity of daily commute VMT wrt price (through 2040)
17	22%	Calculate expected percent reduction in commute VMT (based on increase in price and elasticity) through 2010
18	28%	Calculate expected percent reduction in commute VMT (based on increase in price and elasticity) through 2040
	Assumptions	Can be altered
	Calculations	Should not be altered

Results:

19	605,178,450	2010 Total VMT (000's)
20	307,961,630	2010 VMT (000's) subject to strategy
21	20,530,775	2010 VMT (000's) reduction from strategy
22	3.39%	2010 VMT reduction from strategy (percent)
23	951,485,385	2040 Total VMT (000's)
24	479,353,279	2040 VMT (000's) subject to strategy
25	39,946,107	2040 VMT (000's) reduction from strategy
26	4.20%	2040 VMT reduction from strategy (percent)

Strategy 2: Gas Tax

Approach: Implement a 50 cent per gallon fuel tax on gasoline and diesel (possibly along with aviation, marine, and other motor vehicle) fuels.

Target: Reduce VMT virtually universally.

Limitations: Strategy affects all VMT at least partially. However, it would have somewhat less impact on heavy-duty truck travel, and for light-duty vehicles would be less effective in rural areas than urban areas because of lack of transportation alternatives.

Procedures, Assumptions, and Calculations:

1	Urban	Include Urban area type (Urban=yes, blank=no)
2	Rural	Include Rural area type (Rural=yes, blank=no)
3	Highway	Include Highway road type (Highway=yes, blank=no)
4	Other	Include Other road type (Other=yes, blank=no)
5	Light Duty	Include Light Duty vehicle type (Light Duty=yes, blank=no)
6	Heavy Duty	Include Heavy Duty vehicle type (Heavy Duty=yes, blank=no)
7	95%	Multiply VMT by the percent of travel subject to gas tax
8	$0.08	Average (baseline) marginal cost of travel ($/vmt)
9	35	Average daily vmt
10	$0.50	Average (baseline) daily discrete costs of travel (parking, tolls)
11	$3.13	Calculate total (baseline) out-of-pocket daily cost
12	$0.10	Average (with strategy) marginal cost of trips ($/vmt)
13	$4.00	Calculate total (with strategy) out-of-pocket daily cost
14	28%	Calculate percentage increase in out-of-pocket daily travel cost
15	0.2	Elasticity of daily VMT wrt price (through 2010)
16	0.25	Elasticity of daily VMT wrt price (through 2040)
17	6%	Calculate expected percent reduction in commute VMT (based on increase in price and elasticity) through 2010
18	7%	Calculate expected percent reduction in commute VMT (based on increase in price and elasticity) through 2040
	Assumptions	Can be altered
	Calculations	Should not be altered

Results:

19	605,178,450	2010 Total VMT (000's)
20	605,178,450	2010 VMT (000's) subject to strategy
21	32,195,494	2010 VMT (000's) reduction from strategy
22	5.32%	2010 VMT reduction from strategy (percent)
23	951,485,385	2040 Total VMT (000's)
24	951,485,385	2040 VMT (000's) subject to strategy
25	63,273,778	2040 VMT (000's) reduction from strategy
26	6.65%	2040 VMT reduction from strategy (percent)

Strategy 3: VMT-based Pricing

Approach: Implement a VMT-based auto registration or usage charge system.

Target: Reduce VMT virtually universally.

Limitations: Strategy affects all VMT at least partially. However, it might have less impact on heavy-duty truck travel, and for light-duty vehicles would be less effective in rural areas than urban areas because of lack of transportation alternatives.

Procedures, Assumptions, and Calculations:

1	Urban	Include Urban area type (Urban=yes, blank=no)
2	Rural	Include Rural area type (Rural=yes, blank=no)
3	Highway	Include Highway road type (Highway=yes, blank=no)
4	Other	Include Other road type (Other=yes, blank=no)
5	Light Duty	Include Light Duty vehicle type (Light Duty=yes, blank=no)
6	Heavy Duty	Include Heavy Duty vehicle type (Heavy Duty=yes, blank=no)
7	100%	Multiply VMT by the percent of travel subject to gas tax
8	$0.10	Average (baseline) marginal cost of travel ($/vmt)
9	35	Average daily vmt
10	$0.50	Average (baseline) daily discrete costs of travel (parking, tolls)
11	$4.00	Calculate total (baseline) out-of-pocket daily cost
12	$0.20	Average (with strategy) marginal cost of commute trips ($/vmt)
13	$7.50	Calculate total (with strategy) out-of-pocket daily cost
14	88%	Calculate percentage increase in out-of-pocket daily travel cost
15	0.2	Elasticity of daily VMT wrt price (through 2010)
16	0.3	Elasticity of daily VMT wrt price (through 2040)
17	18%	Calculate expected percent reduction in commute VMT (based on increase in price and elasticity) through 2010
18	26%	Calculate expected percent reduction in commute VMT (based on increase in price and elasticity) through 2040
	Assumptions	Can be altered
	Calculations	Should not be altered

Results:

19	605,178,450	2010 Total VMT (000's)
20	605,178,450	2010 VMT (000's) subject to strategy
21	105,906,229	2010 VMT (000's) reduction from strategy
22	17.50%	2010 VMT reduction from strategy (percent)
23	951,485,385	2040 Total VMT (000's)
24	951,485,385	2040 VMT (000's) subject to strategy
25	249,764,914	2040 VMT (000's) reduction from strategy
26	26.25%	2040 VMT reduction from strategy (percent)

Strategy 4: Transit, Bicycle, & Pedestrian-Oriented Development

Approach: Provide incentives to encourage high-density, mixed use development around major transit corridors and urban form to emphasize bicycle and pedestrian access.

Target: Reduce light-duty urban VMT.

Limitations: Strategy primarily affects light-duty VMT in urbanized (urban and suburban) areas. Would not substantially affect rural areas or heavy-duty trucks.

Procedures, Assumptions, and Calculations:

1	Urban	Include Urban area type (Urban=yes, blank=no)
2		Include Rural area type (Rural=yes, blank=no)
3	Highway	Include Highway road type (Highway=yes, blank=no)
4	Other	Include Other road type (Other=yes, blank=no)
5	Light Duty	Include Light Duty vehicle type (Light Duty=yes, blank=no)
6		Include Heavy Duty vehicle type (Heavy Duty=yes, blank=no)
7	30%	Likely reduction in VMT in areas where new development patterns are implemented.
8		
9		
10		
11		
12		
13		
14		
15	10%	Extent of implementation (through 2010)
16	40%	Extent of implementation (through 2040)
17	3%	Calculate expected percent reduction in VMT (based on reduction impact and implementation extent) through 2010
18	12%	Calculate expected percent reduction in VMT (based on reduction impact and implementation extent) through 2040
	Assumptions	Can be altered
	Calculations	Should not be altered

Results:

19	605,178,450	2010 Total VMT (000's)
20	307,961,630	2010 VMT (000's) subject to strategy
21	9,238,849	2010 VMT (000's) reduction from strategy
22	1.53%	2010 VMT reduction from strategy (percent)
23	951,485,385	2040 Total VMT (000's)
24	479,353,279	2040 VMT (000's) subject to strategy
25	57,522,393	2040 VMT (000's) reduction from strategy
26	6.05%	2040 VMT reduction from strategy (percent)

Strategy 5: Employer-based TDM

Approach: Provide incentives for employers to offer Commuter Choice benefits (e.g., transit or vanpool benefits, pre-tax commute benefit programs, and/or parking cash out), as well as promote telecommuting and ridesharing through preferential parking for carpools, employee trip coordinators, etc.

Target: Reduce light-duty VMT in urbanized areas.

Limitations: Strategy affects commute trips only for light-duty vehicles in urbanized areas. Would not substantially affect rural areas or heavy-duty trucks.

Procedures, Assumptions, and Calculations:

1	Urban	Include Urban area type (Urban=yes, blank=no)
2		Include Rural area type (Rural=yes, blank=no)
3	Highway	Include Highway road type (Highway=yes, blank=no)
4	Other	Include Other road type (Other=yes, blank=no)
5	Light Duty	Include Light Duty vehicle type (Light Duty=yes, blank=no)
6		Include Heavy Duty vehicle type (Heavy Duty=yes, blank=no)
7	30%	Multiply VMT by the percent of travel that is associated with commuting
8		
9		
10		
11		
12		
13		
14		
15	12%	Effectiveness of TDM measures for reducing daily commute VMT (through 2010)
16	20%	Effectiveness of TDM measures for reducing daily commute VMT (through 2040)
17	4%	Calculate expected percent reduction in commute VMT through 2010
18	6%	Calculate expected percent reduction in commute VMT through 2040
	Assumptions	Can be altered
	Calculations	Should not be altered

Results:

19	605,178,450	2010 Total VMT (000's)
20	307,961,630	2010 VMT (000's) subject to strategy
21	11,086,619	2010 VMT (000's) reduction from strategy
22	1.83%	2010 VMT reduction from strategy (percent)
23	951,485,385	2040 Total VMT (000's)
24	479,353,279	2040 VMT (000's) subject to strategy
25	28,761,197	2040 VMT (000's) reduction from strategy
26	3.02%	2040 VMT reduction from strategy (percent)

Strategy 6: Lower Transit Fares and Improve Service

Approach: Lower fares by an average of 50 percent and increase service (e.g., frequency) by 25 percent.

Target: Reduce light-duty VMT in urbanized areas.

Limitations: Fiscal constraints on operating subsides and on capital costs for rail systems.

Procedures, Assumptions, and Calculations:

1	Urban	Include Urban area type (Urban=yes, blank=no)
2		Include Rural area type (Rural=yes, blank=no)
3	Highway	Include Highway road type (Highway=yes, blank=no)
4	Other	Include Other road type (Other=yes, blank=no)
5	Light Duty	Include Light Duty vehicle type (Light Duty=yes, blank=no)
6		Include Heavy Duty vehicle type (Heavy Duty=yes, blank=no)
7	100%	Percent of travel (by VMT) that is divertible to transit service (e.g., parallels transit service)
8	2%	Current pax miles traveled share for transit trips
9	50%	Percentage decrase in transit fares
10	25%	Percentage increase in service
11		
12		
13		
14		
15	0.4	Elasticity of transit demand wrt price
16	0.8	Elasticity of transit demand wrt service
17	2.40%	Calculate expected percent reduction in VMT (based on fare decrease)
18	2.40%	Calculate expected percent reduction in VMT (based on service increase)
	Assumptions	Can be altered
	Calculations	Should not be altered

Results:

19	605,178,450	2010 Total VMT (000's)
20	307,961,630	2010 VMT (000's) subject to strategy
21	14,782,158	2010 VMT (000's) reduction from strategy
22	2.44%	2010 VMT reduction from strategy (percent)
23	951,485,385	2040 Total VMT (000's)
24	479,353,279	2040 VMT (000's) subject to strategy
25	23,008,957	2040 VMT (000's) reduction from strategy
26	2.42%	2040 VMT reduction from strategy (percent)

Strategy 7: Aggressive AFV Program

Approach: Introduce incentives, refueling infrastructure, and mandates to achieve 10% LEV / 5% ZEV by 2010 and 50% LEV / 25% ZEV by 2040. Assumes heavy-duty vehicles will be addressed under Clean Diesel strategy.

Target: Reduce VMT by conventionally fueled vehicles.

Limitations: Likely fiscal constraints on incentives and vehicle conversions / fueling infrastructure. Feasibility may be limited to urbanized areas, where fuel infrastructure is cost-effective.

Procedures, Assumptions, and Calculations:

1	Urban	Include Urban area type (Urban=yes, blank=no)
2		Include Rural area type (Rural=yes, blank=no)
3	Highway	Include Highway road type (Highway=yes, blank=no)
4	Other	Include Other road type (Other=yes, blank=no)
5	Light Duty	Include Light Duty vehicle type (Light Duty=yes, blank=no)
6		Include Heavy Duty vehicle type (Heavy Duty=yes, blank=no)
7	10%	Percent of travel converted to LEV by 2010
8	5%	Percent of travel converted to ZEV by 2010
9	50%	Percent of travel converted to LEV by 2040
10	25%	Percent of travel converted to ZEV by 2040
11		
12		
13		
14		
15	40%	VMT-equivalency of LEV II to baseline vehicles in 2040.
16	20%	VMT-equivalency of LEV II to baseline vehicles in 2010.
17	11.00%	Calculate expected percent reduction in VMT-equivalency of conventional vehicles for 2010.
18	65.00%	Calculate expected percent reduction in VMT-equivalency of conventional vehicles for 2040.
	Assumptions	Can be altered
	Calculations	Should not be altered

Results:

19	605,178,450	2010 Total VMT (000's)
20	307,961,630	2010 VMT (000's) subject to strategy
21	33,875,779	2010 VMT (000's) reduction from strategy
22	5.60%	2010 VMT reduction from strategy (percent)
23	951,485,385	2040 Total VMT (000's)
24	479,353,279	2040 VMT (000's) subject to strategy
25	311,579,631	2040 VMT (000's) reduction from strategy
26	32.75%	2040 VMT reduction from strategy (percent)

Strategy 8: Increase Ridesharing-Oriented Infratructure

Approach: Increase HOV and rideshare infrastructure to serve all urban freeways / expressways, primarily through add-a-lane HOV and park-and-ride facilities.

Target: Reduce light-duty VMT in urbanized areas.

Limitations: Travel patterns limit rideshare penetration rates; add-a-lane approach will likely induce new demand.

Procedures, Assumptions, and Calculations:

1	Urban	Include Urban area type (Urban=yes, blank=no)
2		Include Rural area type (Rural=yes, blank=no)
3	Highway	Include Highway road type (Highway=yes, blank=no)
4		Include Other road type (Other=yes, blank=no)
5	Light Duty	Include Light Duty vehicle type (Light Duty=yes, blank=no)
6		Include Heavy Duty vehicle type (Heavy Duty=yes, blank=no)
7	65%	Adjustment for targeted VMT to account for trips not using or affected by expressway travel. (Spatial / O-D adjustment)
8	50%	Adjustment for targeted VMT to account for single-person trips (errands, medical, time-of-day factors, other trips) not amenable to ride-sharing.
9		
10		
11		
12		
13		
14		
15	20%	Effectiveness of ride-sharing measures for reducing daily commute VMT (through 2010)
16	20%	Effectiveness of ride-sharing measures for reducing daily commute VMT (through 2040)
17	6.50%	Calculate expected percent reduction in VMT (through 2010)
18	6.50%	Calculate expected percent reduction in VMT (through 2040)
	Assumptions	Can be altered
	Calculations	Should not be altered

Results:

19	605,178,450	2010 Total VMT (000's)
20	99,492,881	2010 VMT (000's) subject to strategy
21	6,467,037	2010 VMT (000's) reduction from strategy
22	1.07%	2010 VMT reduction from strategy (percent)
23	951,485,385	2040 Total VMT (000's)
24	155,817,660	2040 VMT (000's) subject to strategy
25	10,128,148	2040 VMT (000's) reduction from strategy
26	1.06%	2040 VMT reduction from strategy (percent)

Strategy 9: Clean Diesel Fuel Technology

Approach: Achieve 50 percent (2010) and 100 percent (2040) penetration rates for public sector, and rates of 5 percent (2010) and 20 percent (2040) for the private sector. Could include some combination of improved engines, emission controls, fuel improvement, or alternative fuels.

Target: Reduce VMT by conventional heavy-duty vehicles.

Limitations: Possible fiscal constraints on vehicle conversions / fueling infrastructure. Private sector participation may require incemtives. Feasibility may be limited to urbanized areas, where fuel infrastructure is cost-effective.

Procedures, Assumptions, and Calculations:

1	Urban	Include Urban area type (Urban=yes, blank=no)
2	Rural	Include Rural area type (Rural=yes, blank=no)
3	Highway	Include Highway road type (Highway=yes, blank=no)
4	Other	Include Other road type (Other=yes, blank=no)
5		Include Light Duty vehicle type (Light Duty=yes, blank=no)
6	Heavy Duty	Include Heavy Duty vehicle type (Heavy Duty=yes, blank=no)
7	10%	Percent of heavy duty travel (by VMT) by public sector.
8	50%	Percent of public sector heavy duty VMT penetrated by clean diesel vehicles through 2010
9	5%	Percent of private sector heavy duty VMT penetrated by clean diesel vehicles through 2010
10	100%	Percent of public sector heavy duty VMT penetrated by clean diesel vehicles through 2040
11	100%	Percent of private sector heavy duty VMT penetrated by clean diesel vehicles through 2040
12		
13		
14		
15	5%	VMT-equivalency conversion factor of Clean Diesel to conventional vehicles in 2010.
16	5%	VMT-equivalency conversion factor of Clean Diesel to conventional vehicles in 2010.
17	9.03%	Calculate expected percent reduction in VMT-equivalency of conventional vehicles for 2010.
18	95.00%	Calculate expected percent reduction in VMT-equivalency of conventional vehicles for 2040.
	Assumptions	Can be altered
	Calculations	Should not be altered

Results:

19	605,178,450	2010 Total VMT (000's)
20	57,019,863	2010 VMT (000's) subject to strategy
21	5,146,043	2010 VMT (000's) reduction from strategy
22	0.85%	2010 VMT reduction from strategy (percent)
23	951,485,385	2040 Total VMT (000's)
24	100,666,411	2040 VMT (000's) subject to strategy
25	95,633,091	2040 VMT (000's) reduction from strategy
26	10.05%	2040 VMT reduction from strategy (percent)

Strategy 10: Inspection & Maintenance

Approach: Improve vehicle efficiency and emissions through aggressive I&M program implementation.

Target: Reduce VMT-equivalency by poorly maintained or high-emitting vehicles.

Limitations: Periodic I&M limited by periodic compliance or non-compliance.

Procedures, Assumptions, and Calculations:

1	Urban	Include Urban area type (Urban=yes, blank=no)
2	Rural	Include Rural area type (Rural=yes, blank=no)
3	Highway	Include Highway road type (Highway=yes, blank=no)
4	Other	Include Other road type (Other=yes, blank=no)
5	Light Duty	Include Light Duty vehicle type (Light Duty=yes, blank=no)
6		Include Heavy Duty vehicle type (Heavy Duty=yes, blank=no)
7	5%	Percent of travel (by VMT) by poorly maintained / high-emitting vehicles.
8	500%	VMT-equivalency conversion factor of poorly maintained / high-emitting vehicles.
9	30%	Percentage decrease in travel to be obtained by high emitting vehicles (through 2010)
10	15%	Percentage decrease in travel to be obtained by high emitting vehicles (through 2040)
11		
12		
13		
14		
15		
16		
17	6.90%	Calculate expected percent reduction in VMT-equivalency through I&M programs by 2010.
18	3.75%	Calculate expected percent reduction in VMT-equivalency through I&M programs by 2040.
	Assumptions	Can be altered
	Calculations	Should not be altered

Results:

19	605,178,450	2010 Total VMT (000's)
20	548,158,588	2010 VMT (000's) subject to strategy
21	37,822,943	2010 VMT (000's) reduction from strategy
22	6.25%	2010 VMT reduction from strategy (percent)
23	951,485,385	2040 Total VMT (000's)
24	850,818,974	2040 VMT (000's) subject to strategy
25	31,905,712	2040 VMT (000's) reduction from strategy
26	3.35%	2040 VMT reduction from strategy (percent)

- ## Building Energy Efficiency

The goal of this project is to assess the potential role of incentives to reduce energy use and emissions from both the building and transportation sectors of the eight state SAMI region. This chapter is focussed on the buildings sector. The scope of work includes both residential and commercial buildings. Industrial facilities are nor addressed. Energy use and related and emissions are projected for a variety of scenarios involving voluntary (incentive driven) implementation of energy efficiency packages in the years 2000, 2010, 2020, 2030, and 2040. The energy efficient technology packages encompass a broad range of technologies addressing the different energy end-use sources: space heating, space cooling, ventilation, hot water heating, and lighting. The energy efficiency measures in each package vary with each of three strategies (i.e., passive, active and aggressive incentive driven programs to promote the adoption of energy efficient upgrades).

The SAMI Region is composed of eight states: Alabama, Georgia, Kentucky, Tennessee, North Carolina, South Carolina, Virginia, and West Virginia. There is climatic variation within this region with some of the states being in mild climates (Kentucky, West Virginia, Virginia) and others being in hot climates (Alabama, Georgia, South Carolina, and Tennessee). There are also population distribution differences: Alabama (4,369,862), Georgia (7,788,240), Virginia (6,872,912), West Virginia (1,806,928), North Carolina (7,650,789), Tennessee (5,483,535), Kentucky (3,960,825), and South Carolina (3,885,736).

- **POTENTIAL BUILDING TECHNOLOGIES AND POLICIES**

- **Residential Buildings - New Construction & Retrofit**

From ICF Consulting's experience in residential energy efficiency (e.g., the ENERGY STAR® Homes program) over the last 5 years, ICF has identified the following ten energy efficient technologies as the most promising for residential buildings (new and existing). ICF has worked with builders, contractors, and manufacturers to develop a deep understanding of how homes are constructed, and the design changes that can most effectively improve energy performance. The most cost-effective energy efficiency technologies are listed below in approximate order of energy savings potential.

1. Duct Tightening
2. Air Sealing & Weatherization
3. Increased Attic Insulation
4. High Efficiency A/C Equipment / Systems
5. High Efficiency Heating Equipment Systems
6. High Efficiency Windows
7. Water Heating System Improvements (e.g., Low Flow, Tank Wrap, Lower Temperature)
8. High Efficiency Appliances (e.g., Refrigerator)
9. High Efficiency Lighting
10. Cool Roofs

- **Commercial Buildings - New Construction & Retrofit**

ICF Consulting has even more experience in the implementation of energy efficiency measures in commercial buildings. ICF has worked with thousands of commercial building owners participating in the ENERGY STAR Buildings Partnership Program. From this experience, the following technologies were identified as cost-effective energy efficiency measures for commercial buildings in each of the eight states in the SAMI region:

1. Building Commissioning , Tune-Up, and Baseline Benchmarking
2. High Efficiency Lighting Systems
3. Envelope Improvements (e.g., roof insulation, cool roof, window films)
4. High Efficiency Fan, Pump & Motor Systems (e.g., VSDs, high efficiency motors)
5. High Efficiency A/C Equipment / Systems
6. High Efficiency Heating Equipment Systems
7. Control Systems Improvements
8. Cool Roofs
9. Combined Heat and Power Systems
10. Photvoltaics

- **DESCRIPTION OF POTENTIAL TECHNOLOGIES AND POLICIES**

- **Residential Buildings (New Construction & Retrofit)**

The ten promising energy efficient technologies for the residential sectors are briefly described below.

1. **Duct Tightening**. Duct leakage is the most significant cause of energy losses in most houses.

2. **Air Sealing & Weatherization**. Air leakage through the home's envelope is the second largest cause of energy losses in most residential buildings.

3. **Increased Attic Insulation.** One of the more effective (and easy) energy efficiency upgrades is to add insulation to the attic of a home, especially older poorly insulated homes. This upgrade reduces both space cooling and heating energy use.

4. **High Efficiency A/C Equipment / Systems.** Space cooling is one of the largest energy end-uses in the southern states. Thus, high efficiency air conditioning equipment is one of the more effective upgrades.

5. **High Efficiency Heating Equipment** Systems. Space heating is a significant energy end-use, even in some southern states. High efficiency space heating equipment offers a significant potential to reduce energy use.

6. **High Efficiency Window**s. Solar heat gain through windows is one of the most significant causes of space cooling energy use in southern states. High efficiency (i.e., low-E) windows can reduce solar gains by more than 50%.

7. **Water Heating System Improvements.** Hot water energy use can be the second largest energy end-use in some homes. There are several effective upgrades for water heating systems, including: low flow faucets and shower heads, insulated water heater tank wrap, and reduced hot water temperature).

8. **High Efficiency Appliances.** There are several high efficiency appliances available in the market. Refrigerators and clothes washers are two of the more significant energy consuming appliances in homes. High efficiency models can reduce energy use by as much as 50%.

9. **High Efficiency Lighting.** Lighting is a relatively small energy end-use in homes. However, compact fluorescent lamps (CFLs) use less than 20% of the energy consumed by incandescent lamps. Thus, in selected applications, CFLS are highly effective in reducing energy use.

10. **Cool Roofs.** Attics can become as hot as 150 degrees in the summer. Light colored roofs and effective ventilation have been shown to significantly reduce attic temperatures. Thereby, cool roofs are gaining recognition for effectively reducing space cooling energy use.

- ***Commercial Buildings (New Construction & Retrofit)***

ICF has over ten years of experience in energy efficiency in commercial buildings (e.g., the ENERGY STAR® Buildings program). During this time, ICF has helped thousands of the program's Partners to identify the most effective energy efficient technologies for both new and existing commercial buildings (including offices, retail, education, warehouses, hospitality, health care, etc.). These technologies are listed below in approximate order of energy savings potential.

1. **Commissioning, Auditing, and Baseline Benchmarking**. The process of testing the energy performance of newly installed energy end-use equipment is called "commissioning". This process ensures that energy efficient is installed properly and is performing as intended. The term "commissioning" is also used to describe a longer term process whereby the energy use of building is closely tracked over time, and the efficiency of the energy systems are continuously refined. An assessment of current and historical energy use is an effective starting point in an energy efficiency program. When historical energy use is compared to "industry-average benchmarks", the potential for energy saving upgrades becomes immediately apparent. Further, when a building is audited for energy use, many obvious causes of energy waste / losses are readily identifiable. Many of these "problems" are easy one-time fixes that result in significant energy savings.

2. **High Efficiency Lighting Systems**. High efficiency fluorescent lighting systems (i.e., T-8 lamps, electronic ballasts, with reflectors) are the most cost effective upgrade for most commercial buildings. Compact fluorescent lamps (CFLs) are also recognized as an effective alternative to incandescent lighting in commercial buildings. Occupant sensors have been proven to reduce lighting energy use in some facilities by as much as 30%.

3. **Envelope Improvements**. Some commercial buildings have relatively large amounts of surface area. Improvements to roof insulation and windows can significantly reduce energy use in these facilities.

4. **High Efficiency Fan, Pump & Motor Systems**. Fan energy use is the third largest energy end-use in many commercial buildings. High efficiency motors with variable speed drives can reduce fan energy use by as much a 50%.

5. **High Efficiency A/C Equipment / Systems**. Space cooling is the second largest energy end-use in most commercial buildings. Further, high efficiency space cooling equipment is readily available and cost effective. Thus, cooling systems upgrades are effective means of reducing energy use, especially in the southern states.

6. **High Efficiency Heating Equipment Systems**. Significant improvements are available in space heating equipment. These technologies are effective in the southern states with colder climates.

7. **Control Strategies.** The on-off operation of every piece of energy end-use equipment must be controlled. Numerous control strategies are available for each type of equipment. A careful review of available control strategies for the primary energy-use equipment usually reveals significant opportunities for improvement. Common controls upgrades include: optimal HVAC start and stop, improved outdoor air damper controls, and enthalpy controlled economizers.

8. **Cool Roofs.** Roofs on commercial buildings are typically very large. Light colored roofs have been shown to significantly reduce summer heat gain through roofs. Thereby, cool roofs are gaining recognition for effectively reducing space cooling energy use in commercial buildings as well.

9. **Combined Heat and Power Systems (Microturbine**s). A recent trend has been to establish on-site electrical power generation capabilities. This technology is primarily used to assure power availability/reliability. However, it is also used in facilities that require significant amount of heat (e.g., manufacturing processes).

10. **Photovoltaics (PV).** Integral wall/envelope panels with PV are becoming increasingly cost-effective. Use of these PV systems is likely to grow in the next couple of decades.

- **TECHNOLOGIES CHOSEN FOR ANALYSIS**

The most cost-effective energy efficiency technologies were selected for inclusion in "technology packages". These technology packages are defined for four levels of energy efficiency, including:

1. **Typical**: the typical set of energy efficiency measures in an existing home.
2. **Efficient**: a moderate improvement of the existing home, or a typical newly constructed home (i.e., code compliant).
3. **High Efficiency**: a substantial improvement of a typical existing home, or a moderate improvement of a code built new home
4. **Very High Efficiency**: a major improvement of a typical existing home, or a substantial improvement of a code built new home.

The energy efficiency measures in each of these technology packages are defined in Exhibit 1. Technologies are identified for both residential and commercial buildings in the Exhibit.

- **POLICIES CHOSEN FOR ANALYSIS**

- **Market Barriers to the Adoption of Energy Efficient Technologies**

The success of voluntary incentive-driven initiatives (to promote energy efficient technologies in the buildings sector) is dependent on the effectiveness in addressing the primary market barriers. Key barriers to the adoption of energy efficiency measures include:

Lack of Market Pull

- Lack of owner/consumer awareness/demand about benefits of energy efficiency.
- Perception of high costs of energy efficiency. Lack of understanding of total costs of ownership (i.e., energy costs not considered in decision criteria)

Lack of Market Push

- Lack of builder/contractor knowledge about how to effectively sell energy efficiency to customers.
- Weak market delivery infrastructure.

- **Policies to Promote the Adoption of Energy Efficiency Measures**

Three general types of policies to promote the voluntary adoption of energy efficiency have been evaluated in this report. These policies/strategies may include both program administration costs and incentives. The incentives may be targeted at both consumers and businesses that are promoting energy efficient technologies. A detailed market assessment is needed to determine the best mix for any given market.

1. *Passive Strategies.* Program administrative costs are low (100 $/home for residential programs, and 0.10 $/SF for commercial programs). Primary program activities include:

    - Consumer Outreach;
    - Contractor Education;
    - No consumer Incentives; and
    - No contractor Incentives.

    Technologies Promoted:

    - Residential: duct tightening, air sealing, increased attic insulation, and whole house design.
    - Commercial: commissioning, high efficiency lighting, and envelope improvements.

    Example Programs:

    - Regional Utility Programs (with limited funds)
    - National Programs like ENERGY STAR®

2. *Active Strategies.* Program administrative costs are moderate (400 $/home for residential programs, and 0.35 $/SF for commercial programs). Primary program activities include:

    - Consumer Outreach;
    - Contractor Education;
    - Multi-Media Advertising Campaign;
    - Marketing and Technical Training;
    - No consumer Incentives;
    - Moderate contractor Incentives: (250 $/home for residential programs, and 0.20 $/SF for commercial programs).

    Technologies Promoted:

    - Residential: duct tightening, air sealing, increased attic insulation, high efficiency HVAC; whole house design, and water heating system improvements.
    - Commercial: commissioning, high efficiency lighting, envelope improvements, high efficiency motor systems, and high efficiency HVAC equipment.

    Example Programs:

    - Regional Utility Programs (moderately funded)
    - State Programs with Public Benefits Funds (moderately funded)

3. *Aggressive Strategies.* Program administrative costs are high (1000 $/home for residential programs, and 0.75 $/SF for commercial programs). Primary program activities include:

- Consumer Outreach;
- Contractor Education;
- Multi-Media Advertising Campaign;
- Marketing and Technical Training;
- Large consumer incentives; and
- Large contractor incentives: (800 $/home for residential programs, and 0.50 $/SF for commercial programs).

Technologies Promoted:

- Residential: duct tightening, air sealing, increased attic insulation, high efficiency HVAC; whole house design, water heating system improvements, high efficiency windows, high efficiency appliances, high efficiency lighting, and cool roofs.
- Commercial: commissioning, high efficiency lighting, envelope improvements, high efficiency motor systems, and high efficiency HVAC equipment, and control system improvements.

Example Programs:

- State Programs with Public Benefits Funds (well funded)

- **ANALYSIS APPROACH**

In Phase 2 of this project, each of these technology packages were evaluated in more detail to quantify:

- Aggregate energy savings by fuel for each state
- SOx and NOx emissions reductions; and
- Greenhouse gas emissions reductions.

Before this analysis could be completed, it was necessary to develop an estimate of what the "business as usual" case (i.e., what if voluntary energy efficient programs did not exist). Three additional levels of energy efficiency programs are defined:

1. **Passive**: voluntary market transformation programs with no incentives
2. **Active**: voluntary market transformation programs with moderate incentives
3. **Aggressive**: voluntary market transformation programs with large incentives

Each of these different scenarios have different technology mixes and different penetration rates (the rate of technology diffusion in the building sector).

The energy savings reduction from the energy efficiency packages defined for each of these three levels of energy efficiency are evaluated relative to the business-as-usual (or baseline) case. The evaluation process for the emission reductions from these technology packages is presented in Exhibit 2

Exhibit 1

Energy Efficiency Packages for Residential and Commercial Buildings

Fuel	End-Use	Technology	Unit	Typical Technology	Efficient Technology		High Efficiency Technology		Very High Efficiency Technology	
				Specification	Specification	% Change	Specification	% Change	Specification	% Change
Residential Buildings										
Neutral	Envelope	Insulation (Attic/Walls/Basement)	R-Value	8/8/3	16/11/3	50%	24/14/3	67%	30/18/11	73%
		Windows	Uo	0.75	0.50	33%	0.33	56%	0.25	67%
		Envelope Air Leakage	ACH	0.80	0.60	25%	0.46	43%	0.35	56%
		Duct Leakage	%	20%	10%	50%	5%	75%	2.5%	88%
	Controls	Programable Thermostat (10 F Setback)	(% of Time)	0%	15%	15%	50%	50%	80%	80%
Electric	Appliances	Refrigerators	KWh/Yr	1200	900	25%	750	38%	600	50%
		Other	KWh/Yr	5500	5000	9%	4500	18%	3500	36%
	HVAC	Space Heating	HSPF	1.0	1.2	17%	1.6	38%	2.0	50%
		Space Cooling	SEER	9.0	11.0	18%	13.0	31%	16.0	44%
	Water Heating	HE Heater	E-Factor	0.80	0.84	5%	0.88	9%	0.92	13%
		Distribution Temperature / Flow Rate	(F / GPM)	140/5	140/4	0%	130/3	7%	120/2	17%
	Lighting	CFLs & Fluorescent	KWh/Yr	1000.0	800.0	20%	600.0	40%	400.0	60%
Gas	HVAC	Space Heating	%	78%	84%	7%	90%	13%	95%	18%
	Water Heating	HE Heater	E-Factor	0.52	0.56	7%	0.60	13%	0.6	19%
Commercial Buildings										
Neutral	Envelope	Insulation (Attic/Walls/Basement)	R-Value	8/8/3	16/11/3	50%	24/14/3	67%	30/18/11	73%
		Windows	Uo	0.75	0.50	33%	0.33	56%	0.25	67%
		Envelope Air Leakage	ACH	0.80	0.60	25%	0.46	43%	0.35	56%
		Duct Leakage	%	20%	10%	50%	5%	75%	2.5%	88%
	Controls	Programable Thermostat		0%	15%	15%	50%	50%	80%	80%
Electric	Lighting	Indoor	W/SF	2.0	1.6	20%	1.2	40%	0.8	60%
		Outdoor	W/SF	0.20	0.16	20%	0.13	35%	0.10	50%
	HVAC Equip	Space Heating	HSPF	1.0	1.2	17%	1.6	38%	2.0	50%
		Space Cooling	COP	2.5	3.5	29%	4.0	38%	5.0	50%
	Office Equip.		W/SF	1.0	0.8	20%	0.6	40%	0.5	50%
	Water Heating		E-Factor	0.80	0.84	5%	0.88	9%	0.92	13%
Gas	HVAC	Space Heating	%	78%	84%	7%	90%	13%	95%	18%
	Water Heating		E-Factor	0.52	0.56	7%	0.60	13%	0.6	19%

Step 1: The energy use is calculated for the baseline case and each of the three energy efficiency scenarios.

Step 2: The emissions factors were defined for each state for of the three main pollutants of interest: SO_2, NO_x, and CO_2.

Step 3: The emissions from the baseline and each energy efficiency scenario were calculated by multiplying the energy use by the appropriate emission factors (i.e., lbs NO_X/kWh, lbs SO_X/Btu, etc.).

Step 4: The emissions reductions of $NO_{X,}$ SO_X and CO_2 for each of these scenarios were the difference between the emissions of the baseline and the given energy efficiency scenario.

Note that the primary emissions from energy use buildings are SO_2, NO_X, and CO_2. We were asked to also consider VOC, CO, and PM. Since, emissions factors for these pollutants are not readily available and they are much less significant than the other three "pollutants", they have not been addressed specifically. The percent reduction in VOC, CO and PM will be directly proportional to the predicted percent reductions for SO_2 and NO_X in this report.

- **Analysis Of Building Energy Efficiency Measures**

A detailed bottom-up spreadsheet model was developed by ICF Consulting to predict the energy consumption needs in residential and commercial buildings in each state in the SAMI region under each of the technology implementation / penetration scenarios. A brief summary of the Energy Use and Emissions Model is provided in Appendix C.

Assumptions -General

A general assumption that may greatly affect the results of this analysis is the "emission factors". The Separate emissions factors are required for each type for pollutant and for each type of fuel used. These factors are used to convert predicted energy savings into the corresponding emission reductions. Emission factors for non-electric fuels are dependent on the efficiency of the technology, "cleanliness" of the fuel, and maintenance of the boiler/device. Emission factors for electrical power are dependent on the proportion f the energy from different generation possibilities (whether hydropower, coal, natural gas, or nuclear.). Emission factors in the future are therefore based on assumptions about improvements on technology efficiency, fuel availability, generation capacity, and fuel quality. The emission factors used are defined in Exhibits 3 and 4 (below).

Exhibit 2

General Methodology for Calculating Emission Reductions

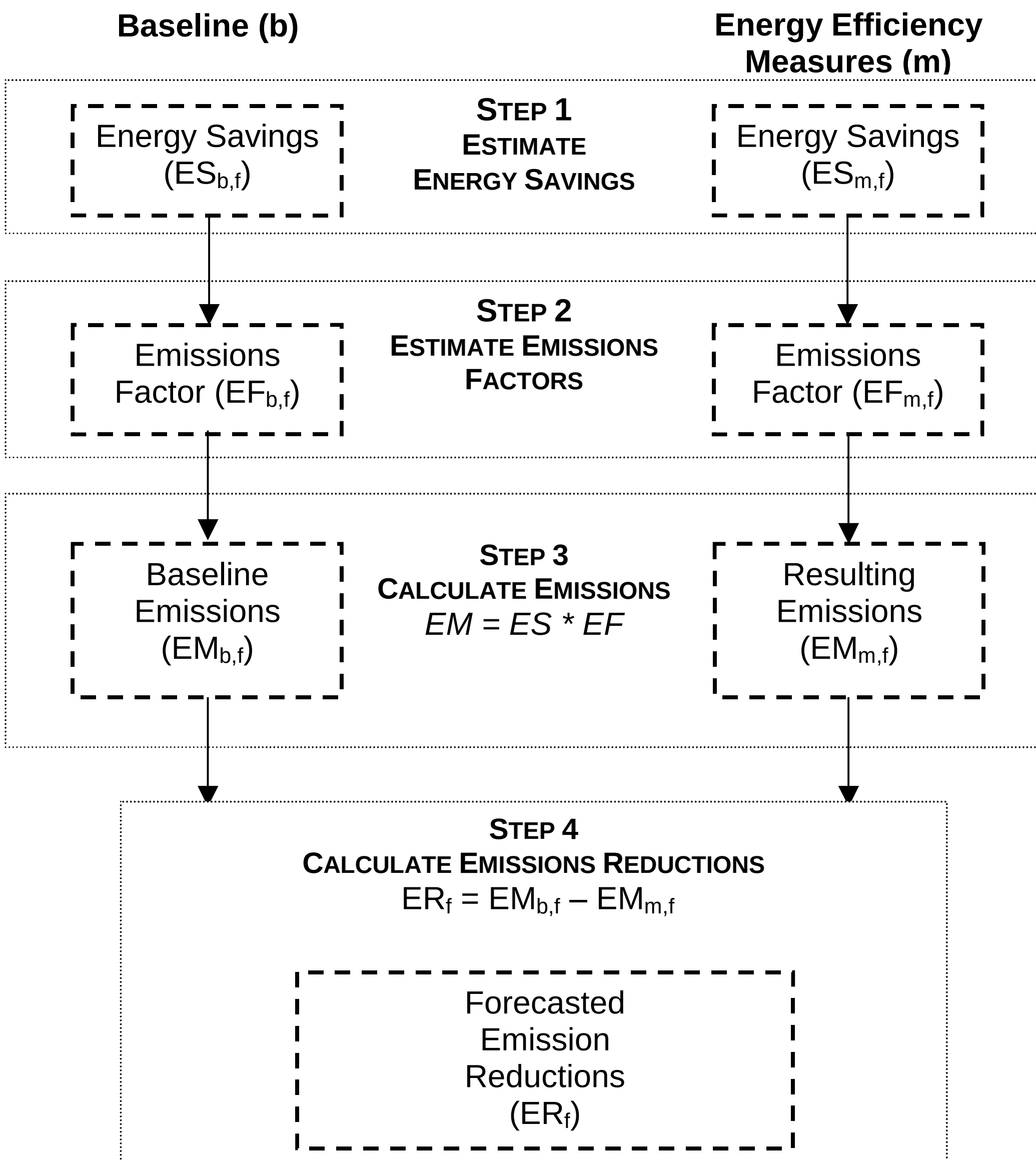


Exhibit 3
Emission Factors for Electricity Consumption

State	Emission Factors (Lb/MWh)		
	SO2	NOx	CO2
AL	10.17	3.81	2.215
GA	9.63	3.35	2.215
KY	14.56	8.31	2.215
NC	9.07	5.31	2.215
SC	5.28	2.89	2.215
TN	11.56	5.81	2.215
VA	6.78	3.66	1.68
WV	6.78	3.66	1.68

Exhibit 4
Emission Factors for Oil & Natural Gas (all SAMI States)

Pollutant	Emission Factor (lb/Mbtu)
CO_2	116.4
NO_x	0
SO_2	1.0

- ***Assumptions - Residential Sector***

Energy efficient technology packages (described above) were developed for both the baseline implementation scenario and the three upgrade scenarios. These packages incorporate various innovations in each of the significant end uses (space heating, space cooling, water heating, lighting, and ventilation). New construction and existing construction are considered separately. The key assumptions in the development of the residential model include:

1. The total number of residential buildings in each state is assumed to be proportional to the population in each state.
2. One prototype residential building is used to represent a mix of building types, including: single family, multifamily, and manufactured homes.
3. Two climatic locations are used to represent the eight-state region.
4. The fuel mix for space and water heating is assumed to be 20 percent electric and 80 percent non-electric in all eight states.

5. The annual growth rate in new homes is 1.2 percent per year.
6. The mix of energy efficient technologies (i.e., typical, efficient, high efficiency, and very high efficiency) in the baseline shifts to more efficient technologies every decade – to reflect periodic enhancements to appliance and equipment energy performance standards.

The diffusion of the technology packages into the existing housing stock and new construction is referred to as the "penetration rate". These penetration rates are different for each scenario and allocate the diffusion across the different efficiency levels (typical, efficiency, high efficiency, and very high efficiency). The assumed mix of technology packages that were implemented in the residential sector is presented in Exhibit 5.

Exhibit 5
Assumed Penetration Rates for Technology Packages in Residential Buildings

Year	Construction Type	New Homes				Existing Homes			
		Baseline	Passive	Active	Aggressive	Baseline	Passive	Active	Aggressive
2000	Typical					0.90			
	Efficient	0.90				0.10			
	High Efficiency	0.10							
	Very High Efficiency								
2010	Typical					0.60	0.40	0.20	
	Efficient	0.70	0.50	0.15		0.30	0.45	0.60	0.75
	High Efficiency	0.25	0.40	0.70	0.75	0.10	0.15	0.20	0.25
	Very High Efficiency	0.05	0.10	0.15	0.25				
2020	Typical					0.35	0.20	0.15	
	Efficient	0.40	0.20			0.40	0.35	0.20	0.20
	High Efficiency	0.50	0.60	0.70	0.50	0.20	0.35	0.45	0.60
	Very High Efficiency	0.10	0.20	0.30	0.50	0.05	0.10	0.20	0.20
2030	Typical					0.20	0.10		
	Efficient	0.10	0.05			0.50	0.35	0.20	
	High Efficiency	0.75	0.65	0.55	0.25	0.20	0.30	0.40	0.50
	Very High Efficiency	0.15	0.30	0.45	0.75	0.10	0.25	0.40	0.50
2040	Typical					0.15			
	Efficient					0.35	0.25		
	High Efficiency	0.90	0.50	0.25		0.30	0.40	0.30	
	Very High Efficiency	0.10	0.50	0.75	1.00	0.20	0.35	0.70	1.00

- ***Commercial Sector***

The assumptions built into the commercial model are very similar to those used in the residential model. The energy efficient technology packages for commercial buildings (described above) were developed for both the baseline implementation scenario and the three upgrade scenarios. These packages incorporate various innovations in each of the significant end uses (lighting, space cooling, ventilation, space heating, office equipment, and water heating). New construction and existing construction are considered separately. The key assumptions in the development of the commercial sector model include:

1. The total square footage of commercial buildings in each state is assumed to be proportional to the population in each state.
2. One prototype commercial building is used to represent a mix of building types, including office, retail, education, warehouse, and others.
3. Two climatic locations are used to represent the eight-state region.
4. The fuel mix for space and water heating is assumed to be 20 percent electric and 80 percent non-electric in all eight states.
5. The annual growth rate in new commercial buildings is 0.9 percent per year.
6. The mix of energy efficient technologies (i.e., typical, efficient, high efficiency, and very high efficiency) in the baseline shifts to more efficient technologies every decade – to reflect periodic enhancements to appliance and equipment energy performance standards.

The diffusion of the technology packages into the existing commercial building stock and new construction is referred to as the "penetration rate". These penetration rates are different for each scenario and allocate the diffusion across the different efficiency levels (typical, efficiency, high efficiency, and very high efficiency). The assumed mix of technology packages that were implemented in the commercial sector is presented in Exhibit 6.

Exhibit 6
Assumed Penetration Rates for Commercial Buildings

Year	Construction Type	New Homes				Existing Homes			
		Baseline	Passive	Active	Aggressive	Baseline	Passive	Active	Aggressive
2000	Typical					0.9			
	Efficient	0.9				0.1			
	High Efficiency	0.1							
	Very High Efficiency								
2010	Typical					0.65	0.5	0.35	0.15
	Efficient	0.7	0.5	0.15		0.25	0.35	0.45	0.6
	High Efficiency	0.25	0.4	0.7	0.75	0.1	0.15	0.2	0.25
	Very High Efficiency	0.05	0.1	0.15	0.25				
2020	Typical					0.35	0.225	0.15	
	Efficient	0.4	0.2			0.4	0.375	0.35	0.2
	High Efficiency	0.5	0.6	0.7	0.5	0.2	0.275	0.3	0.6
	Very High Efficiency	0.1	0.2	0.3	0.5	0.05	0.125	0.2	0.2

2030	Typical					0.2	0.1	0.05	
	Efficient	0.1	0.05			0.5	0.35	0.2	
	High Efficiency	0.75	0.65	0.55	0.25	0.2	0.3	0.4	0.5
	Very High Efficiency	0.15	0.3	0.45	0.75	0.1	0.25	0.35	0.5
2040	Typical					0.15			
	Efficient					0.35	0.25		
	High Efficiency	0.9	0.5	0.25		0.3	0.4	0.3	
	Very High Efficiency	0.1	0.5	0.75	1	0.2	0.35	0.7	1

- **RESULTS - RESIDENTIAL BUILDINGS**

- ***Baseline Energy Use - in Residential Buildings***

An in-depth understanding of the baseline energy use conditions in the region is a critical foundation to the development of realistic energy use projections over time. End use data was needed for each type of typical building type in each state. This data was not available at the start of this project.

In order to develop the baseline, it was necessary to build a bottom up model that estimated energy consumption by end use for each type for building in each state. ICF Consulting developed such a model. The results obtained from this model were compared to the available EIA's historical information on energy consumption in the region at the state level - in order to calibrate the model.

The EIA energy consumption data for 1990 is compared with ICF Consulting's model results for the 1990 baseline in Exhibit 7 (electric use), and Exhibit 8 (oil and gas consumption). The overall agreement between the ICF model and the EIA data is good (+/- 9%). However, there are states where the agreement between the ICF model and the EIA data is not as good. The primary reasons for this mis-alignment for some states are:

- Weak estimates of the size of the building stock in this state;
- An atypical energy end-use patterns in this state; and./or
- An atypical electric/non-electric fuel mix in this state.

The results of the ICF Consulting model were also compared to a baseline electric data provide by Pechan. The purpose of this comparison is to test the validity of using the results of this study in SAMI's Air Quality modeling studies. SAMI's Air Quality model relies on a database that is maintained by Pechan. Pechan's database is similar to the ICF Consulting database/model. However, the Pechan database is structured in a significantly different manner. Pechan's baseline data is for all electricity generated from fossil-fuel-fired (only) electric generation plants in the SAMI region. The differences in the SAMI baseline number from ICF Consulting's baseline data are:

- The SAMI baseline includes industrial energy use; the ICF Consulting model does not.
- The SAMI Baseline number only includes fossil fuel based electric consumption; the ICF Consulting model includes all generation sources.

These differences between the Pechan data, the ICF data, and the EIA baseline data (for the year 1990) are highlighted in Exhibit 9. Note that there is good agreement for the fossil fuel based electric use in the residential and commercial sectors. The difference between ICF and Pechan's total baseline electric use over time is shown in Exhibit 10. Note that the difference between the two sets of data increases with time. This widening difference with time suggests that Pechan has used :

- Significantly more aggressive growth rates than assumed by ICF; and /or
- Less adoption of energy efficiency in the baseline, relative to ICF's assumptions.

The Pechan baseline is compared to EIA's energy use data in Exhibit 11. This EIA data includes residential, commercial, and industrial use. The Pechan baseline number is 18 percent below the EIA baseline number for the aggregate SAMI region. Since, approximately 20 percent of the electric generation in the SAMI region is from non-fossil fuel sources, this indicates strong alignment between the EIA historical electrical energy use and the Pechan baseline data. Since the ICF Consulting model has been shown to align well with the EIA historical electric energy use data, this indicates that the ICF Consulting model will predict baseline electrical energy use that us about 20 percent higher than the Pechan database for the residential and commercial building sectors.

Overall the Pechan, EIA, and ICF data agree for the "fossil fuel" based portion of the baseline electric use for the residential and commercial sectors, especially in the near term future. Generally, the ICF data in this report includes non-fossil and fossil fuel based electric generation/use. *Thus, to apply the ICF data to the SAMI's air quality model, all of ICF's energy use and emissions reductions results should be degraded by twenty percent – to eliminate the non-fossil fuel based portion of the electric generation/ use.* Further, ICF's estimated percentage reductions in electric generation/use and emissions (from implementing energy efficient measures) are based on total se in either the residential or commercial sectors. These percentage reductions cannot be applied directly to the Pecan data, because the Pechan data includes the industrial sector (in addition to the residential and commercial sectors). Since industrial electric energy use is about 40% of the total electric generation use in the SAMI region (from the EIA data), *only 60% of the percent electric and related emissions reductions (identified by ICF in this report) can be applied to the Pechan data.*

ICF Consulting has not been provided with any baseline data developed by Pechan on non-electric energy use in buildings. Therefore, the ICF Consulting model baseline results cannot be calibrated to Pechan data. Clearly, a strong alignment has been demonstrated with EIA historical oil and gas (non-electric) energy use data.

- **Energy Savings - in Residential Buildings**

Based on the energy efficiency technology packages and predicted penetration rates over time (described above), ICF Consulting calculated the energy consumption for the baseline and each of the three different penetration scenarios (i.e., passive, active, and aggressive). The results of these calculations for the electric and non-electric energy use in the residential sector are shown in Exhibits 12 and 13 below. More detailed data are provided in Appendix A. These tables are generated by ICF Consulting's bottom-up model, summarized in Appendix C. By changing the input assumptions and the input data, a user can explore the effects of these variations on the overall results obtained from the model.

- **Emissions and Emissions Reductions - in Residential Buildings**

Based on the energy consumption and estimated emission factors described above, the ICF Consulting model estimates the emission reductions from residential buildings over time for each of three pollutants (i.e., SO_2, NO_X, and CO_2). More detailed data (i.e., state by state results) on SO_X emissions from the residential sector are presented in Appendix A.

The model results for SO_X generated in residential buildings in the SAMI region are presented in Exhibits 14, 15, and 16. A comparison of baseline SO_X emissions from 2000 through 2040 (and potential reductions) is presented in Exhibit 14. Emission reductions are tabulated in Exhibit 15. Percent reductions are presented in Exhibit 16.

The model results for NO_X generated in residential buildings in the SAMI region are presented in Exhibits 17, 18, and 19. A comparison of baseline NO_X emissions from 2000 through 2040 (and potential reductions) is presented in Exhibit 17. Emission reductions are tabulated in Exhibit 18. Percent reductions are presented in Exhibit 19

The model results for CO_2 generated in residential buildings in the SAMI region are presented in Exhibits 20, 21, and 22. A comparison of baseline CO_2 emissions from 2000 through 2040 (and potential reductions) is presented in Exhibit 20. Emission reductions are tabulated in Exhibit 21. Percent reductions are presented in Exhibit 22.

Exhibit 7
Comparison of EIA and ICF Baseline Electric Consumption

Yr	State	Residential Buildings			Commercial Buildings			Total for Residential and Commercial Building Sectors		
		EIA	ICF	% Difference (ICF-EIA)	EIA	ICF	% Difference (ICF-EIA)	EIA	ICF	% Difference (ICF-EIA)
1990	AL	21	19	-8%	12	15	26%	32	34	4%
	GA	30	34	14%	24	26	10%	54	60	12%
	KY	17	16	-8%	12	13	11%	29	29	0%
	NC	33	30	-10%	26	25	-1%	59	55	-6%
	SC	18	17	-7%	13	13	0%	31	30	-4%
	TN	29	21	-25%	13	18	39%	42	40	-5%
	VA	28	27	-5%	28	23	-19%	56	50	-12%
	WV	8	7	-7%	5	6	17%	13	13	3%
	Sub-Total	183	171	-7%	132	139	5%	315	310	-2%

Exhibit 8
Comparison of EIA and ICF Baseline Oil & Gas (Non-Electric) Consumption

Yr	State	Residential Buildings			Commercial Buildings			Total for Residential and Commercial Building Sectors		
		EIA	ICF	% Difference (ICF-EIA)	EIA	ICF	% Difference (ICF-EIA)	EIA	ICF	**% Difference (ICF – EIA)**
1990	AL	57	62	9%	38	33	-14%	95	95	0%
	GA	107	111	3%	64	59	-8%	171	170	-1%
	KY	71	56	-20%	41	38	-7%	112	95	-15%
	NC	80	109	35%	52	74	42%	133	183	38%
	SC	34	55	63%	22	29	35%	56	85	52%
	TN	57	78	36%	53	53	1%	110	131	19%

	VA	98	97	0%	63	67	7%	160	164	2%
	WV	41	26	-37%	28	18	-38%	69	43	-38%
	Sub-Total	545	594	9%	361	372	3%	906	965	7%

Exhibit 9

Comparison of EIA, Pechan, and ICF Baseline Electricity Consumption

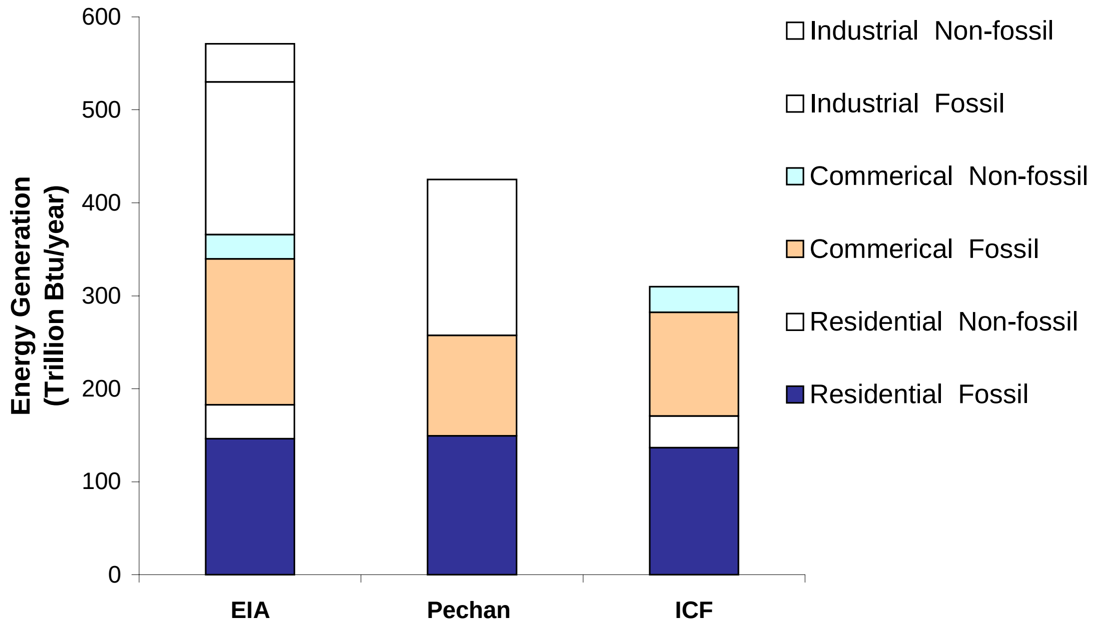


Exhibit 10

Comparison of ICF and Pechan Baseline Electricity Generation

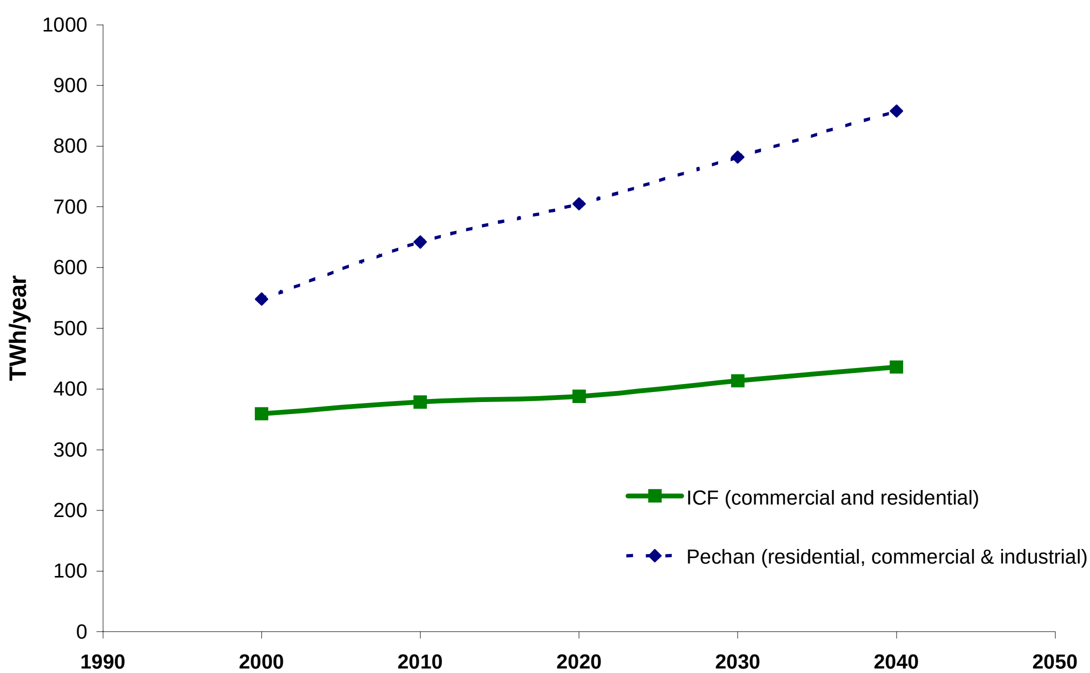


Exhibit 11
Comparison of EIA, ICF, and Pechan Baselines for Electric Consumption

Yr	State	Total for Residential and Commercial Building Sectors			Industrial Facilities	Total for All Buildings			
		EIA	ICF	% Difference (EIA - ICF)	EIA	EIA	ICF	Pechan	% Difference (Pechan-EIA)
1990	AL	32	34	4%	27.6	60	N/A		
	GA	54	60	12%	26.7	80	N/A		
	KY	29	29	0%	32.5	61	N/A		
	NC	59	55	-6%	31.3	90	N/A		
	SC	31	30	-4%	24.7	56	N/A		
	TN	42	40	-5%	35.3	77	N/A		
	VA	56	50	-12%	16.4	73	N/A		
	WV	13	13	3%	10.5	23	N/A		
	Sub-Total	315	310	-2%	205	520	N/A	425	-18%

Exhibit 12
Estimated Annual Electricity Consumption
in Residential Buildings in the SAMI Region

Year	Energy Consumption by Scenario (TWh/yr)			
	Baseline	Passive	Active	Aggressive
2000	203	203	203	203
2010	214	198	182	167
2020	220	196	177	159
2030	235	206	177	160
2040	250	211	176	159

Exhibit 13
Estimated Annual Oil and Gas Consumption
in Residential Buildings in the SAMI Region

Year	Energy Consumption by Scenario (Trillion BTUs/yr)			
	Baseline	Passive	Active	Aggressive
2000	476	476	476	476
2010	510	488	464	442
2020	533	489	447	416

2030	573	509	445	400
2040	603	520	422	364

Exhibit 14
Estimated Annual SO_2 Emissions
from Residential Buildings in the SAMI Region

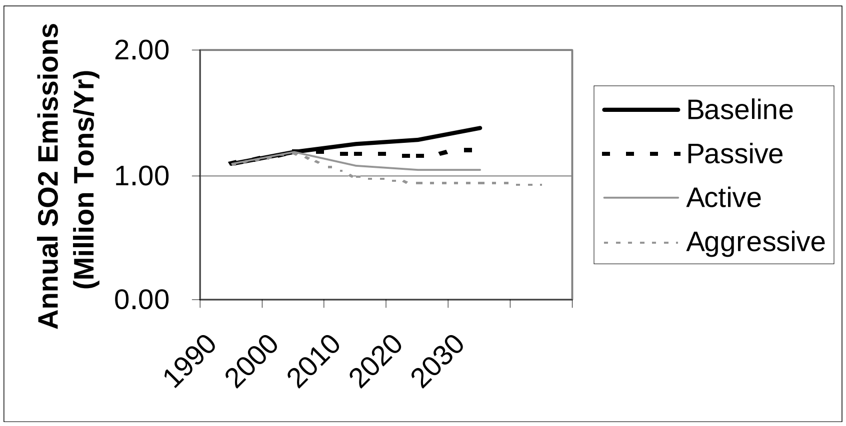


Exhibit 15
Estimated Annual Reduction in SO_2 Emissions
from Residential Buildings in the SAMI Region
(Relative to Baseline)

Year	Reduction per Scenario (in Million Tons)		
	Passive	Active	Aggressive
2010	0.08	0.17	0.25
2020	0.13	0.24	0.34
2030	0.17	0.34	0.44
2040	0.23	0.44	0.54

Exhibit 16
Estimated Annual Percent Reduction in SO_2 Emissions
from Residential Buildings in the SAMI Region

(Relative to Baseline)

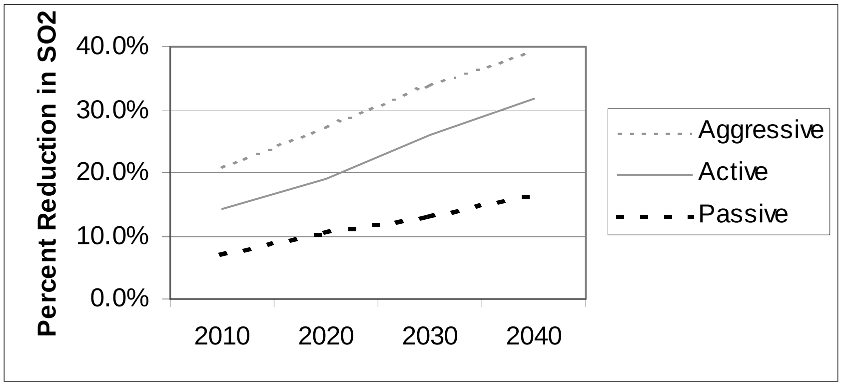


Exhibit 17
Estimated Annual NO_X Emissions
from Residential Buildings in the SAMI Region

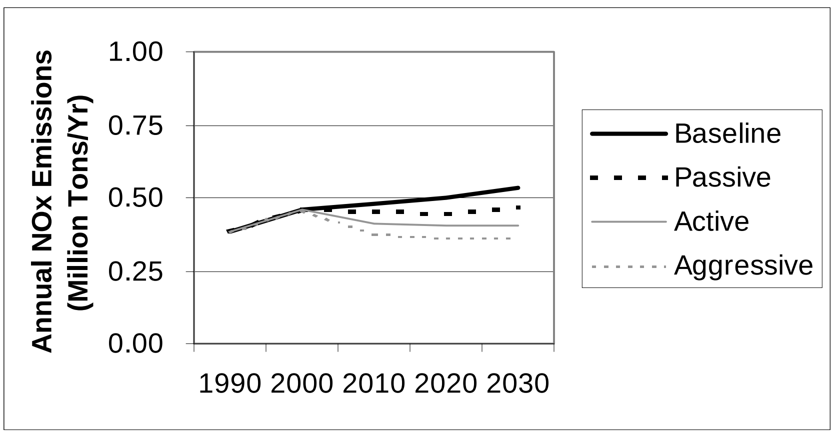


Exhibit 18
Estimated Annual Reduction in NO_X Emissions
from Residential Buildings in the SAMI Region
(Relative to Baseline)

Year	Reduction per Scenario (in Million Tons)		
	Passive	Active	Aggressive
2010	0.03	0.07	0.10
2020	0.05	0.10	0.14
2030	0.07	0.13	0.17
2040	0.09	0.17	0.21

Exhibit 19
Estimated Annual Percent Reduction in NO_X Emissions

from Residential Buildings in the SAMI Region (Relative to Baseline)

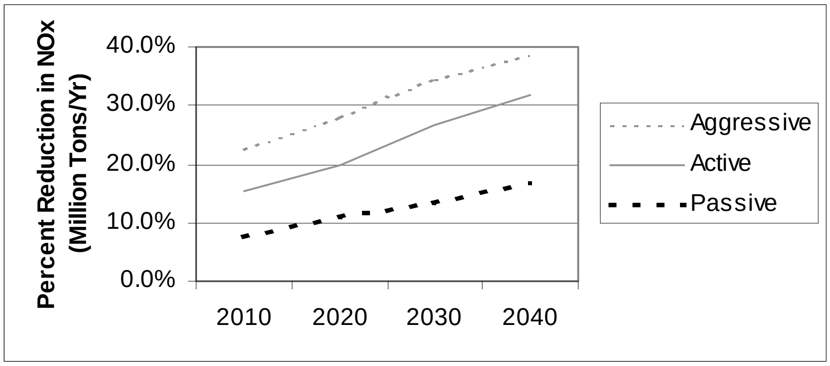


Exhibit 20
Estimated Annual CO_2 Emissions
From Residential Buildings in the SAMI Region

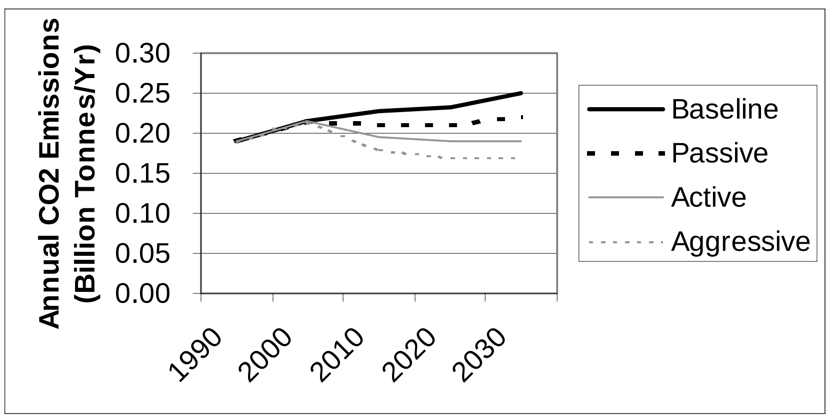
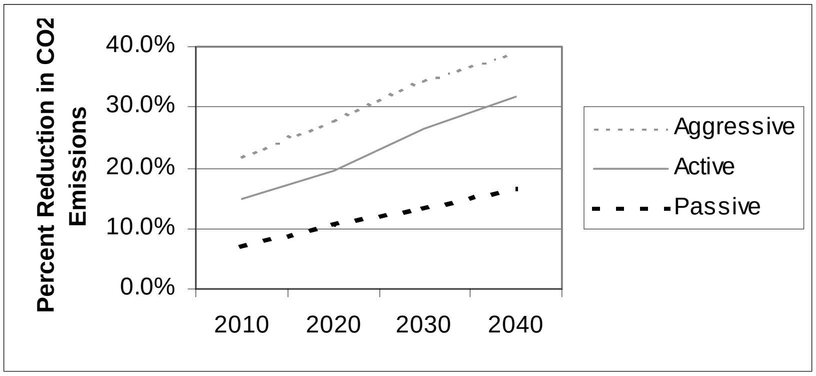


Exhibit 21
Estimated Annual Reduction in CO_2 Emissions
From Residential Buildings in the SAMI Region
(Relative to Baseline)

Year	Reduction per Scenario (in Billion Tonnes)		
	Passive	Active	Aggressive
2010	0.02	0.03	0.05
2020	0.02	0.04	0.06
2030	0.03	0.06	0.08
2040	0.04	0.08	0.10

Exhibit 22
Estimated Annual Percent Reduction in CO_2 Emissions
From Residential Buildings in the SAMI Region
(Relative to Baseline)



Incentives

As indicated earlier, three voluntary incentive-based approaches to promoting energy efficient technologies have been proposed. The purpose of incentives may be to influence both consumer purchase decisions and the willingness of business businesses to promote energy efficient technologies. Most consumers and businesses have a complex, intuitive decision making capability. Part of this decision making process is economically based.

From the state government perspective, a program level decision criteria is presented in Exhibit 23. Annual energy savings per home are compared to program levels costs on a per home basis. Three levels of shading are used to indicate varying levels of "economic-acceptability". The acceptability of the ***passive*** policy/strategy (without incentives) is presented as the dotted box in the upper left of the exhibit. The introduction of incentives increases program costs, but may increase annual savings per home. Similarly, the acceptability of the ***active*** policy/strategy (without incentives) is presented as the dotted box in the middle of the exhibit. The acceptability of the ***aggressive*** policy/strategy (without incentives) is presented as the dotted box in the lower right of the exhibit.

From the consumer's perspective, a decision criteria matrix is presented in Exhibit 24. Annual energy savings per home are compared to the incremental first cost of energy efficient upgrades (on a per home basis). Again, the three levels of shading are used to indicate varying levels of "economic-acceptability". And the three dotted boxes are shown to indicate the relative acceptability of the three policy options (without incentives).

A comparison of the effect of consumer incentives on the "economic acceptability" of the three policy options is presented in Exhibits 25. The incentives need to be sufficient to exceed the consumers economic comfort hurdle.(i.e., minimum acceptable rate of return of approximately 25%). Thus ,the *passive* policy/strategy does not need any consumer incentives. The *active* policy/strategy needs about $250 per home in incentives to deliver a rate of return in excess of 25%. The *aggressive* policy/strategy needs about $800 per home in incentives to deliver a rate of return in excess of 25%.

Exhibit 23
Programmatic Decision Matrix - $ Per KWh Saved

Costs and Impacts of Adopting Energy Efficiency Measures In Residential Buildings

Program Costs - $/Home	Annual Energy Savings Per Home - $/Yr and %: $ 90 5.0%	$ 135 7.5%	$ 180 10.0%	$ 225 12.5%	$ 270 15.0%	$ 315 17.5%	$ 360 20.0%	$ 405 22.5%	$ 450 25.0%	$ 540 30.0%
100	0.10	0.07	0.05	0.04	0.03	0.03	0.03	0.02	0.02	0.02
200	0.20	0.13	0.10	0.08	0.07	0.06	0.05	0.04	0.04	0.03
300	0.30	0.20	0.15	0.12	0.10	0.09	0.08	0.07	0.06	0.05
400	0.40	0.27	0.20	0.16	0.13	0.11	0.10	0.09	0.08	0.07
500	0.50	0.33	0.25	0.20	0.17	0.14	0.13	0.11	0.10	0.08
600	0.60	0.40	0.30	0.24	0.20	0.17	0.15	0.13	0.12	0.10
700	0.70	0.47	0.35	0.28	0.23	0.20	0.18	0.16	0.14	0.12
800	0.80	0.53	0.40	0.32	0.27	0.23	0.20	0.18	0.16	0.13
900	0.90	0.60	0.45	0.36	0.30	0.26	0.23	0.20	0.18	0.15
1000	1.00	0.67	0.50	0.40	0.33	0.29	0.25	0.22	0.20	0.17
1100	1.10	0.73	0.55	0.44	0.37	0.31	0.28	0.24	0.22	0.18
1200	1.20	0.80	0.60	0.48	0.40	0.34	0.30	0.27	0.24	0.20
1300	1.30	0.87	0.65	0.52	0.43	0.37	0.33	0.29	0.26	0.22

Assumptions: Residential Electricity rate = 0.09 $/KWh

Legend:
- Very acceptable (< 0.09 $ / KWh)
- Acceptable (> 0.10 $ / KWh and < 0.18 $ / KWh)
- Minimally acceptable (> 0.19 $ / KWh and < 0.27 $ / KWh)
- Not acceptable (> 0.28 $/KWh)

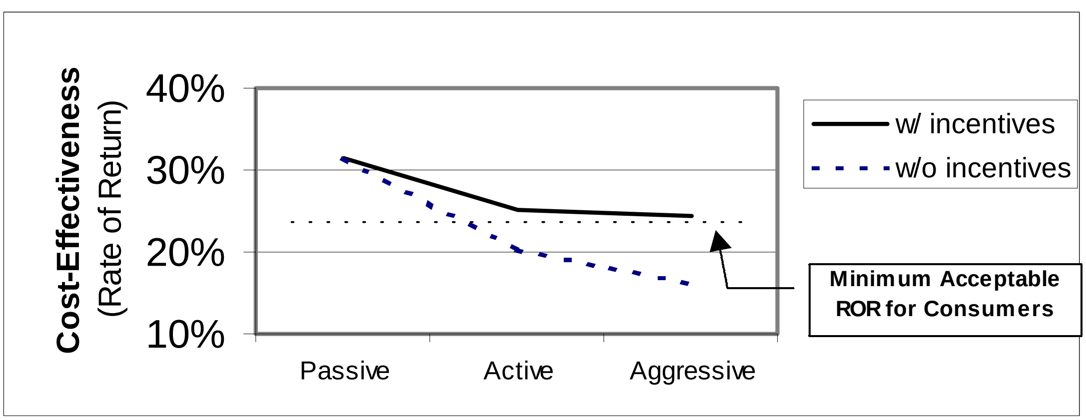
Exhibit 24
Consumer Decision Matrix - Rate of Return (or Savings/Investment Ratio)
Costs and Impacts of Adopting Energy Efficiency Measures In Residential Buildings

First Cost of Upgrades $/Home	Annual Energy Savings Per Home - $/Yr and %									
	$ 90	$ 135	$ 180	$ 225	$ 270	$ 315	$ 360	$ 405	$ 450	$ 540
	5.0%	7.5%	10.0%	12.5%	15.0%	17.5%	20.0%	22.5%	25.0%	30.0%
400	23%	34%	45%	56%	68%	79%	90%	101%	113%	135%
650	14%	21%	28%	35%	42%	48%	55%	62%	69%	83%
900	10%	15%	20%	25%	30%	35%	40%	45%	50%	60%
1150	8%	12%	16%	20%	23%	27%	31%	35%	39%	47%
1400	6%	10%	13%	16%	19%	23%	26%	29%	32%	39%
1650	5%	8%	11%	14%	16%	19%	22%	25%	27%	33%
1900	5%	7%	9%	12%	14%	17%	19%	21%	24%	28%
2150	4%	6%	8%	10%	13%	15%	17%	19%	21%	25%
2400	4%	6%	8%	9%	11%	13%	15%	17%	19%	23%
2650	3%	5%	7%	8%	10%	12%	14%	15%	17%	20%
2900	3%	5%	6%	8%	9%	11%	12%	14%	16%	19%
3150	3%	4%	6%	7%	9%	10%	11%	13%	14%	17%
3400	3%	4%	5%	7%	8%	9%	11%	12%	13%	16%

Assumptions: Residential Electricity rate = 0.09 $/KWh

Legend:
- Very acceptable (ROR > 30%)
- Acceptable (30% > ROR > 20%)
- Minimally acceptable (20% > ROR > 10%)
- Not acceptable (ROR < 10%)

Exhibit 25
Cost-Effectiveness of Energy Efficiency Upgrades for the Residential Buildings Sector



- **RESULTS - COMMERCIAL BUILDINGS**

- **Baseline Energy Use - in Commercial Buildings**

Similar to the discussion above for residential buildings, the ICF Consulting model was used to develop a baseline estimate of energy use in commercial buildings. The EIA statistics from 1990 were compared with the ICF baseline in order to assess and calibrate the ICF model. This comparison is summarized in Exhibits 7 and 8 above. In aggregate, the baseline from the ICF Consulting model agrees with the EIA data within 5 percent. On a state-by-state basis, the agreement is not as good. The reasons for the mis-alignment at the state-by state level were discussed above (in the residential baseline section).

- **Energy Savings – in Commercial Buildings**

Similar to the process described above for residential buildings, ICF Consulting developed detailed bottom-up energy use estimates for the baseline and each of the three different penetration scenarios (i.e., passive, active, and aggressive) for commercial buildings. The results of these calculations for the electric and non-electric energy use in the commercial sector are shown in Exhibits 26 and 27 below. More detailed data are provided in Appendix B. These tables are generated by ICF Consulting's bottom-up model. By changing the input assumptions and the input data, a user can explore the effects of these variations on the overall results obtained from the model.

- **Emissions and Emissions Reductions – in Commercial Buildings**

Based on the energy consumption and estimated emission factors described above, the ICF Consulting model estimates the emission reductions from commercial buildings over time for each of three pollutants (i.e., SO_2, NO_X, and CO_2). More detailed data (i.e., state by state results) on SO_X emissions from the commercial sector are presented in Appendix A.

The model results for SO_X generated in commercial buildings in the SAMI region are presented in Exhibits 28, 29, and 30. A comparison of baseline SO_X emissions from 2000 through 2040 (and potential reductions) is presented in Exhibit 28. Emission reductions are tabulated in Exhibit 29. Percent reductions are presented in Exhibit 30.

The model results for NO_X generated in commercial buildings in the SAMI region are presented in Exhibits 31, 32, and 33. A comparison of baseline NO_X emissions from 2000 through 2040 (and potential reductions) is presented in Exhibit 31. Emission reductions are tabulated in Exhibit 32. Percent reductions are presented in Exhibit 33

The model results for CO_2 generated in commercial buildings in the SAMI region are presented in Exhibits 34, 35, and 36. A comparison of baseline CO_2 emissions from 2000 through 2040 (and potential reductions) is presented in Exhibit 34. Emission reductions are tabulated in Exhibit 35. Percent reductions are presented in Exhibit 36.

Exhibit 26
Estimated Annual Electricity Consumption
in All Commercial Buildings in the SAMI Region

Year	Energy Consumption by Scenario (TWh/yr)			
	Baseline	Passive	Active	Aggressive
2000	157	157	157	157
2010	165	159	153	145
2020	168	157	149	135
2030	178	161	149	134
2040	186	164	142	131

Exhibit 27
Estimated Annual Oil and Gas Consumption
In All Commercial Buildings in the SAMI Region

Year	Energy Consumption by Scenario (Trillion BTUs/yr)			
	Baseline	Passive	Active	Aggressive
2000	419	419	419	419
2010	434	413	392	365
2020	433	403	381	343
2030	454	413	385	350
2040	476	421	377	357

Exhibit 28
Annual SO_2 Emissions
from Commercial Buildings in the SAMI Region

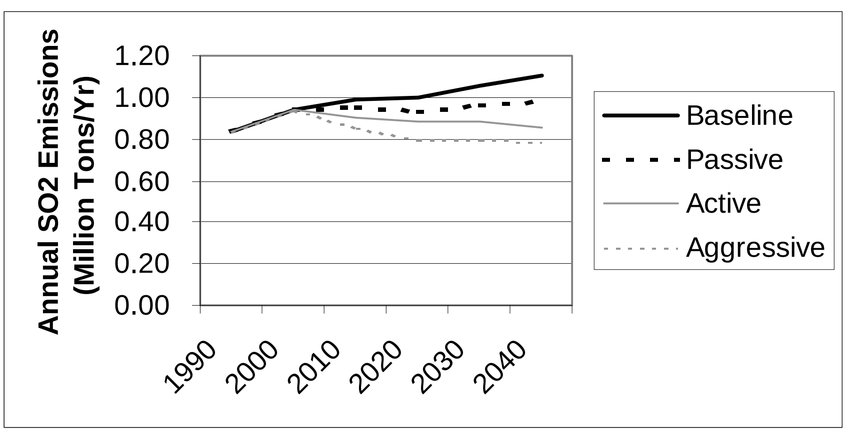


Exhibit 29
Annual Reduction in SO_2 Emissions
from Commercial Buildings in the SAMI Region
(Relative to Baseline)

Year	Reduction per Scenario (in Million Tons)		
	Passive	Active	Aggressive
2010	0.04	0.08	0.13
2020	0.07	0.12	0.20
2030	0.10	0.17	0.26
2040	0.13	0.25	0.31

Exhibit 30
Annual Percent Reduction in SO_2 Emissions
from Commercial Buildings in the SAMI Region
(Relative to Baseline)

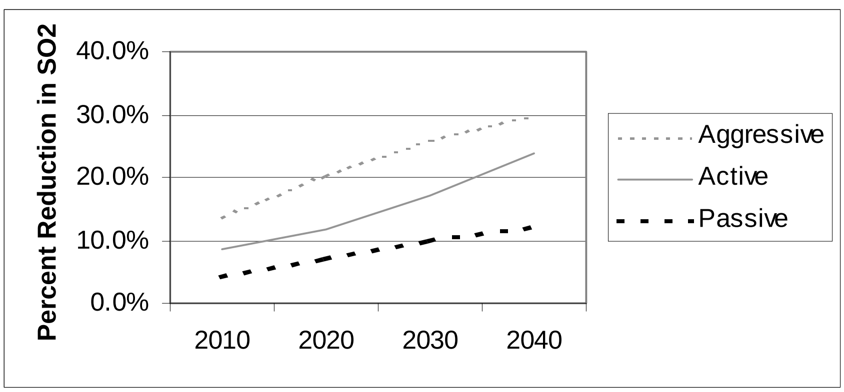


Exhibit 31
Annual NO_X Emi1sions
from Commercial Buildings in the SAMI Region

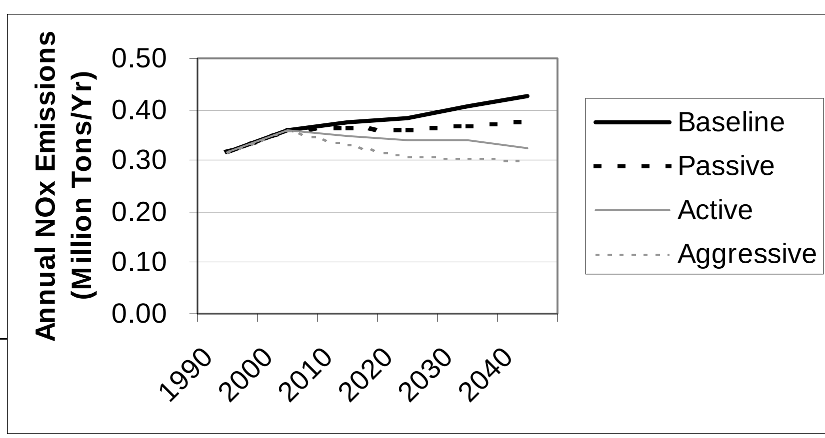


Exhibit 32
Annual Reduction in NO_X Emissions
From Commercial Buildings in the SAMI Region
(Relative to Baseline)

Year	Reduction per Scenario (in Million Tons)		
	Passive	Active	Aggressive
2010	0.01	0.03	0.05
2020	0.03	0.04	0.08
2030	0.04	0.07	0.10
2040	0.05	0.10	0.12

Exhibit 33
Annual Percent Reduction in NO_X Emissions
From Commercial Buildings in the SAMI Region
(Relative to Baseline)

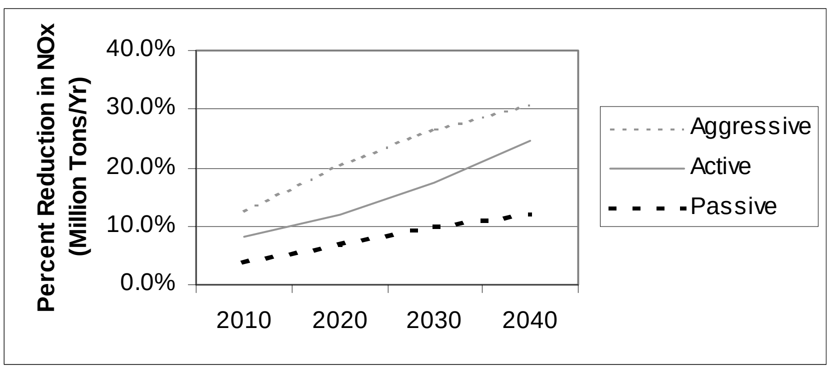


Exhibit 34
Annual CO_2 Emissions
From Commercial Buildings in the SAMI Region

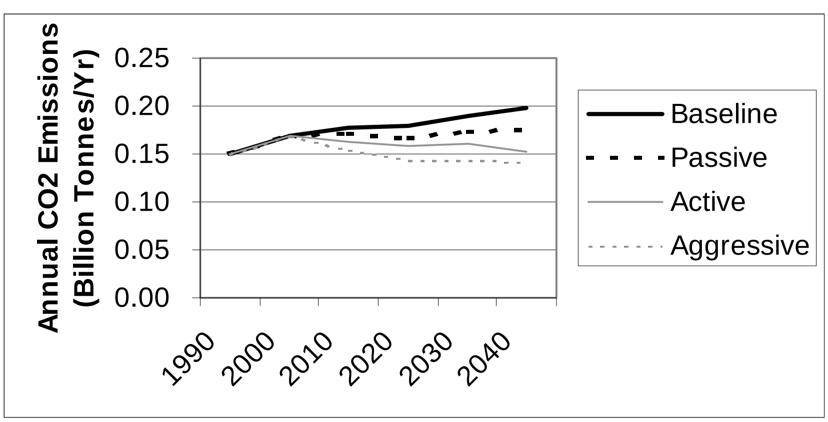
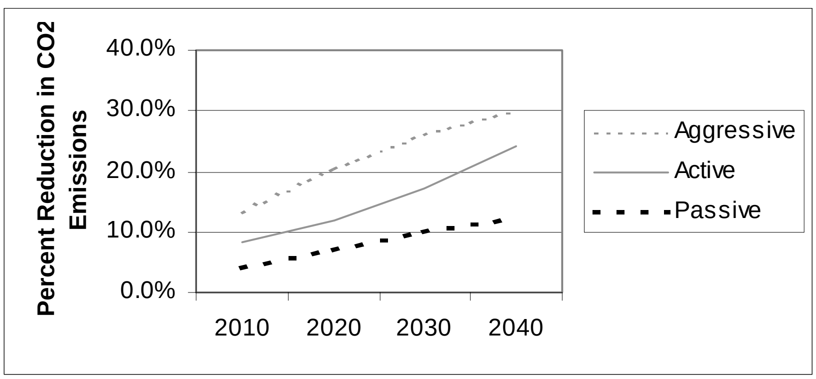


Exhibit 35
Annual Reduction in CO_2 Emissions
from Commercial Buildings in the SAMI Region
(Relative to Baseline)

Year	Reduction per Scenario (in Billion Tonnes)		
	Passive	Active	Aggressive
2010	0.01	0.01	0.02
2020	0.01	0.02	0.04
2030	0.02	0.03	0.05
2040	0.02	0.05	0.06

Exhibit 36
Annual Percent Reduction in CO_2 Emissions
from Commercial Buildings in the SAMI Region
(Relative to Baseline)



Incentives

Similar to the analysis above for residential buildings, three voluntary incentive-based approaches to promoting energy efficient technologies in commercial buildings have been evaluated. The purpose of this evaluation is to assess a building owner's willingness to adopt energy efficient technologies.

From the state government perspective, a program level decision criteria is presented in Exhibit 37. Annual energy savings per square foot of floor area (SF) are compared to program levels costs on a per square foot basis. Three levels of shading are used to indicate varying levels of "economic-acceptability". The acceptability of the ***passive*** policy/strategy (without incentives) is presented as the dotted box in the upper left of the exhibit. The introduction of incentives increases program costs, but may increase annual savings per square foot Similarly, the acceptability of the ***active*** policy/strategy (without incentives) is presented as the dotted box in the middle of the exhibit. The acceptability of the ***aggressive*** policy/strategy (without incentives) is presented as the dotted box in the lower right of the exhibit.

From the building owner's perspective, a decision criteria matrix is presented in Exhibit 38. Annual energy savings per square foot are compared to the incremental first cost of energy efficient upgrades (on a per square foot basis). Again, the three levels of shading are used to indicate varying levels of "economic-acceptability". And the three dotted boxes are shown to indicate the relative acceptability of the three policy options (without incentives).

A comparison of the effect of incentives for building owner's on the "economic acceptability" of the three policy options is presented in Exhibits 39. The incentives need to be sufficient to exceed the building owner's economic comfort hurdle.(i.e., minimum acceptable rate of return of approximately 20%). Thus, the *passive* policy/strategy does not need any consumer incentives. The *active* policy/strategy needs about 0.20 dollars per square foot in incentives to deliver a rate of return in excess of 20%. The *aggressive* policy/strategy needs about 0.55 dollars per square foot in incentives to deliver a rate of return in excess of 20%.

Exhibit 37
Programmatic Decision Matrix - $ Per KWh Saved
Costs and Impacts of Adopting Energy Efficiency Measures In Commercial Buildings

Program Costs - $/SF	Annual Energy Savings Per Building - $/SF/Yr and %: $ 0.08 5.0%	$ 0.11 7.5%	$ 0.15 10.0%	$ 0.19 12.5%	$ 0.23 15.0%	$ 0.26 17.5%	$ 0.30 20.0%	$ 0.34 22.5%	$ 0.38 25.0%	$ 0.45 30.0%
$ 0.10	0.16	0.11	0.08	0.06	0.05	0.05	0.04	0.04	0.03	0.03
$ 0.15	0.24	0.16	0.12	0.10	0.08	0.07	0.06	0.05	0.05	0.04
$ 0.20	0.32	0.21	0.16	0.13	0.11	0.09	0.08	0.07	0.06	0.05
$ 0.25	0.40	0.27	0.20	0.16	0.13	0.11	0.10	0.09	0.08	0.07
$ 0.30	0.48	0.32	0.24	0.19	0.16	0.14	0.12	0.11	0.10	0.08
$ 0.35	0.56	0.37	0.28	0.22	0.19	0.16	0.14	0.12	0.11	0.09
$ 0.40	0.64	0.43	0.32	0.26	0.21	0.18	0.16	0.14	0.13	0.11
$ 0.45	0.72	0.48	0.36	0.29	0.24	0.21	0.18	0.16	0.14	0.12
$ 0.50	0.80	0.53	0.40	0.32	0.27	0.23	0.20	0.18	0.16	0.13
$ 0.55	0.88	0.59	0.44	0.35	0.29	0.25	0.22	0.20	0.18	0.15
$ 0.65	1.04	0.69	0.52	0.42	0.35	0.30	0.26	0.23	0.21	0.17
$ 0.70	1.12	0.75	0.56	0.45	0.37	0.32	0.28	0.25	0.22	0.19
$ 0.75	1.20	0.80	0.60	0.48	0.40	0.34	0.30	0.27	0.24	0.20
$ 0.80	1.28	0.85	0.64	0.51	0.43	0.37	0.32	0.28	0.26	0.21
$ 0.85	1.36	0.91	0.68	0.54	0.45	0.39	0.34	0.30	0.27	0.23

Assumptions: Commercial Electricity rate = 0.12 $/KWh

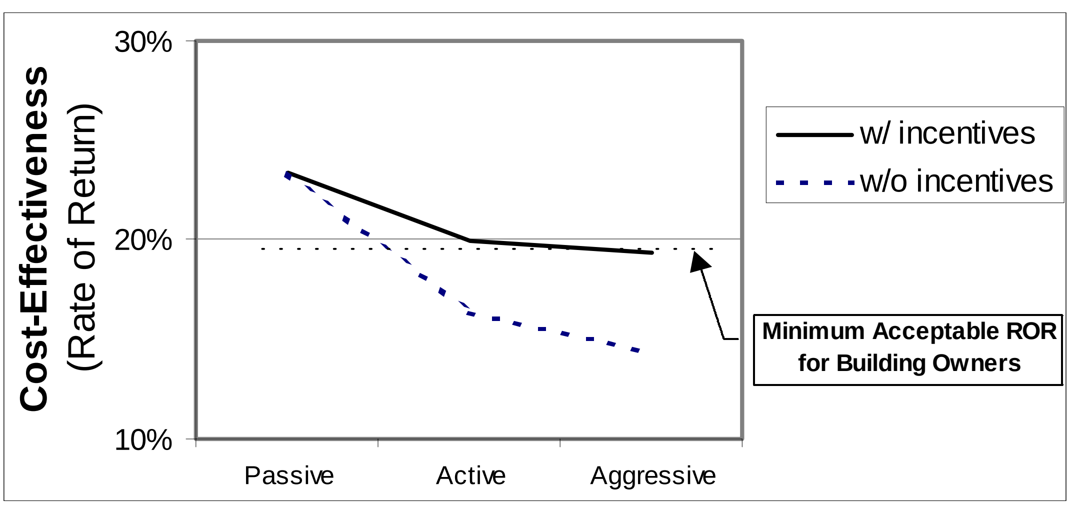
Legend:
- Very acceptable (< 0.12 $ / KWh)
- Acceptable (> 0.13 $ / KWh and < 0.17 $ / KWh)
- Minimally acceptable (> 0.18 $ / KWh and < 0.30 $ / KWh)
- Not acceptable (> 0.31 $/KWh)

Exhibit 39
Building Owner's Decision Matrix - Rate of Return (or Savings/Investment Ratio)
Costs and Impacts of Adopting Energy Efficiency Measures In Commercial Buildings

First Cost of Upgrades $/SF	Annual Energy Savings Per Building - $/SF/Yr and %: $ 0.08 (5.0%)	$ 0.11 (7.5%)	$ 0.15 (10.0%)	$ 0.19 (12.5%)	$ 0.23 (15.0%)	$ 0.26 (17.5%)	$ 0.30 (20.0%)	$ 0.34 (22.5%)	$ 0.38 (25.0%)	$ 0.45 (30.0%)
$ 0.40	19%	28%	38%	47%	56%	66%	75%	84%	94%	113%
$ 0.60	0.13	0.19	0.25	0.31	0.38	0.44	0.50	0.56	0.63	0.75
$ 0.80	0.09	0.14	0.19	0.23	0.28	0.33	0.38	0.42	0.47	0.56
$ 1.00	0.08	0.11	0.15	0.19	0.23	0.26	0.30	0.34	0.38	0.45
$ 1.20	0.06	0.09	0.13	0.16	0.19	0.22	0.25	0.28	0.31	0.38
$ 1.40	0.05	0.08	0.11	0.13	0.16	0.19	0.21	0.24	0.27	0.32
$ 1.60	0.05	0.07	0.09	0.12	0.14	0.16	0.19	0.21	0.23	0.28
$ 1.80	0.04	0.06	0.08	0.10	0.13	0.15	0.17	0.19	0.21	0.25
$ 2.00	0.04	0.06	0.08	0.09	0.11	0.13	0.15	0.17	0.19	0.23
$ 2.20	0.03	0.05	0.07	0.09	0.10	0.12	0.14	0.15	0.17	0.20
$ 2.40	0.03	0.05	0.06	0.08	0.09	0.11	0.13	0.14	0.16	0.19
$ 2.60	0.03	0.04	0.06	0.07	0.09	0.10	0.12	0.13	0.14	0.17
$ 2.80	0.03	0.04	0.05	0.07	0.08	0.09	0.11	0.12	0.13	0.16
$ 3.00	0.03	0.04	0.05	0.06	0.08	0.09	0.10	0.11	0.13	0.15
$ 3.20	0.02	0.04	0.05	0.06	0.07	0.08	0.09	0.11	0.12	0.14

Legend:
- Very acceptable (ROR > 24%)
- Acceptable (24% > ROR > 18%)
- Minimally acceptable (17% > ROR > 11%)
- Not acceptable (ROR < 10%)

Exhibit 39
Cost-effectiveness of Energy Efficiency Upgrades
for the Commercial Buildings Sector



- **RECOMMENDED NEXT STEPS**

1. Refine Assumptions. Several key assumptions underlie the results of this analysis, including assumed values for: new construction growth rates, technology diffusion, and emission factors. Each of these assumptions contributes to the uncertainty in the estimated energy savings and emissions reductions. These assumptions need to be carefully reviewed for ***each state*** in the SAMI region.

2. User-Friendly Front-End for Model. The development of a Visual Basic front end will allow greater user interaction with the model, thereby allowing further scenario analysis and model updates over time. This would allow SAMI members to examine the emission reductions under a number of different assumptions about penetration rates, housing growth, emission factors, and other variables.

3. Improve Compatibility Between Pechan and ICF Databases. There are fundamental differences between Pechan's database and the one developed by ICF Consulting for this project. For example, Pechan's database includes Industrial Facilities, while ICF Consulting's database/model does not. (SAMI did not task ICF Consulting to address Industrial Facilities.) Also, Pechan's database does not account for emissions from non-fossil fuel based Electric generation whereas ICF does. These mis-alignments should be resolved to enable an improved compatibility between the results of ICF Consulting's model and Pechan's data.

- **References**

1. Annual Energy Outlook 2001 With Projections to 2020. Energy Information Administration. http://www.eia.doe.gov/oiaf/aeo/

2. Commercial Buildings Energy Consumption Survey (CBECS) 1997. Energy Information Administration. http://www.eia.doe.gov/

3. County Population Estimates for July 1, 1999 and Population Change: July 1, 1998 to July 1, 1999. U.S. Bureau of Census. http://www.census.gov/population/www/estimates/co_99_1.html

4. "Existing Generating Units at U.S. Electric Utilities by State, Company, and Plant, 1999". Energy Information Administration. http://www.eia.doe.gov/cneaf/electricity/ipp/t20p01.txt

5. Residential Energy Consumption Survey (RECS) 1997. Energy Information Administration. http://www.eia.doe.gov/

6. "Southern Appalachian Mountains Initiative (SAMI) Emission Projections to 2010 and 2040: Growth and Control Data and Emission Estimation Methodologies" Draft Final Report. E.H. Pechan & Associates. July 2001

7. "Green Book: Non attainment Areas for Criteria Pollutants". U.S. Environmental Protection Agency. http://www.epa.gov/oar/oaqps/greenbk/o3co.html

- **Energy Appendices**

A. Detailed Estimates of Energy and Emissions Reductions from the Implementation of Energy Efficiency Upgrades in Residential Buildings

B. Detailed Estimates of Energy and Emissions Reductions from the Implementation of Energy Efficiency Upgrades in Commercial Buildings

C. Description of ICF Consulting's Energy Use and Emissions Forecasting Model

D. List of Abbreviations

• Appendix A: Detailed Estimates of Energy and Emissions Reductions from the Implementation of Energy Efficiency Upgrades in Residential Buildings

Exhibit A-1: Estimated Oil & Gas Consumption in Residential Buildings

Year	State	Number of New Homes (millions)	Number of Existing Homes (millions)	Percent Homes w/ Gas Heat	1990 Ten Year Growth Rate	Annual Gas Energy Use (Trillion BTUs/Yr)											
						New Homes				Existing Homes				Total			
						Baseline	Passive	Active	Aggressive	Baseline	Passive	Active	Aggressive	Baseline	Passive	Active	Aggressive
1990	AL	0.15	1.06	60%	10%	7				55				62			
	GA	0.26	1.90	60%	10%	12				99				111			
	KY	0.13	0.97	60%	10%	6				50				56			
	NC	0.26	1.86	60%	10%	12				97				109			
	SC	0.13	0.95	60%	10%	6				49				55			
	TN	0.18	1.34	60%	10%	8				69				78			
	VA	0.23	1.67	60%	10%	11				87				97			
	WV	0.06	0.44	60%	10%	3				23				26			
	Sub-Total	1.40	10.19			64				529				594			
2000	AL	0.23	1.21	60%	10%	6				38				44			
	GA	0.41	2.16	60%	10%	11				67				79			
	KY	0.21	1.10	60%	10%	8				41				48			
	NC	0.41	2.12	60%	10%	15				79				93			
	SC	0.21	1.08	60%	10%	6				34				39			
	TN	0.29	1.52	60%	10%	10				56				67			
	VA	0.36	1.90	60%	10%	13				71				84			
	WV	0.10	0.50	60%	10%	3				19				22			
	Sub-Total	2.22	11.59			73				404				476			
2010	AL	0.20	1.44	60%	10%	5	5	4	4	42	39	37	35	47	44	42	39
	GA	0.35	2.57	60%	10%	9	9	8	7	74	70	66	63	83	79	74	70

	KY	0.18	1.31	60%	10%	6	6	5	5	46	44	43	41	52	50	48	46
	NC	0.35	2.53	60%	10%	12	11	10	9	89	86	82	79	100	97	92	88
	SC	0.18	1.28	60%	10%	5	4	4	4	37	35	33	31	42	39	37	35
	TN	0.25	1.81	60%	10%	8	8	7	6	64	61	59	57	72	69	66	63
	VA	0.31	2.27	60%	10%	11	10	9	8	80	77	74	71	90	87	83	79
	WV	0.08	0.60	60%	10%	3	3	2	2	21	20	19	19	24	23	22	21
	Sub-Total	1.90	13.80			59	55	49	45	451	433	415	396	510	488	464	442

Exhibit A-1: Estimated Oil & Gas Consumption in Residential Buildings (cont'd)

Year	State	Number of New Homes (millions)	Number of Existing Homes (millions)	Percent Homes w/ Gas Heat	1990 Ten Year Growth Rate	Annual Gas Energy Use (Trillion BTUs/Yr)											
						New Homes				Existing Homes				Total			
						Baseline	Passive	Active	Aggressive	Baseline	Passive	Active	Aggressive	Baseline	Passive	Active	Aggressive
2020	AL	0.23	1.64	60%	10%	5	5	4	4	43	39	36	33	48	44	40	37
	GA	0.40	2.92	60%	10%	10	9	8	7	77	70	64	59	86	79	72	66
	KY	0.21	1.49	60%	10%	6	6	5	5	48	45	41	38	55	50	46	43
	NC	0.40	2.87	60%	10%	12	11	10	9	93	86	79	74	106	97	89	83
	SC	0.20	1.46	60%	10%	5	4	4	4	38	35	32	29	43	39	36	33
	TN	0.28	2.06	60%	10%	9	8	7	7	67	62	56	53	76	70	64	59
	VA	0.36	2.58	60%	10%	11	10	9	8	84	77	71	66	95	87	80	74
	WV	0.09	0.68	60%	10%	3	3	2	2	22	20	19	17	25	23	21	20
	Sub-Total	2.17	15.71			61	56	49	46	472	434	396	370	534	489	448	415
2030	AL	0.26	1.87	60%	10%	6	5	5	4	46	41	35	32	52	46	40	36
	GA	0.46	3.33	60%	10%	10	9	9	8	82	72	63	57	92	82	71	64
	KY	0.23	1.69	60%	10%	7	6	6	5	52	46	40	36	59	52	46	41

	NC	0.45	3.27	60%	10%	13	12	11	9	101	90	78	70	114	101	89	79
	SC	0.23	1.66	60%	10%	5	5	4	4	41	36	31	28	46	41	36	32
	TN	0.32	2.34	60%	10%	9	8	8	7	73	64	56	50	82	73	63	57
	VA	0.40	2.94	60%	10%	11	11	10	8	91	80	70	63	102	91	80	71
	WV	0.11	0.77	60%	10%	3	3	3	2	24	21	18	17	27	24	21	19
	Sub-Total	2.43	17.87			64	59	56	47	510	450	391	353	574	510	446	399
2040	AL	0.29	2.12	60%	10%	6	5	5	4	48	41	33	29	54	47	38	33
	GA	0.52	3.79	60%	10%	11	10	9	8	86	73	60	52	97	83	68	60
	KY	0.27	1.93	60%	10%	7	6	6	5	55	47	38	32	62	54	43	37
	NC	0.51	3.72	60%	10%	14	12	11	9	106	91	73	62	120	103	83	72
	SC	0.26	1.89	60%	10%	6	5	4	4	43	37	30	26	48	41	34	30
	TN	0.37	2.67	60%	10%	10	9	8	7	76	66	52	45	86	74	60	51
	VA	0.46	3.34	60%	10%	13	11	10	8	95	82	65	56	108	93	75	64
	WV	0.12	0.88	60%	10%	3	3	3	2	25	22	17	15	28	24	20	17
	Sub-Total	2.80	20.33			70	61	56	47	534	459	368	317	603	520	422	364

Exhibit A-2: Estimated Reduction in Oil & Gas Consumption from the Implementation of Energy Efficiency Measures in Residential Buildings

Year	State	Reduction in Annual Gas Use - Relative to Baseline (Trillion Btus/Yr)									Percent Reduction in Gas Energy Use - Relative to Baseline								
		New Homes			Existing Homes			Total			New Homes			Existing Homes			Total		
		Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive
2010	AL	0.3	0.8	1.1	2.1	4.3	6.4	2.5	5.1	7.6	6%	15%	22%	5%	10%	15%	5%	11%	16%
	GA	0.6	1.4	2.0	3.8	7.6	11.5	4.4	9.1	13.5	6%	15%	22%	5%	10%	15%	5%	11%	16%
	KY	0.4	1.0	1.4	1.6	3.2	4.8	2.0	4.2	6.2	6%	17%	23%	3%	7%	10%	4%	8%	12%
	NC	0.8	2.0	2.7	3.1	6.2	9.3	3.9	8.1	12.0	6%	17%	23%	3%	7%	10%	4%	8%	12%
	SC	0.3	0.7	1.0	1.9	3.8	5.7	2.2	4.5	6.7	6%	15%	22%	5%	10%	15%	5%	11%	16%
	TN	0.5	1.4	2.0	2.2	4.4	6.7	2.8	5.8	8.6	6%	17%	23%	3%	7%	10%	4%	8%	12%
	VA	0.7	1.8	2.5	2.8	5.6	8.4	3.5	7.3	10.8	6%	17%	23%	3%	7%	10%	4%	8%	12%
	WV	0.2	0.5	0.6	0.7	1.5	2.2	0.9	1.9	2.8	6%	17%	23%	3%	7%	10%	4%	8%	12%
	Sub-Total	3.7	9.5	13.4	18.3	36.6	54.9	22.0	46.1	68.3	6%	16%	23%	4%	8%	12%	4%	9%	13%
2020	AL	0.4	0.9	1.2	3.8	7.1	9.9	4.2	8.0	11.1	8%	16%	23%	9%	16%	23%	9%	16%	23%
	GA	0.8	1.6	2.2	6.7	12.6	17.6	7.5	14.2	19.8	8%	16%	23%	9%	16%	23%	9%	16%	23%

	KY	0.6	1.1	1.5	3.8	7.6	10.2	4.3	8.7	11.7	9%	17%	24%	8%	16%	21%	8%	16%	21%
	NC	1.1	2.1	3.0	7.3	14.7	19.6	8.4	16.8	22.6	9%	17%	24%	8%	16%	21%	8%	16%	21%
	SC	0.4	0.8	1.1	3.4	6.3	8.8	3.7	7.1	9.9	8%	16%	23%	9%	16%	23%	9%	16%	23%
	TN	0.8	1.5	2.1	5.2	10.5	14.1	6.0	12.1	16.2	9%	17%	24%	8%	16%	21%	8%	16%	21%
	VA	1.0	1.9	2.7	6.6	13.2	17.7	7.5	15.1	20.3	9%	17%	24%	8%	16%	21%	8%	16%	21%
	WV	0.3	0.5	0.7	1.7	3.5	4.6	2.0	4.0	5.3	9%	17%	24%	8%	16%	21%	8%	16%	21%
	Sub-Total	5.2	10.4	14.4	38.5	75.6	102.5	43.7	86.0	116.9	9%	17%	24%	8%	16%	22%	8%	16%	22%

Exhibit A-2: Estimated Reduction in Oil & Gas Consumption from the Implementation of Energy Efficiency Measures in Residential Buildings (cont'd)

Year	State	Reduction in Annual Gas Use - Relative to Baseline (Trillion Btus/Yr)									Percent Reduction in Gas Energy Use - Relative to Baseline								
		New Homes			Existing Homes			Total			New Homes			Existing Homes			Total		
		Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive

2030	AL	0.4	0.7	1.3	5.5	10.9	14.1	5.8	11.7	15.4	7%	13%	23%	12%	24%	31%	11%	23%	30%
	GA	0.6	1.3	2.3	9.7	19.5	25.2	10.4	20.8	27.5	7%	13%	23%	12%	24%	31%	11%	23%	30%
	KY	0.5	0.9	1.6	6.1	12.2	16.2	6.6	13.2	17.9	7%	14%	25%	12%	23%	31%	11%	22%	30%
	NC	0.9	1.8	3.2	11.8	23.6	31.3	12.7	25.4	34.5	7%	14%	25%	12%	23%	31%	11%	22%	30%
	SC	0.3	0.6	1.2	4.9	9.7	12.6	5.2	10.4	13.7	7%	13%	23%	12%	24%	31%	11%	23%	30%
	TN	0.6	1.3	2.3	8.5	16.9	22.5	9.1	18.2	24.7	7%	14%	25%	12%	23%	31%	11%	22%	30%
	VA	0.8	1.6	2.9	10.6	21.2	28.1	11.4	22.8	31.0	7%	14%	25%	12%	23%	31%	11%	22%	30%
	WV	0.2	0.4	0.8	2.8	5.6	7.4	3.0	6.0	8.1	7%	14%	25%	12%	23%	31%	11%	22%	30%
	Sub-Total	4.3	8.6	15.5	59.9	119.7	157.5	64.2	128.4	172.9	7%	14%	25%	12%	23%	31%	11%	22%	30%
2040	AL	0.9	1.4	2.0	6.9	14.7	19.0	7.7	16.1	21.0	14%	23%	31%	14%	30%	39%	14%	30%	39%
	GA	1.6	2.5	3.5	12.2	26.1	33.9	13.8	28.7	37.3	14%	23%	31%	14%	30%	39%	14%	30%	39%
	KY	1.1	1.8	2.5	7.4	17.1	22.5	8.5	18.9	25.0	15%	24%	34%	13%	31%	41%	14%	30%	40%
	NC	2.1	3.5	4.8	14.3	33.0	43.4	16.4	36.5	48.2	15%	24%	34%	13%	31%	41%	14%	30%	40%
	SC	0.8	1.3	1.7	6.1	13.0	16.9	6.9	14.3	18.6	14%	23%	31%	14%	30%	39%	14%	30%	39%
	TN	1.5	2.5	3.4	10.2	23.7	31.1	11.7	26.1	34.5	15%	24%	34%	13%	31%	41%	14%	30%	40%
	VA	1.9	3.1	4.3	12.8	29.7	39.0	14.7	32.8	43.3	15%	24%	34%	13%	31%	41%	14%	30%	40%
	WV	0.5	0.8	1.1	3.4	7.8	10.3	3.9	8.6	11.4	15%	24%	34%	13%	31%	41%	14%	30%	40%

	Sub-Total	10.4	16.8	23.3	73.2	165.1	216.0	83.6	181.9	239.3	15%	24%	33%	14%	31%	41%	14%	30%	40%

Exhibit A-3: Estimated Emissions from Oil & Gas Consumption in Residential Buildings

Year	State	Annual Emissions							
		SO_2 (million tons)				CO_2 (million tonnes)			
		Baseline	Passive	Active	Aggressive	Baseline	Passive	Active	Aggressive
1990	AL	0.03				3.21			
	GA	0.06				5.72			
	KY	0.03				2.91			
	NC	0.05				5.62			
	SC	0.03				2.86			
	TN	0.04				4.03			
	VA	0.05				5.03			
	WV	0.01				1.32			
	Sub-Total	0.30				30.71			
2000	AL	0.02				2.28			
	GA	0.04				4.07			
	KY	0.02				2.50			
	NC	0.05				4.83			
	SC	0.02				2.03			
	TN	0.03				3.46			
	VA	0.04				4.34			
	WV	0.01				1.14			
	Sub-Total	0.24				24.64			
2010	AL	0.02	0.02	0.02	0.02	2.42	2.29	2.15	2.03
	GA	0.04	0.04	0.04	0.03	4.31	4.08	3.84	3.61
	KY	0.03	0.02	0.02	0.02	2.69	2.59	2.47	2.37
	NC	0.05	0.05	0.05	0.04	5.19	5.00	4.77	4.57
	SC	0.02	0.02	0.02	0.02	2.15	2.04	1.92	1.80
	TN	0.04	0.03	0.03	0.03	3.72	3.58	3.42	3.28
	VA	0.05	0.04	0.04	0.04	4.67	4.49	4.29	4.11
	WV	0.01	0.01	0.01	0.01	1.23	1.18	1.13	1.08

Year	State	SO2 Baseline	SO2 Passive	SO2 Active	SO2 Aggressive	CO2 Baseline	CO2 Passive	CO2 Active	CO2 Aggressive
	Sub-Total	0.25	0.24	0.23	0.22	26.38	25.24	23.99	22.84
2020	AL	0.02	0.02	0.02	0.02	2.50	2.28	2.09	1.93
	GA	0.04	0.04	0.04	0.03	4.46	4.07	3.72	3.43
	KY	0.03	0.03	0.02	0.02	2.83	2.60	2.38	2.22
	NC	0.05	0.05	0.04	0.04	5.46	5.03	4.59	4.29
	SC	0.02	0.02	0.02	0.02	2.22	2.03	1.86	1.71
	TN	0.04	0.03	0.03	0.03	3.91	3.60	3.29	3.07
	VA	0.05	0.04	0.04	0.04	4.90	4.52	4.12	3.85
	WV	0.01	0.01	0.01	0.01	1.29	1.19	1.08	1.01
	Sub-Total	0.27	0.24	0.22	0.21	27.57	25.31	23.13	21.53

Exhibit A-3: Estimated Emissions from Oil & Gas Consumption in Residential Buildings (cont'd)

Year	State	Annual Emissions							
		SO_2 (million tons)				CO_2 (million tonnes)			
		Baseline	Passive	Active	Aggressive	Baseline	Passive	Active	Aggressive
2030	AL	0.03	0.02	0.02	0.02	2.67	2.37	2.07	1.87
	GA	0.05	0.04	0.04	0.03	4.76	4.22	3.68	3.33
	KY	0.03	0.03	0.02	0.02	3.05	2.71	2.37	2.13
	NC	0.06	0.05	0.04	0.04	5.89	5.24	4.58	4.11
	SC	0.02	0.02	0.02	0.02	2.37	2.11	1.84	1.66
	TN	0.04	0.04	0.03	0.03	4.22	3.75	3.28	2.94
	VA	0.05	0.05	0.04	0.04	5.29	4.70	4.11	3.69
	WV	0.01	0.01	0.01	0.01	1.39	1.24	1.08	0.97

	Sub-Total	0.29	0.25	0.22	0.20	29.65	26.33	23.01	20.71
2040	AL	0.03	0.02	0.02	0.02	2.81	2.41	1.98	1.73
	GA	0.05	0.04	0.03	0.03	5.01	4.30	3.53	3.08
	KY	0.03	0.03	0.02	0.02	3.21	2.77	2.23	1.92
	NC	0.06	0.05	0.04	0.04	6.20	5.35	4.31	3.71
	SC	0.02	0.02	0.02	0.01	2.50	2.14	1.76	1.54
	TN	0.04	0.04	0.03	0.03	4.44	3.84	3.09	2.66
	VA	0.05	0.05	0.04	0.03	5.57	4.81	3.88	3.33
	WV	0.01	0.01	0.01	0.01	1.46	1.26	1.02	0.88
	Sub-Total	0.30	0.26	0.21	0.18	31.22	26.89	21.81	18.84

Exhibit A-4: Estimated Emission Reductions (from Oil & Gas Consumption) from the Implementation of Energy Efficiency Measures in Residential Buildings

Year	State	Reduction in Annual Emissions - Relative to Baseline						Percent Reduction in Emissions -Relative to Baseline					
		SO_2 (million tons)			CO_2 (million tonnes)			SO_2			CO_2		
		Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive
2010	AL	0.00	0.00	0.00	0.13	0.26	0.39	5%	11%	16%	5%	11%	16%
	GA	0.00	0.00	0.01	0.23	0.47	0.70	5%	11%	16%	5%	11%	16%
	KY	0.00	0.00	0.00	0.10	0.22	0.32	4%	8%	12%	4%	8%	12%
	NC	0.00	0.00	0.01	0.20	0.42	0.62	4%	8%	12%	4%	8%	12%
	SC	0.00	0.00	0.00	0.11	0.23	0.35	5%	11%	16%	5%	11%	16%
	TN	0.00	0.00	0.00	0.14	0.30	0.45	4%	8%	12%	4%	8%	12%
	VA	0.00	0.00	0.01	0.18	0.38	0.56	4%	8%	12%	4%	8%	12%
	WV	0.00	0.00	0.00	0.05	0.10	0.15	4%	8%	12%	4%	8%	12%
	Sub-Total	0.01	0.02	0.03	1.14	2.39	3.53	4%	9%	13%	4%	9%	13%
2020	AL	0.00	0.00	0.01	0.22	0.41	0.57	9%	16%	23%	9%	16%	23%
	GA	0.00	0.01	0.01	0.39	0.73	1.02	9%	16%	23%	9%	16%	23%
	KY	0.00	0.00	0.01	0.22	0.45	0.61	8%	16%	21%	8%	16%	21%
	NC	0.00	0.01	0.01	0.43	0.87	1.17	8%	16%	21%	8%	16%	21%
	SC	0.00	0.00	0.00	0.19	0.37	0.51	9%	16%	23%	9%	16%	23%
	TN	0.00	0.01	0.01	0.31	0.62	0.84	8%	16%	21%	8%	16%	21%
	VA	0.00	0.01	0.01	0.39	0.78	1.05	8%	16%	21%	8%	16%	21%
	WV	0.00	0.00	0.00	0.10	0.21	0.28	8%	16%	21%	8%	16%	21%

	Sub-Total	0.02	0.04	0.06	2.26	4.45	6.05	8%	16%	22%	8%	16%	22%
2030	AL	0.00	0.01	0.01	0.30	0.60	0.80	11%	23%	30%	11%	23%	30%
	GA	0.01	0.01	0.01	0.54	1.08	1.42	11%	23%	30%	11%	23%	30%
	KY	0.00	0.01	0.01	0.34	0.68	0.92	11%	22%	30%	11%	22%	30%
	NC	0.01	0.01	0.02	0.66	1.31	1.79	11%	22%	30%	11%	22%	30%
	SC	0.00	0.01	0.01	0.27	0.54	0.71	11%	23%	30%	11%	23%	30%
	TN	0.00	0.01	0.01	0.47	0.94	1.28	11%	22%	30%	11%	22%	30%
	VA	0.01	0.01	0.02	0.59	1.18	1.60	11%	22%	30%	11%	22%	30%
	WV	0.00	0.00	0.00	0.16	0.31	0.42	11%	22%	30%	11%	22%	30%
	Sub-Total	0.03	0.06	0.09	3.32	6.64	8.95	11%	22%	30%	11%	22%	30%
2040	AL	0.00	0.01	0.01	0.40	0.83	1.08	14%	30%	39%	14%	30%	39%
	GA	0.01	0.01	0.02	0.71	1.48	1.93	14%	30%	39%	14%	30%	39%
	KY	0.00	0.01	0.01	0.44	0.98	1.29	14%	30%	40%	14%	30%	40%
	NC	0.01	0.02	0.02	0.85	1.89	2.49	14%	30%	40%	14%	30%	40%
	SC	0.00	0.01	0.01	0.36	0.74	0.96	14%	30%	39%	14%	30%	39%
	TN	0.01	0.01	0.02	0.61	1.35	1.79	14%	30%	40%	14%	30%	40%
	VA	0.01	0.02	0.02	0.76	1.69	2.24	14%	30%	40%	14%	30%	40%
	WV	0.00	0.00	0.01	0.20	0.45	0.59	14%	30%	40%	14%	30%	40%
	Sub-Total	0.04	0.09	0.12	4.33	9.41	12.38	14%	30%	40%	14%	30%	40%

Exhibit A-5: Estimated Electricity Consumption in Residential Buildings

Year	State	Number of New Homes (millions)	Number of Existing Homes (millions)	Percent Homes w/ Gas Heat	1990 Ten Year Growth Rate	Annual Electric Energy Use (TWh/yr)											
						New Homes				Existing Homes				Total			
						Baseline	Passive	Active	Aggressive	Baseline	Passive	Active	Aggressive	Baseline	Passive	Active	Aggressive
1990	AL	0.17	1.04	60%	12%	2				17				19			
	GA	0.30	1.86	60%	12%	4				30				34			
	KY	0.15	0.95	60%	12%	2				14				16			
	NC	0.29	1.83	60%	12%	3				26				30			
	SC	0.15	0.93	60%	12%	2				15				17			
	TN	0.21	1.31	60%	12%	2				19				21			
	VA	0.26	1.64	60%	12%	3				24				27			
	WV	0.07	0.43	60%	12%	1				6				7			
	Sub-Total	1.60	9.99			20				151				171			
2000	AL	0.23	1.21	60%	12%	3				20				23			
	GA	0.41	2.16	60%	12%	5				35				40			
	KY	0.21	1.10	60%	12%	2				16				18			
	NC	0.41	2.12	60%	12%	5				31				35			
	SC	0.21	1.08	60%	12%	3				17				20			
	TN	0.29	1.52	60%	12%	3				22				25			
	VA	0.36	1.90	60%	12%	4				28				32			
	WV	0.10	0.50	60%	12%	1				7				8			
	Sub-Total	2.22	11.59			27				176				203			
2010	AL	0.23	1.44	60%	12%	3	3	2	2	21	19	18	16	24	22	20	18
	GA	0.41	2.57	60%	12%	5	5	4	4	37	35	32	29	42	39	36	33
	KY	0.21	1.31	60%	12%	2	2	2	2	17	16	15	14	19	18	17	15

	NC	0.41	2.53	60%	12%	4	4	4	3	33	31	29	26	37	35	32	30
	SC	0.21	1.28	60%	12%	2	2	2	2	19	17	16	15	21	20	18	16
	TN	0.29	1.81	60%	12%	3	3	3	2	24	22	20	19	27	25	23	21
	VA	0.36	2.27	60%	12%	4	4	3	3	30	28	26	24	34	31	29	27
	WV	0.10	0.60	60%	12%	1	1	1	1	8	7	7	6	9	8	8	7
	Sub-Total	2.22	13.80			25	24	21	19	188	175	162	148	214	198	182	167

Exhibit A-5: Estimated Electricity Consumption in Residential Buildings (cont'd)

Year	State	Number of New Homes (millions)	Number of Existing Homes (millions)	Percent Homes w/ Gas Heat	1990 Ten Year Growth Rate	Annual Electric Energy Use (TWh/yr)											
						New Homes				Existing Homes				Total			
						Baseline	Passive	Active	Aggressive	Baseline	Passive	Active	Aggressive	Baseline	Passive	Active	Aggressive
2020	AL	0.27	1.67	60%	12%	3	3	2	2	21	19	17	15	24	22	20	18
	GA	0.48	2.98	60%	12%	5	5	4	4	38	34	31	27	43	39	35	31
	KY	0.24	1.52	60%	12%	2	2	2	2	18	16	14	13	20	18	16	15
	NC	0.47	2.93	60%	12%	5	4	4	4	34	30	27	25	39	35	31	28
	SC	0.24	1.49	60%	12%	3	2	2	2	19	17	15	14	22	19	17	16
	TN	0.34	2.10	60%	12%	3	3	3	3	24	22	20	18	28	25	22	20
	VA	0.42	2.63	60%	12%	4	4	3	3	31	27	25	22	35	31	28	25
	WV	0.11	0.69	60%	12%	1	1	1	1	8	7	6	6	9	8	7	7
	Sub-Total	2.57	16.02			26	24	22	20	193	172	156	139	220	196	177	159
2030	AL	0.31	1.94	60%	12%	3	3	3	2	23	20	17	15	26	23	19	18
	GA	0.56	3.46	60%	12%	5	5	5	4	41	35	30	27	46	41	35	31
	KY	0.28	1.76	60%	12%	2	2	2	2	19	17	14	13	21	19	16	15
	NC	0.55	3.40	60%	12%	5	5	4	4	37	32	27	24	42	36	31	28
	SC	0.28	1.73	60%	12%	3	3	2	2	20	18	15	13	23	20	17	16
	TN	0.39	2.44	60%	12%	3	3	3	3	26	23	19	17	30	26	22	20

	VA	0.49	3.06	60%	12%	4	4	4	3	33	29	24	22	37	33	28	25
	WV	0.13	0.80	60%	12%	1	1	1	1	9	8	6	6	10	9	7	7
	Sub-Total	2.98	18.59			26	24	22	21	208	182	167	137	235	207	175	160
2040	AL	0.36	2.25	60%	12%	3	3	3	3	24	20	17	15	28	23	19	18
	GA	0.65	4.02	60%	12%	6	5	5	5	43	36	29	27	49	41	34	31
	KY	0.33	2.04	60%	12%	3	3	2	2	20	17	14	12	23	19	16	15
	NC	0.63	3.95	60%	12%	5	5	4	4	39	32	27	24	44	37	31	28
	SC	0.32	2.00	60%	12%	3	3	3	2	22	18	15	13	25	21	17	16
	TN	0.45	2.83	60%	12%	4	3	3	3	28	23	19	17	32	27	22	20
	VA	0.57	3.55	60%	12%	5	4	4	4	35	29	24	22	40	33	28	25
	WV	0.15	0.93	60%	12%	1	1	1	1	9	8	6	6	10	9	7	7
	Sub-Total	3.46	21.57			31	28	25	23	220	183	150	136	250	211	176	159

Exhibit A-6: Estimated Reduction in Electricity Consumption from the Implementation of Energy Efficiency Measures in Residential Buildings

Year	State	Reduction in Annual Electricity Use - Relative to Baseline (TWh)									Percent Reduction in Electricity Use - Relative to Baseline								
		New Homes			Existing Homes			Total			New Homes			Existing Homes			Total		
		Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive
2010	AL	0.2	0.5	0.7	1.5	3.1	4.6	1.7	3.6	5.3	7%	19%	25%	7%	15%	22%	7%	15%	22%
	GA	0.4	0.9	1.3	2.7	5.5	8.2	3.1	6.4	9.5	7%	19%	25%	7%	15%	22%	7%	15%	22%
	KY	0.2	0.4	0.6	1.2	2.3	3.5	1.3	2.8	4.1	7%	18%	25%	7%	14%	20%	7%	14%	21%
	NC	0.3	0.8	1.1	2.3	4.5	6.8	2.6	5.3	7.9	7%	18%	25%	7%	14%	20%	7%	14%	21%
	SC	0.2	0.5	0.6	1.4	2.7	4.1	1.5	3.2	4.7	7%	19%	25%	7%	15%	22%	7%	15%	22%
	TN	0.2	0.6	0.8	1.6	3.2	4.9	1.8	3.8	5.6	7%	18%	25%	7%	14%	20%	7%	14%	21%
	VA	0.3	0.7	1.0	2.0	4.1	6.1	2.3	4.8	7.1	7%	18%	25%	7%	14%	20%	7%	14%	21%
	WV	0.1	0.2	0.3	0.5	1.1	1.6	0.6	1.3	1.9	7%	18%	25%	7%	14%	20%	7%	14%	21%
	Sub-Total	1.8	4.6	6.3	13.3	26.5	39.8	15.0	31.2	46.1	7%	18%	25%	7%	14%	21%	7%	15%	22%
2020	AL	0.3	0.5	0.7	2.4	4.2	6.2	2.7	4.8	6.8	9%	18%	23%	11%	20%	29%	11%	20%	28%
	GA	0.5	0.9	1.2	4.3	7.5	11.0	4.7	8.5	12.2	9%	18%	23%	11%	20%	29%	11%	20%	28%
	KY	0.2	0.4	0.5	1.9	3.4	4.9	2.1	3.8	5.4	9%	18%	23%	11%	19%	28%	11%	19%	27%
	NC	0.4	0.8	1.1	3.6	6.5	9.4	4.1	7.3	10.5	9%	18%	23%	11%	19%	28%	11%	19%	27%
	SC	0.2	0.5	0.6	2.1	3.8	5.5	2.4	4.2	6.1	9%	18%	23%	11%	20%	29%	11%	20%	28%
	TN	0.3	0.6	0.8	2.6	4.7	6.7	2.9	5.3	7.5	9%	18%	23%	11%	19%	28%	11%	19%	27%
	VA	0.4	0.7	0.9	3.3	5.8	8.5	3.6	6.6	9.4	9%	18%	23%	11%	19%	28%	11%	19%	27%
	WV	0.1	0.2	0.2	0.9	1.5	2.2	1.0	1.7	2.5	9%	18%	23%	11%	19%	28%	11%	19%	27%

	Sub-Total	2.4	4.7	6.0	21.1	37.5	54.4	23.5	42.2	60.4	9%	18%	23%	11%	19%	28%	11%	19%	27%
2030	AL	0.2	0.4	0.6	3.1	6.2	7.9	3.3	6.6	8.5	6%	12%	20%	13%	27%	34%	13%	25%	33%
	GA	0.3	0.6	1.1	5.5	11.1	14.1	5.8	11.7	15.1	6%	12%	20%	13%	27%	34%	13%	25%	33%
	KY	0.1	0.3	0.5	2.5	5.0	6.4	2.6	5.3	6.9	6%	12%	20%	13%	26%	34%	12%	25%	32%
	NC	0.3	0.6	1.0	4.8	9.6	12.3	5.1	10.2	13.3	6%	12%	20%	13%	26%	34%	12%	25%	32%
	SC	0.2	0.3	0.5	2.8	5.5	7.0	2.9	5.8	7.5	6%	12%	20%	13%	27%	34%	13%	25%	33%
	TN	0.2	0.4	0.7	3.4	6.9	8.8	3.7	7.3	9.5	6%	12%	20%	13%	26%	34%	12%	25%	32%
	VA	0.3	0.5	0.9	4.3	8.6	11.1	4.6	9.2	11.9	6%	12%	20%	13%	26%	34%	12%	25%	32%
	WV	0.1	0.1	0.2	1.1	2.3	2.9	1.2	2.4	3.1	6%	12%	20%	13%	26%	34%	12%	25%	32%
	Sub-Total	1.6	3.2	5.4	27.6	55.2	70.4	29.2	58.4	75.8	6%	12%	20%	13%	27%	34%	12%	25%	32%
2040	AL	0.4	0.6	0.8	4.1	7.7	9.3	4.5	8.3	10.1	11%	18%	25%	17%	32%	38%	16%	30%	37%
	GA	0.7	1.1	1.5	7.3	13.8	16.5	8.0	14.8	18.0	11%	18%	25%	17%	32%	38%	16%	30%	37%
	KY	0.3	0.5	0.7	3.3	6.3	7.6	3.6	6.8	8.3	11%	18%	25%	16%	31%	38%	16%	30%	36%
	NC	0.6	1.0	1.4	6.3	12.1	14.7	6.9	13.1	16.0	11%	18%	25%	16%	31%	38%	16%	30%	36%
	SC	0.3	0.5	0.7	3.7	6.9	8.2	4.0	7.4	9.0	11%	18%	25%	17%	32%	38%	16%	30%	37%
	TN	0.4	0.7	1.0	4.5	8.7	10.5	5.0	9.4	11.5	11%	18%	25%	16%	31%	38%	16%	30%	36%
	VA	0.5	0.9	1.2	5.7	10.9	13.2	6.2	11.8	14.4	11%	18%	25%	16%	31%	38%	16%	30%	36%
	WV	0.1	0.2	0.3	1.5	2.9	3.5	1.6	3.1	3.8	11%	18%	25%	16%	31%	38%	16%	30%	36%
	Sub-Total	3.4	5.5	7.7	36.4	69.2	83.4	39.8	74.7	91.1	11%	18%	25%	17%	32%	38%	16%	30%	36%

Exhibit A-7: Estimated Emissions from Electricity Consumption in Residential Buildings

Year	State	Annual Emissions		
		SO_2 (Million Tons)	NO_x (Million Tons)	CO_2 (Billion Tonnes)

		Baseline	Passive	Active	Aggressive	Baseline	Passive	Active	Aggressive	Baseline	Passive	Active	Aggressive
1990	AL	0.10				0.04				0.02			
	GA	0.16				0.06				0.03			
	KY	0.11				0.06				0.02			
	NC	0.14				0.08				0.03			
	SC	0.04				0.02				0.02			
	TN	0.12				0.06				0.02			
	VA	0.09				0.05				0.02			
	WV	0.02				0.01				0.01			
	Sub-Total	0.79				0.39				0.16			
2000	AL	0.12				0.04				0.02			
	GA	0.19				0.07				0.04			
	KY	0.13				0.08				0.02			
	NC	0.16				0.09				0.03			
	SC	0.05				0.03				0.02			
	TN	0.15				0.07				0.03			
	VA	0.11				0.06				0.02			
	WV	0.03				0.02				0.01			
	Sub-Total	0.94				0.46				0.19			
2010	AL	0.12	0.11	0.10	0.09	0.05	0.04	0.04	0.04	0.02	0.02	0.02	0.02
	GA	0.20	0.19	0.17	0.16	0.07	0.07	0.06	0.06	0.04	0.04	0.04	0.03
	KY	0.14	0.13	0.12	0.11	0.08	0.08	0.07	0.06	0.02	0.02	0.02	0.02
	NC	0.17	0.16	0.15	0.13	0.10	0.09	0.09	0.08	0.04	0.03	0.03	0.03
	SC	0.06	0.05	0.05	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02
	TN	0.16	0.14	0.13	0.12	0.08	0.07	0.07	0.06	0.03	0.02	0.02	0.02
	VA	0.11	0.11	0.10	0.09	0.06	0.06	0.05	0.05	0.03	0.02	0.02	0.02
	WV	0.03	0.03	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01
	Sub-Total	0.99	0.92	0.85	0.78	0.48	0.45	0.41	0.38	0.20	0.19	0.17	0.16
2020	AL	0.12	0.11	0.10	0.09	0.05	0.04	0.04	0.03	0.02	0.02	0.02	0.02

	GA	0.21	0.19	0.17	0.15	0.07	0.06	0.06	0.05	0.04	0.04	0.03	0.03
	KY	0.15	0.13	0.12	0.11	0.08	0.07	0.07	0.06	0.02	0.02	0.02	0.01
	NC	0.18	0.16	0.14	0.13	0.10	0.09	0.08	0.07	0.04	0.03	0.03	0.03
	SC	0.06	0.05	0.05	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02
	TN	0.16	0.14	0.13	0.12	0.08	0.07	0.07	0.06	0.03	0.02	0.02	0.02
	VA	0.12	0.11	0.10	0.09	0.06	0.06	0.05	0.05	0.03	0.02	0.02	0.02
	WV	0.03	0.03	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.00
	Sub-Total	1.02	0.91	0.82	0.74	0.50	0.44	0.40	0.36	0.21	0.18	0.17	0.15

Exhibit A-7: Estimated Emissions from Electricity Consumption in Residential Buildings (cont'd)

Year	State	Annual Emissions											
		SO_2 (Million Tons)				NO_x (Million Tons)				CO_2 (Billion Tonnes)			
		Baseline	Passive	Active	Aggressive	Baseline	Passive	Active	Aggressive	Baseline	Passive	Active	Aggressive
2030	AL	0.13	0.12	0.10	0.09	0.05	0.04	0.04	0.03	0.03	0.02	0.02	0.02
	GA	0.22	0.20	0.17	0.15	0.08	0.07	0.06	0.05	0.05	0.04	0.03	0.03
	KY	0.16	0.14	0.12	0.11	0.09	0.08	0.07	0.06	0.02	0.02	0.02	0.01
	NC	0.19	0.17	0.14	0.13	0.11	0.10	0.08	0.07	0.04	0.04	0.03	0.03
	SC	0.06	0.05	0.05	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02
	TN	0.17	0.15	0.13	0.12	0.09	0.08	0.07	0.06	0.03	0.03	0.02	0.02
	VA	0.13	0.11	0.10	0.09	0.07	0.06	0.05	0.05	0.03	0.02	0.02	0.02
	WV	0.03	0.03	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.00

	Sub-Total	1.09	0.96	0.82	0.74	0.53	0.47	0.40	0.36	0.22	0.19	0.17	0.15
2040	AL	0.14	0.12	0.10	0.09	0.05	0.04	0.04	0.03	0.03	0.02	0.02	0.02
	GA	0.24	0.20	0.17	0.15	0.08	0.07	0.06	0.05	0.05	0.04	0.03	0.03
	KY	0.17	0.14	0.12	0.11	0.10	0.08	0.07	0.06	0.02	0.02	0.02	0.01
	NC	0.20	0.17	0.14	0.13	0.12	0.10	0.08	0.07	0.04	0.04	0.03	0.03
	SC	0.06	0.05	0.05	0.04	0.04	0.03	0.02	0.02	0.02	0.02	0.02	0.02
	TN	0.18	0.15	0.13	0.12	0.09	0.08	0.06	0.06	0.03	0.03	0.02	0.02
	VA	0.13	0.11	0.09	0.09	0.07	0.06	0.05	0.05	0.03	0.02	0.02	0.02
	WV	0.04	0.03	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.00
	Sub-Total	1.16	0.98	0.82	0.74	0.57	0.48	0.40	0.36	0.23	0.20	0.16	0.15

Exhibit A-8: Emission Reductions (from Electricity Consumption) from the Implementation of Energy Efficiency Measures in Residential Buildings

Year	State	Reduction in Annual Emissions - Relative to Baseline									Percent Reduction in Annual Emissions - Relative to Baseline								
		SO_2 (Million Tons)			NO_x (Million Tons)			CO_2 (Billion Tonnes)			SO_2			NO_x			CO_2		
		Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive
2010	AL	0.01	0.02	0.03	0.00	0.01	0.01	0.00	0.00	0.01	7%	15%	22%	7%	15%	22%	7%	15%	22%
	GA	0.01	0.03	0.05	0.01	0.01	0.02	0.00	0.01	0.01	7%	15%	22%	7%	15%	22%	7%	15%	22%
	KY	0.01	0.02	0.03	0.01	0.01	0.02	0.00	0.00	0.00	7%	14%	21%	7%	14%	21%	7%	14%	21%
	NC	0.01	0.02	0.04	0.01	0.01	0.02	0.00	0.01	0.01	7%	14%	21%	7%	14%	21%	7%	14%	21%
	SC	0.00	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.00	7%	15%	22%	7%	15%	22%	7%	15%	22%
	TN	0.01	0.02	0.03	0.01	0.01	0.02	0.00	0.00	0.01	7%	14%	21%	7%	14%	21%	7%	14%	21%
	VA	0.01	0.02	0.02	0.00	0.01	0.01	0.00	0.00	0.01	7%	14%	21%	7%	14%	21%	7%	14%	21%
	WV	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	7%	14%	21%	7%	14%	21%	7%	14%	21%
	Sub-Total	0.07	0.14	0.21	0.03	0.07	0.10	0.01	0.03	0.04	7%	15%	22%	7%	15%	21%	7%	15%	22%
2020	AL	0.01	0.02	0.03	0.01	0.01	0.01	0.00	0.00	0.01	11%	20%	28%	11%	20%	28%	11%	20%	28%
	GA	0.02	0.04	0.06	0.01	0.01	0.02	0.00	0.01	0.01	11%	20%	28%	11%	20%	28%	11%	20%	28%
	KY	0.02	0.03	0.04	0.01	0.02	0.02	0.00	0.00	0.01	11%	19%	27%	11%	19%	27%	11%	19%	27%
	NC	0.02	0.03	0.05	0.01	0.02	0.03	0.00	0.01	0.01	11%	19%	27%	11%	19%	27%	11%	19%	27%
	SC	0.01	0.01	0.02	0.00	0.01	0.01	0.00	0.00	0.01	11%	20%	28%	11%	20%	28%	11%	20%	28%
	TN	0.02	0.03	0.04	0.01	0.02	0.02	0.00	0.01	0.01	11%	19%	27%	11%	19%	27%	11%	19%	27%
	VA	0.01	0.02	0.03	0.01	0.01	0.02	0.00	0.00	0.01	11%	19%	27%	11%	19%	27%	11%	19%	27%
	WV	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	11%	19%	27%	11%	19%	27%	11%	19%	27%
	Sub-Total	0.11	0.20	0.28	0.05	0.10	0.14	0.02	0.04	0.06	11%	19%	27%	11%	19%	27%	11%	19%	28%

Exhibit A-8: Emission Reductions (from Electricity Consumption) from the Implementation of Energy Efficiency Measures in Residential Buildings (cont'd)

Year	State	Reduction in Annual Emissions – Relative to Baseline									Percent Reduction in Annual Emissions - Relative to Baseline								
		SO_2 (Million Tons)			NO_x (Million Tons)			CO_2 (Billion Tonnes)			SO_2			NO_x			CO_2		
		Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive
2030	AL	0.02	0.03	0.04	0.01	0.01	0.02	0.00	0.01	0.01	13%	25%	33%	13%	25%	33%	13%	25%	33%
	GA	0.03	0.06	0.07	0.01	0.02	0.03	0.01	0.01	0.01	13%	25%	33%	13%	25%	33%	13%	25%	33%
	KY	0.02	0.04	0.05	0.01	0.02	0.03	0.00	0.01	0.01	12%	25%	32%	12%	25%	32%	12%	25%	32%
	NC	0.02	0.05	0.06	0.01	0.03	0.04	0.01	0.01	0.01	12%	25%	32%	12%	25%	32%	12%	25%	32%
	SC	0.01	0.02	0.02	0.00	0.01	0.01	0.00	0.01	0.01	13%	25%	33%	13%	25%	33%	13%	25%	33%
	TN	0.02	0.04	0.05	0.01	0.02	0.03	0.00	0.01	0.01	12%	25%	32%	12%	25%	32%	12%	25%	32%
	VA	0.02	0.03	0.04	0.01	0.02	0.02	0.00	0.01	0.01	12%	25%	32%	12%	25%	32%	12%	25%	32%
	WV	0.00	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.00	12%	25%	32%	12%	25%	32%	12%	25%	32%
	Sub-Total	0.14	0.27	0.35	0.07	0.13	0.17	0.03	0.05	0.07	12%	25%	32%	12%	25%	32%	12%	25%	32%
2040	AL	0.02	0.04	0.05	0.01	0.02	0.02	0.00	0.01	0.01	16%	30%	37%	16%	30%	37%	16%	30%	37%
	GA	0.04	0.07	0.09	0.01	0.02	0.03	0.01	0.01	0.02	16%	30%	37%	16%	30%	37%	16%	30%	37%
	KY	0.03	0.05	0.06	0.01	0.03	0.03	0.00	0.01	0.01	16%	30%	36%	16%	30%	36%	16%	30%	36%
	NC	0.03	0.06	0.07	0.02	0.03	0.04	0.01	0.01	0.02	16%	30%	36%	16%	30%	36%	16%	30%	36%
	SC	0.01	0.02	0.02	0.01	0.01	0.01	0.00	0.01	0.01	16%	30%	37%	16%	30%	37%	16%	30%	37%
	TN	0.03	0.05	0.07	0.01	0.03	0.03	0.00	0.01	0.01	16%	30%	36%	16%	30%	36%	16%	30%	36%
	VA	0.02	0.04	0.05	0.01	0.02	0.03	0.00	0.01	0.01	16%	30%	36%	16%	30%	36%	16%	30%	36%

	WV	0.01	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.00	16%	30%	36%	16%	30%	36%	16%	30%	36%
	Sub-Total	0.18	0.35	0.42	0.09	0.17	0.21	0.04	0.07	0.09	16%	30%	36%	16%	30%	36%	16%	30%	36%

- **Appendix B: Detailed Estimates of Energy and Emissions Reductions from the Implementation of Energy Efficiency Upgrades in Commercial Buildings**

Exhibit B-1: Estimated Oil & Gas Consumption in Commercial Buildings

Year	State	Number of New Buildings (Billion SF)	Number of Existing Buildings (Billion SF)	Percent Building w/ Gas Heat	1990 Ten Year Growth Rate	Annual Oil & Gas Energy Use (Trillion Btus/Yr)											
						New Buildings				Existing Buildings				Total			
						Baseline	Passive	Active	Aggressive	Baseline	Passive	Active	Aggressive	Baseline	Passive	Active	Aggressive
1990	AL	0.10	0.82	80%	9%	3				30				33			
	GA	0.17	1.47	80%	9%	5				54				59			
	KY	0.09	0.74	80%	9%	3				35				38			
	NC	0.17	1.44	80%	9%	5				69				74			
	SC	0.08	0.74	80%	9%	2				27				29			
	TN	0.12	1.04	80%	9%	4				49				53			
	VA	0.15	1.30	80%	9%	5				62				67			
	WV	0.04	0.34	80%	9%	1				16				18			
	Sub-Total	0.91	7.90			28				344				372			
2000	AL	0.12	0.92	80%	9%	3				34				37			
	GA	0.21	1.64	80%	9%	6				61				67			
	KY	0.11	0.83	80%	9%	4				40				43			
	NC	0.21	1.61	80%	9%	7				77				84			
	SC	0.11	0.82	80%	9%	3				30				33			
	TN	0.15	1.16	80%	9%	5				55				60			
	VA	0.19	1.45	80%	9%	6				69				75			
	WV	0.05	0.38	80%	9%	2				18				20			
	Sub Total	1.15	8.82			35				384				419			
2010	AL	0.12	1.04	80%	9%	3	3	3	3	36	34	33	31	39	37	36	33
	GA	0.21	1.86	80%	9%	6	5	5	5	64	61	58	55	69	66	63	59

	KY	0.11	0.94	80%	9%	3	3	3	3	41	39	37	34	45	43	40	37
	NC	0.21	1.82	80%	9%	7	6	6	6	80	76	72	66	86	82	78	72
	SC	0.11	0.93	80%	9%	3	3	3	2	32	30	29	27	35	33	32	30
	TN	0.15	1.31	80%	9%	5	5	4	4	57	54	51	48	62	59	56	52
	VA	0.19	1.64	80%	9%	6	6	5	5	72	68	64	60	78	74	70	65
	WV	0.05	0.43	80%	9%	2	2	1	1	19	18	17	16	20	19	18	17
	Sub-Total	1.15	9.97			34	33	31	29	400	381	361	336	434	413	392	365

Exhibit B-1: Estimated Oil & Gas Consumption in Commercial Buildings (cont'd)

Year	State	Number of New Buildings (Billion SF)	Number of Existing Buildings (Billion SF)	Percent Building w/ Gas Heat	1990 Ten Year Growth Rate	Annual Oil & Gas Energy Use (Trillion Btus/Yr)											
						New Buildings				Existing Buildings				Total			
						Baseline	Passive	Active	Aggressive	Baseline	Passive	Active	Aggressive	Baseline	Passive	Active	Aggressive
2020	AL	0.13	1.16	80%	9%	3	3	3	3	36	34	32	29	39	37	35	32
	GA	0.24	2.07	80%	9%	6	6	5	5	64	60	57	51	70	66	62	57
	KY	0.12	1.05	80%	9%	4	3	3	3	41	38	36	32	44	41	39	35
	NC	0.24	2.03	80%	9%	7	7	6	6	79	73	69	61	86	79	75	67
	SC	0.12	1.03	80%	9%	3	3	3	3	32	30	28	26	35	33	31	28
	TN	0.17	1.46	80%	9%	5	5	5	4	56	52	49	44	61	57	54	48
	VA	0.21	1.83	80%	9%	6	6	6	5	71	65	62	55	77	71	67	60
	WV	0.06	0.48	80%	9%	2	2	1	1	19	17	16	14	20	19	18	16
	Sub-Total	1.29	11.12			36	34	32	31	397	368	349	311	433	403	381	343
2030	AL	0.15	1.30	80%	9%	4	3	3	3	38	35	32	30	41	38	36	33
	GA	0.27	2.31	80%	9%	6	6	6	6	68	62	58	53	74	68	64	58
	KY	0.14	1.18	80%	9%	4	4	4	3	43	38	35	32	46	42	39	35
	NC	0.26	2.27	80%	9%	7	7	7	6	82	74	68	62	90	81	75	68

	SC	0.13	1.15	80%	9%	3	3	3	3	34	31	29	26	37	34	32	29
	TN	0.19	1.63	80%	9%	5	5	5	5	59	53	49	44	64	58	54	49
	VA	0.24	2.04	80%	9%	7	6	6	6	74	66	61	55	80	73	68	61
	WV	0.06	0.54	80%	9%	2	2	2	2	19	17	16	15	21	19	18	16
	Sub-Total	1.43	12.41			38	34	35	33	377	376	349	316	454	413	385	350
2040	AL	0.17	1.45	80%	9%	4	4	4	3	40	35	32	30	44	39	36	34
	GA	0.30	2.58	80%	9%	7	7	6	6	71	63	57	54	78	70	63	60
	KY	0.15	1.31	80%	9%	4	4	4	4	44	39	34	32	48	43	38	36
	NC	0.29	2.53	80%	9%	8	8	7	7	86	75	66	62	94	82	73	69
	SC	0.15	1.29	80%	9%	3	3	3	3	35	32	28	27	39	35	32	30
	TN	0.21	1.81	80%	9%	6	5	5	5	61	54	47	45	67	59	53	50
	VA	0.26	2.27	80%	9%	7	7	6	6	77	67	59	56	84	74	66	62
	WV	0.07	0.60	80%	9%	2	2	2	2	20	18	16	15	22	19	17	16
	Sub-Total	1.60	13.84			42	39	37	35	434	382	340	321	476	421	377	357

Exhibit B-2: Estimated Reductions in Oil & Gas Consumption from the Implementation of Energy Efficiency Measures in Commercial Buildings

Year	State	Reduction in Annual Oil & Gas Energy Use -Relative to Baseline (Trillion Btus/Yr)									Percent Reduction in Oil & Gas Energy Use - Relative to Baseline								
		New Buildings			Existing Buildings			Total			New Buildings			Existing Buildings			Total		
		Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive
2010	AL	0.1	0.3	0.4	1.6	3.2	5.2	1.7	3.5	5.6	4%	9%	13%	4%	9%	15%	4%	9%	14%

	GA	0.2	0.5	0.7	2.8	5.6	9.3	3.0	6.2	10.0	4%	9%	13%	4%	9%	15%	4%	9%	14%
	KY	0.1	0.4	0.5	2.1	4.2	7.0	2.3	4.6	7.4	4%	10%	14%	5%	10%	17%	5%	10%	17%
	NC	0.3	0.7	1.0	4.1	8.2	13.4	4.4	8.9	14.4	4%	10%	14%	5%	10%	17%	5%	10%	17%
	SC	0.1	0.3	0.4	1.4	2.8	4.6	1.5	3.1	5.0	4%	9%	13%	4%	9%	15%	4%	9%	14%
	TN	0.2	0.5	0.7	2.9	5.9	9.6	3.1	6.4	10.3	4%	10%	14%	5%	10%	17%	5%	10%	17%
	VA	0.2	0.6	0.9	3.7	7.3	12.1	3.9	8.0	12.9	4%	10%	14%	5%	10%	17%	5%	10%	17%
	WV	0.1	0.2	0.2	1.0	1.9	3.2	1.0	2.1	3.4	4%	10%	14%	5%	10%	17%	5%	10%	17%
	Sub-Total	1.3	3.4	4.7	19.6	39.2	64.3	20.9	42.5	69.0	4%	10%	14%	5%	10%	16%	5%	10%	16%
2020	AL	0.1	0.3	0.4	2.4	4.0	7.0	2.5	4.3	7.4	4%	9%	12%	7%	11%	20%	6%	11%	19%
	GA	0.3	0.5	0.7	4.2	7.1	12.5	4.5	7.6	13.2	4%	9%	12%	7%	11%	20%	6%	11%	19%
	KY	0.2	0.4	0.5	3.1	5.2	9.2	3.3	5.6	9.7	5%	10%	13%	8%	13%	23%	7%	13%	22%
	NC	0.4	0.7	0.9	6.0	10.0	17.8	6.3	10.7	18.8	5%	10%	13%	8%	13%	23%	7%	13%	22%
	SC	0.1	0.3	0.3	2.1	3.5	6.3	2.2	3.8	6.6	4%	9%	12%	7%	11%	20%	6%	11%	19%
	TN	0.3	0.5	0.7	4.3	7.2	12.8	4.5	7.7	13.5	5%	10%	13%	8%	13%	23%	7%	13%	22%
	VA	0.3	0.6	0.8	5.4	9.0	16.0	5.7	9.6	16.9	5%	10%	13%	8%	13%	23%	7%	13%	22%
	WV	0.1	0.2	0.2	1.4	2.4	4.2	1.5	2.5	4.4	5%	10%	13%	8%	13%	23%	7%	13%	22%
	Sub-Total	1.7	3.5	4.6	28.8	48.3	85.9	30.6	51.7	90.5	5%	10%	13%	7%	12%	22%	7%	12%	21%

Exhibit B-2: Estimated Reductions in Oil & Gas Consumption from the Implementation of Energy Efficiency Measures in Commercial Buildings (cont'd)

Year	State	Reduction in Annual Oil & Gas Energy se - Relative to Baseline (Trillion Btus/Yr))									Percent Reduction in Oil & Gas Energy Use -Relative to Baseline								
		New Buildings			Existing Buildings			Total			New Buildings			Existing Buildings			Total		
		Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive
2030	AL	0.1	0.2	0.4	3.3	5.5	8.2	3.4	5.7	8.6	3%	6%	11%	9%	15%	22%	8%	14%	21%
	GA	0.2	0.4	0.7	5.9	9.8	14.7	6.1	10.2	15.4	3%	6%	11%	9%	15%	22%	8%	14%	21%
	KY	0.1	0.3	0.5	4.3	7.1	10.7	4.4	7.4	11.1	4%	7%	12%	10%	17%	25%	10%	16%	24%
	NC	0.3	0.5	0.9	8.3	13.8	20.6	8.5	14.3	21.5	4%	7%	12%	10%	17%	25%	10%	16%	24%
	SC	0.1	0.2	0.3	2.9	4.9	7.3	3.0	5.1	7.7	3%	6%	11%	9%	15%	22%	8%	14%	21%
	TN	0.2	0.4	0.7	5.9	9.9	14.8	6.1	10.2	15.4	4%	7%	12%	10%	17%	25%	10%	16%	24%
	VA	0.2	0.5	0.8	7.4	12.4	18.5	7.7	12.8	19.3	4%	7%	12%	10%	17%	25%	10%	16%	24%
	WV	0.1	0.1	0.2	2.0	3.3	4.9	2.0	3.4	5.1	4%	7%	12%	10%	17%	25%	10%	16%	24%

	Sub-Total	1.3	2.6	4.5	39.9	66.6	99.6	41.2	69.2	104.1	3%	7%	12%	10%	16%	24%	9%	15%	23%
2040	AL	0.2	0.4	0.5	4.3	7.8	9.4	4.5	8.2	9.9	6%	10%	14%	11%	20%	24%	10%	19%	23%
	GA	0.4	0.7	1.0	7.7	13.9	16.7	8.1	14.6	17.7	6%	10%	14%	11%	20%	24%	10%	19%	23%
	KY	0.3	0.5	0.7	5.6	10.0	12.0	5.9	10.5	12.7	7%	12%	16%	13%	23%	27%	12%	22%	26%
	NC	0.6	0.9	1.3	10.8	19.4	23.3	11.4	20.4	24.6	7%	12%	16%	13%	23%	27%	12%	22%	26%
	SC	0.2	0.3	0.5	3.8	6.9	8.3	4.0	7.3	8.8	6%	10%	14%	11%	20%	24%	10%	19%	23%
	TN	0.4	0.7	0.9	7.8	13.9	16.7	8.2	14.6	17.6	7%	12%	16%	13%	23%	27%	12%	22%	26%
	VA	0.5	0.9	1.2	9.7	17.4	20.9	10.3	18.3	22.1	7%	12%	16%	13%	23%	27%	12%	22%	26%
	WV	0.1	0.2	0.3	2.6	4.6	5.5	2.7	4.8	5.8	7%	12%	16%	13%	23%	27%	12%	22%	26%
	Sub-Total	2.9	4.6	6.4	52.3	94.0	112.9	55.2	98.6	119.3	7%	11%	15%	12%	22%	26%	12%	21%	25%

Exhibit B-3: Estimated Emissions from Oil & Gas Consumption in Commercial Buildings

Year	State	Annual Emissions: SO_2 (million tons)				CO_2 (million tonnes)			
		Baseline	Passive	Active	Aggressive	Baseline	Passive	Active	Aggressive
1990	AL	0.02				1.71			
	GA	0.03				3.05			
	KY	0.02				1.98			
	NC	0.04				3.84			
	SC	0.01				1.53			
	TN	0.03				2.76			
	VA	0.03				3.46			
	WV	0.01				0.91			
	Sub-Total	0.19				19.23			
2000	AL	0.02				1.93			
	GA	0.03				3.44			
	KY	0.02				2.24			
	NC	0.04				4.33			
	SC	0.02				1.72			
	TN	0.03				3.10			
	VA	0.04				3.89			
	WV	0.01				1.02			
	Sub-Total	0.21				21.68			
2010	AL	0.02	0.02	0.02	0.02	2.02	1.93	1.84	1.73
	GA	0.03	0.03	0.03	0.03	3.59	3.44	3.27	3.08
	KY	0.02	0.02	0.02	0.02	2.32	2.20	2.08	1.93
	NC	0.04	0.04	0.04	0.04	4.47	4.25	4.01	3.73
	SC	0.02	0.02	0.02	0.01	1.79	1.71	1.63	1.53
	TN	0.03	0.03	0.03	0.03	3.21	3.04	2.88	2.67
	VA	0.04	0.04	0.03	0.03	4.02	3.82	3.61	3.35
	WV	0.01	0.01	0.01	0.01	1.06	1.00	0.95	0.88
	Sub-Total	0.22	0.21	0.20	0.18	22.47	21.39	20.27	18.90

2020	AL	0.02	0.02	0.02	0.02	2.03	1.90	1.81	1.65
	GA	0.04	0.03	0.03	0.03	3.62	3.39	3.23	2.94
	KY	0.02	0.02	0.02	0.02	2.30	2.13	2.01	1.79
	NC	0.04	0.04	0.04	0.03	4.44	4.11	3.88	3.47
	SC	0.02	0.02	0.02	0.01	1.81	1.69	1.61	1.47
	TN	0.03	0.03	0.03	0.02	3.18	2.94	2.78	2.48
	VA	0.04	0.04	0.03	0.03	3.99	3.69	3.49	3.11
	WV	0.01	0.01	0.01	0.01	1.05	0.97	0.92	0.82
	Sub-Total	0.22	0.20	0.19	0.17	22.41	20.83	19.73	17.73

Exhibit B-3: Estimated Emissions from Oil & Gas Consumption in Commercial Buildings (cont'd)

Year	State	Annual Emissions							
		SO_2 (million tons)				CO_2 (million tonnes)			
		Baseline	Passive	Active	Aggressive	Baseline	Passive	Active	Aggressive
2030	AL	0.02	0.02	0.02	0.02	2.14	1.97	1.85	1.70
	GA	0.04	0.03	0.03	0.03	3.82	3.51	3.29	3.02
	KY	0.02	0.02	0.02	0.02	2.40	2.17	2.02	1.82
	NC	0.04	0.04	0.04	0.03	4.63	4.19	3.89	3.52
	SC	0.02	0.02	0.02	0.01	1.91	1.75	1.64	1.51
	TN	0.03	0.03	0.03	0.02	3.32	3.00	2.79	2.52
	VA	0.04	0.04	0.03	0.03	4.16	3.77	3.50	3.16

	WV	0.01	0.01	0.01	0.01	1.09	0.99	0.92	0.83
	Sub-Total	0.23	0.21	0.19	0.17	23.47	21.34	19.90	18.09
2040	AL	0.02	0.02	0.02	0.02	2.26	2.03	1.84	1.75
	GA	0.04	0.03	0.03	0.03	4.03	3.61	3.28	3.12
	KY	0.02	0.02	0.02	0.02	2.51	2.20	1.96	1.85
	NC	0.05	0.04	0.04	0.03	4.85	4.25	3.79	3.57
	SC	0.02	0.02	0.02	0.02	2.01	1.80	1.63	1.55
	TN	0.03	0.03	0.03	0.02	3.47	3.05	2.72	2.56
	VA	0.04	0.04	0.03	0.03	4.35	3.82	3.41	3.21
	WV	0.01	0.01	0.01	0.01	1.14	1.00	0.90	0.84
	Sub-Total	0.24	0.21	0.19	0.18	24.63	21.78	19.53	18.46

Exhibit B-4: Estimated Emission Reductions (from Reduced Oil & Gas Consumption) from the Implementation of Energy Efficiency Measures in Commercial Buildings

Year	State	Reduction in Annual Emissions - Relative to Baseline						Percent Reduction in Emissions					
		SO_2 (million tons)			CO_2 (million tonnes)			SO2			CO2		
		Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive
2010	AL	0.00	0.00	0.00	0.09	0.18	0.29	4%	9%	14%	4%	9%	14%
	GA	0.00	0.00	0.00	0.16	0.32	0.52	4%	9%	14%	4%	9%	14%
	KY	0.00	0.00	0.00	0.12	0.24	0.39	5%	10%	17%	5%	10%	17%
	NC	0.00	0.00	0.01	0.23	0.46	0.74	5%	10%	17%	5%	10%	17%
	SC	0.00	0.00	0.00	0.08	0.16	0.26	4%	9%	14%	4%	9%	14%
	TN	0.00	0.00	0.01	0.16	0.33	0.53	5%	10%	17%	5%	10%	17%
	VA	0.00	0.00	0.01	0.20	0.41	0.67	5%	10%	17%	5%	10%	17%
	WV	0.00	0.00	0.00	0.05	0.11	0.18	5%	10%	17%	5%	10%	17%
	Sub-Total	0.01	0.02	0.03	1.08	2.20	3.57	5%	10%	16%	5%	10%	16%
2020	AL	0.00	0.00	0.00	0.13	0.22	0.38	6%	11%	19%	6%	11%	19%
	GA	0.00	0.00	0.01	0.23	0.39	0.68	6%	11%	19%	6%	11%	19%
	KY	0.00	0.00	0.00	0.17	0.29	0.50	7%	13%	22%	7%	13%	22%
	NC	0.00	0.01	0.01	0.33	0.55	0.97	7%	13%	22%	7%	13%	22%
	SC	0.00	0.00	0.00	0.12	0.20	0.34	6%	11%	19%	6%	11%	19%
	TN	0.00	0.00	0.01	0.24	0.40	0.70	7%	13%	22%	7%	13%	22%
	VA	0.00	0.00	0.01	0.29	0.50	0.87	7%	13%	22%	7%	13%	22%
	WV	0.00	0.00	0.00	0.08	0.13	0.23	7%	13%	22%	7%	13%	22%
	Sub-	0.02	0.03	0.0	1.58	2.68	4.68	7%	12%	21%	7%	12%	21%

	Total			5									
2030	AL	0.00	0.00	0.00	0.18	0.30	0.45	8%	14%	21%	8%	14%	21%
	GA	0.00	0.01	0.01	0.31	0.53	0.79	8%	14%	21%	8%	14%	21%
	KY	0.00	0.00	0.01	0.23	0.38	0.58	10%	16%	24%	10%	16%	24%
	NC	0.00	0.01	0.01	0.44	0.74	1.11	10%	16%	24%	10%	16%	24%
	SC	0.00	0.00	0.00	0.16	0.26	0.40	8%	14%	21%	8%	14%	21%
	TN	0.00	0.01	0.01	0.32	0.53	0.80	10%	16%	24%	10%	16%	24%
	VA	0.00	0.01	0.01	0.40	0.66	1.00	10%	16%	24%	10%	16%	24%
	WV	0.00	0.00	0.00	0.10	0.17	0.26	10%	16%	24%	10%	16%	24%
	Sub-Total	0.02	0.03	0.05	2.13	3.58	5.39	9%	15%	23%	9%	15%	23%
2040	AL	0.00	0.00	0.00	0.23	0.42	0.51	10%	19%	23%	10%	19%	23%
	GA	0.00	0.01	0.01	0.42	0.75	0.91	10%	19%	23%	10%	19%	23%
	KY	0.00	0.01	0.01	0.31	0.55	0.66	12%	22%	26%	12%	22%	26%
	NC	0.01	0.01	0.01	0.59	1.05	1.27	12%	22%	26%	12%	22%	26%
	SC	0.00	0.00	0.00	0.21	0.38	0.46	10%	19%	23%	10%	19%	23%
	TN	0.00	0.01	0.01	0.42	0.75	0.91	12%	22%	26%	12%	22%	26%
	VA	0.01	0.01	0.01	0.53	0.95	1.14	12%	22%	26%	12%	22%	26%
	WV	0.00	0.00	0.00	0.14	0.25	0.30	12%	22%	26%	12%	22%	26%
	Sub-Total	0.03	0.05	0.06	2.85	5.10	6.17	12%	21%	25%	12%	21%	25%

Exhibit B-5: Estimated Electricity Consumption in Commercial Buildings

Year	State	Number of New Buildings (Billion SF)	Number of Existing Buildings (Billion SF)	1990 Ten Year Growth Rate	Annual Electric Energy Use (TWh/yr)											
					New Buildings				Existing Buildings				Total			
					Baseline	Passive	Active	Aggressive	Baseline	Passive	Active	Aggressive	Baseline	Passive	Active	Aggressive
1990	AL	0.10	0.82	9%	1				13				15			
	GA	0.17	1.47	9%	2				24				26			
	KY	0.09	0.74	9%	1				12				13			
	NC	0.17	1.44	9%	2				23				25			
	SC	0.08	0.74	9%	1				12				13			
	TN	0.12	1.04	9%	2				17				18			
	VA	0.15	1.30	9%	2				21				23			
	WV	0.04	0.34	9%	1				5				6			
	Sub-Total	0.91	7.90		12				127				139			
2000	AL	0.12	0.92	9%	2				15				17			
	GA	0.21	1.64	9%	3				27				29			
	KY	0.11	0.83	9%	1				13				15			
	NC	0.21	1.61	9%	3				26				29			
	SC	0.11	0.82	9%	1				13				15			
	TN	0.15	1.16	9%	2				18				20			
	VA	0.19	1.45	9%	2				23				26			
	WV	0.05	0.38	9%	1				6				7			
	Sub-Total	1.15	8.82		15				141				157			
2010	AL	0.12	1.04	9%	2	1	1	1	16	15	15	14	17	17	16	15
	GA	0.21	1.86	9%	3	3	2	2	28	27	26	25	31	30	29	27
	KY	0.11	0.94	9%	1	1	1	1	14	14	13	13	16	15	14	14
	NC	0.21	1.82	9%	3	3	2	2	27	26	25	24	30	29	28	26
	SC	0.11	0.93	9%	1	1	1	1	14	14	13	12	15	15	14	14
	TN	0.15	1.31	9%	2	2	2	2	20	19	18	17	22	21	20	19
	VA	0.19	1.64	9%	2	2	2	2	25	24	23	22	27	26	25	24
	WV	0.05	0.43	9%	1	1	1	1	6	6	6	6	7	7	7	6

	Sub-Total	1.15	9.97		15	14	13	12	151	145	140	133	165	159	153	145

Exhibit B-5: Estimated Electricity Consumption in Commercial Buildings (cont'd)

Year	State	Number of New Buildings (Billion SF)	Number of Existing Buildings (Billion SF)	1990 Ten Year Growth Rate	Annual Electric Energy Use (TWh/yr)											
					New Buildings				Existing Buildings				Total			
					Baseline	Passive	Active	Aggressive	Baseline	Passive	Active	Aggressive	Baseline	Passive	Active	Aggressive
2020	AL	0.13	1.16	9%	2	1	1	1	16	15	14	13	18	17	16	14
	GA	0.24	2.07	9%	3	3	2	2	29	27	26	23	32	30	28	25
	KY	0.12	1.05	9%	1	1	1	1	14	13	13	12	16	15	14	13
	NC	0.24	2.03	9%	3	3	2	2	28	26	25	22	31	29	27	24
	SC	0.12	1.03	9%	1	1	1	1	14	13	13	11	16	15	14	13
	TN	0.17	1.46	9%	2	2	2	2	20	19	18	16	22	20	19	18
	VA	0.21	1.83	9%	2	2	2	2	25	23	22	20	27	26	24	22
	WV	0.06	0.48	9%	1	1	1	1	7	6	6	5	7	7	6	6
	Sub-Total	1.29	11.12		15	14	13	12	153	143	136	122	168	157	149	135
2030	AL	0.15	1.30	9%	2	2	1	1	17	15	14	13	19	17	16	14
	GA	0.27	2.31	9%	3	3	3	2	31	28	25	23	34	30	28	25
	KY	0.14	1.18	9%	1	1	1	1	15	14	13	11	17	15	14	13
	NC	0.26	2.27	9%	3	3	3	2	30	27	25	22	32	29	27	24
	SC	0.13	1.15	9%	1	1	1	1	15	14	13	11	17	15	14	13
	TN	0.19	1.63	9%	2	2	2	2	21	19	18	16	23	21	19	17
	VA	0.24	2.04	9%	3	2	2	2	27	24	22	20	29	26	24	22
	WV	0.06	0.54	9%	1	1	1	1	7	6	6	5	8	7	6	6
	Sub-Total	1.43	12.41		15	15	14	13	163	147	135	121	178	161	149	134
04	AL	0.17	1.45	9%	2	2	2	1	18	16	13	12	20	17	15	14

	GA	0.30	2.58	9%	3	3	3	3	32	28	24	22	35	31	27	25
	KY	0.15	1.31	9%	2	1	1	1	16	14	12	11	18	15	13	12
	NC	0.29	2.53	9%	3	3	3	2	31	27	23	21	34	30	26	24
	SC	0.15	1.29	9%	2	1	1	1	16	14	12	11	17	15	13	12
	TN	0.21	1.81	9%	2	2	2	2	22	19	17	15	24	21	19	17
	VA	0.26	2.27	9%	3	3	2	2	28	24	21	19	30	27	23	21
	WV	0.07	0.60	9%	1	1	1	1	7	6	5	5	8	7	6	6
	Sub-Total	1.60	13.84		17	15	15	14	169	149	128	118	186	164	142	131

Exhibit B-6: Estimated Reductions in Electricity Consumption from the Implementation of Energy Efficiency Measures in Commercial Buildings

Year	State	Reduction in Annual Electricity Use -Relative to Baseline (TWh)									Percent Reduction in Electricity Use - Relative to Baseline								
		New Buildings			Existing Buildings			Total			New Buildings			Existing Buildings			Total		
		Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive
2010	AL	0.1	0.2	0.3	0.6	1.1	1.8	0.6	1.3	2.1	5%	13%	19%	4%	7%	11%	4%	8%	12%
	GA	0.1	0.4	0.5	1.0	2.0	3.3	1.1	2.4	3.8	5%	13%	19%	4%	7%	11%	4%	8%	12%
	KY	0.1	0.2	0.3	0.5	1.0	1.6	0.6	1.2	1.9	5%	13%	18%	4%	7%	12%	4%	8%	12%
	NC	0.1	0.4	0.5	1.0	1.9	3.2	1.1	2.3	3.6	5%	13%	18%	4%	7%	12%	4%	8%	12%
	SC	0.1	0.2	0.3	0.5	1.0	1.6	0.6	1.2	1.9	5%	13%	19%	4%	7%	11%	4%	8%	12%
	TN	0.1	0.3	0.3	0.7	1.4	2.3	0.8	1.6	2.6	5%	13%	18%	4%	7%	12%	4%	8%	12%
	VA	0.1	0.3	0.4	0.9	1.7	2.8	1.0	2.1	3.3	5%	13%	18%	4%	7%	12%	4%	8%	12%
	WV	0.0	0.1	0.1	0.2	0.5	0.7	0.3	0.5	0.9	5%	13%	18%	4%	7%	12%	4%	8%	12%
	Sub-Total	0.7	1.9	2.7	5.3	10.7	17.3	6.1	12.6	20.0	5%	13%	18%	4%	7%	12%	4%	8%	12%
2020	AL	0.1	0.2	0.3	1.1	1.8	3.3	1.2	2.1	3.5	7%	13%	17%	7%	11%	20%	7%	12%	20%
	GA	0.2	0.4	0.5	1.9	3.3	5.8	2.1	3.7	6.3	7%	13%	17%	7%	11%	20%	7%	12%	20%

	KY	0.1	0.2	0.2	1.0	1.7	2.9	1.1	1.8	3.2	7%	13%	17%	7%	11%	20%	7%	12%	20%
	NC	0.2	0.4	0.5	1.9	3.2	5.6	2.0	3.6	6.1	7%	13%	17%	7%	11%	20%	7%	12%	20%
	SC	0.1	0.2	0.2	1.0	1.6	2.9	1.1	1.8	3.2	7%	13%	17%	7%	11%	20%	7%	12%	20%
	TN	0.1	0.3	0.3	1.3	2.3	4.0	1.5	2.5	4.4	7%	13%	17%	7%	11%	20%	7%	12%	20%
	VA	0.2	0.3	0.4	1.7	2.9	5.1	1.8	3.2	5.5	7%	13%	17%	7%	11%	20%	7%	12%	20%
	WV	0.0	0.1	0.1	0.4	0.8	1.3	0.5	0.8	1.4	7%	13%	17%	7%	11%	20%	7%	12%	20%
	Sub-Total	1.0	2.0	2.6	10.3	17.5	31.0	11.3	19.5	33.6	7%	13%	17%	7%	11%	20%	7%	12%	20%

Exhibit B-6: Estimated Reductions in Electricity Consumption from the Implementation of Energy Efficiency Measures in Commercial Buildings (cont'd)

Year	State	Reduction in Annual Electricity Use - Relative to Baseline (TWh)									Percent Reduction in Electricity Use - Relative to Baseline								
		New Buildings			Existing Buildings			Total			New Buildings			Existing Buildings			Total		
		Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive
2030	AL	0.1	0.2	0.3	1.7	2.9	4.5	1.8	3.1	4.7	5%	9%	16%	10%	17%	26%	10%	16%	25%

	GA	0.1	0.3	0.5	3.1	5.2	7.9	3.2	5.5	8.4	5%	9%	16%	10%	17%	26%	10%	16%	25%
	KY	0.1	0.1	0.2	1.5	2.6	4.0	1.6	2.7	4.2	5%	9%	16%	10%	17%	26%	10%	16%	25%
	NC	0.1	0.3	0.4	3.0	5.0	7.7	3.1	5.3	8.1	5%	9%	16%	10%	17%	26%	10%	16%	25%
	SC	0.1	0.1	0.2	1.5	2.6	4.0	1.6	2.7	4.2	5%	9%	16%	10%	17%	26%	10%	16%	25%
	TN	0.1	0.2	0.3	2.1	3.6	5.5	2.2	3.8	5.8	5%	9%	16%	10%	17%	26%	10%	16%	25%
	VA	0.1	0.2	0.4	2.7	4.5	6.9	2.8	4.8	7.3	5%	9%	16%	10%	17%	26%	10%	16%	25%
	WV	0.0	0.1	0.1	0.7	1.2	1.8	0.7	1.2	1.9	5%	9%	16%	10%	17%	26%	10%	16%	25%
	Sub-Total	0.7	1.4	2.5	16.3	27.7	42.3	17.0	29.1	44.7	5%	9%	16%	10%	17%	26%	10%	16%	25%
2040	AL	0.2	0.3	0.4	2.1	4.3	5.4	2.3	4.6	5.8	9%	15%	21%	12%	24%	30%	12%	24%	29%
	GA	0.3	0.5	0.7	3.8	7.7	9.6	4.0	8.2	10.3	9%	15%	21%	12%	24%	30%	12%	24%	29%
	KY	0.1	0.2	0.3	1.9	3.9	4.8	2.0	4.1	5.2	9%	15%	21%	12%	24%	30%	12%	23%	29%
	NC	0.3	0.5	0.6	3.6	7.5	9.3	3.9	7.9	10.0	9%	15%	21%	12%	24%	30%	12%	23%	29%
	SC	0.1	0.2	0.3	1.9	3.9	4.8	2.0	4.1	5.1	9%	15%	21%	12%	24%	30%	12%	24%	29%
	TN	0.2	0.3	0.5	2.6	5.4	6.7	2.8	5.7	7.1	9%	15%	21%	12%	24%	30%	12%	23%	29%
	VA	0.3	0.4	0.6	3.3	6.7	8.4	3.5	7.1	8.9	9%	15%	21%	12%	24%	30%	12%	23%	29%
	WV	0.1	0.1	0.2	0.9	1.8	2.2	0.9	1.9	2.4	9%	15%	21%	12%	24%	30%	12%	23%	29%
	Sub-Total	1.6	2.5	3.5	20.0	41.2	51.3	21.5	43.7	54.8	9%	15%	21%	12%	24%	30%	12%	23%	29%

Exhibit B-7: Estimated Emissions from Electricity Consumption in Commercial Buildings

Year	State	Annual Emissions											
		SO_2 (Million Tons)				NO_x (Million Tons)				CO_2 (Billion Tonnes)			
		Baseline	Passive	Active	Aggressive	Baseline	Passive	Active	Aggressive	Baseline	Passive	Active	Aggressive
1990	AL	0.07				0.03				0.01			
	GA	0.13				0.04				0.03			
	KY	0.09				0.05				0.01			
	NC	0.11				0.07				0.02			
	SC	0.03				0.02				0.01			
	TN	0.11				0.05				0.02			
	VA	0.08				0.04				0.02			
	WV	0.02				0.01				0.00			
	Sub-Total	0.65				0.32				0.13			
2000	AL	0.08				0.03				0.02			
	GA	0.14				0.05				0.03			
	KY	0.11				0.06				0.01			
	NC	0.13				0.08				0.03			
	SC	0.04				0.02				0.01			
	TN	0.12				0.06				0.02			
	VA	0.09				0.05				0.02			
	WV	0.02				0.01				0.01			
	Sub-Total	0.73				0.36				0.15			
2010	AL	0.09	0.09	0.08	0.08	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02
	GA	0.15	0.14	0.14	0.13	0.05	0.05	0.05	0.05	0.03	0.03	0.03	0.03
	KY	0.11	0.11	0.10	0.10	0.06	0.06	0.06	0.06	0.02	0.01	0.01	0.01
	NC	0.14	0.13	0.13	0.12	0.08	0.08	0.07	0.07	0.03	0.03	0.03	0.03
	SC	0.04	0.04	0.04	0.04	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01
	TN	0.12	0.12	0.11	0.11	0.06	0.06	0.06	0.05	0.02	0.02	0.02	0.02
	VA	0.09	0.09	0.08	0.08	0.05	0.05	0.05	0.04	0.02	0.02	0.02	0.02

	WV	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00
	Sub-Total	0.77	0.74	0.71	0.68	0.38	0.36	0.35	0.33	0.15	0.15	0.14	0.14
2020	AL	0.09	0.08	0.08	0.07	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.01
	GA	0.15	0.14	0.13	0.12	0.05	0.05	0.05	0.04	0.03	0.03	0.03	0.02
	KY	0.12	0.11	0.10	0.09	0.07	0.06	0.06	0.05	0.02	0.01	0.01	0.01
	NC	0.14	0.13	0.12	0.11	0.08	0.08	0.07	0.07	0.03	0.03	0.03	0.02
	SC	0.04	0.04	0.04	0.03	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01
	TN	0.13	0.12	0.11	0.10	0.06	0.06	0.06	0.05	0.02	0.02	0.02	0.02
	VA	0.09	0.09	0.08	0.07	0.05	0.05	0.04	0.04	0.02	0.02	0.02	0.02
	WV	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00
	Sub-Total	0.78	0.73	0.69	0.63	0.38	0.36	0.34	0.31	0.16	0.15	0.14	0.13

Exhibit B-7: Estimated Emissions from Electricity Consumption in Commercial Buildings (cont'd)

Year	State	Annual Emissions											
		SO_2 (Million Tons)				NO_x (Million Tons)				CO_2 (Billion Tonnes)			
		Baseline	Passive	Active	Aggressive	Baseline	Passive	Active	Aggressive	Baseline	Passive	Active	Aggressive
2030	AL	0.10	0.09	0.08	0.07	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.01
	GA	0.16	0.15	0.14	0.12	0.06	0.05	0.05	0.04	0.03	0.03	0.03	0.02
	KY	0.12	0.11	0.10	0.09	0.07	0.06	0.06	0.05	0.02	0.01	0.01	0.01
	NC	0.15	0.13	0.12	0.11	0.09	0.08	0.07	0.06	0.03	0.03	0.03	0.02
	SC	0.04	0.04	0.04	0.03	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01

	TN	0.13	0.12	0.11	0.10	0.07	0.06	0.06	0.05	0.02	0.02	0.02	0.02
	VA	0.10	0.09	0.08	0.07	0.05	0.05	0.04	0.04	0.02	0.02	0.02	0.02
	WV	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00
	Sub-Total	0.83	0.75	0.69	0.62	0.41	0.37	0.34	0.30	0.17	0.15	0.14	0.12
2040	AL	0.10	0.09	0.08	0.07	0.04	0.03	0.03	0.03	0.02	0.02	0.01	0.01
	GA	0.17	0.15	0.13	0.12	0.06	0.05	0.04	0.04	0.03	0.03	0.03	0.02
	KY	0.13	0.11	0.10	0.09	0.07	0.06	0.06	0.05	0.02	0.02	0.01	0.01
	NC	0.15	0.14	0.12	0.11	0.09	0.08	0.07	0.06	0.03	0.03	0.03	0.02
	SC	0.05	0.04	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.01	0.01
	TN	0.14	0.12	0.11	0.10	0.07	0.06	0.05	0.05	0.02	0.02	0.02	0.02
	VA	0.10	0.09	0.08	0.07	0.06	0.05	0.04	0.04	0.02	0.02	0.02	0.02
	WV	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00
	Sub-Total	0.86	0.76	0.66	0.61	0.42	0.38	0.32	0.30	0.17	0.17	0.13	0.12

Exhibit B-8: Estimated Emission Reductions (from Reduced Electricity Consumption) from the Implementation of Energy Efficiency Measures in Commercial Buildings

Year	State	Reduction in Annual Emissions - Relative to Baseline									Percent Reduction in Annual Emissions - Relative to Baseline								
		SO_2 (Million Tons)			NO_x (Million Tons)			CO_2 (Billion Tonnes)			SO_2			NO_x			CO_2		
		Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive
2010	AL	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	4%	8%	12%	4%	8%	12%	4%	8%	12%
	GA	0.01	0.01	0.02	0.00	0.00	0.01	0.00	0.00	0.00	4%	8%	12%	4%	8%	12%	4%	8%	12%
	KY	0.00	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.00	4%	8%	12%	4%	8%	12%	4%	8%	12%
	NC	0.01	0.01	0.02	0.00	0.01	0.01	0.00	0.00	0.00	4%	8%	12%	4%	8%	12%	4%	8%	12%
	SC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4%	8%	12%	4%	8%	12%	4%	8%	12%
	TN	0.00	0.01	0.02	0.00	0.00	0.01	0.00	0.00	0.00	4%	8%	12%	4%	8%	12%	4%	8%	12%
	VA	0.00	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.00	4%	8%	12%	4%	8%	12%	4%	8%	12%
	WV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4%	8%	12%	4%	8%	12%	4%	8%	12%
	Sub-Total	0.03	0.06	0.09	0.01	0.01	0.05	0.01	0.01	0.02	4%	8%	12%	4%	8%	12%	4%	8%	12%
2020	AL	0.01	0.01	0.02	0.00	0.00	0.01	0.00	0.00	0.00	7%	12%	20%	7%	12%	20%	7%	12%	20%
	GA	0.01	0.02	0.03	0.00	0.01	0.01	0.00	0.00	0.01	7%	12%	20%	7%	12%	20%	7%	12%	20%
	KY	0.01	0.01	0.02	0.00	0.01	0.01	0.00	0.00	0.00	7%	12%	20%	7%	12%	20%	7%	12%	20%
	NC	0.01	0.02	0.03	0.01	0.01	0.02	0.00	0.00	0.01	7%	12%	20%	7%	12%	20%	7%	12%	20%
	SC	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	7%	12%	20%	7%	12%	20%	7%	12%	20%
	TN	0.01	0.01	0.03	0.00	0.01	0.01	0.00	0.00	0.00	7%	12%	20%	7%	12%	20%	7%	12%	20%
	VA	0.01	0.01	0.02	0.00	0.01	0.01	0.00	0.00	0.00	7%	12%	20%	7%	12%	20%	7%	12%	20%
	WV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7%	12%	20%	7%	12%	20%	7%	12%	20%
	Sub-Total	0.05	0.09	0.16	0.01	0.04	0.08	0.01	0.02	0.03	7%	12%	20%	7%	12%	20%	7%	12%	20%

Exhibit B-8: Estimated Emission Reductions (from Reduced Electricity Consumption) from the Implementation of Energy Efficiency Measures in Commercial Buildings (cont'd)

Year	State	Reduction in Annual Emissions - Relative to Baseline									Percent Reduction in Annual Emissions - Relative to Baseline								
		SO_2 (Million Tons)			NO_x (Million Tons)			CO_2 (Billion Tonnes)			SO_2			NO_x			CO_2		
		Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive	Passive	Active	Aggressive
2030	AL	0.01	0.02	0.02	0.00	0.01	0.01	0.00	0.00	0.00	10%	16%	25%	10%	16%	25%	10%	16%	25%
	GA	0.02	0.03	0.04	0.01	0.01	0.01	0.00	0.01	0.01	10%	16%	25%	10%	16%	25%	10%	16%	25%
	KY	0.01	0.02	0.03	0.01	0.01	0.02	0.00	0.00	0.00	10%	16%	25%	10%	16%	25%	10%	16%	25%
	NC	0.01	0.02	0.04	0.01	0.01	0.02	0.00	0.01	0.01	10%	16%	25%	10%	16%	25%	10%	16%	25%
	SC	0.00	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.00	10%	16%	25%	10%	16%	25%	10%	16%	25%
	TN	0.01	0.02	0.03	0.01	0.01	0.02	0.00	0.00	0.01	10%	16%	25%	10%	16%	25%	10%	16%	25%
	VA	0.01	0.02	0.02	0.01	0.01	0.01	0.00	0.00	0.01	10%	16%	25%	10%	16%	25%	10%	16%	25%
	WV	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	10%	16%	25%	10%	16%	25%	10%	16%	25%
	Sub-Total	0.08	0.14	0.21	0.04	0.07	0.10	0.01	0.03	0.04	10%	16%	25%	10%	16%	25%	10%	16%	25%
2040	AL	0.01	0.02	0.03	0.00	0.01	0.01	0.00	0.00	0.01	12%	24%	29%	12%	24%	29%	12%	24%	29%
	GA	0.02	0.04	0.05	0.01	0.01	0.02	0.00	0.01	0.01	12%	24%	29%	12%	24%	29%	12%	24%	29%
	KY	0.01	0.03	0.04	0.01	0.02	0.02	0.00	0.00	0.01	12%	23%	29%	12%	23%	29%	12%	23%	29%
	NC	0.02	0.04	0.05	0.01	0.02	0.03	0.00	0.01	0.01	12%	23%	29%	12%	23%	29%	12%	23%	29%
	SC	0.01	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.01	12%	24%	29%	12%	24%	29%	12%	24%	29%
	TN	0.02	0.03	0.04	0.01	0.02	0.02	0.00	0.01	0.01	12%	23%	29%	12%	23%	29%	12%	23%	29%
	VA	0.01	0.02	0.03	0.01	0.01	0.02	0.00	0.01	0.01	12%	23%	29%	12%	23%	29%	12%	23%	29%
	WV	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	12%	23%	29%	12%	23%	29%	12%	23%	29%

	Sub-Total	0.10	0.20	0.25	0.05	0.10	0.12	0.01	0.04	0.05	12%	23%	29%	12%	23%	29%	12%	23%	29%

- **Appendix C: Description of ICF Consulting’s Energy Use and Emissions Forecasting Model**

APPENDIX C
DESCRIPTION OF ICF CONSULTING'S ENERGY USE AND EMISSIONS FORECASTING MODEL

ICF Consulting developed an energy end-use and emissions model to quantify the impacts from various energy efficiency programs in the eight-state region served by the Southern Appalachian Mountain Initiative. This model has a high degree of complexity due to the different types of building sectors, the diverse building types, the different model scenarios, growth rates, and other elements.

The model has three main modules:

1. Energy Use Model for Residential Buildings
2. Energy Use Model for Commercial Buildings
3. Emissions Model for Residential and Commercial Buildings

These modules are separate EXCEL files that are linked together. The structure of each of these three modules is summarized in the sections below. Each component of a module is a distinct "tab" in the spreadsheet model.

- **Energy Use Model For Residential Buildings**

The energy use model for residential buildings calculates electric and gas use on a per home basis. These energy use estimates are aggregated to the state level, based on the number of homes per state. The eight state SAMI region is divided into two climate regions hot (AL GA, and SC) and mild (KY, NC, TN, VA and WV). These data are aggregated to obtain the total residential electric and gas use estimates for the SAMI region.

The per home energy use estimates are calculated on an end-use basis. A degree day approach is used for the heating and cooling energy use estimates. The structure of the residential module is summarized in Exhibit C-1.

- **Energy Use Model For Commercial Buildings**

The energy use module for commercial buildings is structured in a manner similar to the residential module described above. The main difference is that energy use for the commercial buildings is calculated on a per square foot basis, rather than on a per building basis (as used in the residential module). These energy use estimates are aggregated to the state level, based on the number of square foot of commercial building space per state. The eight state SAMI region is divided into two climate regions hot (AL GA, and SC) and mild (KY, NC, TN, VA and WV). These data are aggregated to obtain the total residential electric and gas use estimates for the SAMI region.

The per square foot energy use estimates are also calculated on an end-use basis. A degree day approach is used for the heating and cooling energy use estimates. The structure of the commercial module is summarized in Exhibit C-2.

- **Emissions Model For Residential And Commercial Buildings**

The electric and non-electric energy use estimates for each state are translated into SO_X, NO_X, and CO_2 emission estimates using emissions factors. Unique emissions factors are used for each state.

The baseline, passive, active and aggressive emissions are calculated for each of the years 2000, 2010, 2020, 2030, and 2040. Emissions reductions (relative to the baseline) are then calculated for the passive, active and aggressive cases for each of these years.

The key components of ICF's emissions spreadsheet model are summarized in Exhibit C-3.

Exhibit C-1
Primary Components of the Energy Use Model for Residential Buildings

File	Tab	Purpose
Residential	Energy	Calculates the energy consumption reductions for each scenario and year at the SAMI region level. Graphics provided.
	Unit Reduction	Calculates the reduction in consumption for each component in each scenario at the home level. Graphics provided.
	Gas Reduction	Calculates the reduction in gas consumption for each scenario and state. Also calculates the percentage reduction.
	Elect Reduction	Calculates the reduction in electricity consumption for each scenario and state. Also calculates the percentage reduction.
	Pen- Mild	Calculates the distribution of housing types (efficient, high efficient, etc.) according to the penetration rates of the different technologies by scenario in the mild climate.
	Pen-Hot	Calculates the distribution of housing types (efficient, high efficient, etc.) according to the penetration rates of the different technologies by scenario in the hot climate.
	Energy Mild	Calculates the energy consumption used to heat and cool the home in the mild climate based on the heating loads and cooling loads calculated on the Htg Load and Clg Load tabs.
	Energy Hot	Calculates the energy consumption used to heat and cool the home in the hot climate based on the heating loads and cooling loads calculated on the Htg Load and Clg Load tabs.
	Clg Load	Calculates the cooling load for homes of different sizes from engineering approximations based on their characteristics.
	Htg Load	Calculates the heating load for homes of different sizes from engineering approximations based on their characteristics.
	DHW	Estimates the contribution of hot water heating to the gas consumption of homes. A function of the number of people in the home
	Appl	Estimates the contribution of lighting and appliances to household energy consumption for each of the scenarios.
	No of Homes	Calculates the number of existing and new homes in each of the SAMI states based on the total number nationwide, the population distribution, and the estimated growth rate

Exhibit C-2
Primary Components of the Energy Use Model for Commercial Buildings

File	Tab	Purpose
Commercial	Energy	Calculates the energy consumption reductions for each scenario and year at the SAMI region level. Graphics provided.
	Unit Reduction	Calculates the reduction in consumption for each component in each scenario at the building level. Graphics provided.
	Gas Reduction	Calculates the reduction in gas consumption for each scenario and state. Also calculates the percentage reduction.
	Elect Reduction	Calculates the reduction in electricity consumption for each scenario and state. Also calculates the percentage reduction.
	Pen- Mild	Calculates the distribution of housing types (efficient, high efficient, etc.) according to the penetration rates of the different technologies by scenario in the mild climate.
	Pen-Hot	Calculates the distribution of housing types (efficient, high efficient, etc.) according to the penetration rates of the different technologies by scenario in the hot climate.
	Energy Mild	Calculates the energy consumption used to heat and cool the building in the mild climate based on the heating loads and cooling loads calculated on the Htg Load and Clg Load tabs.
	Energy Hot	Calculates the energy consumption used to heat and cool the building in the hot climate based on the heating loads and cooling loads calculated on the Htg Load and Clg Load tabs.
	Clg Load	Calculates the cooling load for buildings of different sizes from engineering approximations based on their characteristics.
	Htg Load	Calculates the heating load for buildings of different sizes from engineering approximations based on their characteristics.
	DHW	Estimates the contribution of hot water heating to the gas consumption of buildings. A function of the number of people in the building.
	Office Equipment	Estimates the contribution of office equipment to building energy consumption for each of the scenarios.
	No of Buildings	Calculates the number of existing and new buildings (expressed in square footage) in each of the SAMI states based on the total number nationwide, the population distribution, and the estimated growth rate.

Exhibit C-3
Primary Components of the Emissions Module
for both Residential and Commercial Buildings

File	Tab	Purpose
Emissions	Res Emissions	Summarizes the emissions reductions from both electric and gas consumption reduction in the residential sector. Emissions and emission reductions given for each pollutant, by scenario, by percentage, and by year. Provides simple graphics to show trends.
	Com Emissions	Summarizes the emissions reductions from both electric and gas consumption reduction in the commercial sector. Emissions and emission reductions given for each pollutant, by scenario, by percentage, and by year. Provides simple graphics to show trends.
	Res Elect Emissions	Calculates the emissions reductions from reduced electricity consumption for all years and scenarios in the residential sector. Based on the electricity consumption and reductions calculated in the Residential spreadsheet.
	Res Gas Emissions	Calculates the emissions reductions from reduced gas consumption for all years and scenarios in the residential sector. Based on the gas consumption and reductions calculated in the Residential spreadsheet.
	Com Elect Emissions	Calculates the emissions reductions from reduced electricity consumption for all years and scenarios in the commercial sector. Based on the electricity consumption and reductions calculated in the Commercial spreadsheet.
	Com Gas Emissions	Calculates the emissions reductions from reduced gas consumption for all years and scenarios in the commercial sector. Based on the gas consumption and reductions calculated in the Commercial spreadsheet.

- **Appendix D List of Abbreviations**

Abbreviations

AL	Alabama
Btus	British Thermal Units. One kWh is equivalent to 3414 Btus.
CFLs	Compact fluorescent lightbulbs provide light with significantly less energy than incandesents
EE	"Energy Efficiency"
EIA	Energy Information Administration. A U.S. agency responsible for collecting and disseminating statistics on energy generation and consumption.
EM	"Emissions"
ER	"Emission Reductions". Frequently expressed in tons, tonnes, or pounds.
ES	"Energy Savings"
GA	Georgia
HVAC	Heating, ventilation, air conditioning system. The systems that control the temperature in the home and circulate clean air
KY	Kentucky
Low-E	Low emissivity. A coating on the windows that reduces the transmission of solar heat
MBtu	Million British Thermal Units
NC	North Carolina
Nox	Nitrogen dioxide (NO2) is a brownish, highly reactive gas that is present in all urban atmospheres. NO2 can irritate the lungs, cause bronchitis and pneumonia, and lower resistance to respiratory infections. Nitrogen oxides are an important precursor both to ozone (O3) and acid rain, and may affect both terrestrial and aquatic ecosystems. The major mechanism for the formation of NO2 in the atmosphere is the oxidation of the primary air pollutant nitric oxide (NO). NOx plays a major role, together with VOCs, in the atmospheric reactions that produce O3. NOx forms when fuel is burned at high temperatures. The two major emissions sources are transportation and stationary fuel combustion sources such as electric utility and industrial boilers.
PM	Air pollutants called particulate matter include dust, dirt, soot, smoke and liquid droplets directly emitted into the air by sources such as factories, power plants, cars, construction activity, fires and natural windblown dust. Particles formed in the atmosphere by condensation or the transformation of emitted gases such as SO2 and VOCs are also considered particulate matter. Based on studies of human populations exposed to high concentrations of particles (sometimes in the presence of SO2) and laboratory studies of animals and humans, there are major effects of concern for human health. These include effects on breathing and respiratory symptoms, aggravation of existing respiratory and

	cardiovascular disease, alterations in the body's defense systems against foreign materials, damage to lung tissue, carcinogenesis and premature death.
PV	Photovoltaic. Photovoltaic describes a solid-state electronic cell that produces direct current electrical energy from the radiant energy of the sun. Photovoltaic cells are made of semi-conducting material, most commonly silicon, coated with special additives.
SC	South Carolina
Sox	Sulphur Oxides. A type of air pollutant made of sulphur and oxygen atoms. One of the causes of acid rain. High concentrations of sulfur dioxide (SO2) affect breathing and may aggravate existing respiratory and cardiovascular disease. Sensitive populations include asthmatics, individuals with bronchitis or emphysema, children and the elderly. SO2 is also a primary contributor to acid deposition, or acid rain, which causes acidification of lakes and streams and can damage trees, crops, historic buildings and statues. In addition, sulfur compounds in the air contribute to visibility impairment in large parts of the country. This is especially noticeable in national parks.
TN	Tennessee
TWh	Terra-watt hours, equivalent to one trillion (10^{12}) watt hours
VA	Virginia
VOCs	VOCs are organic compounds that occur either naturally or synthetically and that vaporize during the manufacture or use of many different products. Adverse health effects (referred to as "sick building syndrome") have been attributed to increased levels of VOCs from all sources of building materials and contents.
VSD	Variable speed drive
WV	West Virginia