Town of Blacksburg
Climate Action Plan Technical Report

Prepared By:
Dr. John Randolph and Dr. Damian Pitt
and their respective students from the Virginia Tech Urban Affairs and Planning

Town of Blacksburg Staff:
Susan Garrison, Environmental Manager
Joseph Gruss, Energy and Environmental Specialist
Carol Davis, Sustainability Manager

with guidance from:
The Mayor's Task Force on Climate & Sustainability (2007 – 2011) and
The Climate Action Plan Working Group (2013)

February, 20 2013

Update and Notes:

The Climate Action Plan Technical Report was developed between 2008 and 2011 in partnership with the VT Urban Affairs and Planning Department. The final Climate Action Plan was developed from the findings found in this report, but a number of noteworthy changes were made, particularly to the approach of dividing goals, objectives and strategies into "Community Strategies" and "Government Strategies". With guidance from the Climate Action Plan Working Group, the goals, objectives and strategies were re-organized into three different segments: "Individual Actions", "Let's Get Started" strategies which are intended for a shorter-term implementation horizon, and "Looking Ahead" strategies, which are planned for implementation farther in the future, perhaps over a 5-15 year period.

Chapter 1. Introduction

Climate change is one of the most pressing challenges of the 21st century. The world's foremost scientists have been predicting and documenting the environmental changes driven by carbon emissions of human-generated greenhouse gases (GHGs) for more than five decades. In response to this accumulating evidence, and recognizing that climate change impacts span political boundaries, world leaders have sought to establish, with limited success, multiple national and international agreements to address GHG emissions. Observing the limitations of national governments to meaningfully address the root causes of climate change, local governments around the country began to take action on their own, primarily through the U.S. Conference of Mayors Climate Protection Agreement. This agreement was established in February 2005 by Seattle Mayor, Greg Nickels, with the intention of supporting and encouraging local governments in their efforts to address this global challenge at the local level. By the U.S. Conference of Mayor's annual meeting, held four months later in June of 2005, an additional 141 mayors had signed on to participate.

Under the Agreement, participating towns and cities commit to take following three actions:

- Strive to meet or beat the Kyoto Protocol targets in their own communities, through actions ranging from anti-sprawl land-use policies to urban forest restoration projects to public information campaigns;
- Urge their state governments, and the federal government, to enact policies and programs to meet or beat the greenhouse gas emission reduction target suggested for the United States in the Kyoto Protocol -- 7% reduction from 1990 levels by 2012; and
- Urge the U.S. Congress to pass the bipartisan greenhouse gas reduction legislation, which would establish a national emission trading system

In November of 2006, The Town of Blacksburg, joined many other American municipalities, and signed onto the Mayors' Agreement as well, committing to reduce greenhouse gas (GHG) emissions. To those ends, Blacksburg Town Council has set a target of reducing GHGs by 80% below 1990 levels by 2050. To meet this target will require municipal policy initiatives, as well as collaboration and partnerships between citizens, businesses, and institutions to reduce energy waste . and reduce the overall carbon footprint of the Town.

This Climate Action Plan (CAP) describes the Town of Blacksburg's desire to reduce energy use and greenhouse gas (GHG) emissions in Blacksburg. The opportunities for achieving these reductions are primarily through energy efficiency and conservation, renewable energy use, alternative transportation, and community design.   This Climate Action plan details those primary avenues for reducing overall energy use as well as the Town's goals, objectives, and strategies for pursuing those opportunities.

Blacksburg is an attractive and thriving community located in the mountains of Southwest Virginia. Known as being a "Special Place", Blacksburg is renowned for its quality of life, natural beauty, civic pride, and educational leadership. Its population of more than 43,000 residents in 2006 includes a diverse mix of students, professionals, retirees, and workers in local industries and commercial establishments. The Town of Blacksburg is a "whole life community" with varied housing opportunities and neighborhoods; emphasizes economic development within its historical downtown area; and promotes environmental stewardship that includes protecting its natural surroundings, open space, and watersheds. The Town of Blacksburg is also noted for its open government, strong citizen involvement, and commitment to regional collaboration with the surrounding counties and towns of the New River Valley and beyond.

Blacksburg is home to Virginia Tech Polytechnic Institute and State University (Virginia Tech), the state's largest research university, with 6,900 faculty and staff members and just over 28,800 students as of 2013. These students, faculty, and staff come from across the world to study and work and they contribute immeasurably to the Town's lively intellectual quality. Their presence offers a unique set of opportunities, as students often use Blacksburg as a "living laboratory", engaging their particular area of scholarship to explore real-world challenges the Town is facing, and in return receive practical, hands-on experience in their respective fields. Also, since Virginia Tech uses the most electricity, and generates the most GHGs in the area, it is essential that the university and the Town work together to investigate their energy policies and reduce their respective carbon footprints. The composition of the Mayor's Task Force on Climate Protection and Sustainability reflects the collaborative nature of this effort: Town staff and officials, VT faculty, students and administrators, citizens, businesses, and non-governmental organizations are working together to lead Blacksburg toward a sustainable energy future. The CAP focuses its recommendations on clean and renewable energy sources, energy efficiency, community design and transportation options to reduce vehicle emissions, and informed citizens practicing energy conservation in their homes and businesses.

1.1. Sustainability and Climate Action Planning in Blacksburg

1.1.1. Town's Work to Date on Environmental Sustainability

One of the goals of Blacksburg's Comprehensive Plan, *Blacksburg 2046*, is to retain the beauty and functions of the natural and rural environments that characterize Blacksburg. The Town works with numerous local partners and local non-governmental organizations (NGO) to collaborate on initiatives that promote sustainability in the area. As a result of these and other efforts, the Town is designated an Exemplary Environmental Enterprise (E3) by the Virginia Department of Environmental Quality. After the Town became a signatory to the Mayor's Climate Protection agreement in 2006, it established the Mayor's Task Force on Climate Protection and Sustainability to assist staff with implementation of the agreement. The Town joined ICLEI Local Governments for Sustainability in 2007. In addition to steps the Town of Blacksburg has taken on Climate Action Planning, the Town has also implemented numerous other sustainability initiatives in recent years, including:

- Adopted a policy that requires the US Green Building Council (USGBC) LEED Silver designation for all new building construction or renovation over 5,000 sq. ft.
- Adopted a Green Fleet Policy that encourages the purchase of low emitting, fuel efficient vehicles.
- Adopted a Green Commuting Policy and provides free transit service for Town employees.
- Has provided curbside recycling to Town residents since 1992.
- Has hosted Household Hazardous Waste collection days for over ten years.
- Partnered with the YMCA at Virginia Tech to provide electronics recycling to residents free of charge.
- Installed recycling services in all Town facilities including collection of batteries, cell phones, and other electronics.
- Has been designated a Tree City USA recipient for over ten years and established a Municipal Tree Nursery in 2007 to provide a minimum two-to-one replacement for trees removed on Town property.
- Implemented a biodiesel (B20) conversion program in 2007, which has converted all diesel fuel vehicles in the Public Works and Parks and Recreation departments to B20 along with some Blacksburg Transit vehicles.
- Hosts Sustainability Week each year in conjunction with in partnership with Virginia Tech and Sustainable Blacksburg. This sustainability awareness and education event is scheduled to continue in the future.

1.1.2. Climate Action Planning Process

On November 28, 2006 the Blacksburg Town Council passed Resolution 11-E-06 endorsing the U.S. Mayors' Climate Protection Agreement (USMCPA) and authorized Mayor Ron Rordam to sign the agreement. The Resolution directed the Town of Blacksburg to work in conjunction with appropriate supporting organizations such as ICLEI - Local Governments for Sustainability to track progress and access technical resources that would support implementation of the USMCPA.

In January 2007, Blacksburg established the Mayor's Task Force on Climate Protection and Sustainability to implement the USMCPA and steer the Town's climate action planning process. The fourteen members of the Mayor's Task Force represent a cross-section of the community, including representatives from the Town, the University, citizens, businesses, and non-governmental organizations The immediate goals of the Mayor's Task Force were to prepare a community greenhouse gas inventory and emissions forecast, adopt emission reduction targets, and work with University and community partners to draft the Blacksburg Energy Conservation and Climate Action Plan (CAP). Table 1 lists the current members of the Mayor's Task Force on Climate Protection and Sustainability and identifies their respective affiliations.

Table 1-1. Mayor's Task Force – Fall 2009

Name	Affiliation
Mayor Ron Rordam	Mayor of Blacksburg
Pat Bixler	Executive Director of Sustainable Blacksburg
David Roper	Community Representative
Bill Claus	Community Representative
Joe Meredith	Industry Representative
Todd Holt	Industry Representative
Joyce Graham	Industry Representative
Sean McGinnis	University Representative
John Randolph	University Representative
Denny Cochrane	University Representative
Fran DeBellis	Electric Company Representative
Kelly Mattingly	Town of Blacksburg
Susan Garrison	Town of Blacksburg

Under direction and ongoing guidance from the Mayors' Task Force, students and faculty in the Urban Affairs and Planning (UAP) program at Virginia Tech gathered data on local energy consumption trends and completed the initial Town of Blacksburg Energy Use and Greenhouse Gas Emissions Inventory in the spring of 2008, followed by an investigation of greenhouse gas reduction and climate mitigation options, and developed a framework for the eventual CAP. A public forum was held during Sustainability Week, in October 2008, during which the public asked questions, voiced ideas, and raised concerns about CAP-related issues. UAP prepared a preliminary draft of the CAP at that time, which suggested a number of initiatives to reduce GHG emissions and evaluated their approximate costs, benefits, and feasibility. This draft report was submitted to the Mayor's Task Force for review.

In November 2008, the Mayor's Task Force sub-committee on climate change recommended a target for the Town of Blacksburg to reduce communitywide GHG emissions to 80% below 1990 levels by 2050, a number which reflects the consensus understanding from the scientific community as to the global emissions reductions that must be achieved to reduce the likelihood of catastrophic, long-term climate change. This local target applies to Town operations and communitywide emissions from transportation and the residential, commercial, and industrial sectors, but does not include Virginia Tech. Virginia Tech adopted a separate Climate Action Commitment and Sustainability Plan in June, 2009.

By addressing GHGs and energy use, Blacksburg aims to sustain and enhance the quality of life its residents already enjoy. Fewer GHG emissions mean improved physical health for everyone from newborns to grandparents; increased building efficiencies decrease families' monthly utility bills; and a focus on greener development and retrofitting older buildings for increased energy efficiency creates jobs.

Chapter 2. Baseline and Projected Energy Sources and Uses

2.1. Baseline GHG Emissions Inventory

The Town of Blacksburg's GHG Emissions Inventory was completed in early 2008, based on data from 2000-2006. This baseline inventory was subsequently updated in early 2010*, and again in 2013.

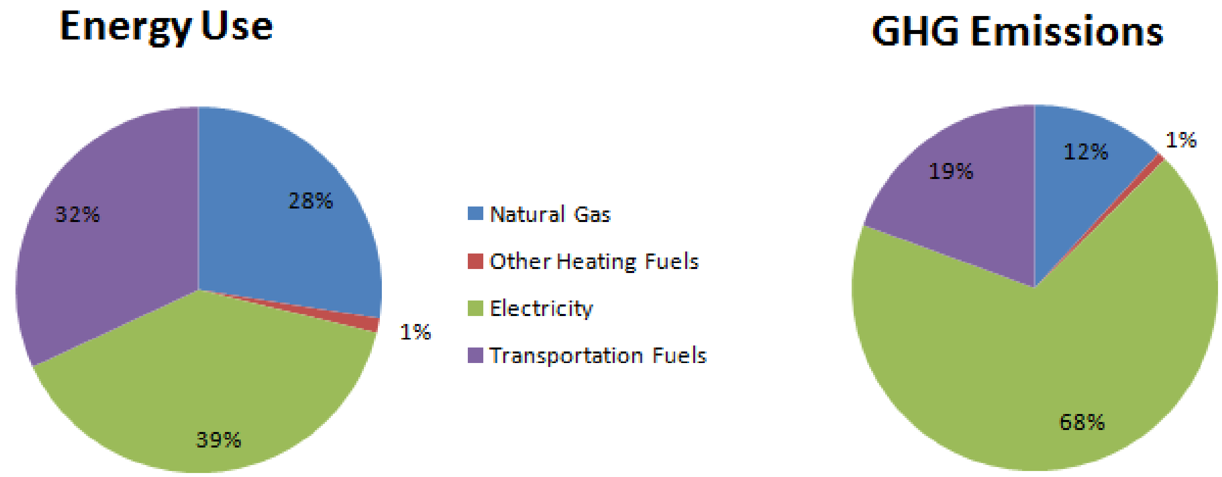
In 2012, the Blacksburg community, not including Virginia Tech, consumed a total of 3.0 trillion British thermal units (Btu) of end use energy and emitted a total of 363,411 metric tons of CO_2-equivalent GHG emissions (hereafter referred to as tons CO_2-e). This includes all electricity, natural gas, and other fuels consumed by the Town's residents, businesses, and institutions other than Virginia Tech.

Figure 2-1 illustrates the total end-use energy consumption and resulting GHG emissions by energy source for 2012. Electricity represents the largest source of energy use (39 percent), followed by transportation fuels (32 percent), and natural gas (28 percent). Other fuels – fuel oil, propane, and wood – combine for approximately 1 percent. When converted to GHG emissions, electricity accounts for a far greater portion (68 percent) than any other fuel source, because over 88 percent of the electricity Blacksburg receives from the grid comes from coal-fired power plants. Burning coal generates greater GHG emissions per unit of usable energy than natural gas or transportation fuels. Furthermore, GHG emissions are measured in terms of the fuel consumed at the point of generation, and the massive conversion and transmission losses associated with coal-fired power plants mean that each unit of end-use energy consumption represents about three units of energy consumed at the power plant (i.e., only about 1/3 of the energy consumed at the power plant makes it to the consumer as end-use electricity consumption).

* Baseline inventory updates:

- Revised natural gas consumption figures to adjust for the fact that the local natural gas provider, Atmos Energy, had reported natural gas consumption in apartment buildings as part of the commercial sector. Shifted approximately 1/3 of the reported commercial sector consumption to the residential sector (details in Appendix A).
- Used data on natural gas consumption in TOB facilities for the years 2003-2005 and 2008 to estimate the TOB's yearly natural gas consumption for the years 2000-2009.
- Removed VT water consumption percentages from water/wastewater energy use calculations.

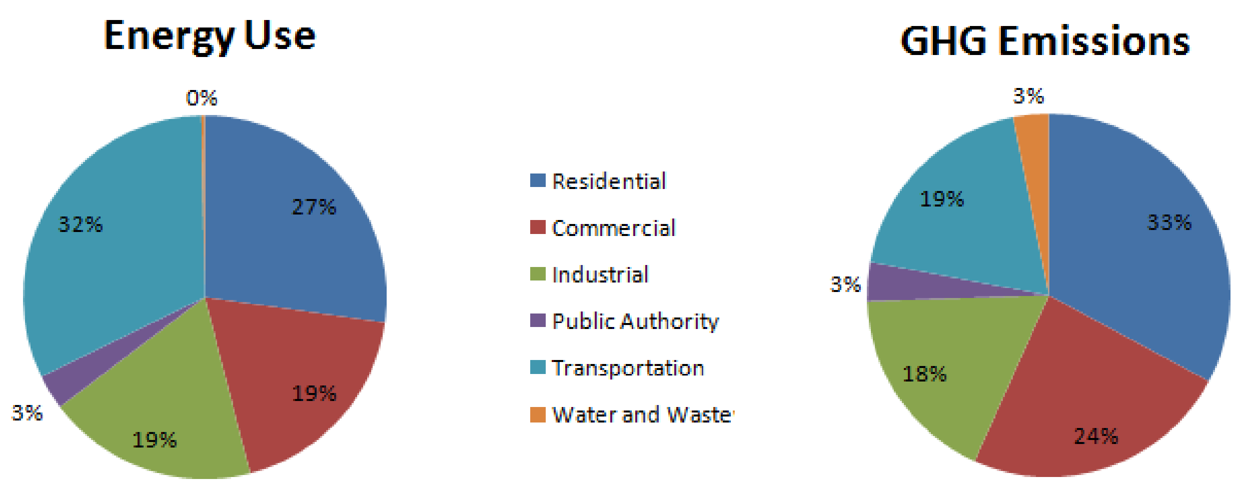
Figure 2-1. Blacksburg End Use Energy and Emissions by Energy Source (2012)



Source: Blacksburg Energy Use and Greenhouse Gas Emissions Inventory

Figure 2-2 illustrates the total end-use energy consumption and resulting GHG emissions by consuming sector in 2006. The transportation sector represents the greatest share of total energy use (32 percent), followed by the residential sector (27 percent). The commercial and industrial sectors both contribute an additional 19 percent each.

Figure 2-2. Blacksburg End Use Energy and Emissions by Consuming Sectors (2012)



Source: Blacksburg Energy Use and Greenhouse Gas Emissions Inventory

The residential and commercial sectors represent noticeably larger portions of Blacksburg's total GHG emissions (33 percent and 24 percent respectively, 57 percent total) than its total end use energy use (27 percent and 19 percent, 46 percent total). This is due to these sectors' reliance on electricity, which as mentioned above creates greater GHG emissions per unit of usable energy than natural gas or transportation fuels. GHG emissions were also estimated for water and wastewater processing and distribution and Town of Blacksburg government operations. These combined for less than 6 percent of total GHG emissions.

2.2. GHG Emission Projections

Estimates of future energy use and GHG emissions in Blacksburg are based on projections from the The U.S. Energy Information Administration (EIA) Annual Energy Outlook 2013. Nationwide projections from that report were compared to US population projections from the 2010 census to determine current and projected per capita energy use and GHG emission estimates for 2013 – 2050. Current US per capita estimates were compared to current Blacksburg per capita energy use and GHG emissions data to determine the proportion by which the EIA projections needed to be scaled down for each sector. Finally the resulting per capita projections for Blacksburg were multiplied by Blacksburg population projections from the Weldon Cooper Center to arrive at estimates for total energy use and GHG emissions for the town from 2013 - 2050. Table 2-1 summarizes the resulting GHG emissions projections from this analysis.

Table 2-1. Growth Rates and Projections by Sector / Source *

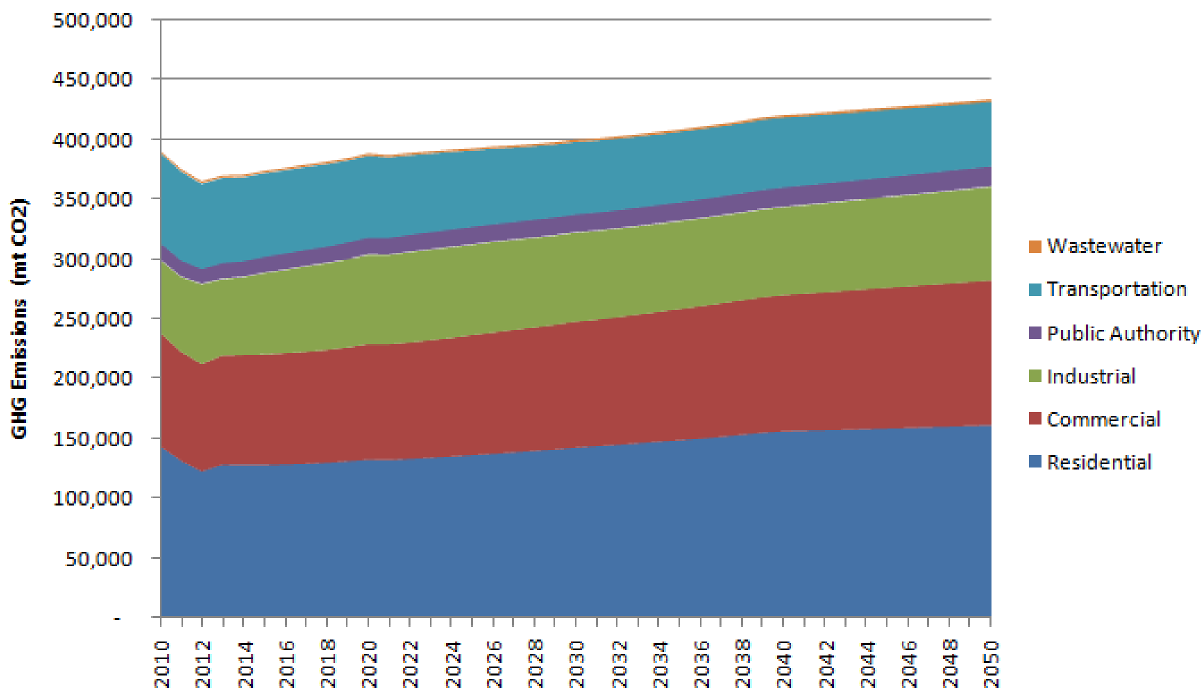
Fuel Type	**Sector**	**2012 - 2050 AAGR**	**GHG Emissions (metric tons)**		
			2012	**2030**	**2050**
Natural Gas	Residential	-0.26%	14,361	14,942	13,022
Natural Gas	Commercial	0.69%	9,589	11,706	12,445
Natural Gas	Industrial	0.37%	16,989	18,056	19,585
Natural Gas	Public Authority	0.45%	2,232	2,635	2,650
	Total	0.26%	**43,170**	**47,339**	**47,701**
Bottled, tank, or LP gas	Residential	0.00%	93	96	93
Fuel Oil, Kerosene, etc.	Residential	-2.08%	2,569	1,785	1,155
	Total	-1.97%	**2,662**	**1,881**	**1,248**
Electricity	Residential	0.86%	106,036	126,040	147,082
Electricity	Commercial	0.81%	79,943	93,266	108,542
Electricity	Industrial	0.43%	49,748	56,362	58,572
Electricity	Public Authority	0.83%	10,751	13,006	14,718
	Total	0.76%	**246,479**	**288,674**	**328,914**

Gasoline	Transportation	-0.89%	66,278	54,140	47,177
Diesel	Transportation	1.18%	4,647	6,451	7,248
	Total	-0.69%	**70,925**	**60,591**	**54,426**
Electricity	Wastewater	0.49%	**1,872**	**1,860**	**2,252**
	Grand Total	**0.46%**	**365,107**	**400,346**	**434,541**

Source: Blacksburg Energy Use and Greenhouse Gas Emissions Inventory

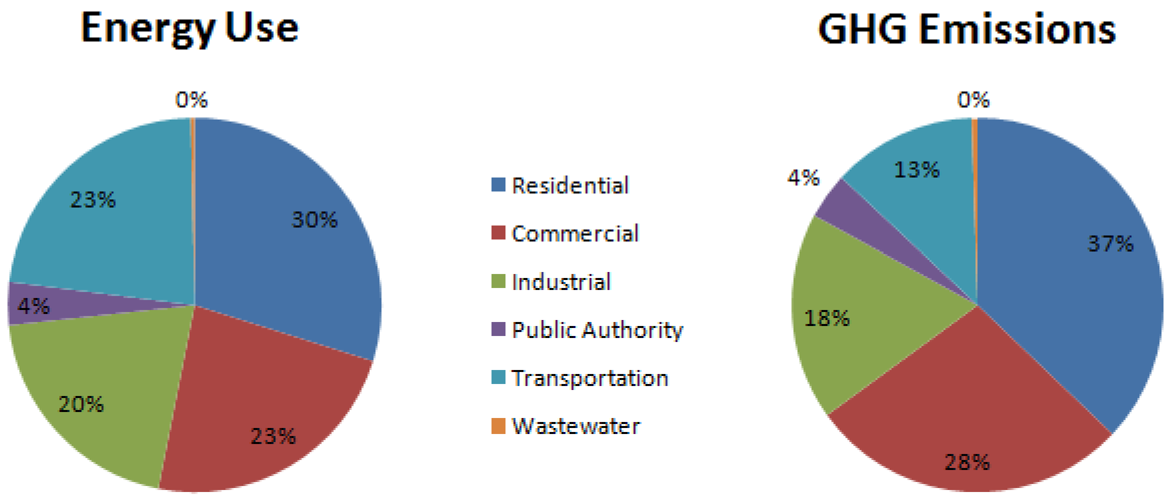
* These data assume that all coefficients for converting energy use to GHG emissions remain constant.

Figure 2-3. Original Emission Projections by Sector, 2010-2050



Source: Blacksburg Energy Use and Greenhouse Gas Emissions Inventory

Figure 2-3 illustrates the projected 2050 GHG emissions per sector based upon the AAGR assumptions described above. The GHG emission projections are shown in greater detail in Table 2-5. These projections show a total annual increase in the residential sector of 1.98 percent. This is the second-highest energy consumption projection of all the end use sectors, producing the most GHG emissions. The transportation sector increases far less dramatically; and ceases to be the largest consumer of end use energy by 2050, and fourth in GHG emissions behind the residential, industria land commercial sectors. Total GHG emissions from all sectors are projected to reach 1,041,152 tons CO_2-e by the year 2050.Figure 2-4. Revised Energy-Use and Emissions Projections by Sector (2050)



Of equal importance to the Town's GHG emissions inventory are assumptions about baseline conditions in 1990 because Blacksburg's goal for 2050 is to lower its GHG emissions to 80% below 1990 levels. 1990 was selected as a benchmark year because it is used as the base year for emissions goals for countries participating in the landmark Kyoto Protocol. However, detailed energy use and GHG emissions data is not available for that year in Blacksburg. To estimate our 1990 emissions levels, the projected average annual growth rate from 2010 to 2040 for each sector of the inventory was used to project that sector's emissions backward to 1990.

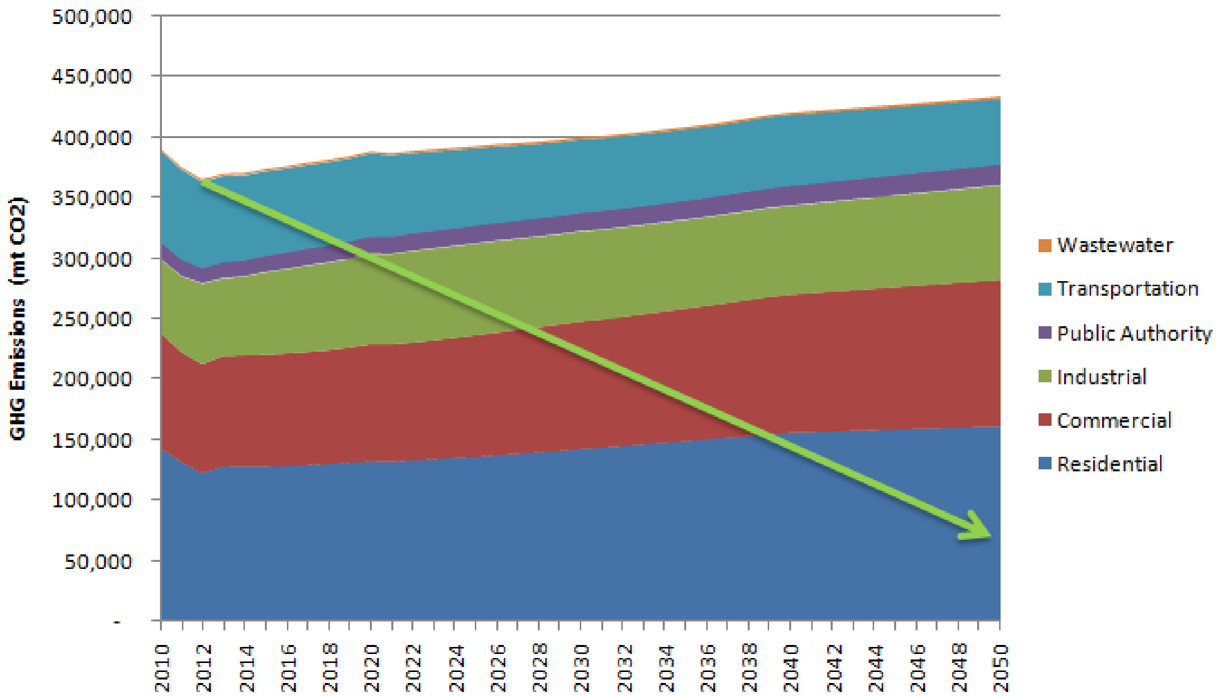
Table 2-4. Revised Growth Rates and GHG Emission Projections (tons CO_2-e) by Sector

Fuel Type	Sector	2010	2040	1990	Emissions Goal (80% below 1990)
Natural Gas	Residential	17,902	14,100	20,990	4,198
Natural Gas	Commercial	11,599	12,228	11,197	2,239
Natural Gas	Industrial	14,569	18,189	12,566	2,513
Natural Gas	Public Authority	2,549	2,624	2,501	500
	Total	46,619	47,141	47,254	9,451
Bottled, tank, or LP gas	Residential	107	96	114	23
Fuel Oil, Kerosene, etc.	Residential	2,754	1,436	4,252	850
	Total	2,861	1,532	4,366	873
Electricity	Residential	123,322	140,744	112,922	22,584
Electricity	Commercial	83,024	101,508	72,612	14,522
Electricity	Industrial	46,272	55,220	41,128	8,226
Electricity	Public				

	Authority	**12,170**	**14,035**	**11,066**	**2,213**
	Total	**264,788**	**311,507**	**237,728**	**47,546**
Gasoline	**Transportation**	**70,050**	**52,078**	**85,359**	**17,072**
Diesel	**Transportation**	**5,137**	**6,651**	**4,325**	**865**
	Total	**75,188**	**58,728**	**89,684**	**17,937**
Electricity	**Wastewater**	**1,420**	**2,007**	**1,128**	**226**
	Grand Total:	**390,875**	**420,914**	**380,160**	**76,032**

Figure 2-5 below overlays Blacksburg's GHG 2050 emission target of 84,525 tons CO_2 over the projections of future GHG emissions by sector.

Figure 2-5. Revised GHG Emission Projections by Sector with Emissions Reduction Target



Looking at these future projections, the residential and commercial sectors will represent the largest portion of Blacksburg's energy use, and even larger portions of its GHG emissions, making these two sectors prime candidates for emission-reduction efforts, both now and in the future. Because space heating and cooling make up the largest energy end-use for these two sectors, initiatives to improve residential and commercial buildings' efficiency will be key for reaching the Town's emissions goals. Emissions from the industrial sector are projected to trail those of the residential and commercial sectors. Nevertheless, this sector presents a significant area of opportunity to reduce community-wide emissions, particularly because there are only a handful of large manufacturing and industrial facilities within the Town. Energy-efficiency and conservation efforts at a few of the larger firms could substantially reduce emissions within this sector by 2050.

Projections indicate that the transportation sector will be the fourth largest in terms of emissions by 2050. Emissions reductions within this sector may be the most challenging to achieve because implementation of transportation strategies depend on a complex interplay between personal consumer choices, future fuel prices and vehicle fuel efficiencies, transportation infrastructure investments, and land use planning, making the impact of transportation strategies harder to accurately predict and slower to implement.

2.3 Scenarios for Reductions

In the chapters that follow, a three-tiered "scenario" approach is used to explore the levels of change required to progress toward the Town's overall emissions-reduction goals. These three tiers, Conservative, Maximum and On Target are detailed at the beginning of each section for clarity and easy reference.

Chapter 3. Transportation

Update and Notes:

The narrative and data tables of this chapter is shown in their original format, in which the implementation scenarios are identified progressively as "baseline", "conservative", "aggressive", and "maximum". When the Climate Action Plan Working Group picked up the planning process in early 2013, it was decided that only an "On Target" scenario would be utilized to devise the priority goals, objectives and strategies for inclusion in the final plan. For the most part, these are reflected the "maximum" scenario. Since this technical report was created, the Town has completed and adopted the Town of Blacksburg Bike Master Plan.

3.1. Impact of the Transportation Sector on Energy Use and the CAP

Transportation is one of the most promising areas for reducing overall energy use and GHG emissions. Transportation accounted for 33 percent of Blacksburg's energy use, and 19 percent of GHG emissions in 2011. In that same year, more than 176 million vehicle miles were traveled in the Town, emitting almost 77,000 tons CO2-e. This figure is projected to decrease to about 58,300 tons CO2-3 by 2050. To bring about a more significant reduction in transportation-related emissions, community members will need to reduce miles traveled in single-occupancy vehicles; utilize multiple modes of travel such as biking, walking, and mass transit; and use alternative fuel vehicles when a car is necessary.

Work commutes are a particularly promising area for reducing energy use and GHG emissions as they represent a large portion of total community-wide energy use. Commuting trips are also potentially easier to switch to alternative modes, as they typically follow a fixed daily route, tend to be solo trips (single occupancy vehicle), and don't involve transporting goods such as groceries.

In support of the goal to increase the use of alternative transportation and commuting options, the Greenway/Bikeway/Sidewalk Committee advocates for planning and development of multi-use trails, bike lanes, and sidewalks. As a result, Blacksburg has a robust system of biking and walking trails as depicted in the "Paths to the Future" map. Blacksburg residents are enthusiastic in their support and use of the community's walking and biking infrastructure, and the percentage of Town residents who bike or walk to work exceeds national averages. In addition, the community is working on a Bike Master Plan that will address some of the infrastructure obstacles limiting bicycling and walking.

There is a high proportion of Virginia Tech students who use the Blacksburg Transit bus system in their daily commute to campus. However, according to 2011 American Community Survey data, only 7.9 percent of non-student residents reported riding the bus for their commute. As a result, Blacksburg Transit has taken steps to expand and improve its service, such as starting a new “Go Anywhere” transit system in a neighboring locality and considering the feasibility of providing bus service near Blacksburg neighborhoods.

Even with convenient and affordable alternative modes of transportation around town, demand for personal private vehicle use in Blacksburg will continue for the foreseeable future. Section 3.2.1 shows that in the most aggressive scenario, wherein 80 percent of transportation trips are shifted to alternative modes, transportation-related GHG emissions are reduced by over 80%, even though most longer distance in-town trips would still be in private vehicles. It is hoped that improved overall mileage efficiency with newer cars will also help the community meet its transportation-related emission reduction goals. Beyond private vehicles, the Town government has a Green Fleet Policy which commits to improving the fuel efficiency of the government fleet through purchasing hybrid-electric vehicles when financially feasible, and using alternative fuel such as bio-diesel B20 when it is available.

While Blacksburg is a relatively small town, the total annual Vehicle Miles Traveled (VMT) averages 10 miles per person, per day. Utilizing infill development and, compact and mixed-use development patterns such as those outlined in the Town’s Comprehensive Plan and Chapter 9 of this document will provide more localized, shorter-distance travel patterns which will expand the feasibility and convenience of walking, biking, and the use of mass transit.

3.2. Potential Energy and GHG Savings in Transportation Sector

To determine how to meet Blacksburg’s CAP goal, three scenarios (conservative, aggressive, and maximum efficiency) were compared to a baseline, business-as-usual projection for the year 2050. These scenarios were chosen to provide a wide range of potential outcomes.

Scenario Assumptions for Work Commuting	Baseline	Conservative	Aggressive	Maximum
	Distribution of VMT is unchanged	30% of total community trips taken by alternative transportation modes	60% of total community trips taken by alternative transportation modes	80% of total community trips taken by alternative transportation modes

3.2.1. Reduce Vehicle Miles Traveled through Increased use of Alternative Transportation Modes

While there are many methods of increasing the use of alternative transportation, the following discussion focuses on shifting travel choices made for daily commutes to and from work Commuting is a particularly promising opportunity for reducing local energy use and GHG emissions because it represents a large percentage of Blacksburg’s total community-wide energy use. An estimated 27 percent of annual US VMT and 5.7 percent of the Town's community-wide energy use and 3.5 percent of community-wide GHG emissions are associated with the daily commute to work.

Table 3-1 shows the distribution of work commute modes based on 2011 American Community Survey data. Over three-quarters of Blacksburg's commuters drove a private vehicle to work, and two-thirds drove alone. These figures are lower than the national averages of 88 percent and 76 percent respectively. Eleven percent of Blacksburg's commuters reported that they walk to work, while 2 percent ride bikes. These figures are higher than the national averages of 3 and 0.4 percent respectively.

Table 3-1. Means of Transportation to Work for Workers Age 16 and Over

Mode	United States	U.S. %	Virginia	Virginia %	Blacksburg	Blacksburg %
Total	139,488,206	100.0%	3,877,505	100.0%	17,203	100.0%
Car, truck, or van	120,315,446	86.3%	3,397,163	87.6%	12,284	71.4%
Drove alone	106,138,652	76.1%	2,994,405	77.2%	10,840	63.0%
Carpooled	14,176,794	10.2%	402,758	10.4%	1,444	8.4%
Public Transportation	6,915,130	5.0%	166,735	4.3%	1,287	7.5%
Motorcycle	308,935	0.2%	6,101	0.2%	0	0.0%
Bicycle	744,560	0.5%	13,234	0.3%	517	3.0%
Walked	3,948,202	2.8%	89,366	2.3%	1,718	10.0%
Other means	1,203,746	0.9%	30,112	0.8%	21	0.1%
Worked at home	5,889,768	4.2%	170,730	4.4%	1,376	8.0%

Source: American Community Survey 5-year estimates, 2011, B08301

Appendix B includes information regarding the methodology used to estimate the total annual passenger miles traveled (PMT) and VMT from work commuting and the total VMT and resulting energy consumption and GHG emissions from each scenario described below.

Table 3-2 outlines the current estimated distribution of daily commuters by mode and travel distance.

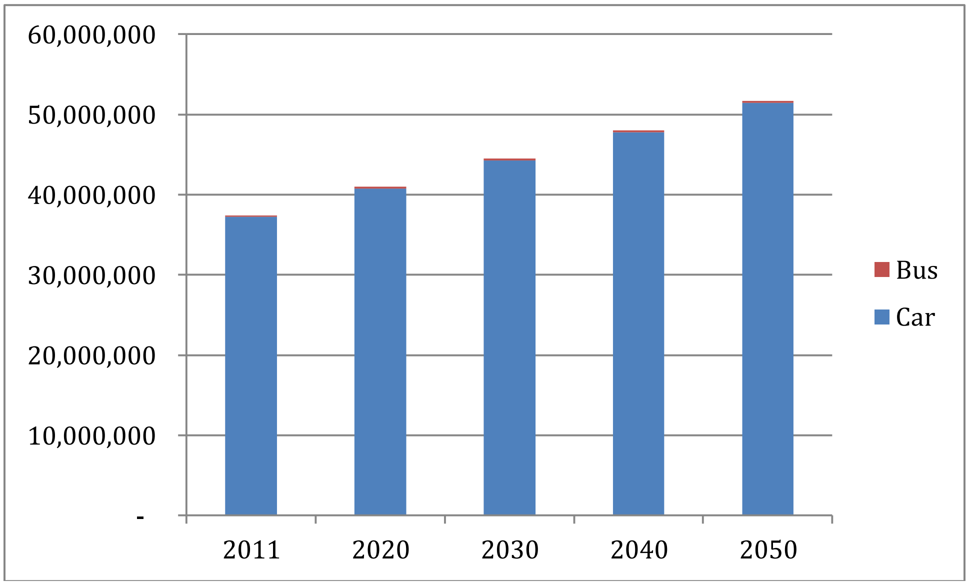
Table 3-2. Percent of Daily Commuters by Mode and Distance Interval - 2011

Mode	0-1 Mile	2-4 Miles	5-7 Miles	8-15 Miles	Total
Car	11%	13%	27%	27%	**78%**
Bus	1%	2%	5%	1%	**8%**
Bike	1%	3%	0%	0%	**3%**

Walk	11%	0%	0%	0%	**11%**
Total	**22%**	**17%**	**32%**	**28%**	**100%**

Figure 3-1 shows that under the baseline scenario, commuting VMTs will increase steadily through to 2050, with buses representing less than 1 percent of total VMTs (a small enough portion that it is difficult to see the bar representing bus VMTs in Figure 3-1, the baseline scenario). The analysis assumes the distribution of commute trips by distance will not change.

Figure 3-1. Annual (Commuter) VMT under the Baseline Scenario



Appendix B describes the analysis used to estimate total VMT and resulting energy consumption and GHG emissions from each scenario. Figure 3-2 shows the estimated car VMT in each scenario. A shift in trip modes akin to that shown in the aggressive scenario will be necessary to decrease Blacksburg's current work commute VMT figures over the next 40 years, given the anticipated growth in the number of workers. A substantial change in commuting patterns, such as the maximum efficiency scenario, is necessary to achieve more significant VMT reductions.

Figure 3-2. Commuting Vehicle Miles Traveled by Car per Year

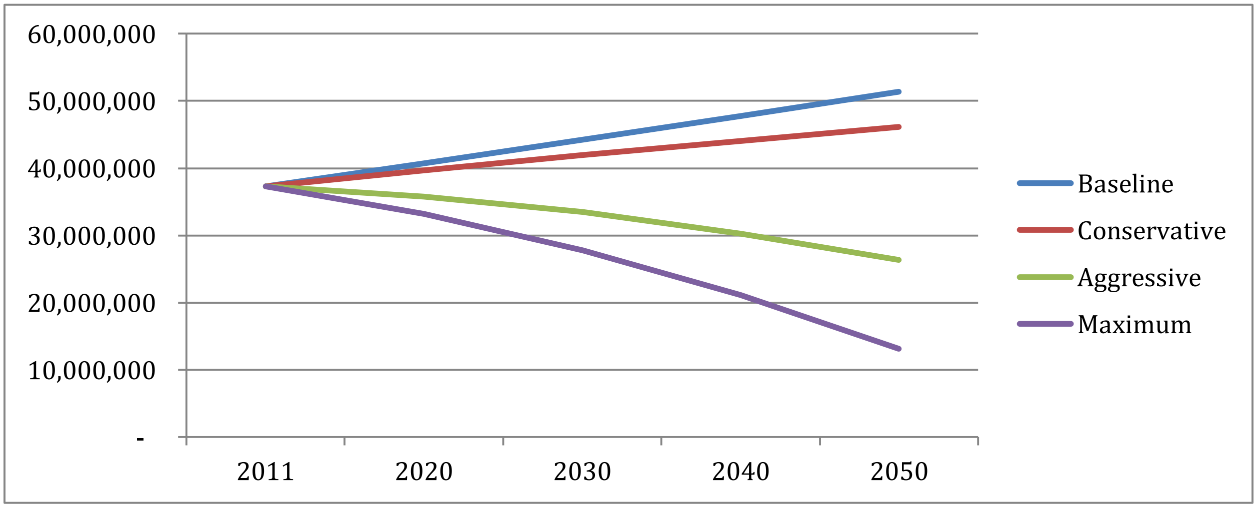
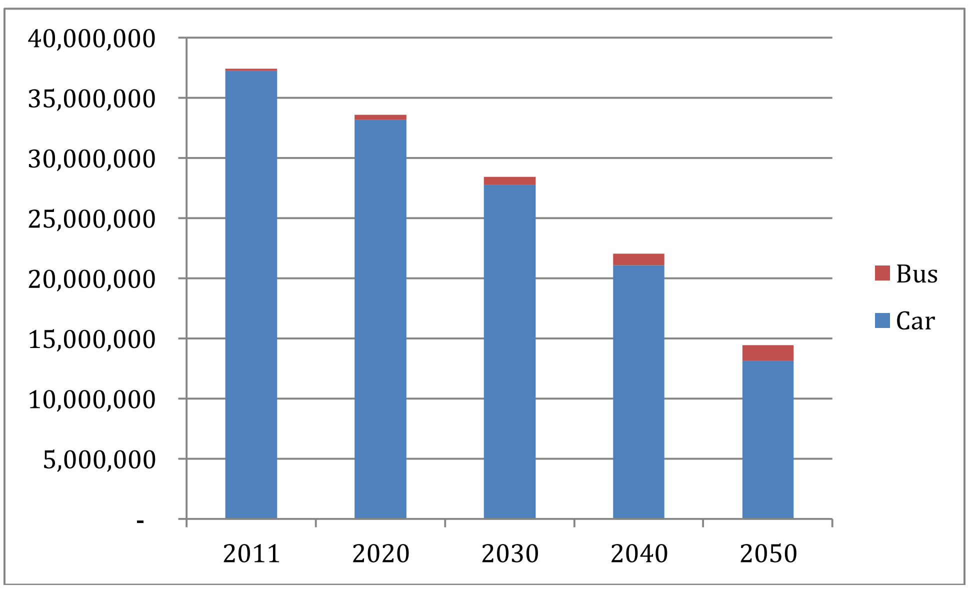


Figure 3-3 shows the maximum scenario's effect on total projected VMT, which includes a substantial decrease in private car VMT, offset slightly by a concurrent increase in bus VMT .

Figure 3-3. Annual Commuting VMT under the Maxiumum Efficiency Scenario



The estimated work commuting VMT for 2010 represents about 22 percent of total VMT in Blacksburg, a figure consistent with national averages as estimated by the U.S. Department of Transportation. For meaningful a meaningful change to occur in our transportation energy use and GHG emissions though, our driving habits will have to change for the other three quarters of our trips as well. Table 3-3 shows the potential energy consumption and GHG emission savings from the three alternative scenarios, assuming that we follow the same trends for our non-commuting trips as those proposed for our commuting behavior.

The energy use savings represent a 13 percent reduction in community-wide transportation energy use in the conservative scenario, 55 percent in the aggressive scenario, and 85 percent in the maximum scenario. The transportation GHG emission savings in the three scenarios are 13 percent, 54 percent, and 84 percent respectively. This equals a 2 percent reduction in total community-wide GHG emissions from all sectors in the conservative scenario, versus 7 percent and 11 percent in the aggressive and maximum scenarios.

Table 3-3. Community-Wide Energy and GHG Emissions Savings

Mode	Year			
	2020	**2030**	**2040**	**2050**
Conservative Scenario				
Energy savings (million Btu)	20,612	44,755	72,431	104,009
GHG savings (mt CO_2)	1,539	3,341	5,407	7,764
Aggressive Scenario				
Energy savings (million Btu)	84,237	182,910	296,018	425,075
GHG savings (mt CO_2)	6,258	13,588	21,990	31,577
Maximum Scenario				
Energy savings (million Btu)	130,325	282,984	457,975	657,642
GHG savings (mt CO_2)	9,686	21,032	34,037	48,877

3.2.2. Improve Vehicle Efficiency

Note: Our baseline scenario, from EIA data, assumes a 65% decrease in average Btu/VMT, i.e. a 65% increase in fuel efficiency. This outpaces the "Maximum" action scenario for vehicle efficiency improvements described below.

The estimates of potential energy consumption and GHG emission savings are based on a number of critical sets of assumptions regarding future fuel efficiency (miles per gallon) of different types of cars and buses as well as the potential distributions of vehicle types throughout the community vehicle fleet. The analysis, described in detail in Appendix C, is based on the baseline VMT projections for cars and buses described in Section 3.2.1.

The baseline fleet distribution for private vehicles is from the Town of Blacksburg's 2008 Energy Use and Greenhouse Gas Emissions Inventory, which used data from the Virginia Department of Transportation (VDOT) and a field survey of Blacksburg parking lots to estimate the distribution of the local vehicle types (heavy trucks, full and mid-size cars, light trucks and SUVs.). (Table 3-4)

Table 3-4. Baseline Distribution of Private Vehicles and Buses by Vehicle Type (2010)

Vehicle Type	VMT	% of VMT	MPG	% of Energy	% of GHG's
Gasoline Vehicles	**174,228,985**	**95%**		91%	91%
Auto - Full-Size	11,074,519	6%	19	6%	6%
Auto - Mid-Size	42,889,029	23%	22	19%	19%
Auto - Sub-Compact/Compact	52,231,194	28%	25	20%	20%
Light Truck/SUV/Pickup	57,565,074	31%	14	40%	40%
Motorcycle	552,788	0%	35	0%	0%
Vanpool Van	9,917,728	5%	17	6%	6%
Diesel Vehicles	**9,296,697**	**5%**		9%	9%
Auto - Full-Size, Mid-Size	390,865	0%	30	0%	0%
Heavy Truck	5,896,407	3%	10	6%	7%
Light Truck/SUV/Pickup	3,064,879	2%	14	2%	2%
Buses	**737,051**	**100%**		**100%**	**100%**
Diesel	700,198	95%	5	94%	95%
Bio-Diesel	36,853	5%	4	6%	5%

Sources: Town of Blacksburg Energy Use and Greenhouse Gas Emissions Inventory; United States Department of Energy, accessed 8-4-10 from http://www.fueleconomy.gov/

To simplify analysis, the baseline vehicle distribution assumption does not include hybrids or alternative-fuel vehicles. While such vehicles are currently used in Blacksburg, they likely represent less than 1 percent of the current vehicle fleet, and therefore the resulting error in current and projected baseline transportation energy consumption and GHG emissions is minimal.

Scenario Assumptions for Vehicle Distributions	Baseline	Conservative	Aggressive	Maximum
	Distribution is unchanged	25% of vehicles are hybrid or alternative fuel	60% of vehicles are hybrid or alternative	90% of vehicles are hybrid or alternative

These three scenarios are evaluated in the analysis described in Appendix C, to show the potential energy consumption and GHG emissions reductions that could be achieved by shifting the vehicle fleet to include more energy efficient or alternative-fuel vehicles.

The baseline distribution of bus VMT by fuel type is based on the current distribution of fuel use in the Blacksburg Transit fleet. The other three scenarios are based on plans by Blacksburg Transit to move toward using more biodiesel and ethanol fuels.

Scenario Assumptions for Bus Fuel Types	Baseline	Conservative	Aggressive	Maximum
	Distribution is unchanged	50% diesel, 50% bio-diesel	10% flex-fuel ethanol hybrid, 30% diesel, 60% biodiesel	50% biodiesel, 50% flex-fuel ethanol hybrid

Within each fuel type category the VMTs are further distributed between various applicable vehicle types, such as full-size auto, heavy truck, light truck etc. (Appendix C). The scenarios assume that change would begin slowly, with most of the shifts to more efficient fuel sources occurring between 2020 and 2040, ultimately reaching the 2050 percentages shown in Figure 3-6.

Figure 3-7 shows the projected energy use from the four scenarios in 2020 and 2050, assuming the baseline VMT growth projections shown in Figure 3-1. In the conservative scenario, energy use increases from 2020 to 2050, as the slight improvements in fuel efficiency cannot offset the additional vehicle miles traveled. The aggressive scenario results in a slight decrease in total transportation energy use, and significant energy savings are found only in the maximum scenario.

Figure 3-7. Energy Use (million Btu) under the Baseline VMT Scenario

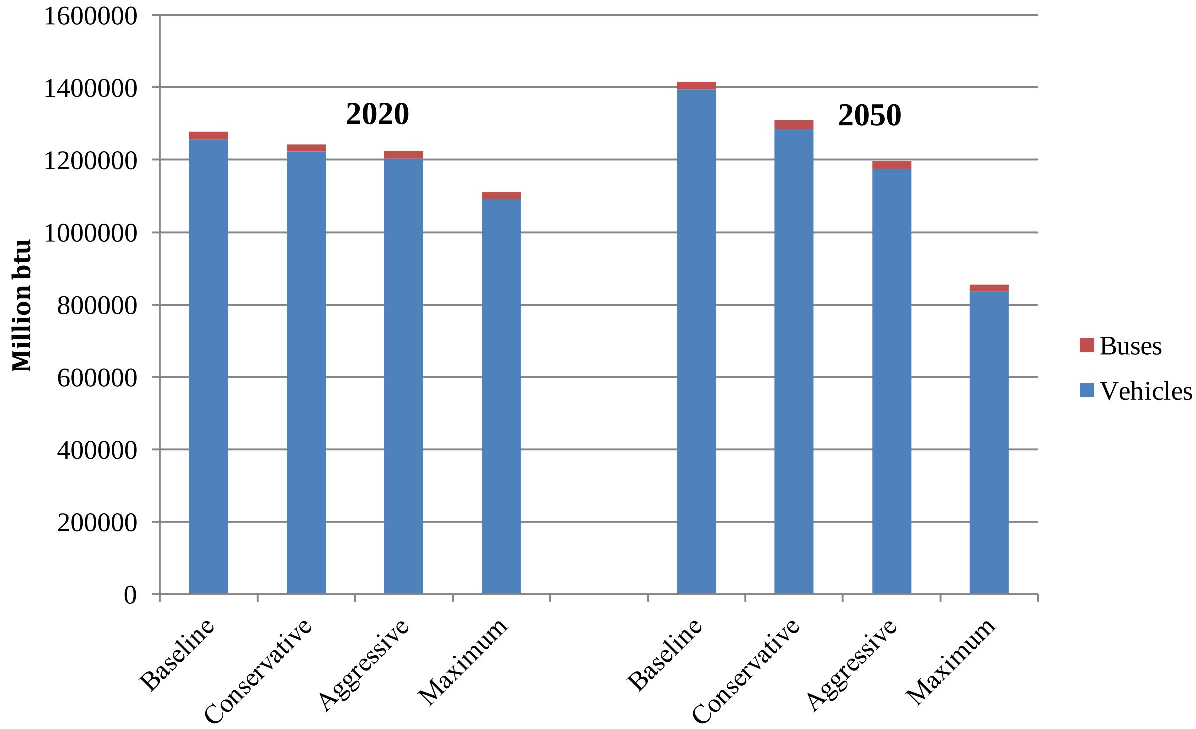
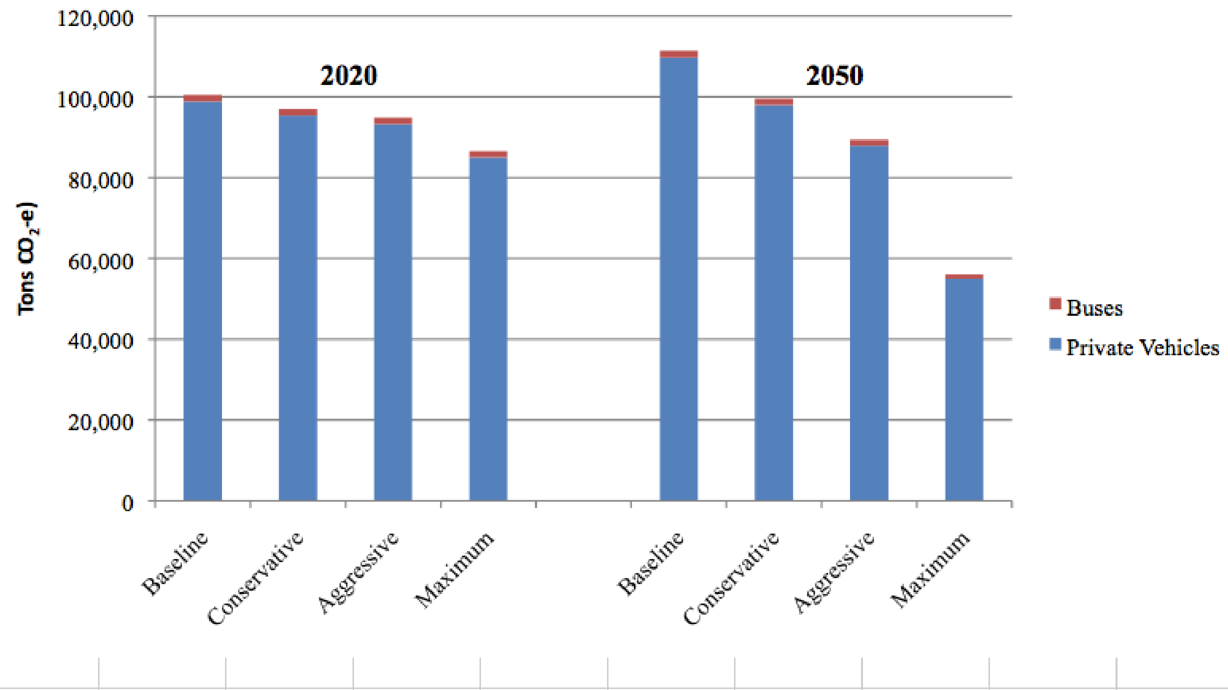


Figure 3-8 shows the impact on GHG emissions from the four vehicle efficiency scenarios. The conservative scenario results in no significant in GHG emissions between 2020 and 2050, as the slight improvement in vehicle efficiency merely offsets the projected increases in VMT. Only the maximum efficiency scenario demonstrates significant reductions in GHG emissions, with 55,000 tons CO_2-e projected in 2050 emissions, approximately half the baseline scenario projection.

Figure 3-8. GHG Emissions from Vehicle Efficiency Scenarios (tons of CO_2-e) under Baseline VMT Projection



All of the GHG emissions projections shown in Figure 3-8 are based on the baseline VMT scenario; in other words, they assume that total vehicle travel will continue to increase by about 1.5% per year through 2050.

3.2.3. Combined Transportation Energy Use and GHG Emissions Savings

Applying the four vehicle efficiency scenarios (including the baseline assumption) to the three remaining VMT scenarios results in 12 possible outcomes (Figure 3-9).

Significant energy savings are possible when improved vehicle efficiency is combined with VMT reductions. In the most ambitious approach, combining both maximum efficiency scenarios reduces 2050 projected energy consumption by two-thirds compared to the baseline fuel efficiency and conservative VMT scenarios.

Figure 3-9. Energy Use under Various VMT and Vehicle Efficiency Scenarios in 2050

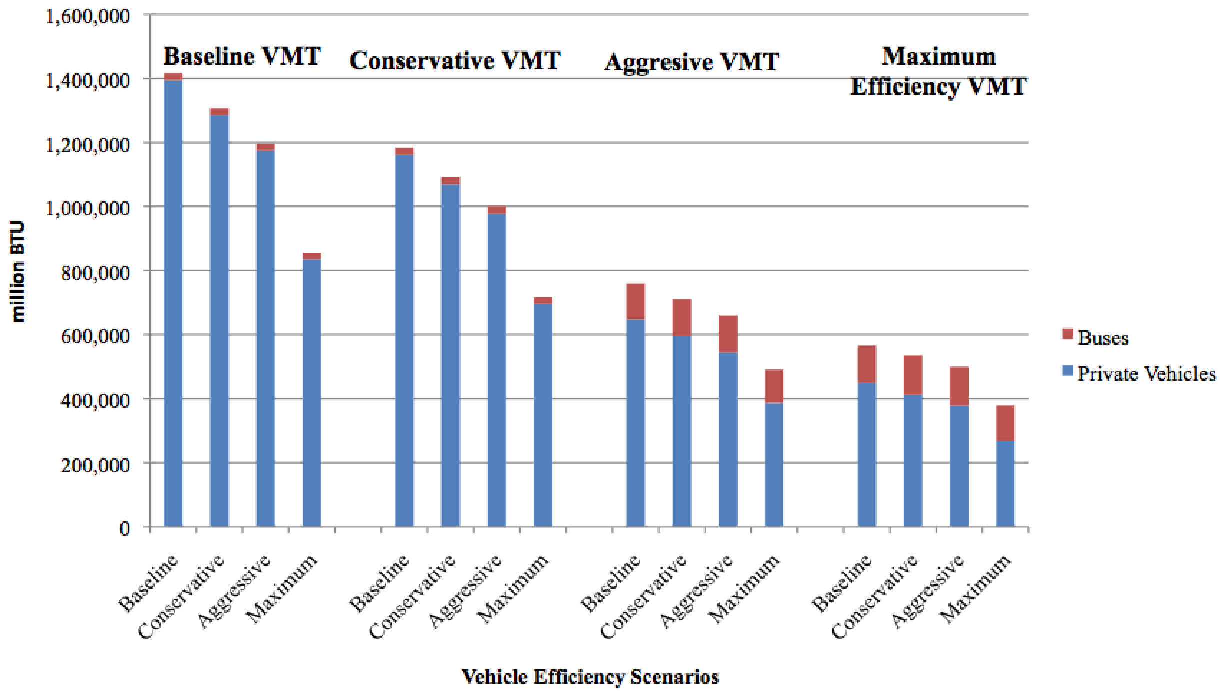
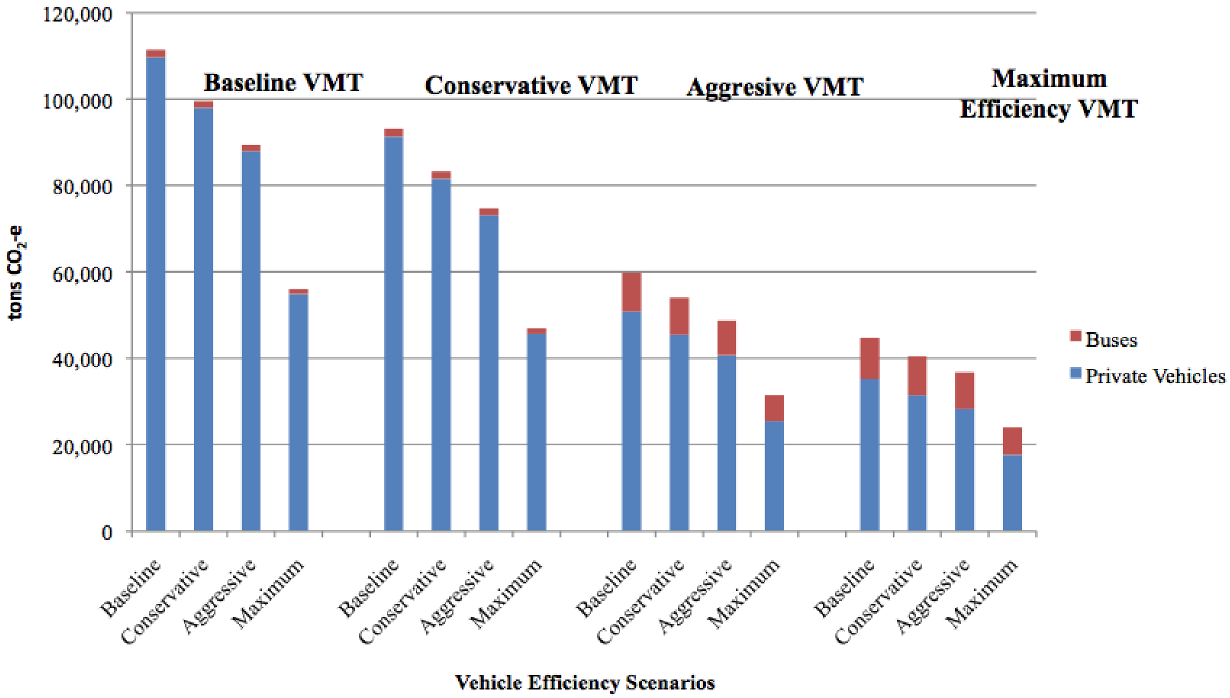


Figure 3-10 shows the potential reductions in transportation-related GHG emissions from reducing VMT and improving vehicle efficiency. These reductions can be as much as 78 percent below baseline levels in the "maximum-maximum" scenario, in which total transportation-related GHG emissions would be reduced from the 109,713 tons CO_2-e baseline projection to 24,045 tons CO_2-e by 2050.

Figure 3-10 also demonstrates how an increasingly larger portion of the GHG emissions are from buses as the VMT scenarios become more ambitious. Even though total VMT, energy consumption, and GHG emissions from buses increase in the more aggressive VMT scenarios, the simultaneous reductions in private passenger vehicle VMT result in overall energy and GHG emission decreases, particularly when paired with the more aggressive vehicle efficiency scenarios.

Figure 3-10. GHG Emissions under Various VMT Scenarios in 2050



It must be noted that even in the highly ambitious maximum scenario, the resulting 24,045 tons of CO_2-e GHG emissions are only 68 percent below Blacksburg's estimated transportation-related GHG emissions in 1990 (as shown in the revised GHG emissions projections in Chapter 2). The "maximum-maximum" scenario thus falls short of the 80% below 1990 level target, which would require transportation-related GHG emissions to drop to 14,932 tons CO_2-e by 2050.

3.3. Policies and Programs to Achieve Transportation Energy and GHG Savings

The Blacksburg community faces a number of financial, procedural, and institutional obstacles as it strives to reduce its environmental impacts. Innovative policies are needed to overcome these obstacles. It will take the combined efforts of citizens, the government, businesses, and non-profits to meet our energy reduction goals. The Blacksburg government, though its policies and public investments, can directly affect energy reduction, GHG reductions, and community-wide sustainability. . For transportation, this will mean investing in public infrastructure that supports alternative transportation modes, such as constructing bike lanes and improving the safety of pedestrian routes. The Town can also increase the efficiency and convenience of its public transportation systems, spurring greater numbers of citizens to use public transit for their daily commute. Citizens groups such as Sustainable Blacksburg and can partner with community groups and the private sector to offer educational resources or incentive programs that expand residents' awareness of their transportation choices. Any feasibility studies that have been completed on specific transportation goals, objectives, and strategies can be found in Appendix G.

3.4. Goals, Objectives, and Strategies: Transportation

Strategies to increase biking, walking, and the use of mass transit and to improve the efficiency of vehicles are outlined below. Goals will have to be undertaken by citizens, businesses, non-profits, and the government to take advantage of growing fuel efficiency technology and its associated environmental and monetary benefits.

Goal #1: Increase the percentage of trips taken by bicycle and walking from the current 15 percent to 20 percent by 2020 and 30 percent by 2050.

Objective 1-A: Improve local pedestrian and bicycling infrastructure.

Community Strategies

Strategy 1: Expand the Go Green NRV community led "Green Business" ranking system, to motivate business owners to provide employees with more bicycle racks, secure bicycle parking, showers, bicycle repair facilities and reward businesses for their achievements.

Strategy 2: Create a community-wide bicycle share program that allows residents to pick up a bicycle at a conveniently located bicycle sharing station and drop it off after use.

Government Strategies

Strategy 1: Provide a network that enables walking and biking to be used as a primary means of transportation, as well as for recreational purposes.

a. Continue to develop a continuous and interconnected system of on-road bicycle lanes and off road shared use paths as outlined in the "Paths to the Future" map.

b. Continue to develop bicycle lanes and shared use lanes as part of an intermodal transportation system by providing easy access from pedestrian and bicycle routes to transit stops.

c. Include bicycle lanes when new roads are planned and in repaving plans for Town streets where feasible.

d. Include shared use lane designations when repaving roads if bicycle lanes are not feasible.

Strategy 2: Complete the Town of Blacksburg Bicycle and Pedestrian Master Plan.

Strategy 3: Maintain and expand the existing pedestrian and bicycle network and associated facilities to maximize safety and convenience for all users.

a. Continue to provide and enhance appropriate signage, lighting, markings, and other physical improvements along bikeways and walkways to ensure safe and easy use by bicyclists and pedestrians.

b. Develop and implement a comprehensive bicycle parking program throughout Town in coordination with Blacksburg Transit and the community.

c. Continue to install bicycle racks at public sites such as downtown as well as commercial and residential locations.

d. Use art as a tool when design and creating back racks and locate the racks close to roads and destinations to increase visibility and encourage cycling.

e. Provide bicycle route signage, wayfinding signage and maps to guide users through bicycle systems.

f. Install "bicycle corrals," which would replace two motor vehicle parking spaces with parking for up to 24 bicycles.

g. Consider the incorporation of inroad bicycle facilities such as cycle tracks, bicycle boxes, and bicycle boulevards to facilitate the safe and effective travel of cyclists.

Strategy 4: Provide a safe and convenient network of sidewalks that serve the entire community and enables pedestrian access to all potential destinations in Town.

a. Complete construction of all Corridor Committee sidewalk priorities in support of the Comprehensive Plan.

b. Consider the inclusion of sidewalks and/or trails on both sides of each street in all new subdivisions.

c. Develop a sidewalk system that minimizes pedestrian/vehicle conflicts by providing pedestrian crossing signals at all signalized intersections

d. Continue to develop a sidewalk system that maximizes pedestrian safety by providing appropriate signage, lighting, markings, and other physical improvements.

e. Continue to coordinate with Montgomery County School System to establish the Safe Routes to School Program at all public schools located within the Town.

f. Provide pedestrian actuated midblock crosswalks in areas that receive significant pedestrian traffic.

g. Create dedicated bicycle traffic lights as technology becomes available.

h. Enhance safety by reducing the crossing distance for pedestrians and cyclists at intersections.

i. Identify intersections that allow right turns and create a conflict or safety hazard between pedestrians, cyclists, and vehicles.

j. Identify opportunities to continue to improve accessibility in the right-of-way through the use of sidewalks, curb ramps, and tactile paving.

Strategy 5: Continue to increase access to the trail and sidewalk network to enhance the effectiveness of the network for pedestrian and bicycling transportation use.

a. Complete the Blacksburg Outer Loop trail system.

b. Complete an internal off-road network of trails that is continuous, interconnected, and consistent with the latest edition of the Paths to the Future map.

c. Complete the Huckleberry Trail extension.

d. Finish the Ellet Valley Loop Trail, an "Outer Loop" around the perimeter of Blacksburg, bounded by the Cedar Run drainage basin along Cedar Run road, Norfolk Southern Railroad, VDOT Smart Road, and South Main Street.

e. Complete the Cedar Run Valley Trail to connect the Industrial Park to the Corporate Research Center through existing trail segments, and provide neighborhoods in the South End Sector of Blacksburg access to nearby trails.

f. Complete the Central Blacksburg Greenway to link downtown Blacksburg, Wong Park, Harding Avenue Elementary, Owens Park, Blacksburg High School, and the Municipal Park.

Strategy 6: Establish methods and funding for additional greenway acquisition and construction.

a. Incorporate pedestrian walkways and bike lanes in planning for all transportation and capital projects and seek funding for the construction of bicycle/pedestrian walkways from both public and private sources, including funding derived from the development process.

b. Incorporate trails and sidewalks in roadway designs, including preliminary engineering, right-of-way acquisition, construction, and funding where the greenway system parallels or shares highway access.

Strategy 7: Coordinate Blacksburg's bike paths locally and regionally.

a. Work with neighboring jurisdictions, as well as civic and corporate entities to connect the Town's Greenway system to a regional greenway system, with connections throughout the New River Valley and Roanoke Valley.

a. Continue to plan and develop trail system to coordinate with the bicycle lane and sidewalk systems throughout Blacksburg

b. Extend the trail network to schools, parks, public buildings, neighborhoods, private trails, and businesses.

c. Connect sidewalks, footpaths, or appropriate alternative pedestrian circulation systems in all new residential developments to the Town's trail system.

d. Consider reviewing and amending the Zoning and Subdivision Ordinances to establish design standards to require external greenway loops around the perimeter of developments with connections to other existing greenways and with connections to sidewalks and greenway trails internal to the development.

e. Establish appropriate transitions between subdivision trails and Town trails.

Strategy 8: Continue to maintain and upgrade alternative transportation infrastructure as necessary to allow and encourage long-term use.

Strategy 9: Locate development of future alternative transportation routes and upgrades to current routes based on public input.

Strategy 10: Pursue federal and state grants to fund improvements to public pedestrian and bicycling infrastructure.

Strategy 11: Increase the convenience of biking and walking by creating a car share program that allows citizens to have short-term access to vehicles. **.**

Objective 1-B: Establish programs and incentives to increase bicycling and walking.

Community Strategies

Strategy 1: Encourage employers to provide incentives to employees who regularly bicycle or walk to work.

Strategy 2: Encourage residents to increase commuter trips by encouraging participation in annual "clean commute days" such as the Sustainability Week *Active Commuter Celebration* and the Earth Week *Dump the Pump Day*.

Strategy 3: Integrate and encourage national and regional bicycle festivals such as "Bicycle VA."

Strategy 4: Continue to expand the number of organized "group rides" around Blacksburg.

Government Strategies

Strategy 1: Partner with the American League of Cyclists and work towards recognition as a "Bicycle Friendly Community of America."

Strategy 2: Allow bike-share stations at Town facilities.

Objective 1-C: Educate the community about the benefits of bicycling and walking.

Community Strategies

Strategy 1: Increase alternative transportation awareness and safety education through community-led programs.

Strategy 2: Distribute an educational guide to citizens on the personal savings and environmental benefits of using mass transit, riding a bicycle, or walking instead of driving a car.

Strategy 3: Establish a Blacksburg Bicycle Community Program in conjunction with local bicycle clubs that promotes bicycle use, teaches bicycle mechanics, and teaches youth how to bicycle.

Government Strategies

Strategy 1: Promote awareness and safe use of the trail system through comprehensive education programs.

Strategy 2: Create and distribute "bicycle information kits" to residents in conjunction with local bicycle clubs that include a bicycle map, safety information, and a calendar of bicycle-oriented events.

Strategy 3: Implement educational wellness programs focusing on the health benefits of walking and biking.

Goal #2: Increase the percentage of trips taken by bus or other mass transit to 14 percent by 2020 and 30 percent by 2050.

Objective 2-A: Expand local bus service and infrastructure to provide alternative transportation options to multi-family, neighborhoods, and businesses.

<u>Community Strategies</u>

Strategy 2: Distribute an educational guide to citizens on the personal savings and environmental benefits of using mass transit instead of driving a car.

<u>Government Strategies</u>

Strategy 1: Increase Blacksburg Transit route coverage and frequency to residential neighborhoods especially during work commuting hours.

Strategy 2: Continue to coordinate land use decisions with existing and planned alternative transportation services.

a. Expand Blacksburg Transit access to all high-density residential developments, mixed use developments, affordable housing developments, commercial centers, research parks, and industrial parks.

b. Promote the Town Code's mixed-use zoning classification to encourage compact/mixed-use development to allow opportunities for citizens to perform daily tasks without driving.

Strategy 3: Reduce the demand for public and private parking through the promotion of alternate modes of transportation.

a. Explore the development of "Park and Ride" lots for citizens carpooling or using regional transit to commute to work.

b. Explore the development of a shuttle service from outlying parking nodes into the downtown areas.

c. Connect existing regional "Park and Ride" lots with the Blacksburg transit system.

Strategy 6: Convert all bus stops to covered, well-lit stations to create an inviting and encouraging community space.

Strategy 7: Utilize public transportation to stimulate economic development in the community, including telecommunications.

a. Continue to work with area developers and community businesses to ensure public transportation accessibility and bus stops are included in their development plans.

b. Support the expansion of public transportation to better serve citizen commutes including those for work, shopping, and errands, and sporting or leisure activities.

Strategy 8: Continue to pursue federal and state grants to fund improvements to local bus infrastructure.

Objective 2-B: Establish programs and incentives to increase bus use.

Community Strategies

Strategy 1: Encourage business owners to reimburse employees for the cost of bus fares.

Strategy 2: Encourage employers to provide incentives for employees to use alternative transportation to commute, adopt a flexible work schedule, or telecommute.

Strategy 3: Implement an "Adopt-A-Stop" campaign to get local organizations and clubs to maintain a bus stop, thus encouraging bus commuting.

Strategy 4: In collaboration with Blacksburg Transit, include reward programs for bus riders such as occasional early morning commute breakfast stations at bus stops.

Strategy 5: Establish bus route ambassadors on designated "clean commute days" to welcome and assist new riders.

Government Strategies

Strategy 1: Continue to provide free bus fares for Town of Blacksburg employees.

Strategy 2: Provide accessible and reliable transportation options for low-income and elderly residents.

Strategy 3: Increase the convenience of using transit by creating a car share program that allows citizens to have short term access to a vehicle for appointments**.**

Objective 2-C: Educate the community about the benefits of bus use.

Community Strategies

Strategy 1: Increase education about the benefits of bus use through community-led programs.

Strategy 2: Distribute an educational guide to citizens on the financial and environmental benefits of riding the bus instead of driving a car.

Strategy 3: Use non-profit and business websites to provide educational information about the benefits of using alternative transportation.

Government Strategies

Strategy 1: Continue to include educational information about Blacksburg Transit on partner websites, buses, and other advertising spaces.

Strategy 2: Use the Town of Blacksburg's website to provide educational information about the benefits of using alternative transportation.

Goal #3: Improve vehicle efficiency (the ratio of GHG emissions to VMT) by 20 percent by 2020 and 50 percent by 2050.

Objective 3-A: Improve local infrastructure to support the use of higher-efficiency and alternative fuel vehicles.

Community Strategies

Strategy 1: Encourage local gas stations to provide alternative fuels.

Strategy 2: Encourage local auto repair business owners to provide free air for tires to improve fuel efficiency.

Strategy 3: Encourage business and non-profits to provide electric charging stations for plug-in hybrids.

Government Strategies

Strategy 1: Support Blacksburg Transit's acquisition of hybrid electric buses and future use of alternative fuels.

Strategy 2: Continue to purchase low-emission, alternatively fueled vehicles in the Town's municipal fleet as outlined in the Town government Green Fleet Policy

Strategy 3: Continue to encourage employees to adopt fuel efficient driving practices as outlined in the Town government Green Fleet Policy.

Strategy 4: Develop incentives for low-emission vehicles registered in Town.

Strategy 5: Provide electric charging stations for plug-in hybrids at Town facilities.

Strategy 6: Pursue federal and state grants to fund improvements to local alternative fuel infrastructure.

Objective 3-B: Establish programs and incentives to increase the use of higher-efficiency and alternative-fueled vehicles.

Community Strategies

Strategy 1: Encourage employers to designate convenient parking or other benefits to employees who use alternative fuel or high-efficiency vehicles.

Strategy 2: Encourage citizens to purchase fuel-efficient and alternative fuel vehicles.

Government Strategies

Strategy 1: Provide town-funded subsidy, grant, or loan programs to encourage the purchase of fuel-efficient or alternative-fuel vehicles.

Objective 3-C: Encourage the use of carpooling and telecommuting to reduce vehicle use for worker commuting.

Community Strategies

Strategy 1: Work with employers to encourage employees to take advantage of existing ride-share and carpool matching programs in the region.

Strategy 2: Encourage employers to participate in existing ride share programs or establish new carpooling and ride-sharing programs.

Strategy 3: Encourage employers to designate convenient parking spaces and other incentives to employees who carpool to work.

Strategy 4: Encourage employers to allow and encourage employee telecommuting.

Government Strategies

Strategy 1: Provide convenient parking spaces and other incentives to Town employees who carpool to work as outlined in the Green Commuting administrative directive.

Strategy 2: Allow and encourage telecommuting by Town employees as outlined in the Alternative Work Schedule administrative directive.

Strategy 3: Partner with regional businesses and economic development agencies to establish private telecommuting facilities for citizens with long commutes outside of Blacksburg.

Objective 3-D: Educate the community about the benefits of higher-efficiency and alternative-fueled vehicles.

Community Strategies

Strategy 1: Provide community-led educational programs to promote awareness of alternative/ efficient vehicles.

Strategy 2: Provide information booklets at local car dealerships that educate the public on the benefits of energy and fuel-efficient vehicles.

Strategy 3: Increase awareness and education on the benefits of and access to the "Zip-Car" program in Blacksburg.

Chapter 4. Residential Sector

Update and Notes:

The narrative and data tables of this chapter is shown in their original format, in which the implementation scenarios are identified progressively as "baseline", "conservative", "aggressive", and "maximum". When the Climate Action Plan Working Group picked up the planning process in early 2013, it was decided that only an "On Target" scenario would be utilized to devise the priority goals, objectives and strategies for inclusion in the final plan, i.e. one that enable the Town of Blacksburg to meet its emissions reduction target of 80% below 1990 levels by 2050. For the most part, these are reflected the "maximum" scenario.

Residential buildings account for 28 percent of Blacksburg's community-wide energy consumption and 35 percent of its greenhouse gas (GHG) emissions as of 2011, making it the largest source of GHG emissions by sector and the second largest source, after transportation, of energy consumption. In the baseline scenario for our community, based on EIA projections, it is anticipated that these percentages will grow to 29 percent and 37 percent respectively by 2050, at which time Blacksburg residences would account for just under 1 trillion Btu of energy consumption and about 160,000 tons of CO_2-e GHG emissions per year.

Improving residential energy efficiency can substantially reduce community-wide energy consumption and GHG emissions. Blacksburg has a large percentage of older homes and apartment buildings that can be made significantly more energy-efficient. Recent American Community Survey data shows that more than half of the existing residential stock was built prior to 1980.[1] Retrofitting these buildings is arguably the simplest and most direct way to reduce overall residential energy consumption. Such retrofits increase energy efficiency by adding insulation to the ceilings, floors, and walls, installing more efficient windows and doors, and patching up holes to reduce infiltration of outside air into the building. These types of residential retrofits improve residents' indoor air quality and thermal comfort, and reduce household energy costs.

Other residential energy efficiency opportunities include more efficient water heaters, appliances and lighting, as well as residential solar photovoltaic (PV) systems. Appliance upgrades and installation of residential solar photovoltaic systems often involve substantial up-front costs, however, they have been demonstrated to pay for themselves over time and can be considered cost-effective investments. The biggest challenge in encouraging residential energy efficiency improvements is identifying creative ways to reduce up-front costs so more residents can take advantage of these long-term financial savings while helping the community reach its goals on reducing energy consumption and GHG emissions.

[1] U.S. Census Bureau. 2011 American Community Survey 5 year estimates.

4.1. Background and Methodology

The approach to estimating future energy use and GHG emissions in the residential sector focuses on potential savings that can be realized for specific end uses such as space heating, cooling, lighting, etc. (See Appendix D for data sources and methodology.) This was accomplished by assessing the current breakdown of residential energy consumption by end use (space heating, appliances, water heating, etc.) according to national-level data from the U.S. Energy Information Administration (EIA). Calculated estimates for potential residential energy and GHG savings are based on EIA data on average residential energy consumption by end use, which is further broken down by tenure (renter vs. owner) and units in structure (single family homes vs. townhomes, apartments, etc.).

The national average consumption numbers by tenure/units in structure were then adjusted them for local climate conditions (heating degree days) and multiplied by the number of units for each housing type in Blacksburg to estimate the Town's residential energy consumption by end use in each category (a more detailed discussion of this methodology can be found in Appendix D). This method resulted in an estimated residential energy consumption that was only 10 percent higher than the observed total in the revised GHG emissions inventory. This difference is accounted for by Blacksburg's much higher proportion of renter-occupied units, which are largely occupied by college students who use less energy over the course of the year than non-college student renters, in large part because many spend approximately a quarter of the year at home on school breaks, do laundry off-site, etc.

Specific adjustments to account for Blacksburg's high proportion of university students and renter-occupied units are as follows:

- Space heating: -10%
- Air conditioning: -40%
- Water heating: -20%
- Refrigerators: no change
- All Other Appliances: -22% (includes washers and dryers, which many student units do not have, although these emissions are almost certainly accounted for in commercial energy use – either through share laundry facilities in an apartment complex or by commercial laundromats)

Table 4-1 shows the resulting estimate of energy demand by end use for different types of residences in Blacksburg.

Table 4-1. Estimated Current Average Residential Energy Consumption by End Uses 2011

Housing Type	Total Housing Units	Energy End Uses (Million Btu/yr of consumption)					
		All End Uses	Space Heating	Water Heating	Air Conditioning	Refrig-erators	Other Appliances & Lighting
Single Family Homes (SFH)							
Owner-occupied	4,069	107.2	43.0	18.4	7.8	5.1	33.0
Houses/Townhouses	*3,881*	*109.1*	*44.0*	*18.7*	*7.8*	*5.1*	*33.4*
Mobile Homes	*188*	*69.8*	*21.8*	*11.7*	*6.5*	*4.4*	*25.4*
Renter-occupied	1,516	72.1	32.0	11.6	3.3	4.2	21.0
Houses/Townhouses	*1,461*	72.6	32.5	11.7	3.3	4.2	21.0
Mobile Homes	*55*	58.9	20.6	9.1	3.4	4.8	21.0
Avg. for all SFH's	**5,585**	**97.7**	**40.0**	**16.6**	**6.6**	**4.9**	**29.7**
Multi-Family Homes (MFH)							
Owner-occupied	206	76.8	38.1	14.5	3.3	3.4	17.6
Renter-occupied	7,191	45.5	22.7	7.3	1.7	3.2	10.6
Avg. for all MFH's	**7,397**	**46.4**	**23.1**	**7.5**	**1.7**	**3.2**	**10.8**
Avg. for all Units	**12,996**	**70.9**	**31.1**	**11.8**	**4.0**	**4.0**	**20.1**
% of End Use Energy		**100%**	**44%**	**17%**	**6%**	**6%**	**28%**

Sources: U.S. Energy Information Administration, 2009 Residential Energy Consumption Survey; U.S. Census Bureau, 2011 American Community Survey 5-year estimates

Space heating/cooling, water heating, and "other appliances and lighting" are particularly important, as they represent the greatest shares of residential energy consumption. Individually, these three categories are responsible for 50 percent, 17 percent, and 28 percent of all end uses in the residential sector, respectively. Finding workable strategies for rental property retrofits is particularly important in our community considering that renter-occupied units account for almost two-thirds of all housing in Blacksburg (compared to one-third of housing units nationwide). Rental properties present unique challenges for energy efficiency improvements, namely because of the "split incentives" that renters and owners have around conservation and efficiency. In a typical scenario, a property owner would bear the up-front cost of doing the efficiency retrofit, but the occupant would reap the reward in reduced utility bills. In cases where utilities are included in the rent, the property owner may have a bit more incentive to pursue an efficiency upgrade, but will still be faced with a tenant who has little incentive to conserve energy day-to-day.

Because of the unique considerations for retrofitting single-family homes (76 percent of which in Blacksburg are owner-occupied) versus multi-family units (97 percent of which in Blacksburg are renter-occupied), separate analyses have been conducted for these types of residences.

4.2. Potential Energy and GHG Savings from Single-Family Homes

This section describes potential energy use and GHG emissions savings that can be achieved by making homes more energy-efficient, focusing on three types of energy efficiency improvements – heating and cooling, water heating, and lighting/appliances.

4.2.1. Building Energy Efficiency Retrofits

Residential retrofits can achieve substantial, long-lasting energy savings while also improving the livability and comfort of people's homes and creating new green jobs in the community. Residential retrofits specifically address energy consumption for space heating, and to a lesser extent, air conditioning; these two end uses account for the largest share of total annual energy consumption for single-family homes in Blacksburg – 50 percent. (Table 4-1).

A detailed analysis of potential energy savings from thermal conditioning (space heating and air conditioning) is included in Appendix D. Potential energy savings from efficiency retrofits were modeled on a typical 1,500 ft^2 owner-occupied single-family home (SFH) in Blacksburg, then compared the predicted thermal conditioning energy consumption in that same home that would likely result after three "tiers" of energy efficiency retrofits:

- Tier 1: upgrades to ceilings and windows,
- Tier 2: upgrades to building envelope and HVAC system, and
- Tier 3: super-efficient upgrades to building envelope and HVAC system.

Table 4-2 summarizes the impacts of each tier of retrofit on space heating energy consumption for the owner-occupied single-family detached home model, compared to the baseline demand in that model home before the retrofits. Delivered energy (Qdel) represents the thermal energy needed to maintain a constant interior temperature of 67^o F throughout the winter. Fuel consumption (Qfuel) refers to the amount of energy consumed from electricity, natural gas, or another heating fuel, in order to provide the needed thermal energy to heat the home. This Qfuel value takes into account the efficiency of the home's HVAC system. The fuel bill shown for electric heating assumes a rate of $.12/kWh. The natural gas fuel bill is based on a cost of $14.00 per million Btu.

Table 4-2. Energy Consumption Results for Baseline Single Family Home and Retrofits

Energy Use Indicators	Unit	No Retrofit	Tier 1	Tier 2	Tier 3
Delivered energy (Qdel)	Million Btu/yr	43.6	35.9	24.9	11.9
Fuel consumption (Qfuel) - electric	Million Btu/yr	30.6	25.2	11.7	4.6
Fuel consumption (Qfuel) - gas	Million Btu/yr	72.6	59.8	31.8	13.7
Fuel Bill	$ / year	$1,088	$897	$417	$162
Fuel Bill	$ / year	$1,016	$837	$445	$191
GHG emissions - electric	Tons CO_2-e / yr	6.5	5.4	2.5	1.0

GHG emissions – natural gas	Tons CO_2-e / yr	3.9	3.2	1.7	0.7

Table 4-2 shows a Tier 1 retrofit would decrease energy consumption in the electric heat model by 18 percent, from a baseline of 30.6 million British thermal units (million Btu) per year to 25.2 million Btu/yr. The Tier 2 and Tier 3 retrofits in the electric heat model caused drops of 62 percent and 85 percent respectively. The results were comparable in the natural gas model, with savings of 18 percent, 54 percent, and 81 percent.

Appendix D details the models used to estimate the potential for community-wide savings from three scenarios in which all existing single-family homes in Blacksburg would receive some retrofits by 2050, taking into account potential savings from all of the different types of single-family homes (owner vs. renter-occupied homes, attached vs. detached homes, etc.). Note that even within the baseline scenario, a certain percentage of existing homes will receive retrofits by 2050. Table 4-3 summarizes the distribution of retrofits in each scenario.

Table 4-3. Scenarios for Distribution of Single-Family Home Retrofits by 2050

Retrofit Type	Percent of Existing Homes (2011) Retrofitted by 2050			
	Baseline	Conservative	Substantial	On-target
Tier 1: upgrades to ceilings and windows	30%	30%	0%	0%
Tier 2: upgrades to building envelope and HVAC system	22%	35%	50%	20%
Tier 3: super-efficient upgrades to building envelope and HVAC system	0%	35%	50%	80%

Figure 4-1 summarizes the impact of these building energy retrofits on existing single-family homes' projected thermal conditioning energy demand by the year 2050.

Figure 4-1. Potential Savings in SFH Energy Demand from Thermal Conditioning (2050)

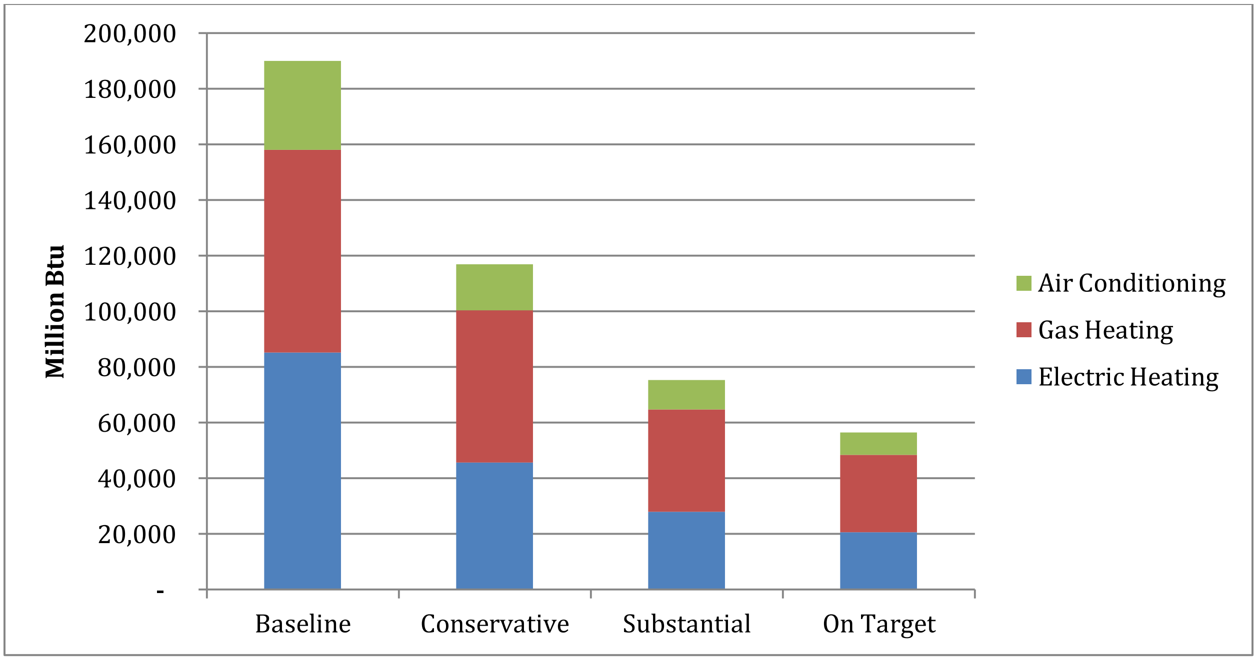
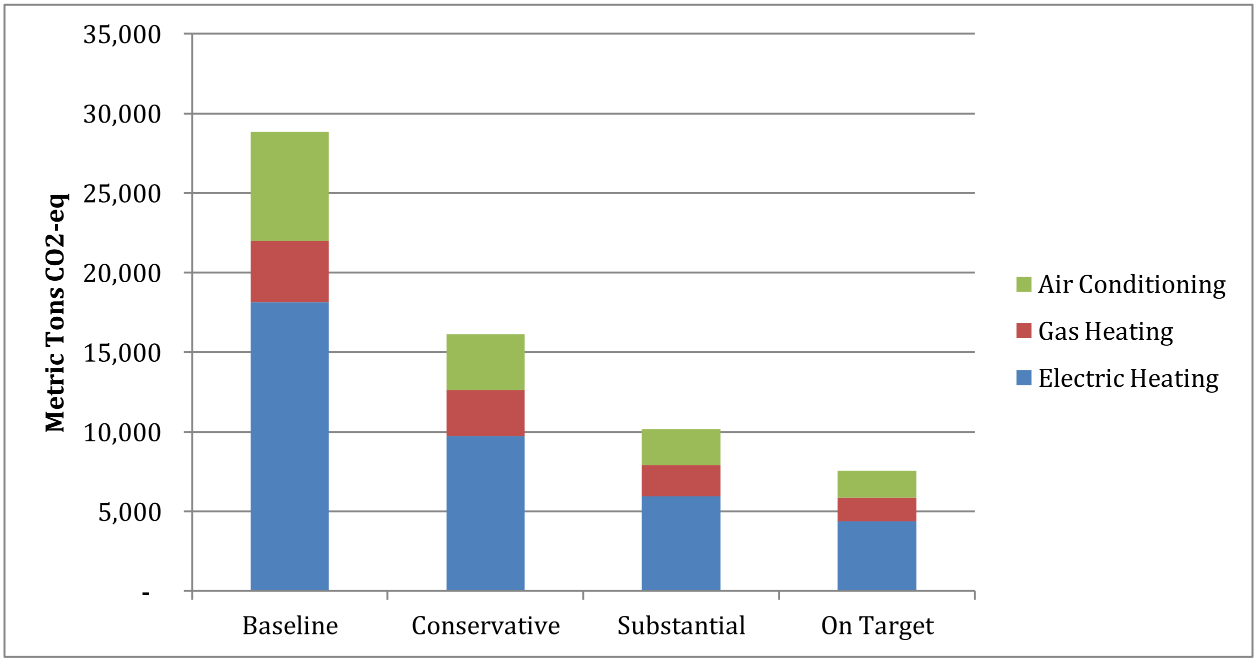


Figure 4-1 shows thermal conditioning ***energy demand*** would drop dramatically under all scenarios. The energy savings in natural gas heat and electric heat are similar. Natural gas heat represents a slightly larger percentage of heating energy demand, despite being used in only one-third of existing single-family homes, because natural gas furnaces are less efficient than electric heat pumps and consume more fuel energy to deliver the same amount of heat to the home. However, natural gas is also significantly cheaper per Btu, and thus the resulting energy costs for residents are roughly the same, as shown in Table 4-2. That said, it is difficult to predict with accuracy the price of various fuel types. Natural gas has enjoyed a dramatic drop in price since 2009, but may level off or rise between now and 2050.

While Figure 4-1 demonstrates potential reductions in ***energy demand***, Figure 4-2 demonstrates the effect of the retrofits on ***GHG emissions*** from energy consumption for thermal conditioning. While the percentage change between the baseline emissions and the various scenarios is roughly the same as that shown for energy demand, the relative shares of the GHG emissions by fuel type vary dramatically. Electricity in Blacksburg, 88 percent of which comes from coal-fired power plants, has a much higher carbon coefficient (0.21 metric tons CO_2-e per million Btu) than natural gas (0.05 metric tons CO_2-e per million Btu) and therefore, electric heat represents a much greater share of local GHG emissions than natural gas, although its share total energy consumption is smaller.

Figure 4-2. Potential Savings in SFH GHG Emissions from Thermal Conditioning (2050)



Overall, GHG emissions are expected to decrease by 44 percent in the conservative scenario, 65 percent in the substantial scenario, and 74 percent in the on-target scenario, compared to the baseline projection – what would be expected under a "business as usual" scenario.

4.2.2. Water Heating

Water heating represents another opportunity to improve residential energy efficiency, as it accounts for an estimated 17 percent of energy consumption in Blacksburg's single-family homes.

Conventional water heating systems include a tank of water that is kept hot at all times. Newer, more efficient versions of these conventional systems can provide some energy savings, but much greater savings are possibly by using technologies such as combined water heater/heat pumps or on-demand water heaters. Solar hot water systems are by far the most energy-efficient option although they have high up-front costs and long pay-back periods.

This analysis begins with an examination of current water heater technologies as well as nationwide data from the 2009 US Energy Information Administration's Residential Energy Consumption Survey. Assumed hot water usage per household was adjusted downward from a commonly accepted value 64 gallons per household per day to 56 gallons per day in order to account for Blacksburg's high proportion of student renters, most of whom leave the community in the summer months. The analysis then evaluates a new "2050 Baseline", and three potential scenarios in which single-family homes in Blacksburg switch to various combinations of more energy-efficient water heating systems. These three scenarios are summarized in Table 4-4.

Across the scenarios, households are projected to adopt various energy conservation and efficiency technologies related to water heating. In the baseline and conservative scenarios, the focus is on lower tech solutions - adding an insulating blanket to their conventional water heater while an additional quarter (23%) are expected shift to an electric heat pump-style water heating system. In the substantial and on-target scenarios we expect to see a greater proportion of households moving toward a heat pump-style water heater as well as significant adoption of solar hot water systems. The analysis assumes that approximately 68 percent of homes in Blacksburg currently have electric water heaters, while 32 percent have systems that run on natural gas, and this basic breakdown of primary fuel sources will remain constant. The per-day hot water demand estimates for renter-occupied and attached units are adjusted to match their respective estimated annual total water heating energy demand (Table 4-1).

Table 4-4. Three Scenarios for Domestic Water Heating in Single-Family Homes (2050)

Type of Water Heater	Energy Factor*	Original Distribution (2011)	2050 Baseline	Distribution of Heating Technologies		
				Scenario 1 Conservative	Scenario 2 Substantial	Scenario 3 On-Target
Electric Water Heaters						
Conventional	0.9	58%	5%	2%	2%	1%
Conventional w/ insulating blanket	1.0	8%	31%	17%	6%	1%
Instantaneous demand	1.0	2%	2%	2%	2%	0%
Heat pump-style	2.0	0%	23%	30%	36%	15%
Solar w/ electric back-up (insulated)	0.9	0%	4%	15%	20%	47%
Solar w/ electric back-up (high eff.)	0.95	0%	2%	2%	2%	4%
Natural Gas Water Heaters						
Conventional	0.57	27%	4%	2%	2%	1%
Conventional / insulating blanket	0.6	4%	19%	16%	10%	1%
Instantaneous demand	0.7	1%	4%	2%	2%	0%
Instantaneous high efficiency	0.84	0%	0%	0%	0%	0%
Solar w/ natural gas back-up (insulated)	0.57	0%	2%	10%	16%	27%

Solar w/ natural gas back-up (high eff.)	0.57	0%	2%	2%	2%	3%

Source (energy factors only): Randolph, J., and Masters, G. 2008. Energy for Sustainability: Technology, Planning, Policy. Washington, DC: Island Press.

** Energy Factor is the ratio of useful energy output from a water heater to the total amount of energy delivered to the water heater. A higher EF indicates that the system is more energy-efficient.*

Figure 4-3 compares the projected energy consumption for water heating in single-family homes under each of the three scenarios to the baseline estimate. All the projections are for 2050, but refer only to water heating in the 5,885 single-family homes in Blacksburg as of 2011 (i.e, the projections do not account for population growth and the resulting increase in total housing units). They also assume that the base water demand remains 56 gallons per day for single-family homes, although that demand could be reduced through water conservation.

Figure 4-3. Projected Water Heating Energy Demand by 2050 from Existing Single-Family Homes (million Btu)

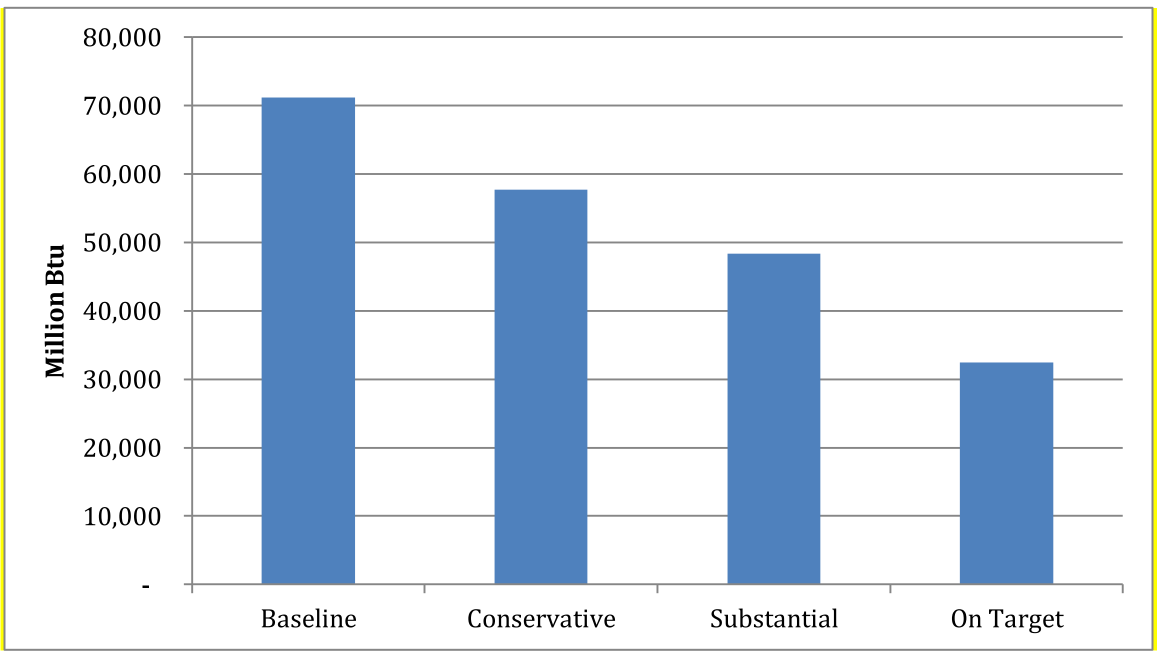
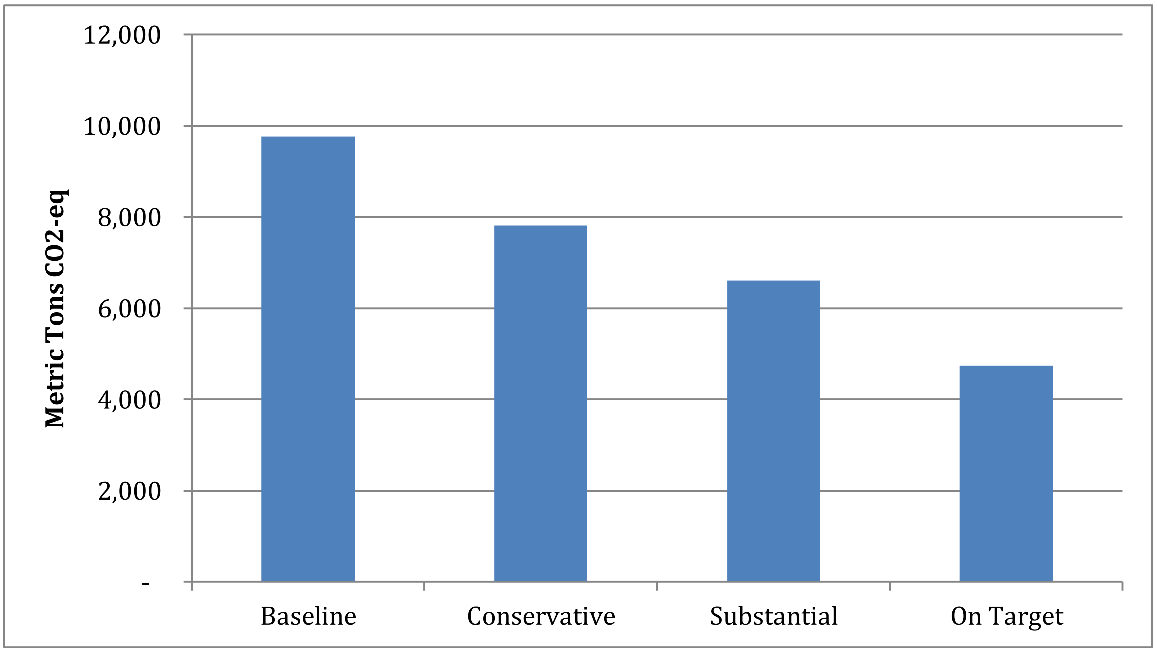


Figure 4-3 shows that the 2050 baseline water heating energy consumption in existing SFH's is estimated at just over 70,000 million Btu, which works out to an average of 12.8 million Btu per single-family home. The savings under the three scenarios represent a 1.4 percent reduction in total projected 2050 residential energy use in the conservative scenario, 2.4 percent in the substantial scenario, and 4.1 percent in the on-target scenario.

Figure 4-4 shows the GHG emissions reductions that result from the three water heating scenarios, compared to the baseline.

Figure 4-4. Projected Water Heating GHG Emissions by 2050 from Existing Single-Family Homes (metric tons CO_2-e)



The percentage savings in GHG emissions are nearly identical to those projected for water heating energy consumption. Total GHG emissions from water heating would drop from 9,763 tons CO_2-e in the baseline scenario to as low as 4,740 tons in the on-target efficiency scenario. This on-target scenario represents a 3.3 percent reduction in total projected 2050 residential sector GHG emissions, versus 1.3 percent and 2.1 percent respectively in the conservative and substantial scenarios.

Table 4.-5 summarizes the costs and anticipated payback periods for investments in different types of water heating technologies. The results demonstrate that a simple insulating blanket, which can reduce water-heating energy demand by 5 percent, can save the same amount of energy as a high-efficiency water tank or an on-demand system, at a fraction of the cost. Heat pump-style electric water heaters achieve much higher energy savings than high-efficiency water tanks or on-demand systems, and while the initial cost of the heat pump-style systems is two to three times greater than those other systems, their simple payback periods are much shorter. Solar water heater systems have the highest initial costs and the greatest energy and GHG savings. Their payback periods and costs per ton of GHG emissions saved are comparable to those of an on-demand system when they are installed with a high-efficiency electric back-up system.

Table 4-5. Analysis of Per-Unit Energy and Cost Savings for Water Heating Technologies

Water Heater Type	Energy Demand	Energy savings (mmBtu)	GHG savings (mt CO_2-e)	Cost per Unit ($)	Simple Payback Period (years)
Electric Water Heaters (Base Energy Consumption = 14.1 MBtu/ unit; cost = $29.30/MBtu)					
Conventional w/ insulating blanket	13.4	0.7	0.16	$27	1.2
Instantaneous demand	12.7	1.4	0.30	$600	14.5
Heat pump	6.4	7.8	1.66	$1,200	5.3
Solar w/ insulated back-up	4.2	9.9	2.11	$7,500	25.8
Solar with high-efficiency back-up	4.0	10.1	2.16	$8,000	27.0
Natural Gas Water Heaters (Base Energy Consumption = 22.3 MBtu/ unit; cost = $14.00 / MBtu)					
Conventional w/ insulating blanket	21.2	1.1	0.06	$27	0.8
Instantaneous demand	18.2	4.1	0.22	$650	5.3
High-efficiency instant demand	15.2	7.2	0.38	$1,200	5.7
Solar w/ insulated back-up	6.7	15.6	0.83	$7,500	16.4
Solar with high-efficiency back-up	6.2	16.2	0.86	$8,000	16.9

Source (base energy demands): Randolph, J., and Masters, G. 2008. Energy for Sustainability: Technology, Planning, Policy. Washington, DC: Island Press.

Table 4-5 also shows that natural gas systems, in general, have greater energy demand than electric water heaters, but lower resulting GHG emission savings because natural gas consumption releases fewer GHGs per Btu than electricity consumption. The simple payback periods are also shorter, as the cost of natural gas per Btu is currently lower than that of electricity.

4.2.3. Appliances and Lighting

Among sources of energy consumption, appliances and lighting together are second only to space heating in terms of the percent of average residential energy consumption. In Blacksburg, the current estimated average energy demand from these two end uses (including refrigerators) in single-family homes is 34.6 million Btu per year, or close to 35 percent of the per-unit total (Table 4-1).

By upgrading household appliances to more efficient units, such as those rated as Energy Star-certified by the U.S. Department of Energy, energy use and fuel bills can be dramatically reduced (Table 4-6).

Table 4-6. Comparison of Appliance Energy Use Standards for Average Home

Appliances	Assumptions	1990 Standard (kWh/yr)	Present Standard (kWh/yr)	Energy Star Standard (kWh/yr)	Most Efficient (kWh/yr)
Refrigerator	20 ft^3	900	501	410	230
Microwave Oven*	1 ft^3	120	132	132	132
Conventional Oven*	30"	1118	822	822	822
Indoor Lights	40 bulbs	2,628	900	789	395
Outdoor Lights	15 bulbs	3,696	972	885	444
Stereo		132	46	25	25
Color Television		456	200	171	171
Computer		216	100	79	79
Dish Washer	Standard	620	576	262	157
Clothes Washer	3 ft^3	890	600	168	100
Clothes Dryer*		939	939	939	939
Totals		11,715	5,788	4,682	3,494

** Note: Energy Star does not rate clothes dryers, microwaves, or conventional ovens, as currently there is little difference in energy consumption among the various models available on the market.*

Table 4-7 shows three scenarios for reducing the baseline appliance energy consumption by the year 2050 for existing SFHs. To meet baseline energy demand projections, 65% of homes will have to at least meet the present standard for appliances by the year 2050, a very conservative assumption given the lifespan of most new appliances does not exceed 15 years. The conservative scenario assumes appliance energy consumption if 50 percent of the homes have current standard appliances and 50 percent have appliances meeting current Energy Star standards. The substantial scenario assumes 50 percent of homes meet current Energy Star standards and 50 percent employ the most efficient technologies currently available. The final, on-target efficiency scenario assumes a 25 percent reduction beyond the substantial scenario.

Table 4-7. Per-Unit Appliance Energy Use SFH for Baseline and Upgrade Scenarios

Energy Use Indicators	Unit	2050 Baseline	Conservative	Substantial	On-target
Energy use	Million Btu/yr	26.8	17.9	13.9	10.5
Energy use	Kilowatt-Hrs/yr	7,862	5,235	4,088	3,066
Energy cost*	$ / year	$943	$628	$491	$368
Energy use Reduction	Percentage Saved	---	33%	48%	61%

rate of $0.12/kWh

Table 4-7 shows that the conservative scenario would reduce average per-unit appliance energy use by one third (33 percent); appliance energy use would be reduced by 48 percent in the substantial scenario and 61 percent in the on-target scenario. Under each appliance efficiency scenario, the potential for reduced household energy expenditures can be estimated. For instance, a comparison of the baseline and on-target scenarios indicate that the average household could expect spend less than half (39%) on appliance-related energy costs - from $943/yr in the baseline scenario to as low as $368/yr in the on-target scenario, assuming a constant energy cost of $.12/kWh. The potential for savings becomes even more significant if utility rates continue to rise.

Figure 4-5 compares the projected appliance energy use in all single-family homes by 2050 under these scenarios.

Figure 4-5. Projected Appliance Energy Use by 2050 from Existing SFH's

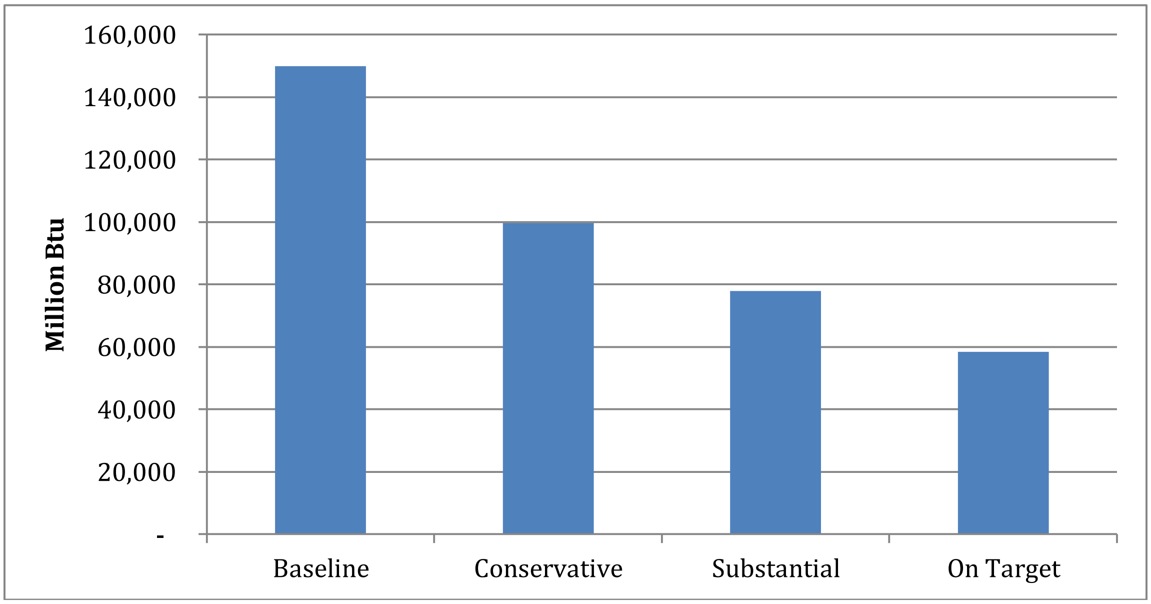
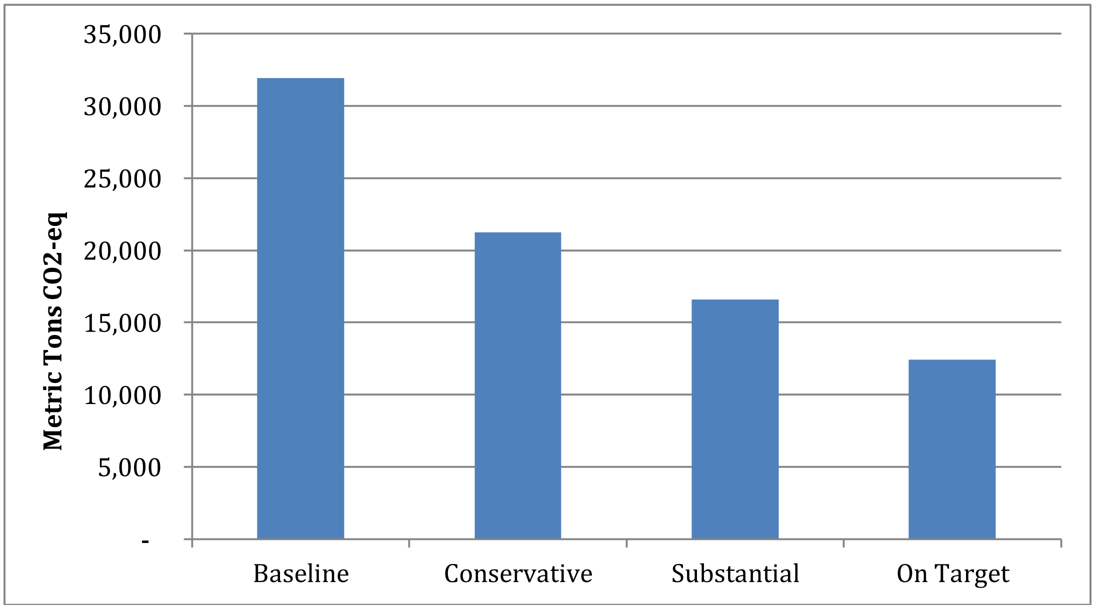


Figure 4-5 highlights the drop in community-wide l appliance energy consumption, from 150,000 million Btu in the baseline scenario to just under 60,000 million Btu under the on-target. The savings from the three scenarios would reduce total projected residential energy demand in 2050 by 5.3 percent, 7.5 percent, and 9.6 percent respectively. Figure 4-6 illustrates potential GHG emissions savings from appliance upgrades.

Figure 4-6. Projected Appliance GHG Emissions by 2050 from Existing SFH's



GHG emissions are expected to decline by roughly the proportions as energy use. For the 2050 baseline, community-wide emissions due to appliances in single-family homes are estimated to be about 32,000 metric tons CO_2-e. These emissions could be reduced to about 12,500 metric tons CO_2-e in the on-target scenario. This would translate to a 12.1 percent drop in total projected 2050 GHG emissions for the residential sector, while the conservative and substantial scenarios would reduce projected residential GHG emissions by 6.6 percent and 9.5 percent respectively.

4.3. Potential Energy and GHG Savings from Existing Multi-Family Units

4.3.1. Building Energy Efficiency Retrofits

Blacksburg has a relatively high proportion of condos and apartment buildings, which are grouped into one category: multi-family homes or MFHs.In Blacksburg, MFHs make up 57 percent of residential units, compared to a national average of 25 percent. Notably, the estimated current perunit annual energy use of a MFH (46.4 mmBtu/year) is much lower than that of a single family house (SFH), (97.7 mmBtu/year); therefore MFHs are estimated to account for 39 percent of Blacksburg's overall residential energy use. This analysis assumes that the building efficiency scenarios described in the SFH analysis will result in similar reductions, on a percentage basis, in demand for space heating and air conditioning in MFHs.

Figure 4-7 summarizes the impact on projected thermal conditioning energy demand if existing MFHs were retrofitted.

Figure 4-7. Projected Existing MFH Energy Demand from Thermal Conditioning (2050)

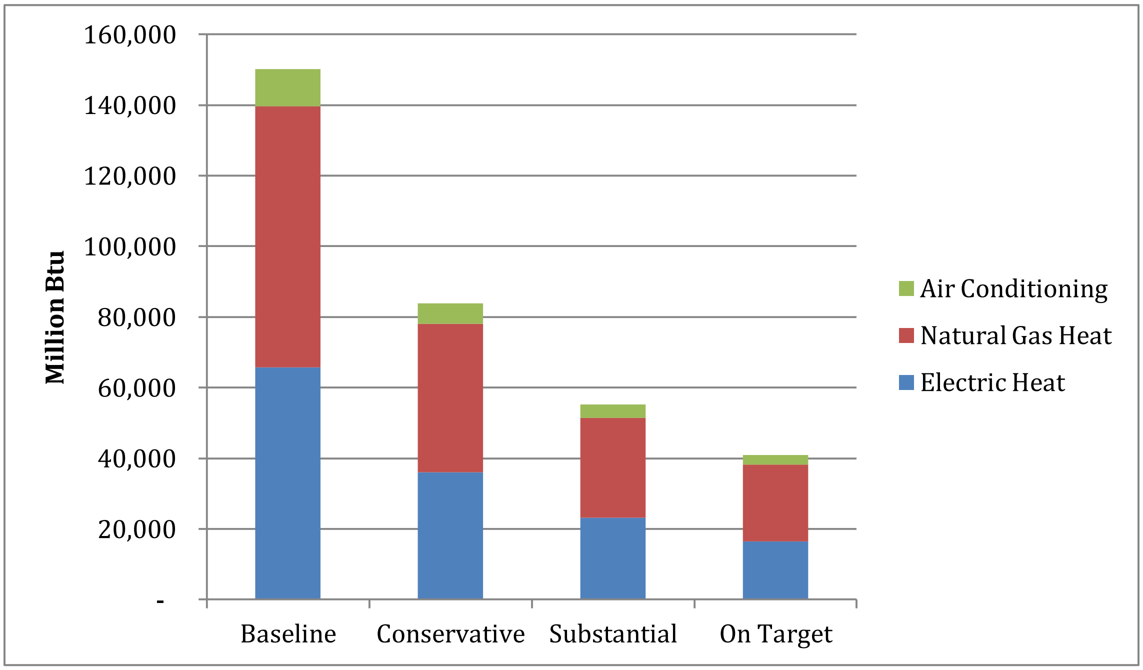


Figure 4-7 shows thermal conditioning energy demand would drop dramatically under all three scenarios. As with the SFH analysis, natural gas represents a slightly larger share of the energy consumption than electricity in all scenarios. The relative shares of GHG emissions, however, are skewed heavily towards electricity consumption, for the reasons discussed in the single-family retrofits section. The effects of the three scenarios on GHG emissions from thermal conditioning energy consumption are shown in Figure 4-8.

Figure 4-8. Projected Existing MFH GHG Emissions from Thermal Conditioning (2050)

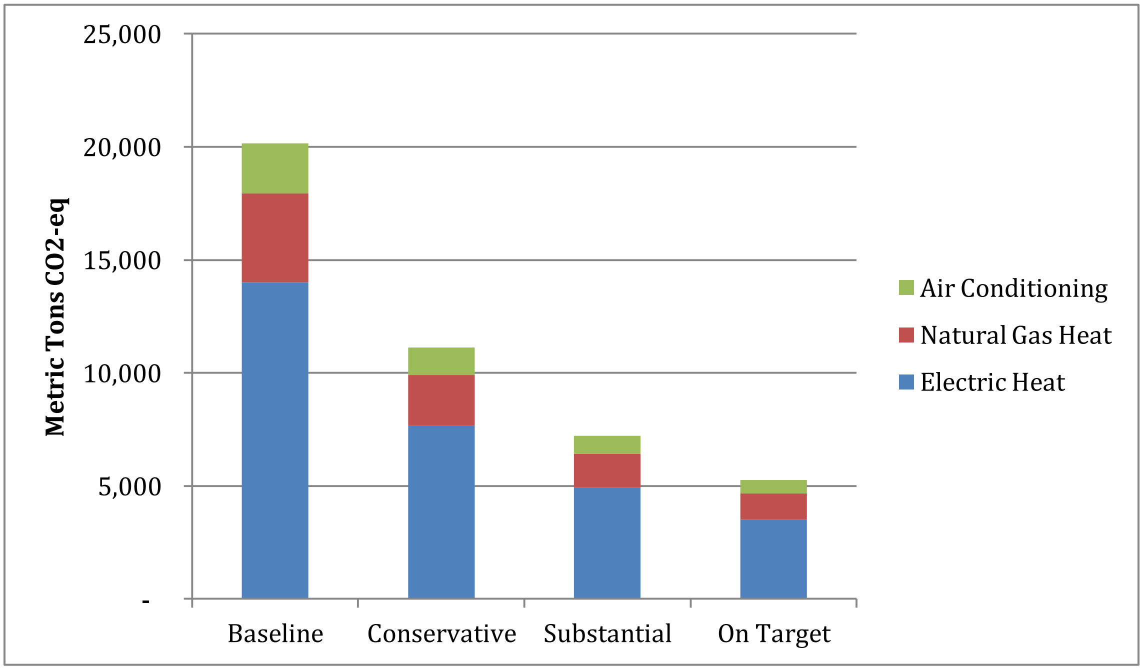


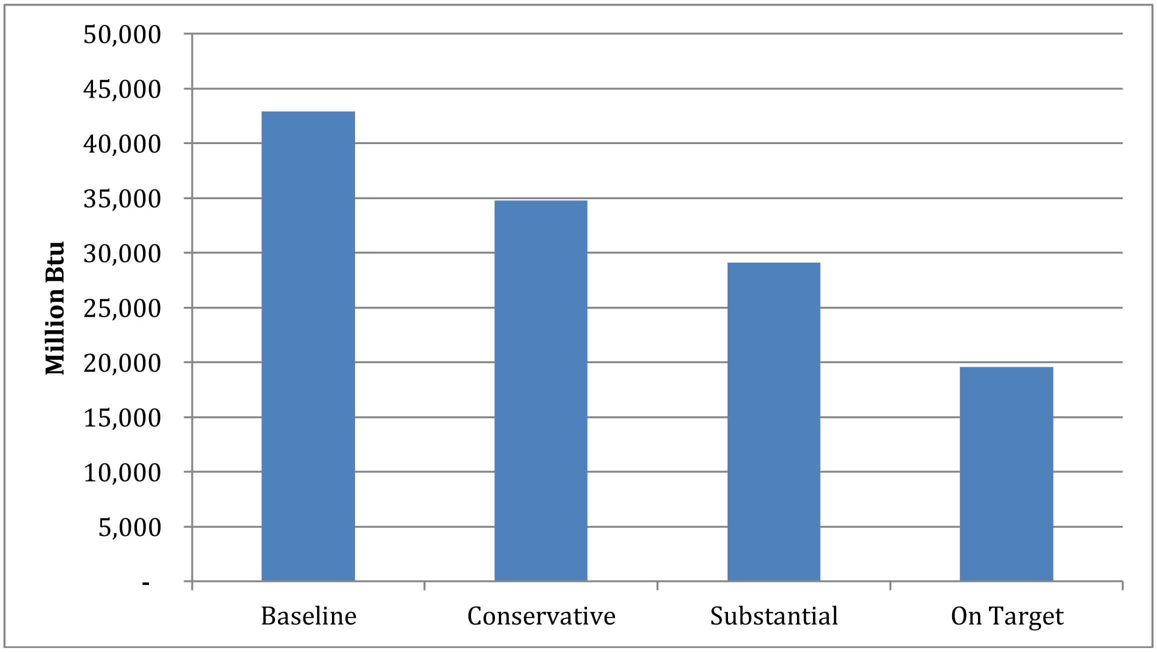
Figure 4-8 shows retrofits to MFHs would reduce their heating and cooling GHG emissions by 45 percent in the conservative scenario, 64 percent in the substantial scenario, and 74 percent in the on-target scenario.

Although the projected savings potential from widespread MFH efficiency retrofits could be substantial, it should be noted that the vast majority of multi-family units in Blacksburg are renter-occupied (97%). This ownership structure presents particular financial obstacles to adoption of efficiency upgrades. Meaningful progress to improve the efficiency of rental properties, especially existing buildings, will require strategies to address these challenges.

4.3.2. Water Heating

As discussed in the analysis of single-family homes (SFHs), upgrading to more energy-efficient water heaters in apartments offers another way to significantly reduce energy consumption and GHG emissions. The assumptions from the SFH analysis of the current distribution of water heating system types and the three potential future scenarios (Table 4-5) are applied here to evaluate potential energy and GHG savings from water heating in MFHs. Figure 4-9 compares the energy savings afforded by each scenario to the 2050 baseline water heating energy demand for MFHs, estimated at 43,000 million Btu.

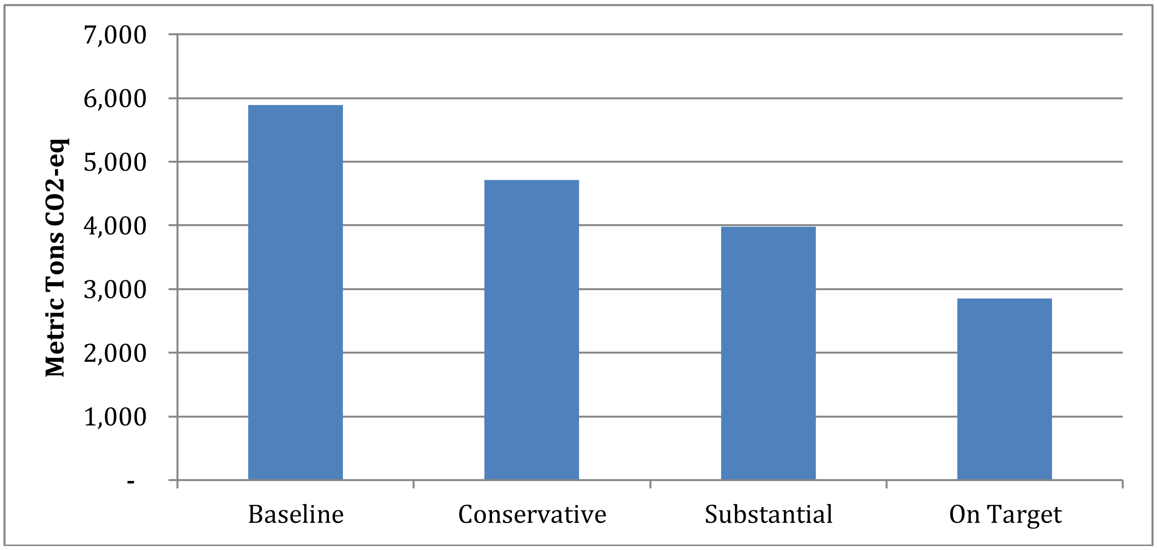
Figure 4-9. Projected Water Heating Demand by 2050 from Existing Multi-Family Homes



The most conservative scenario would reduce average water-heating related energy per-unit consumption for renter-occupied MFHs by 19 percent. Water heating energy demand would drop by 32 percent in the substantial scenario and by 54 percent, in the on-target scenario. The savings from these scenarios would reduce projected 2050 energy consumption in the residential sector by 0.9 percent, 1.4 percent, and 2.5 percent respectively if applied to all existing MFHs in Blacksburg.

Figure 4-10 shows potential reductions in MFH water heating GHG emissions. The baseline of 8,059 metric tons CO_2-e represents the projected 2050 community-wide emissions from MFH water heating.

Figure 4-10. Projected Water Heating GHG Emissions by 2050 from Existing Multi-Family Homes



GHG emissions from water heating in MFHs can be reduced by as much as 3,000 metric tons CO_2-e under the on-target scenario; 52 percent of baseline emissions. The emissions reductions could add up to as much as 1.9 percent of total residential GHG emissions in the on-target scenario.

Payback periods were calculated for water heater upgrades in MFHs, assuming the same size and cost of the average system, but with lower annual hot water demand. The only exception to these assumptions are solar water heater costs, which are shown at half that of a SFH unit since a solar water heater sized for a single-family home can typically support two apartment units. The results (Table 4-8) show payback periods for MFHs are approximately double those for SFHs because apartments use about half as much hot water per-unit on an annual basis.

Table 4-8. Analysis of Water Heating Technologies Per-Unit for Multi-Family Buildings

Water Heater Type	Base Energy Demand	Energy savings (MBtu)	GHG savings (tons CO_2.e)	Cost per Unit ($)	Simple Payback Period (years)
Electric Water Heaters (Base Energy Consumption = 6.4 millionBtu/ unit; cost = $29.30 / Mbtu)					
Conventional w/ insulating blanket	6.1	0.3	0.07	$27	2.7
Instantaneous demand	5.8	0.6	0.14	$600	31.8
Heat pump	2.9	3.5	0.75	$1,200	11.6
Solar w/ insulated back-up	1.9	4.5	0.96	$3,750	28.4
Solar with high-efficiency back-up	1.8	4.6	0.98	$4,000	29.6
Natural Gas Water Heaters (Base Energy Consumption = 10.2 MBtu/ unit; cost = $14.00 / Mbtu)					
Conventional w/ insulating blanket	9.7	0.5	0.03	$27	1.8

Instantaneous demand	8.3	1.9	0.10	$650	11.8
High-efficiency instant demand	6.9	3.3	0.17	$1,200	12.5
Solar w/ insulated back-up	3.0	7.1	0.38	$3,750	18.0
Solar with high-efficiency back-up	2.8	7.4	0.39	$4,000	18.5

4.3.3. Appliances and Lighting

Appliance upgrades in multi-family housing units represent another opportunity to significantly reduce energy use. This analysis assumes Blacksburg MFHs currently have the same distribution of older, standard, and high-efficiency appliances as estimated for SHFs, and that the same potential savings percentages will be realized with upgraded energy-efficient appliances. Current energy demand due to appliances in MFHs is estimated to be 103,940 million Btu, 30 percent of total MFH energy consumption and approximately 12 percent of energy use for the residential sector.

Table 4-9 shows the potential energy use and fuel bill savings from upgrading appliances in MFHs.

Table 4-9. Appliance Energy Use Per-Unit for Baseline MFH and Upgrade Scenarios

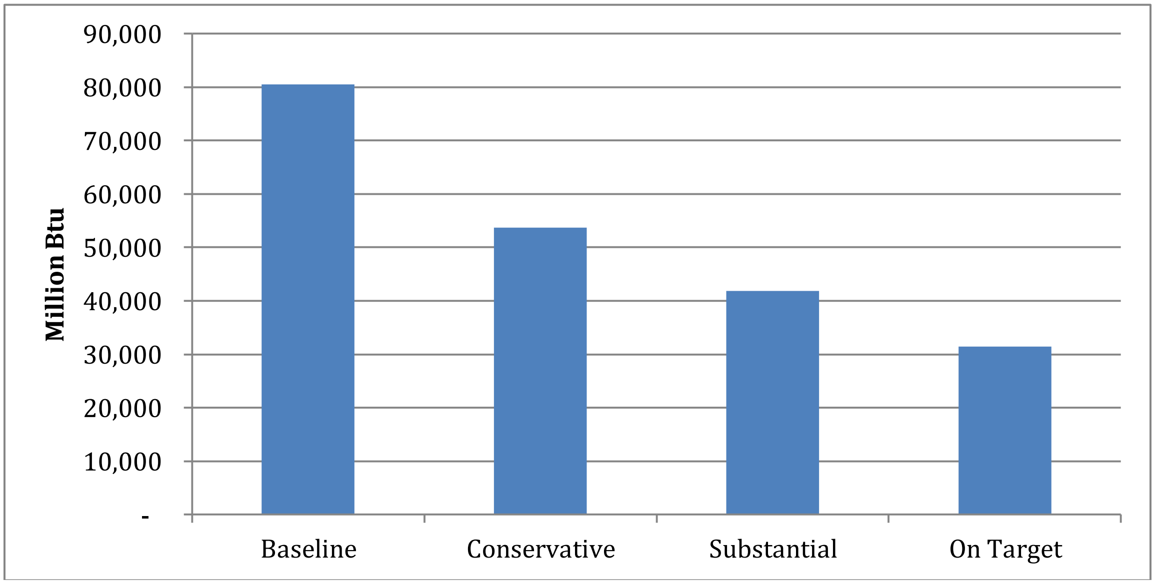
Energy Use Indicators	Unit	Baseline	Conservative	Substantial	On-target
Energy Use	Million Btu/yr	10.9	7.3	5.7	4.2
Energy Use	kWh/yr	3,193	2,126	1,660	1,245
Fuel Bill*	$ / year	$383	$255	$199	$149
Energy Use Reduction	% saved	---	33%	48%	61%

**rate of $0.12/kWh*

As shown in Table 4-9, the per-unit appliance energy demand for MFHs can be significantly reduced. Energy consumption falls from 10.9 million Btu/yr to 7.3 million Btu/yr under the conservative scenario, and is reduced to as little as 4.2 million Btu/yr under the on-target scenario. The resulting effect on energy bills is dramatic, potentially saving occupants as much as $220 per year.

Figure 4-11 depicts the reductions in total appliance energy demand for MFHs in Blacksburg from the three scenarios compared to current baseline consumption.

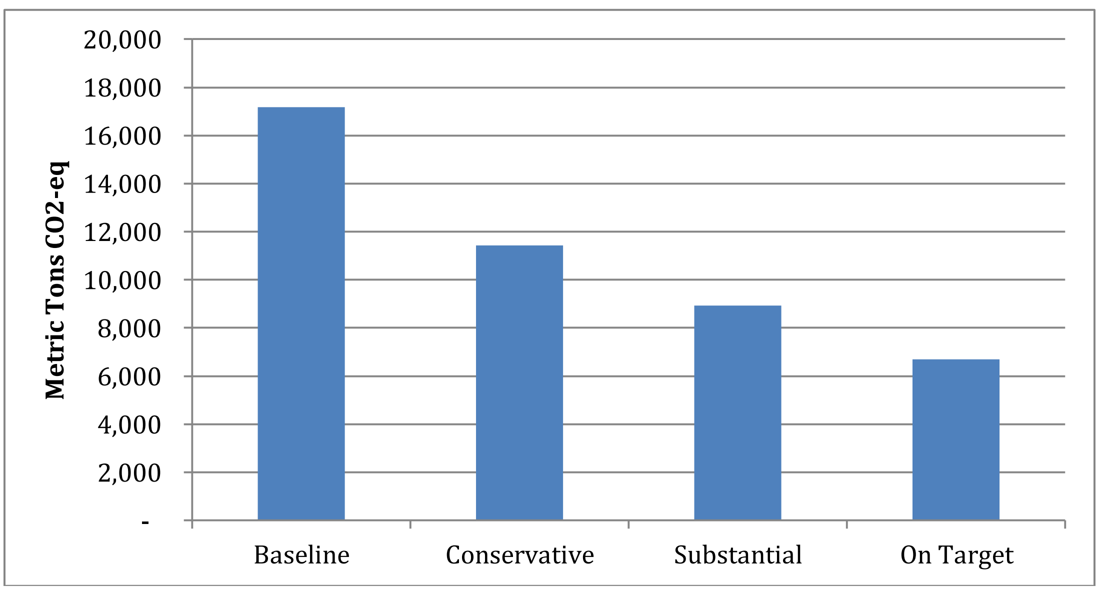
Figure 4-11. Projected Appliance Energy Use by 2050 in Existing Multi-Family Buildings



In the conservative scenario, appliance energy-use drops from over 80,000 million Btu to about 54,000 million Btu. The reductions in appliance demand across the three scenarios shown above would translate to 2.8 percent, 4.1 percent, or up to 5.2 percent of total projected 2050 residential energy demand.

Figure 4-12 shows potential GHG emissions savings from updating appliances in MFHs.

Figure 4-12. Projected Appliance GHG Emissions by 2050 from Existing Multi-Family Buildings



Projected 2050 baseline GHG emissions from MFH appliance energy use are estimated at 17,164 metric tons CO_2-e. The conservative, substantial, and on-target scenarios would reduce total projected 2050 GHG emissions for the residential sector by 3.6 percent, 5.1 percent, and 6.5 percent respectively.

4.4. Potential Energy and GHG Savings from New Residential Buildings

According to projections from the Weldon Cooper Institute, Blacksburg's population is expected to grow by 0.85% a year over the next 30 years. Assuming that this trend continues until 2050, and applying the same growth rate to Blacksburg's housing units gives us the total housing unit projections in Table 4-11. Subtracting the number of current housing units from the projected totals for each year gives us the number of new housing units built by that year, also displayed in Table 4-11.

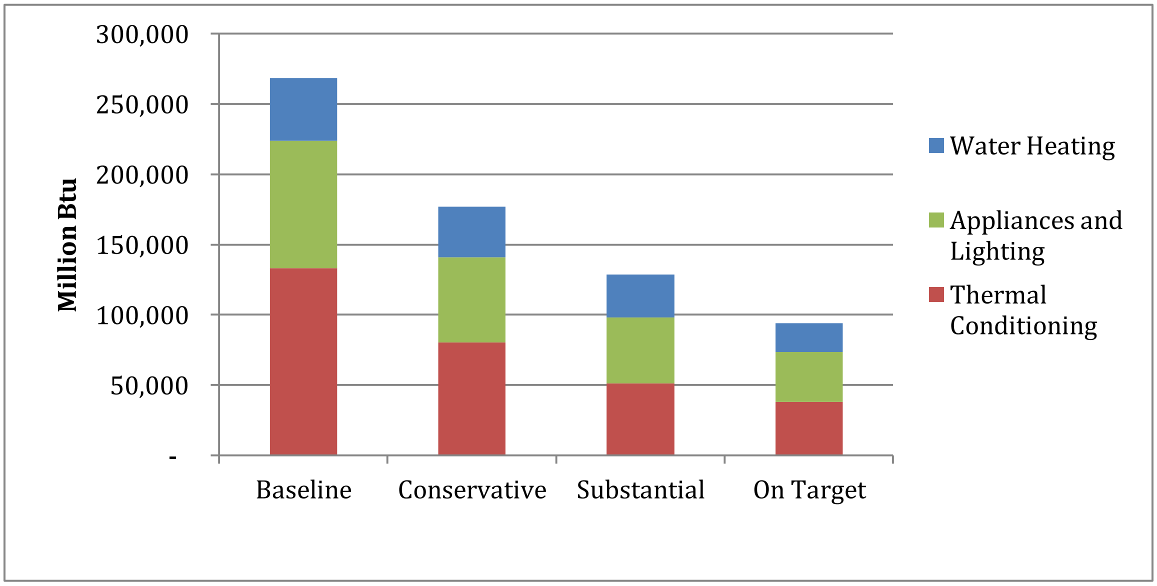
Table 4-11. Projected Blacksburg Housing Units

Housing Unit Type	2011	2020	2030	2040	2050
Total Housing Units	**12,982**	**14,205**	**15,422**	**16,640**	**18,072**
Single-Family	5,585	6,111	6,635	7,159	7,775
Multi-Family	*7,397*	8,094	8,787	9,481	10,297
New Housing Units		**1,223**	**2,440**	**3,658**	**5,090**
Single-Family		526	1,050	1,574	2,190
Multi-Family		697	1,390	2,084	2,900

If these new homes operate at the same efficiency currently estimated for existing homes, they will add approximately 270,000 million Btu of energy consumption and 45,000 metric tons of GHG emissions in 2050, about 28 percent of residential energy use and emissions at that time.

However, this future energy consumption and GHG emission production can be decreased dramatically if new residential development embraces energy-efficient construction practices and uses efficient water heaters and other appliances. To estimate these potential savings, the same scenarios described above for existing homes are applied to the anticipated new residential units. It also assumes the ratio of SFH to MFH units in the new construction will match that of currently existing units. Figure 4-13 compares the projected future energy consumption in new residential units (those built between 2012 and 2050) after applying the three scenarios for thermal conditioning, water heating, and appliances / lighting.

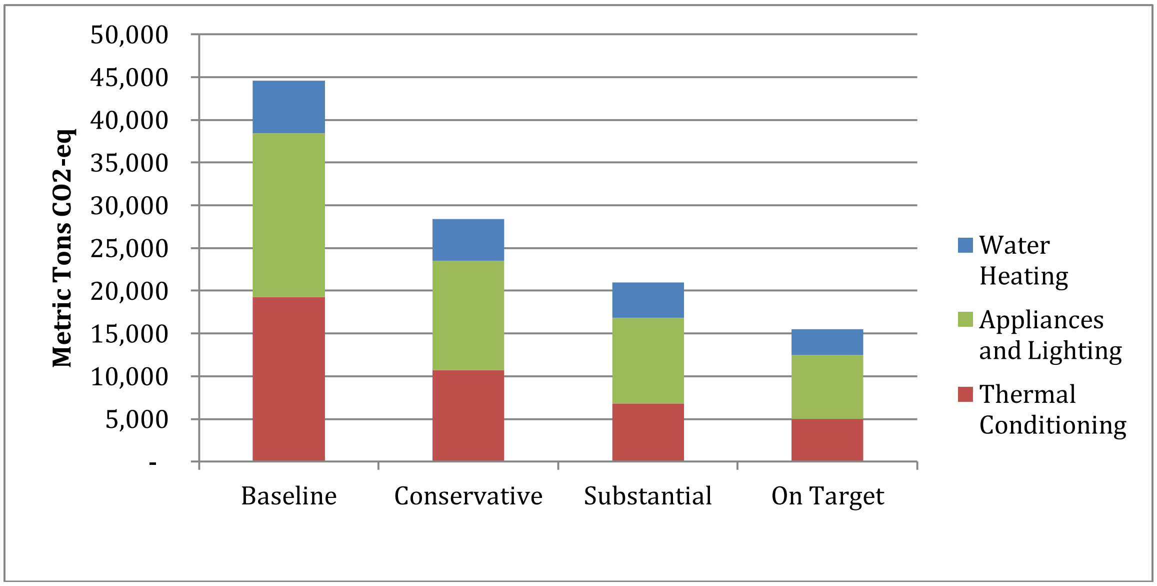
Figure 4-13. Energy Consumption in 2050 From Residential Units built 2012-2050



Thermal conditioning requires the most energy consumption in new residential units under all scenarios, followed by appliances and lighting. Figure 4-15 demonstrates the GHG emissions that would result from the three scenarios, compared to the baseline. These calculations assume the fuel distribution used for space heating and water heating in new homes will match that assumed for existing homes (68 percent electricity and 32 percent natural gas).

Figure 4-14 shows that while each scenario's relative reduction from the baseline is similar for both energy use (Figure 4-13) and GHG emissions, the share of total emissions among the different residential end uses varies from their respective shares of energy use. Most notably, appliances and lighting are responsible for a relatively greater share of GHG emissions than energy consumption, because they run entirely on electricity, which produces more GHG emissions per Btu of delivered energy than natural gas.

Figure 4-14. Greenhouse Gas Emissions in 2050 From Residential Units projected to be built 2012-2050



4.5. Potential Energy and GHG Savings from Solar PV on Existing and New Residential Buildings

Using renewable energy sources, particularly solar PV, to offset some of the energy consumption that would otherwise come from natural gas can also reduce residential GHG emissions. Installing solar PV systems on south-facing roof space could produce enough electricity to offset approximately 14 percent of Blacksburg's projected energy consumption in 2050. Existing residential roof space in Blacksburg is approximately 1.5 million m^2. Assuming that about 25 percent of that roof space faces south, about 375,000 m^2 of roof space is theoretically available for PV systems. This total south facing area is anticipated to grow to over 500,000 m^2 by 2050, which could support up to 64 MW of PV. This would produce about 37.8 million kWh of electricity, or 128,700 Million Btu. Table 4-12 describes three scenarios in which solar PV systems would be installed on a given percentage of available residential roof space per year.

Table 4-12. Installed Solar PV, Capacities, and Savings According to Level of Application

	Percentage of Available Roof Space (by 2050)	Area of Installed PV (m^2)	Installed Capacity (MW)	Electricity Generated (million kWh/yr)	Energy Saved (mmBtu/yr)	CO_2-e Emissions Reductions (mt/yr)
Conservative	10%	52,203	6.39	11.64	39,615	8,438
Substantial	20%	104,407	12.79	23.28	79,230	16,876
On-target	32%	169,593	20.77	37.81	128,697	27,412

In the most conservative scenario solar PV systems will be installed on 0.3 percent of available roof space each year from 2014 through 2050. At that rate solar panels would be installed on 10 percent of available roof space by 2050 (approximately 52,000 m^2), yielding 6.4 MW of installed capacity. Given the local insolation of 4.8 kWh/m^2 per day, 11.6 million kWh would be generated per year saving 40,000 million Btu in energy and reducing emissions by 8,400 metric tons CO_2–e. A more substantial approach would add solar PV to 0.5 percent of the available roof space annually. This would result in 20 percent of the available roof space being covered in 2050, or just under 105,000 m^2, yielding 12.8 MW of installed PV capacity. In the ”On Target” scenario, PV would be installed on 0.9 percent of available space each year, thus covering 32 percent of available residential roof space by 2050 and providing 20.8 MW of installed capacity. This scenario would generate approximately 37.8 million kWh of electricity, saving 128,700 million Btu of energy that would otherwise come from the electric grid and thus reducing projected 2050 residential energy consumption by almost 14 percent. The total solar electricity production shown in the on-target scenario would save 27,400 metric tons CO_2-e in 2050, a 17 percent reduction of the projected residential total and a 6.3 percent reduction of the projected community-wide total.

4.6. Combined Residential Sector Energy and GHG Savings

Figures 4-15, 4-16 and 4-17 demonstrate the combined reductions in projected emissions of the conservative, substantial, and on-target scenarios in relation to the target of 80 percent below 1990 levels by 2050. In this “wedge analysis” the colored wedges represent the potential savings by reducing energy consumption from space heating, air conditioning, etc., or by installing solar PV systems on residential buildings in Blacksburg. The green bar at the bottom of the chart represents the 2050 goal of 27,656 metric tons CO2-eq. The unshaded area between the wedges and the goal bar shows the left over emissions that are not accounted for. Figure 4-16 demonstrates the conservative scenarios.

Figure 4-15. Combined GHG Emissions Savings from Conservative Scenarios

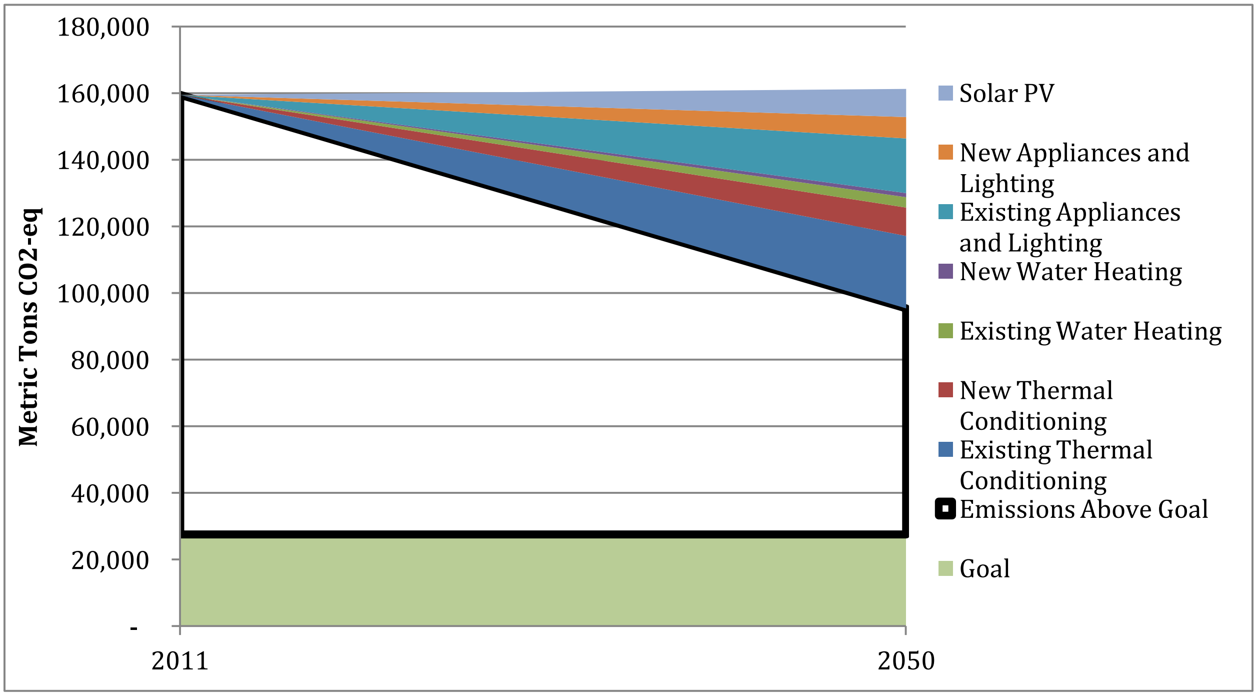
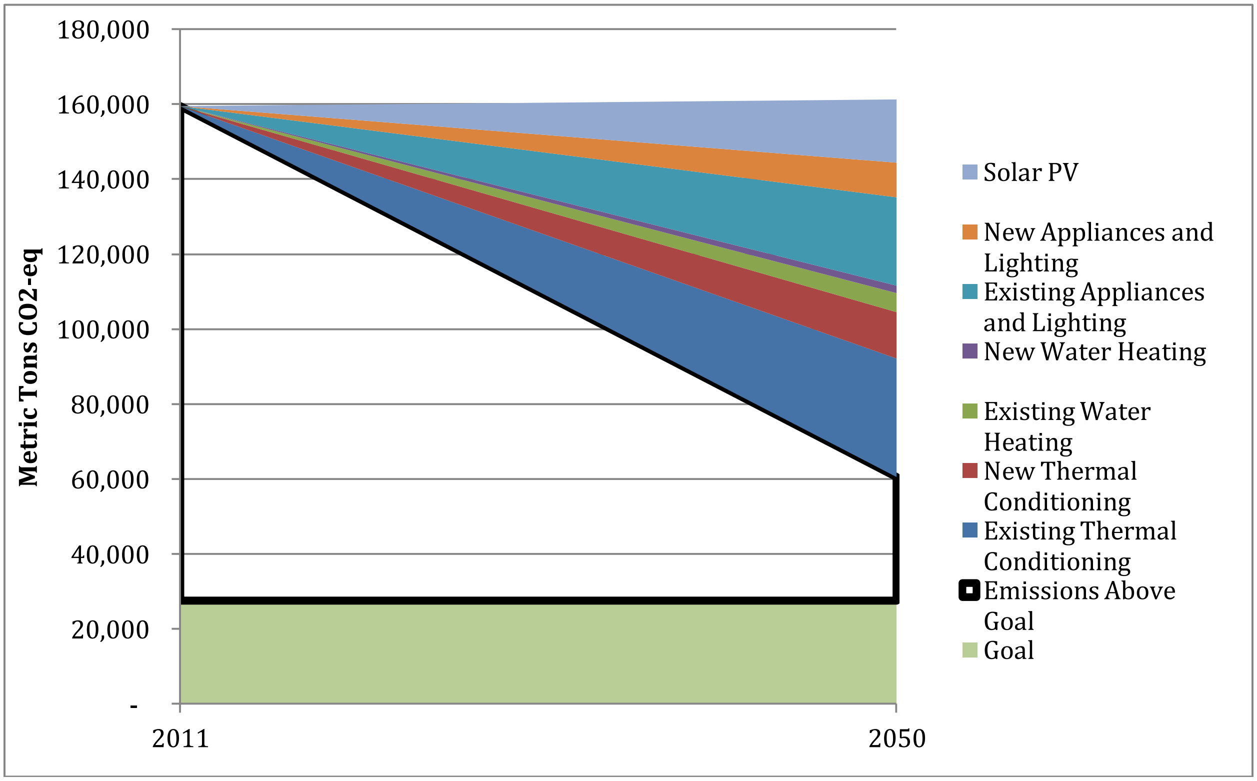


Figure 4-15 shows the combined effect of the conservative scenarios would mitigate more than half the projected emissions by 2050. However, approximately 92,500 metric tons CO_2-e would still be emitted, more than three times the 2050 target.

More significant GHG reductions would be achieved under the substantial scenario, shown in Figure 4-16.

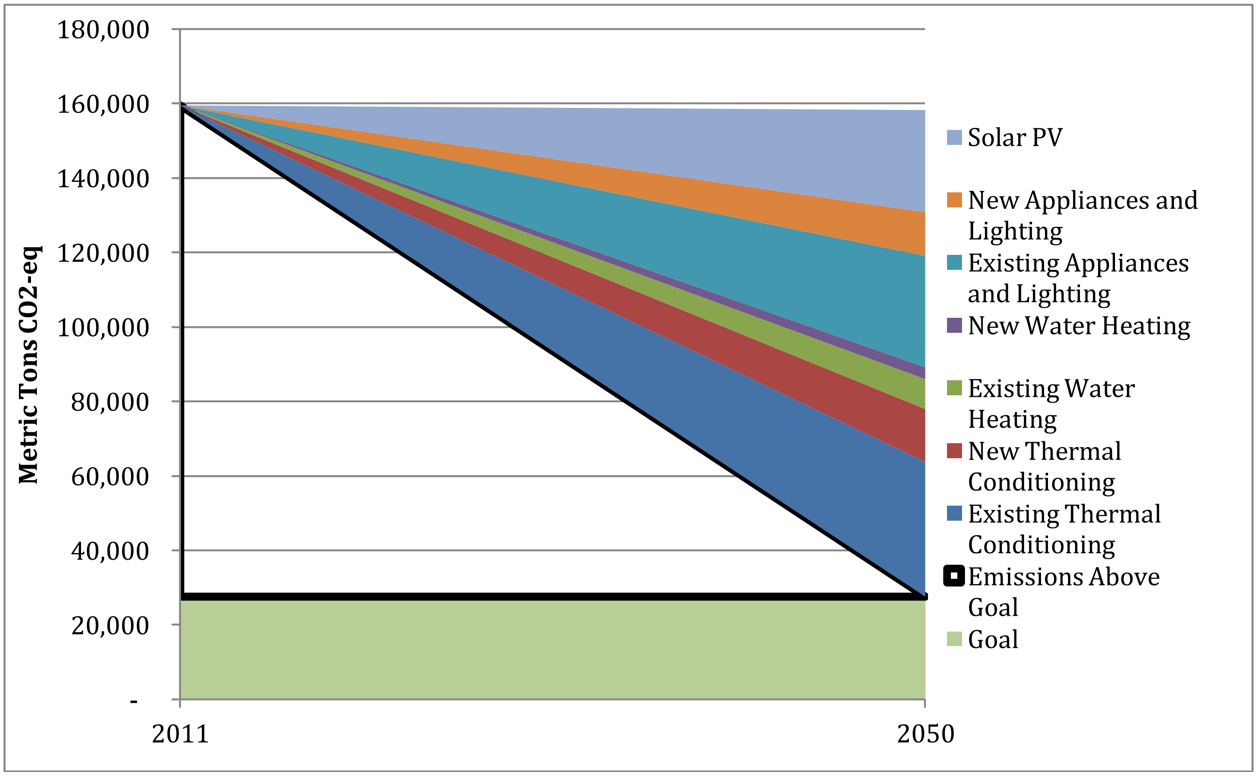
Figure 4-16. Combined GHG Emissions Savings from Substantial Scenarios



In the substantial scenario, GHG emissions by the year 2050 would be just below 60,000 metric tons CO2-eq, about one third of the baseline total, but the target would still not be met. A further reduction of 30,000 metric tons would be necessary to meet the goal.

Figure 4-17 demonstrates the on-target scenarios, in which all of the necessary steps are taken to meet the emissions goal set for 2050.

Figure 4-17. Combined GHG Emissions Savings from On Target Scenarios



4.7. Goals, Objectives, and Strategies: Residential Energy Efficiency

The recommended goals, objectives and strategies to reduce energy use in Blacksburg's residential sector have been broken into five major goals, followed by specific objectives and strategies to meet these goals.

Goal #1: Establish programs and incentives to reduce greenhouse gas emissions from single-family homes by 66% by 2050

Objective 1-A. Reduce greenhouse gas emissions from existing single-family homes by 66% by 2050.

Community Strategies

Strategy 1: Establish a community "branding" program for energy-efficient single-family homes.

a. Develop detailed efficiency standards, based on the federal Energy Star program.

b. Develop how-to guidelines for residents to achieve the certification.

c. Create separate requirements/labels/certifications for renter-occupied and owner-occupied homes.

d. Provide signage for homes and apartment buildings that achieve the local standard.

e. Partner with realtors and property managers to promote the program.

Strategy 2: Require an energy assessment as part of the home sales process.

a. Adopt a standard rating system for assessments.

b. Require that homes be labeled with an energy rating before selling.

Strategy 3: Develop a community loan program for home energy monitors and other tools or devices that residents can use to track their energy use.

Strategy 4: Incorporate energy efficiency improvements into the capital budgets of homeowners associations.

Strategy 5: Increase energy assessments of single-family homes – including blower door evaluations and infrared camera testing – to test the efficiency of building envelopes.

Strategy 6: Use energy assessments as guides for efficiency retrofits.

Strategy 7: Improve building envelope performance by continuing to identify, insulate and weather-seal homes that fall short of optimum insulation and infiltration levels.

Strategy 8: Provide residents with discounted low-flow shower heads, water heaters, etc. through a collaboration of homeowners associations and wholesalers/home supply outlets.

<u>Government Strategies</u>

Strategy 1: Develop programs to raise money to fund residential energy efficiency incentive programs.

a. Develop a voluntary surcharge on energy, in cooperation with AEP and VT Electric that would mimic AEP's voluntary green pricing option.

b. Set aside a portion of the fee that Blacksburg collects from Virginia Tech Electric to create incentives for energy conservation.

c. Pursue grants and other financial allocations from state and federal government sources.

Strategy 2: Partner with a local bank to establish a loan fund, for which the Town provides a loan loss reserve fund to keep interest rates low.

Strategy 3: Offer rebates or other financial incentives to encourage residential energy assessments and SFH retrofits.

Strategy 4: Expedite building permit approvals for SFH energy efficiency retrofits.

Strategy 5: Consider a program to bulk-purchase low-flow fixtures, compact fluorescent (CFLs) or LED light bulbs, pipe insulation, and other relatively inexpensive energy efficiency products for re-sale or distribution to residents.

Objective 1-B. Reduce average per-unit greenhouse gas emissions from new single-family homes by 66%.

<u>Community Strategies</u>

Strategy 1: Create programs that educate prospective home buyers on Energy Star, Earth Craft, and Leadership in Energy and Environmental Design (LEED) certification and the long term advantages of owning an energy-efficient home.

Strategy 2: Promote energy-efficient building practices and certifications for new homes through the New River Valley Home Builders Association (NRVBA).

Strategy 3: Invest in best available technologies for HVAC systems, water heating, appliances, and lighting as they are developed.

Strategy 4: Encourage developers to build zero-energy homes.

a. Maximize the use of energy-efficient HVAC systems, water heaters, lighting, and appliances.

b. Incorporate distributed energy production such as photovoltaic (PV) and wind as a resource owned by all members of a development.

c. Incorporate district water heating.

d. Incorporate efficient district space heating, such as a development sized, centrally located geo-thermal heat pump system.

Strategy 5: Encourage developers to reduce construction waste and recycle construction materials.

a. Donate unwanted materials to art classes, woodshop classes, etc.

b. Trade-in or donate wooden pallets.

Strategy 6: Encourage developers to minimize the graded area of construction sites, leaving native vegetation, and to re-plant with native vegetation when possible.

Strategy 7: Promote the construction of homes with modular components which facilitate replacement and upgrades as home performance technologies progress.

Government Strategies

Strategy 1: Ensure that the Town permitting and tax structure encourages energy efficiency in new residential construction.

a. Increase density allowances for energy efficient residential developments.

b. Expedite plan approvals for energy-efficient residential developments.

c. Consider reduced property tax rates for energy-efficient residential developments.

Strategy 2: Adjust zoning where possible to accommodate the increased use of modular homes as a way to decrease embodied energy in new construction.

Strategy 3: Partner with local builders and trade organizations to promote energy-efficient construction.

Strategy 4: Continue to develop and implement progressive pilot programs to demonstrate the potential of zero-net-energy homes.

Goal #2: Establish programs and incentives to reduce greenhouse gas emissions from multi-family housing units by 66% by 2050

Objective 2-A. Reduce greenhouse gas emissions from existing multi-family housing units by 66% by 2050.

Community Strategies

Strategy 1: Create an energy rating guide and efficiency certificate for rental units through the collaborative efforts of Virginia Tech's Off Campus Housing department, the New River Valley Apartment Council, other rental owners and the Town.

Strategy 2: Establish energy reduction contests between apartment units, buildings and complexes.

Strategy 3: Increase energy assessments of multi-family housing units– including blower door evaluations and infrared camera testing – to test the efficiency of building envelopes.

Strategy 4: Perform an energy assessment on a "typical" apartment within a complex to create a retrofit guide for the entire complex.

Government Strategies

Strategy 1: Offer rebates or other financial incentives to encourage residential energy assessments and retrofits to multi-family buildings.

Strategy 2: Expedite building permit approvals for energy efficiency retrofits to multi-family building

Objective 2-B. Reduce average per-unit energy use and greenhouse gas emissions from new multi-family housing units by 66% by 2050.

<u>Community Strategies</u>

Strategy 1: Invest in best available technologies for HVAC systems, water heating, appliances, and lighting as they are developed.

Strategy 2: Encourage developers to build minimum energy demand multi-family housing units.

a. Maximize the use of energy-efficient HVAC systems, water heaters, lighting, and appliances.

b. Incorporate distributed energy production such as photovoltaic (PV) and wind energy systems into multi-family housing developments, and allow community ownership of these systems in owner-occupied multi-family developments.

c. Incorporate district water heating.

d. Incorporate efficient district space heating, such as a development sized, centrally located geo-thermal heat pump system.

Strategy 3: Encourage developers to reduce construction waste and recycle construction materials.

a. Donate unwanted materials to art classes, woodshop classes, etc.

b. Trade-in or donate wooden pallets.

<u>Government Strategies</u>

Strategy 1: Ensure that the Town permitting and tax structure encourages energy efficiency in new multi-family residential construction.

a. Increase density allowances for energy-efficient multi-family developments.

b. Expedite plan approvals for energy-efficient multi-family developments.

c. Consider reduced property tax rates for energy-efficient multi-family developments.

Strategy 2: Continue to develop and implement progressive pilot programs to demonstrate the potential of minimum energy demand multi-family housing units.

Goal #3: Undertake individual actions to improve building energy efficiency in residences.

Objective 3-A: Improve energy efficiency in existing single-family homes and multi-family housing units.

Community Strategies

Strategy 1: Improve building envelopes' resistance to heating and cooling losses and gains.

a. Weather-seal windows and doors.

b. Add insulation to attics, walls, ceilings, and floors.

c. Seal air infiltration gaps at attic and floor levels.

d. Replace windows and doors with high efficiency models.

Strategy 2: Improve HVAC system performance.

a. Install programmable thermostats.

b. Adjust thermostat set points seasonally.

c. Evaluate existing systems with duct blaster assessments and seal ductwork as necessary.

d. Schedule regular HVAC maintenance.

e. Replace older, inefficient HVAC systems with newer, higher efficiency models.

Strategy 3: Optimize water heating efficiency, such as by insulating conventional tanks and supply lines and lowering water heater temperatures.

Strategy 4: Utilize low-flow shower heads and faucets and water-saving clothes and dishwashers.

Strategy 5: Replace or upgrade conventional water heating systems with heat-pump, on-demand, or solar thermal systems.

Strategy 6: Reduce energy use from appliances and lighting.

a. Replace appliances (clothes washers, refrigerators, dishwashers, dehumidifiers, clothes dryers, etc.) with Energy Star models.

b. Replace plug-in loads (televisions, computers, home printers, etc.) with Energy Star models.

Strategy 7: Reduce energy use from lighting.

a. Replace incandescent bulbs and fixtures with compact fluorescent or light emitting diodes (LED).

b. Turn off lights when leaving rooms/home.

c. Install motion sensor outdoor lights.

d. Use dimmers.

e. Minimize need for superfluous lighting by using task lamps, spot lighting, etc.

Strategy 8: Educate individuals about energy-conservation behaviors.

a. Install power strips to cut phantom loads.

b. Unplug unused and underused freezers and refrigerators.

c. Line dry clothes.

d. Wash clothes using cold water.

Objective 3-B: Implement energy efficiency measures in the construction of new single-family homes and multi-family housing units.

<u>Community Strategies</u>

Strategy 1: Align housing developments to maximize southern exposure.

Strategy 2: Design individual homes to take advantage of passive solar gains.

a. Provide proper overhangs on the south side for summer shade.

b. Plant deciduous trees on the west side to block afternoon sun.

c. Employ thermal mass applications to increase heat retention during cold seasons.

Strategy 3: Design plumbing systems to incorporate water and energy conservation.

a. Place water heaters near baths and kitchens.

b. Incorporate grey water retention and re-use.

c. Incorporate rain water collection and on-site re-use.

Strategy 4: Design homes with a "kill switch" located in a convenient place that shuts down outlets that have phantom load devices.

Strategy 5: Utilize the SmartHome concept, which turns off specific appliances when the resident goes to bed or leaves for an extended period of time.

Goal #4: Increase the use of renewable energy in the residential sector.

Objective 4-A: Increase the installation of solar PV and solar water heating systems on residential buildings.

Community Strategies

Strategy 1: Utilize tax credits and other incentives to install residential-scale solar energy systems, such as the 30% federal tax credit on all new solar PV equipment and possible property tax and permitting fee waivers initiated at the local level.

Strategy 2: Encourage community groups to increase renewable energy use through public advocacy and dialogue with town officials.

Strategy 3: Explore the potential for neighborhood collaboration on the bulk purchasing of solar installations to take advantage of economies of scale.

Government Strategies

Strategy 1: Provide fast-track permitting for residents interested in solar PV or solar water heater installation.

Strategy 2: Waive local property tax assessments on solar energy equipment.

Strategy 3: Provide assistance to residents interested in installing solar energy systems by providing information on permitting, costs, and recommendations on how to utilize space.

Strategy 4: Enact a program to supply interest-free loans for solar energy equipment that residents can pay back over time through property taxes.

Objective 4-B: Increase geothermal as a renewable energy source in residential buildings.

Community Strategies

Strategy 1: Establish cooperatives or joint ventures to install larger-scale geothermal systems for residential buildings.

Government Strategies

Strategy 1: Encourage local residents to showcase their geothermal systems and offer advice to others who are interested in investing in alternative energy sources.

a. Publicize state and federal renewable tax credits and incentives and make this information available to residents.

b. Make information readily available about state and national renewable energy credits and incentives.

Strategy 2: Encourage residents and businesses to invest in geothermal energy through public education forums.

Strategy 3: Offer financial incentives to residents and business owners who install geothermal systems

a. Offer a grant to cover a portion of installation costs.

b. Enact a program to supply interest-free loans that residents can pay back over time through property taxes.

Goal #5: Establish education and outreach programs to encourage residential energy efficiency.

Objective 5-A: Encourage groups of housing industry professionals to promote energy efficiency as part of their core mission.

Community Strategies

Strategy 1: Make energy performance information on homes available through realtors to prospective buyers.

Strategy 2: Provide energy use information packets to prospective renters through Virginia Tech's Off Campus Housing department and the New River Valley Apartment Council.

Strategy 3: Post home energy ratings on the Multiple Listing Service (MLS) guide.

Strategy 4: Host continuing education seminars and apprenticeships through the NRVBA to keep contractors and trades-people updated on installing, maintaining and repairing new technologies.

Strategy 5: Incorporate building energy performance as a primary focus in the business operations of building contractors and trades groups.

Strategy 6: Facilitate HVAC contractor involvement in performing regular maintenance and duct sealing programs.

<u>Government Strategies</u>

Strategy 1: Engage the Building Official and staff in the effort to build green homes.

a. Educate the building official and staff on the fundamentals of energy-efficient building practices.

b. Require LEED or other certification of building official staff.

c. Hire a "green homes specialist" to work out of the building official's office.

Strategy 2: Collaborate with other organizations to develop training programs and demonstrations.

a. Partner with Virginia Tech's Myers Lawson School of Construction to develop educational demonstrations using currently available and cost effective energy-efficient technologies.

b. Partner with local non-profits such as Habitat for Humanity and Community Housing Partners, and others to build a zero-energy home as a demonstration project for local builders.

Strategy 3: Reach out to the community through the building official's office.

a. Building officials could be "green ambassadors" to the local building industry.

b. Information on building with efficiency could be provided along with building permits.

c. The building official's office could be the "go to" place for information on high efficiency homes.

d. When a person receives building code information, incorporate energy efficiency options and information on where to go for assistance.

Objective 5-B: Encourage existing civic groups, homeowners associations and religious organizations to promote energy conservation to their members.

<u>Community Strategies</u>

Strategy 1: Encourage the sharing of resources between neighbors and friends to reach energy reduction goals.

Strategy 2: Establish energy reduction contests between neighborhoods, organizations, and groups of individuals.

Strategy 3: Develop energy reduction goals and pledges for residents to sign.

Strategy 4: Host professional speakers to speak about how to reduce energy use in the home.

Strategy 5: Engage in fund raising events to raise money for low income weatherization.

Strategy 6: Create partnerships between homeowners associations and energy assessment companies to bulk purchase energy efficiency products and services.

Strategy 7: Host continuing education seminars and apprenticeships through the NRVBA to keep contractors and trades-people updated on installing, maintaining and repairing new technologies.

Strategy 8: Have local PTA members introduce the topic of energy conservation, "Energy Conservation Day", into the K-12 curriculum.

Government Strategies

Strategy 1: Partner with regional governments and agencies to create cooperative efforts to encourage energy efficiency.

Strategy 2: Partner with researchers at Virginia Tech to pilot energy reduction strategies.

Strategy 3: Develop and implement annual community-wide surveys to detail and track residents' efforts to reduce their energy use. Use the surveys to track the implementation of the strategies in the Climate Action Plan.

Strategy 4: Educate town residents about energy reducing strategies.

a. Create a list of items that have short payback periods (low flow showerheads, compact fluorescent light bulbs (CFLs), power strips, etc.) and distribute to residents through their water bill or other town mailings.

b. Develop a section of the town's website that is set up to allow residents to post information on their personal energy use, house type and size, number of residents, and other information, to act as a means for residents to compare their energy use to others in the town.

Strategy 5: Distribute informational sources on energy retrofit priorities and opportunities by sending out pamphlets with town bills, holding energy education sessions, or through other means.

a. Provide residents with an informational website focusing on residential energy efficiency.

b. Provide comparisons between degrees of energy-efficient homes.

c. Provide information tailored to local housing that focuses on the value of investing in deeper energy retrofits.

d. Partner with Virginia Tech to train students to become "energy concierges" that would perform community outreach and informational sessions.

Strategy 6: Partner with local building supply stores to offer reduced cost insulated water tank jackets in exchange for free advertising.

Strategy 7: Provide information on savings associated with different water heating technologies and actions.

Strategy 8: Install a demonstration project in town hall that makes a side-by-side comparison of the energy use from incandescent, compact fluorescent (CFL), and light emitting diode (LED) bulbs. Display this information in real time on the town's website.

Strategy 9: Provide information on the town website about local residential energy efficiency success stories.

a. Provide easily accessible and user-friendly information about energy options to the community (pictures, before-and-after comparisons).

b. Provide geographic representations of energy-efficient homes (i.e. pinning homes and buildings on a town map) because visually seeing the change could help to motivate others to join the movement.

Chapter 5. Commercial and Industrial Sectors

Update and Notes:

The narrative and data tables of this chapter is shown in their original format, in which the implementation scenarios are identified progressively as "baseline", "conservative", "aggressive", and "maximum". When the Climate Action Plan Working Group picked up the planning process in early 2013, it was decided that only an "On Target" scenario would be utilized to devise the priority goals, objectives and strategies for inclusion in the final plan, i.e. one that enable the Town of Blacksburg to meet its emissions reduction target of 80% below 1990 levels by 2050. For the most part, these are reflected the "maximum" scenario.

In 2012, the industrial sector accounted for approximately 18 percent of the energy used in Blacksburg. About 57 percent of that energy was produced from natural gas, while the remainder came from electricity. The industrial sector also accounted for 18 percent of the green house gas (GHG) emissions in 2012.

Commercial buildings, on the other hand, rely on electricity for 67 percent of their energy consumption, with the remainder coming from natural gas. As a result, the commercial sector accounts for 24 percent of Blacksburg's GHG emissions, despite only consuming 19 percent of the total energy in Blacksburg.

The commercial sector is particularly important when planning for future energy use and emissions reductions. In Blacksburg, energy use and emissions in the commercial sector are projected to grow more quickly than in the other sectors analyzed, accounting for 23 percent of Blacksburg's energy use and 28 percent of GHG emissions by 2050.

Primary strategies for GHG mitigation in the commercial sector typically center on developing small business incentive programs that promote energy-efficient retrofits and on-site renewable energy systems for existing buildings, mandating baseline efficiency requirements for new construction (with some municipalities opting to adopt LEED certification as a minimum requirement), and removing regulatory barriers that may impede high quality mixed-use or infill-type development.

Local government operations typically set more stringent standards for themselves than for non-governmental entities. Even smaller communities choose to make a point of ensuring that civic structures serve as models for sustainability through high efficiency upgrades and on-site renewable energy generation. Most municipalities also establish ways to help business owners and the wider community adopt similar efficiency standards.

Opportunities presented by the industrial sector are similar to those of the commercial sector. Primary strategies for reducing energy waste and GHG emissions typically center on cost-sharing or other incentive programs that promote energy-efficient retrofits, or upgrading of lighting or office equipment. Secondary strategies include incentives for on-site renewable energy systems, raising baseline efficiency requirements for new construction (with many municipalities opting to adopt LEED certification as a minimum requirement), and removing regulatory barriers that may impede market-driven efficiency improvements.

Industrial operations are usually characterized by intensive energy use. Although the industrial sector in Blacksburg may be smaller than both the commercial and residential sectors, it can play a key role in reducing community-scale emissions due to the relative energy intensity associated with industrial operations. Industry often leads other sectors in efficiency implementation because of the substantial savings that can be realized. Additionally, as Blacksburg and the region move toward increased efficiency and alternative energy sources, there is potential to develop "green" industry and enjoy its benefits for the local and regional economy.

5.1. Background and Methodology

5.1.1 Commercial Sector

The approach to estimating future energy use and GHG emissions in the commercial sector focuses on potential savings that can be realized for specific end uses such as space heating and cooling, lighting, etc. The analysis is based on the current breakdown of commercial sector energy consumption by end use according to national data from the U.S. Energy Information Administration (EIA). To better estimate Blacksburg's commercial sector energy use breakdown, these national figures were adjusted to account for the local climate.

Opportunities to reduce energy use and GHG emissions in commercial buildings focus on thermal conditioning (space heating, cooling, and ventilation), lighting, water heating, and computers / appliances. Within this chapter, we present options for reducing current energy use in these areas, on a per building basis, employing the best currently available technologies. These savings are then extrapolated to estimate potential future savings based on conservative, substantial, or on-target scenarios for future energy savings in each end use.

Table 5-1 shows the breakdown of commercial energy use by building type in the U.S. and the multipliers used to adjust the national averages for Blacksburg's climate. According to the EIA data, businesses in Blacksburg's climate zone (defined as an area with less than 2,000 cooling degree days per year and between 4,000 and 5,400 heating degree days) consume about 9 percent more energy per year than the national average. These adjustments were only made for the end uses deemed most likely to be affected by local climate: space heating, cooling, ventilation, and water heating. Because the ratio for ventilation was close to one, no significant adjustment was made.

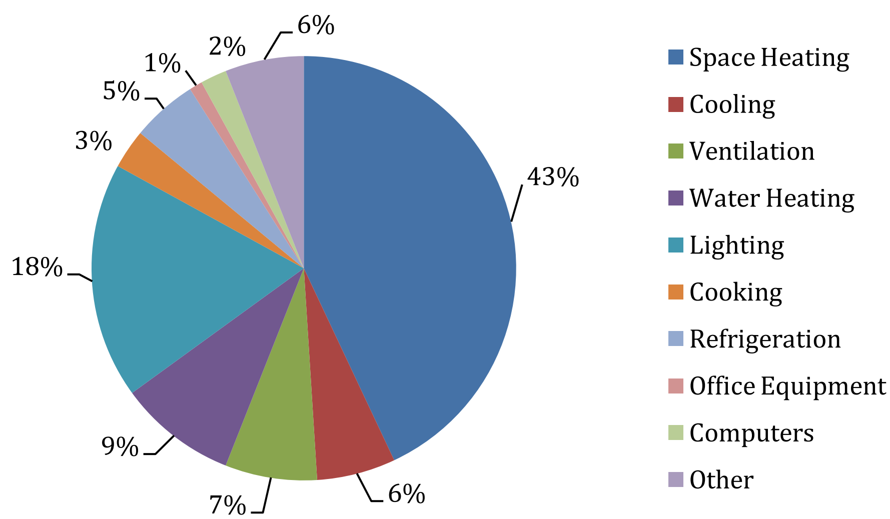
Table 5-1. National and Local Average Commercial Energy Consumption by End Use

	Space Heating	Cooling	Ventilation	Water Heating	Lighting	Cooking	Refriger-ation	Office Equipment	Computers	Other
Pct. of National Consumption	38%	7%	7%	8%	20%	3%	6%	1%	2%	8%
Climate Adjustment	1.12	0.88	1.00	1.09	NA	NA	NA	NA	NA	NA
Pct. of Blacksburg Consumption	43%	6%	7%	9%	18%	3%	5%	1%	2%	6%

Source: U.S. Energy Information Administration, 2003 Commercial Building Energy Consumption Survey.

Figure 5-1 shows the climate-adjusted estimated breakdown of commercial energy use in Blacksburg. Space heating represents the greatest source of commercial energy use, at 43 percent, followed by lighting at 18 percent.

Figure 5-1. Blacksburg Estimated Commercial Energy Consumption by End Use



Source: U.S. Energy Information Administration, 2003 Commercial Building Energy Consumption Survey.

Space heating consumes the most energy in all commercial building types except for food sales, food service, and lodging; in most cases, representing 40-60 percent of annual energy consumption in commercial buildings.

Lighting is the second greatest share of energy consumption in a majority of commercial buildings including retail, office, education, food sales, health care, public order and safety, service, warehouse and storage, and other building types. For retail, office, warehouse and storage, and lodging buildings the percentage of energy use due to lighting is particularly significant. In many cases, much of this energy consumption can be addressed easily and inexpensively through simple, cost-effective measures such as switching to more efficient light bulbs.

Water heating is responsible for the third greatest share of energy consumption, although it is not as uniformly important. For many building types water heating represents less than 5 percent of total energy consumption. For other types water heating makes up a much higher percentage, consuming the most energy in lodging buildings, for instance.

Table 5-2. Blacksburg Estimated Commercial Energy Consumption by End Uses

Building Type	Space Heating	Cooling	Ventilation	Water Heating	Lighting	Cooking	Refriger-ation	Office Equipment	Computers	Other
Education	51%	8%	10%	7%	13%	1%	2%	0%	4%	5%
Food Sales	16%	4%	3%	2%	18%	4%	47%	1%	1%	4%
Food Service	18%	6%	5%	17%	10%	24%	16%	0%	0%	4%
Health Care	40%	6%	7%	17%	17%	2%	1%	1%	2%	8%
Lodging	24%	4%	3%	33%	23%	3%	2%	1%	1%	7%
Retail (Other Than Mall)	36%	7%	5%	2%	34%	1%	7%	1%	1%	7%
Office	38%	8%	5%	2%	24%	0%	3%	3%	6%	9%
Public Assembly	56%	9%	16%	1%	7%	1%	2%	1%	1%	7%
Public Order and Safety	46%	7%	8%	12%	14%	1%	2%	1%	2%	9%
Religious Worship	63%	6%	3%	2%	10%	2%	3%	1%	1%	11%
Service	50%	4%	7%	1%	19%	0%	3%	0%	1%	14%
Warehouse and Storage	45%	3%	4%	1%	28%	0%	8%	0%	1%	10%
Other	51%	5%	4%	1%	20%	1%	3%	1%	2%	11%
Vacant	71%	3%	2%	1%	7%	1%	1%	1%	1%	14%

Source: U.S. Energy Information Administration, 2003 Commercial Building Energy Consumption Survey.

Offices, food services, and retail establishments are of particular interest to Blacksburg because these are the town's most common commercial building types, differing somewhat from national averages. For offices and retail buildings, space heating and lighting make up the vast majority of energy consumption. Space heating and lighting play a large role in food service facilities as well, but water heating, refrigeration, and cooking play a far greater role. Thus, special attention should be given to reducing energy usage from appliances in this particular subsector.

5.1.2 Industrial Sector

In Blacksburg, energy use in the industrial sector is projected to increase by only 16 percent from 2010 to 2050, compared to 34 percent in the commercial sector and 18 percent in the residential. Similarly, industrial GHG emissions are expected to increase 17 percent by 2050, while commercial emissions are projected to increase 35 percent in that same time frame. Table 5-3 compares the cumulative growth of these sectors.

Table 5-3. Projected Growth: Energy Use and GHG Emissions by Sector 2010-2050

	Industrial	Commercial	Residential
Energy Use	16%	34%	18%
GHG Emissions	17%	35%	31%

5.2. Potential Energy and GHG Savings from Commercial Buildings

This section describes potential energy use and GHG emissions savings that can be achieved by making commercial buildings more energy-efficient. It focuses on four types of energy efficiency improvements: thermal conditioning, lighting, water heating, and appliances

5.2.1. Thermal Conditioning

Similar to residential retrofits, improvements in this category aim to increase the efficiency of the thermal building envelope. Strategies include using higher-rated insulation materials, creating effective air barriers to reduce infiltration, and improving the efficiency of heating/cooling units and their distribution systems. Employing an effective combination of these measures can result in significant energy savings.

Table 5-4 shows the heat loss percentage associated with each commercial building component and the estimated pre- and post-retrofit R-values for each component. The column for heat loss reduction shows the total heat loss reduction associated with each building component, based on the percentage difference between the associated U-values (the inverse of the R-values). The estimated 55.5 percent reduction in heat loss from infiltration is based on an assumed improvement from 0.6 to 0.2 air changes per hour (ACH), with an additional 0.15 ACH provided by mechanical ventilation in the post-retrofit scenario. Multiplying the heat loss reduction for each component by the respective percentages of total building heat loss produces an estimate of the percentage of total building heat loss saved from each improved building component.

Table 5-4 shows heat loss in the average commercial building could be reduced by 37.5 percent, assuming comparable R-values were observed. In Table 5-1, it is estimated that approximately 49 percent of commercial energy is used for space heating and cooling. Therefore, total commercial energy demand would be reduced by roughly 18 percent if all commercial buildings underwent the modeled retrofit. Assuming air conditioning demand, which accounts for an average of 5 percent of commercial energy consumption, would be reduced by a similar percentage, the total building energy savings from these retrofits would equal approximately 21 percent.

Table 5-4. Estimate of Potential Heat Loss Retrofit Savings for All Commercial Buildings

Building Component	Percent of Heat Loss[1]	Initial R-Value (Est.)	Post-Retrofit R-Value	Heat Loss Reduction	Percent of Total Heat Loss Saved
Ceilings	12%	30	46	34.8%	4.2%
Floors	11%	30	36	16.7%	1.8%
Walls	21%	25	35	28.6%	6.0%
Windows	22%	2	3	33.3%	7.3%
Doors	4% (est.)	2.5	4	37.5%	1.5%
Infiltration	30% (est.)	NA	NA	55.5%	16.7%
Total	100%	NA	NA	NA	37.5%

Improving the heating, ventilation, and air-conditioning (HVAC) system can further reduce the amount of energy consumed in a commercial building. According to the U.S. Department of Energy, HVAC systems consume 29.3 percent of the end use energy in commercial buildings.[2] Many factors influence the cost-effectiveness of HVAC retrofits including: age of the system, size of the building, type of system, efficiency of the building envelope, etc. Generally speaking, older HVAC systems achieve about 80 percent furnace efficiency and 75 percent distribution efficiency. This results in a total system efficiency of 60 percent. Current top-of-the-line HVAC systems can have furnace efficiencies as high as 95 percent, with 90 percent distribution efficiency, resulting in a total system efficiency of 85.5 percent.

Combining the effects of building envelope retrofits and improved HVAC systems results in significant potential energy savings. For example, an average commercial building consuming 200 million Btu of energy per year, uses approximately 49 percent, or 98 million Btu, for space heating and air conditioning. Assuming an HVAC efficiency of 60 percent, the actual thermal conditioning demand would be 58.8 million Btu, with HVAC losses accounting for the remaining 39.2 million Btu. After a building envelope retrofit, the thermal conditioning demand would drop 18.35 percent, to 48 million Btu. Combined with a new HVAC system that was 85.5 percent efficient, the total energy consumption for heating and cooling would be approximately 55 million Btu, a 43.8 percent reduction from the original total. Given that space heating, air conditioning, and ventilation together account for about 56 percent of the average commercial building energy demand, the efficiency improvements would reduce total energy consumption for a commercial building by about 24.5 percent.

---

[1] *Buildings energy data book: 3.1 commercial sector energy consumption*. (2009, October). Retrieved from http://buildingsdatabook.eren.doe.gov/docs/xls_pdf/3.1.12.pdf

[2] *Buildings energy data book: 3.1 commercial sector energy consumption*. (2009, October). Retrieved from http://buildingsdatabook.eren.doe.gov/docs/xls_pdf/3.1.12.pdf

Figure 5-2. Projected Thermal Energy Demand (2050) from Commercial Buildings

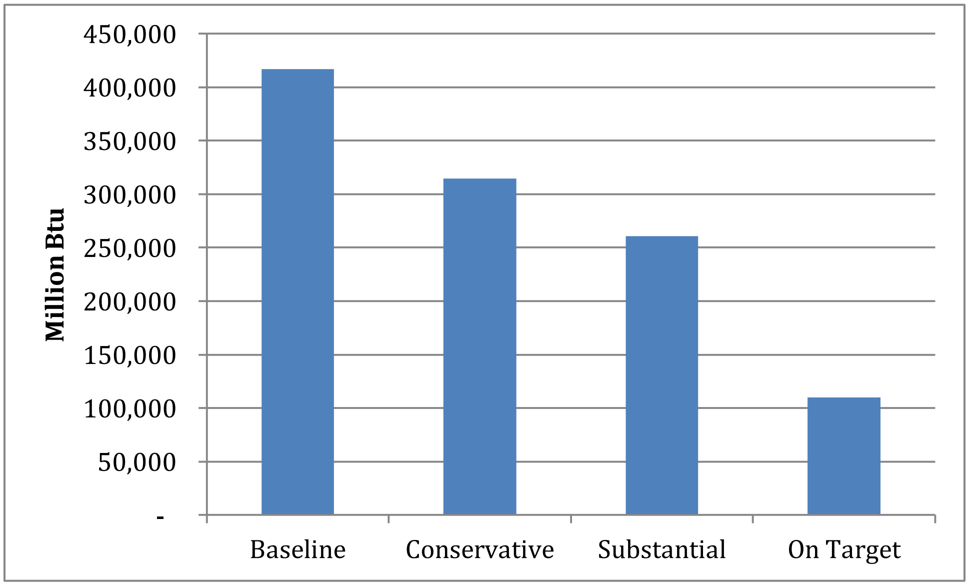


Figure 5-2 assumes the average commercial building in 2050 matches the model baseline building from Table 5-4. The average building in Blacksburg today is not this efficient, but due to the high turnover rate of commercial buildings, it is reasonable to assume this may be the case by 2050. It is estimated that the conservative improvements to the efficiency of the thermal envelope discussed above would reduce heating, cooling, and ventilation energy use by 24.5 percent. Figure 5-2 compares this conservative scenario to the baseline thermal energy demand of 416,419 million Btu. This represents best available technology in 2012, but is likely to be a conservative figure by 2050. The aggressive and maximum scenarios anticipate technological improvements and enhanced building construction practices that will increase savings by 37.5 percent and 65 percent respectively.

Figure 5-3. Total Commercial Sector Energy Consumption (2050) Under Thermal Energy Scenarios (million Btu)

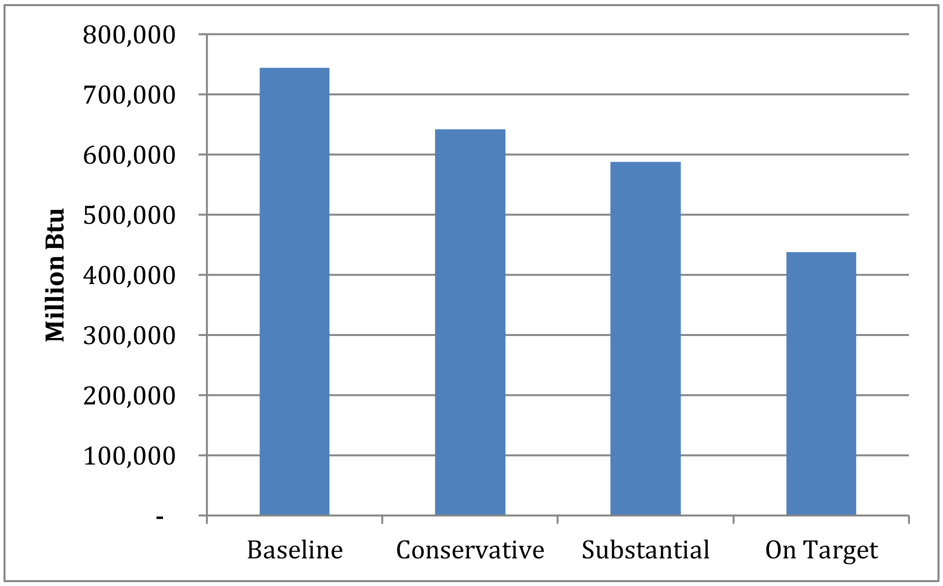


Figure 5-3 shows how improving commercial building thermal energy efficiency effects total commercial sector energy consumption. In the on target scenario, energy consumption in the commercial sector would be reduced 41 percent below the baseline by 2050, to about 400,000 million Btu. Energy savings in the conservative and substantial scenarios would be 14 percent and 21 percent respectively.

5.2.2. Lighting

Lighting is the second largest consumer of end use energy behind thermal conditioning systems. Therefore, substantial reductions in energy use and GHG emissions can be achieved by retrofitting inefficient lighting components. The most common commercial lighting retrofits replace incandescent bulbs with compact fluorescents or upgrade high-watt fluorescent tubes to low-watt, high-efficiency tubes. Some businesses and municipalities elect to incorporate super-efficient technologies like LED and solid-state lighting. An additional strategy can include motion sensors on fixtures, particularly in office environments, to reduce wasted electricity.

Upgrading inefficient lighting is a quick and easy way for businesses to reduce energy consumption. Lighting is a "low-hanging fruit" in the retrofit process; the relatively low upfront cost and short payback period make it an attractive option for most commercial buildings. Within the commercial sector, retail buildings and office spaces have the greatest lighting demand. Much of Blacksburg's commercial stock is composed of these two types of buildings, so lighting retrofits are especially applicable. Table 5-5 summarizes the annual energy use and cost of two common inefficient bulbs and their high-efficiency replacements. Switching from a normal incandescent light bulb to a compact fluorescent light (CFL) or LED reduces energy consumption and cost by 75 percent or even more in the case of LEDs. Switching from T12 to T8 linear fluorescent lights reduces energy use and cost by roughly 40 percent.

Table 5-5. Light Bulb Cost and Energy Use Comparison

	Incandescent A-Bulb	Compact Fluorescent	4-Lamp T12 40W	3-Lamp T8 32W	3-Lamp T8 24W	LED
Wattage (W)	100	23	160	96	72	10
Lifespan (hours)	1,000	10,000	12,000	20,000	25,000	50,000
Annual Energy Use (kWh)	292	67.16	467	280	210	14.6
Annual Energy Cost	$35.04	$8.05	$56.06	$33.64	$25.23	$3.50

**Assumes energy cost of $0.12/kWh. 0.9 ballast factor. Run 8hr/day*

Using a similar method as was used to calculate potential energy saving in the residential sector, a standard model office building was simulated to estimate energy and cost savings resulting from lighting efficiency upgrades. Calculations were based on a 10,000 square foot office building. 60 percent of the lighting in the office was assumed to come from 4-lamp 160-watt T12 fluorescent tubes. 25 percent of these bulbs run 24/7 for security purposes. The remaining 75 percent run 16 hours a day. The other 40 percent of the lighting is provided by 100-watt incandescent lamps that run for 12 hours a day. To upgrade the lighting, 32-watt T8 tubes replace the 40-watt T12 fluorescent tubes, and 23-watt compact fluorescent bulbs replace the 100-watt incandescent bulbs. To create the model, EIA data was used to estimate the total energy usage attributable to lighting in kilowatt-hours (kWh) per square foot for a commercial office.[3] With this information, the total number of each type of fixture in an office building of this size can be estimated by dividing the total annual energy consumption due to lighting (in kWh) by the individual bulb electricity usage multiplied by the assumed percentages for the fluorescent tube and incandescent fixtures (60 and 40 percent, respectively).

Table 5-6. Estimate of Energy Savings, Conservative Lighting Retrofit

	Baseline		Conservative	
	Incandescent A-Bulb	4-Lamp T12 40W*	Compact Fluorescent	3-Lamp T8 32W*
Bulbs	60	160	60	120
Wattage (W)	100	40	23	32
Daily Run Time (hr)	12	18	12	18
Annual Energy Use (kWh)	26,280	42,048	6,044	25,229
Total Energy Use (kWh)		68,328		31,273

**0.9 ballast factor*

The results of a model office lighting retrofit are summarized in Table 5-6. Assuming the 40/60 split between incandescent and fluorescent lighting load, the pre-retrofitted office building used 68,328 kWh of energy. After retrofit, the building would use 31,273 kWh of energy. For the

---

[3] *Table e3a. electricity consumption (btu) by end use for all buildings, 2003.* (2008, September). Retrieved from http://www.eia.doe.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/2003alltables/set25.pdf

model commercial building, lighting retrofits were estimated to reduce energy consumption for lighting by 54 percent.

Table 5-7 shows the results of the aggressive and maximum scenarios; all scenarios reflect 100 percent of commercial buildings adopting the lighting technologies. In the aggressive scenario, the standard fluorescent lights are split between 24-watt and 32-watt T8 fluorescent bulbs. The incandescent bulbs are split evenly between CFLs and LED lights. This scenario reduces energy consumption 60 percent below the baseline. The aggressive scenario uses both LED and 24-watt T8 bulbs, reducing energy consumption by 67 percent. LED lights are an emerging technology for traditional lighting applications. Although the white light quality and cost are not very competitive in the current market, these scenarios assume technology breakthroughs will make these lights applicable in the near future, and certainly by 2050. Figure 5-4 presents these estimates graphically. All scenarios reflect 100 percent of commercial buildings adopting the respective lighting technologies.

Table 5-7. Estimate of Savings, Aggressive and Maximum Scenario

	Aggressive				Maximum	
	Compact Fluorescent	LED	3-Lamp T8 32W	3-Lamp T8 24W*	LED	3-Lamp T8 24W*
Bulbs	30	30	60	60	60	120
Wattage (W)	23	10	32	24	10	24
Daily Run Time (hr)	12	12	18	18	12	18
Annual Energy Use (kWh)	3,022	1,314	12,614	9,461	2,628	18,922
Total Energy Use (kWh)				26,411		21,550

**0.9 ballast factor*

Figure 5-4. Projected Lighting Energy Demand (2050) from Commercial Buildings

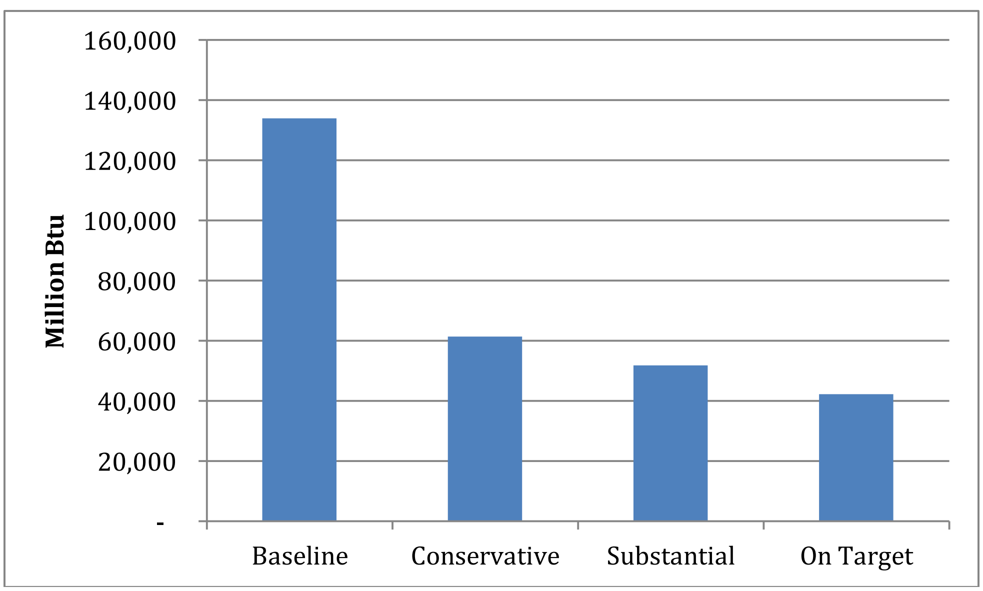


Figure 5-5 shows the reductions to GHG emissions under these scenarios. Under the maximum scenario, emissions fall to just under 10,000 metric tons CO_2-e. This is about 20,000 metric tons less than the projected baseline total in 2050.

Figure 5-5. Projected Lighting GHG Emissions (2050) from Commercial Buildings

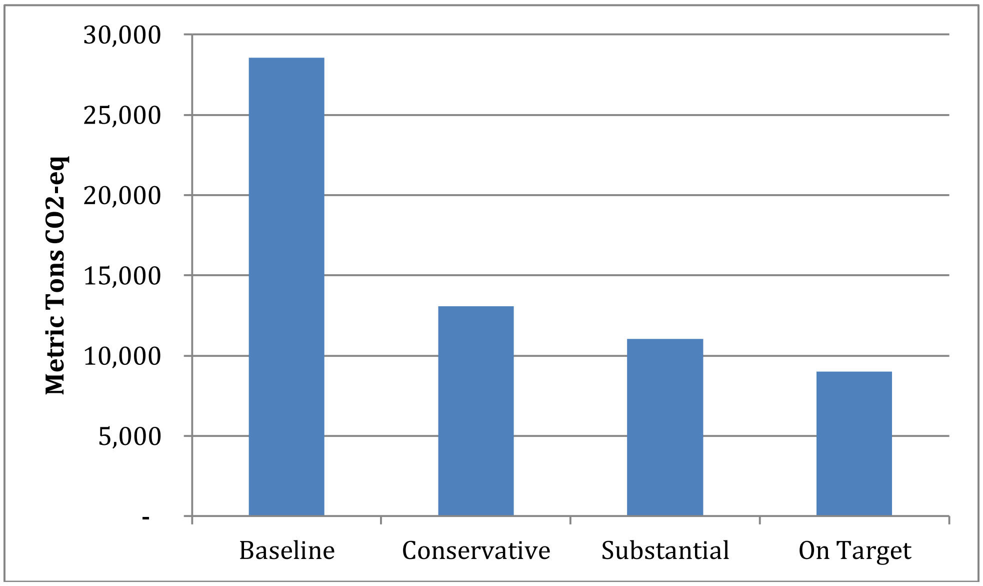


Figure 5-6 shows the impact the reductions to lighting energy will have on the energy consumption totals for entire commercial sector. If lighting accounts for 18 percent of end use energy in Blacksburg's commercial sector, lighting improvements under the conservative scenario would decrease consumption by 9.8 percent.

Figure 5-6. Total Commercial Energy Consumption (2050) Under Lighting Scenarios

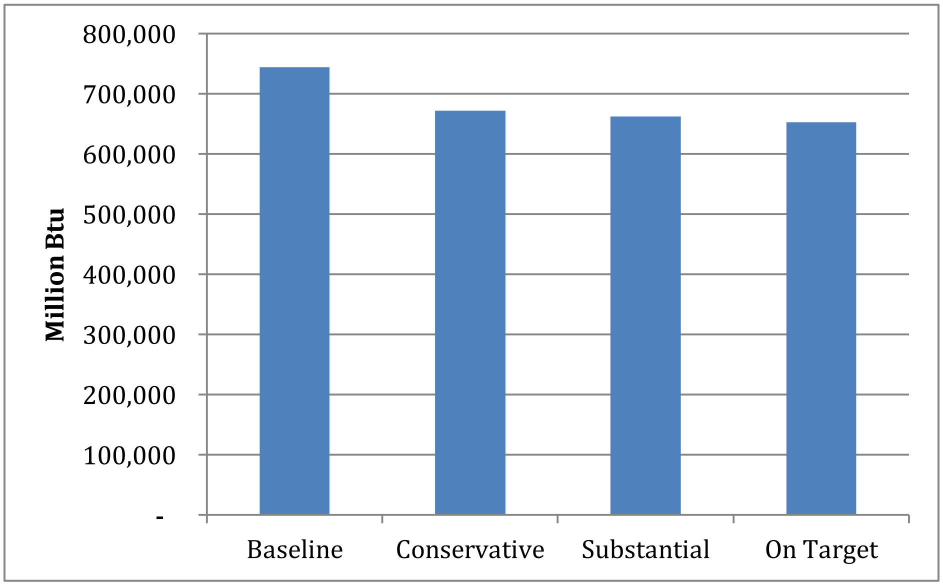


Figure 5-6 shows that under the maximum scenario, energy use falls from a baseline of 745,000 million Btu to 650,000 million Btu. This reduces total commercial energy use 12 percent.

5.2.3. Water Heating

Water heating represents another opportunity to improve commercial energy efficiency. Although it only accounts for an estimated 9 percent of energy consumption in the commercial sector, several commercial building types, notably lodging, food service, and healthcare spend a much higher portion of their energy use heating water . Updating existing water heating systems, especially in these types of buildings, can reduce energy costs and GHG emissions.

The thermal efficiency of a typical gas- or oil-fired unit is about 80 percent, but can go up to 95 percent. Upgrading a gas-fired water heater to a more efficient gas-condensing water heater can save a substantial amount of wasted energy. In a gas-condensing system, nearly all the fuel's heat is transferred to the water, leading to 95 percent efficiencies or greater. Switching to gas-condensing water heaters may save up to 20 percent on energy bills, depending upon the amount of water that is used and whether the building has continuous or peak demand.

Electric water heaters are more efficient, at about 98 percent thermal efficiency, without much deviation. Of the two options, heat pumps are generally far more efficient. Heat-pump water heaters use approximately half the energy of a typical electric resistance water heater, and can provide the additional benefits of cooling and dehumidification in some applications.

A commercial facility often uses a complex distribution scheme with multiple pumps and timers to deliver hot water; this type of system is common in lodging facilities because it allows patrons instant access to hot water. Complexity in any mechanical system often results in inefficiency, particularly as a system ages. This fact, combined with the sheer volume of water demanded in the hotel industry, leads to large quantities of wasted heat, making water heating system retrofits in the lodging building type relevant. Restaurants can also have relatively complex systems with large refrigeration condensers that waste significant amounts of heat.[4]

Geothermal or ground source heat pumps (GSHPs) get their heat from pumping fluid through underground pipes. They can provide the additional benefit of space heating and cooling, as well, increasing efficiency. The average commercial geothermal heat pump can reduce energy use 40-72 percent and reduce operation costs 31-56 percent annually.[5] While the upfront cost of installing these systems can be prohibitive, due to the significant energy savings, larger commercial facilities may find installation of GSHPs cost-effective.

Recent DOE energy data is used to estimate the energy and GHG savings from water heating retrofits (Table 5-8).

Table 5-8. Three Scenarios for Commercial Water Heating

Type of Water Heater	Energy Factor*	2050 Distribution			
		Baseline	Conservative	Aggressive	Maximum
Electric Water Heaters					
Conventional	0.9	18%	2%	1%	0%
Conventional w/ insulating blanket	1.0	3%	10%	3%	1%
Instantaneous demand	1.0	1%	1%	1%	1%
Heat pump	2.0	0%	7%	10%	4%
Solar w/ electric back-up (insulated)	0.9	0%	1%	6%	15%
Solar w/ electric back-up (high eff.)	0.95	0%	1%	1%	1%
Natural Gas Water Heaters					
Conventional	0.57	62%	9%	4%	2%
Conventional / insulating blanket	0.6	12%	56%	35%	2%
Instantaneous demand	0.7	4%	5%	1%	0%
Instantaneous high efficiency	0.84	0%	0%	1%	0%
Solar w/ nat. gas back-up (insulated)	0.57	0%	4%	33%	67%
Solar w/ nat. gas back-up (high eff.)	0.57	0%	4%	4%	7%

[4] *Commercial water heaters*. (2010). Retrieved from http://www.fypower.org/com/tools/products_results.html?id=100208#technologyoptions

[5] Lienau, P. J., Boyd, T. L., & Rogers, R. L. (1995, April). *Ground-source heat pump case studies and utility programs*. Retrieved from http://geoheat.oit.edu/pdf/hp1.pdf

Source (energy factors only): Randolph, J., and Masters, G. 2008. Energy for Sustainability: Technology, Planning, Policy. Washington, DC: Island Press.

**Energy Factor is the ratio of useful energy output from a water heater to the total amount of energy delivered to the water heater. A higher EF indicates that the system is more energy-efficient.*

Figure 5-7 illustrates the reduction in energy under the water heating scenarios.

Figure 5-7. Projected Water Heating Energy Demand (2050) for Commercial Sector

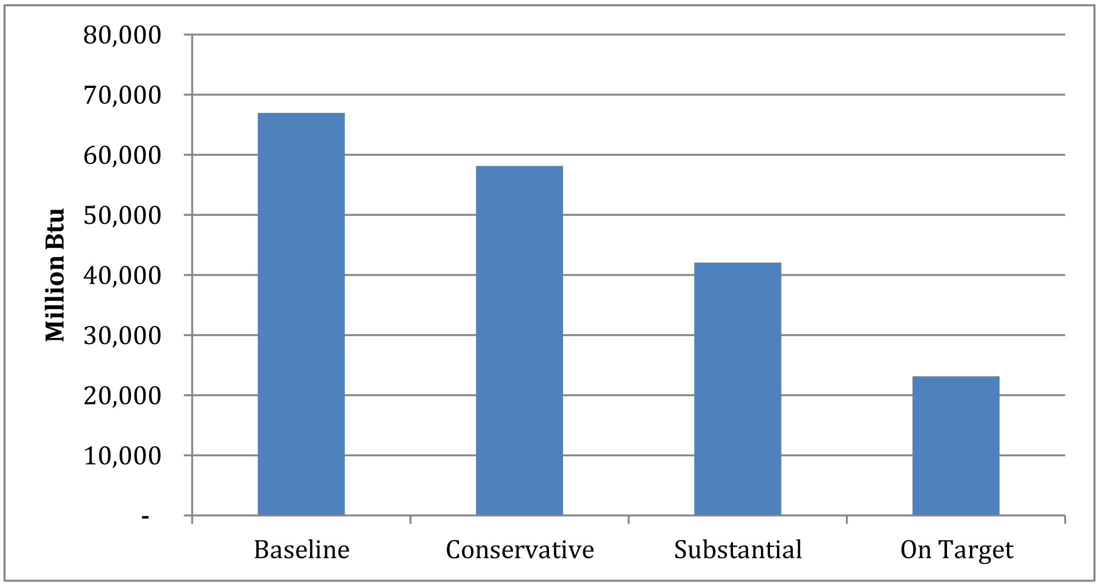


Figure 5-8 shows the overall reduction to commercial sector energy consumption under the assumed water heating retrofit scenarios. Although water heating does not represent a large share of total energy consumption in the commercial sector, it remains an important component of energy and GHG reduction in an overall reduction strategy.

Figure 5-8. Total Commercial Sector Energy Consumption (2050) Under Water Heating Scenarios

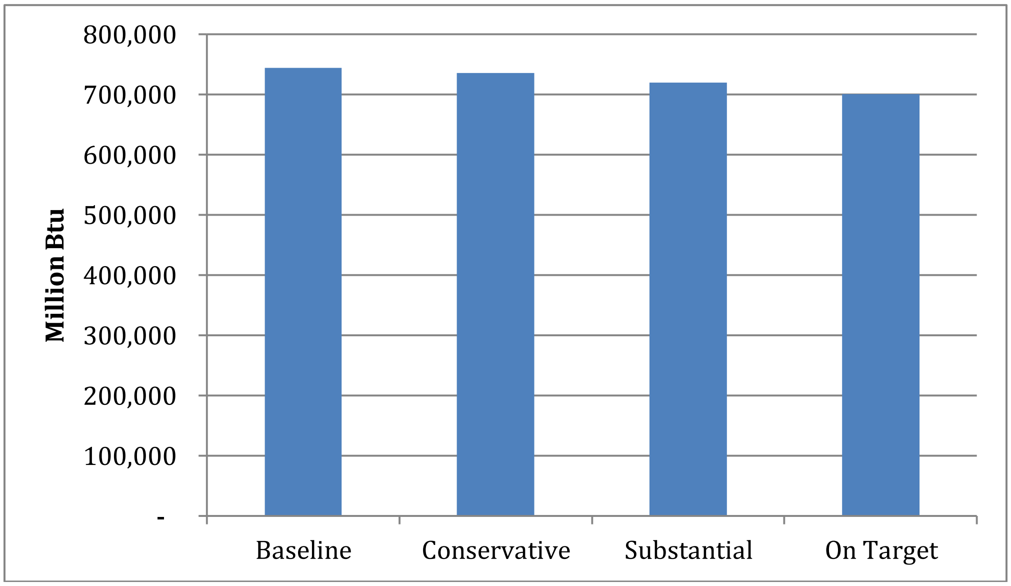


Figure 5-9. Projected Water Heating GHG Emissions (2050) from Commercial Buildings

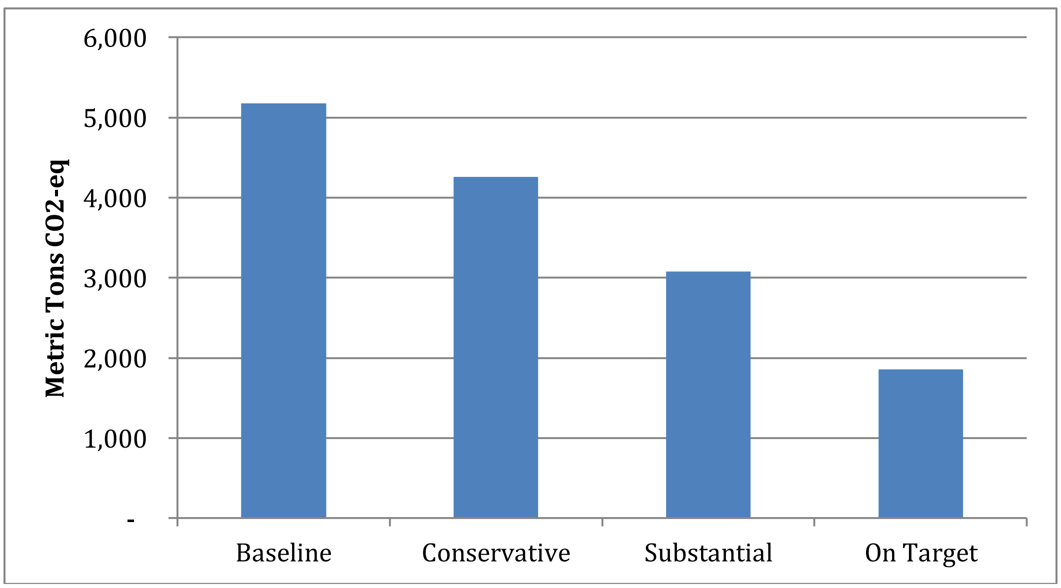
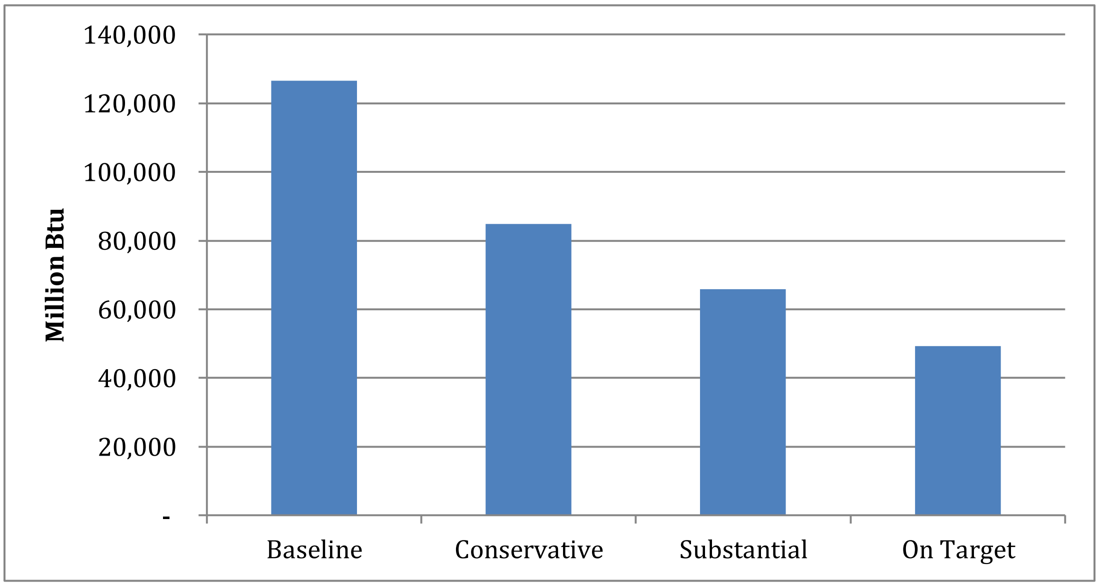


Figure 5-9 shows the GHG reductions under the water-heating scenario. These reductions were estimated by using the modified percent reduction figures from the residential water heating model and applying them to the use projections for the commercial sector. Under the maximum scenario, GHG emissions are projected to be 64 percent below the baseline levels.

5.2.4. Appliances (Cooking, Refrigeration, Office Equipment, Computers, Other)

The various appliances used in the commercial sector account for 17 percent of the energy used. Individually, this includes cooking (3 percent), refrigeration (5 percent), office equipment (1 percent), computers (2 percent), and other (6 percent). Lacking detailed appliance energy use data for Blacksburg, this section borrows from the residential sector analysis. Under the conservative scenario, energy consumption is reduced 33 percent. Under the aggressive and maximum scenarios, energy consumption is reduced by 48 percent and 61 percent, respectively (Figure 5-10).

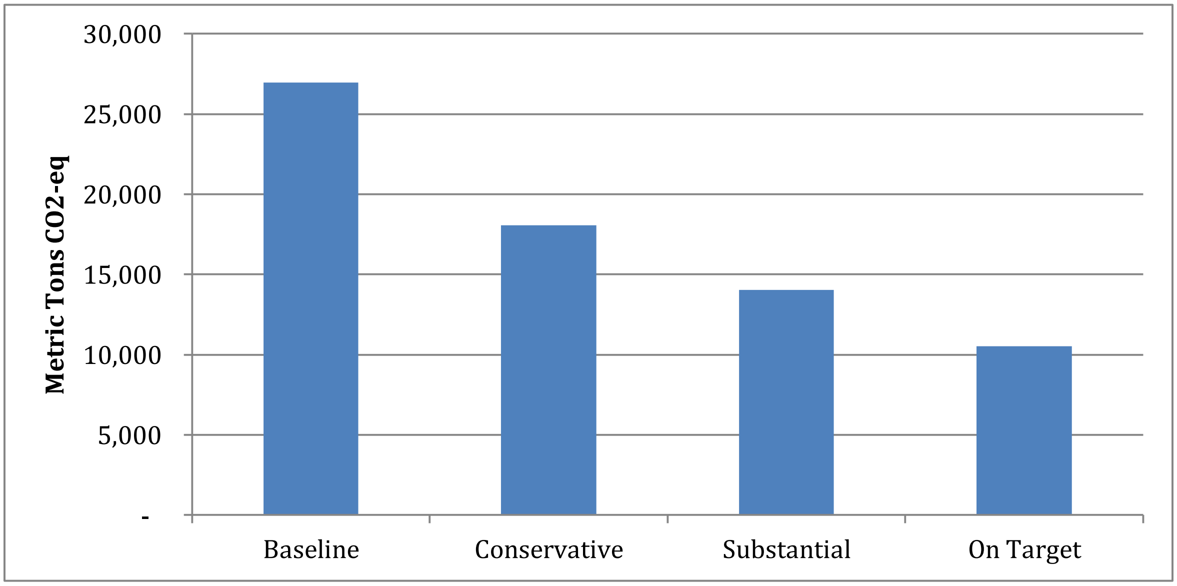
Figure 5-10. Projected Appliance Energy Use (2050) from Commercial Sector



Under the conservative scenario, energy use is reduced from 126,600 million Btu to 84,800 million Btu. The aggressive and maximum scenarios estimate energy consumption of 65,800 and 49,400 million Btu, respectively.

Figure 5-11 presents the overall GHG emissions reductions based on these energy consumption totals. Under the conservative scenario, GHG emissions fall from the projected baseline of 27,000 metric tons to 18,100 metric tons CO_2-e. The aggressive strategy drops emissions to 14,000 metric tons, and the maximum scenario drops emissions down to 10,500 metric tons.

Figure 5-11. Projected Appliance GHG Emissions (2050) from Commercial Buildings



5.2.5. Combined Energy Efficiency Savings

The estimated total potential energy and GHG savings for commercial buildings by 2050 are based on the findings described above for different types of energy savings.

Figure 5-12. Projected GHG Emissions (2050) from Commercial Sector

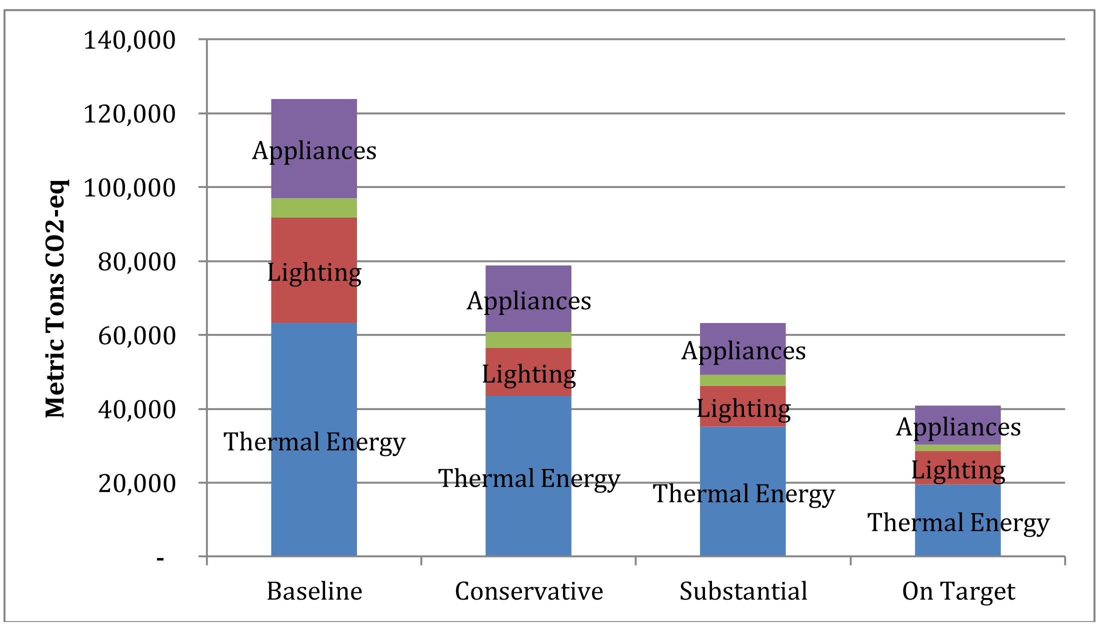


Figure 5-12 compares the baseline GHG emissions to the scenario estimates for 2050. Under the conservative scenarios for each category, emissions are predicted to decrease by 36 percent. Under the aggressive scenario, they decrease 49 percent. Under the maximum scenarios for each category, GHG emissions are projected to decrease from a baseline of 124,000 metric tons CO_2-e to 41,000 metric tons CO_2-e, a 67 percent decrease.

Figure 5-13. Projected Energy Consumption (2050) from Commercial Sector

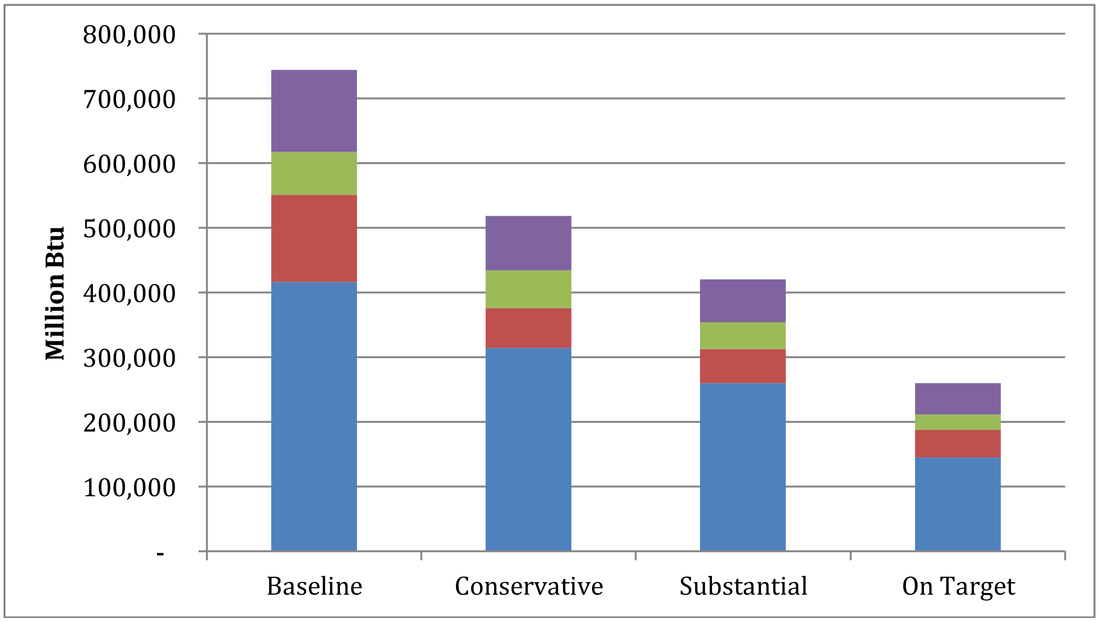


Figure 5-13 compares the energy consumption reductions under the maximum scenarios to the 2050 projected baseline. It highlights the increasing reductions to energy consumption for each scenario. Under the conservative scenarios for each category, energy use is predicted to decrease by 30 percent. Under the aggressive scenario, it decreases by 44 percent. Under the maximum scenarios, projected energy use decreases from a baseline of 744,000 million Btu to 261,000 million Btu, a 65 percent decrease in energy consumption.

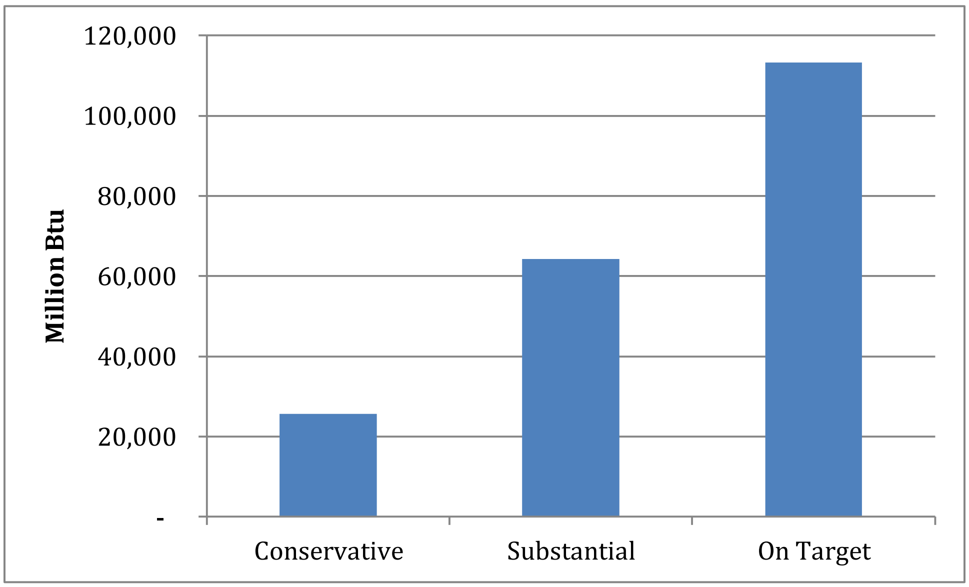
5.3. Potential Energy and GHG Savings from Solar PV on Existing and New Commercial Buildings

The potential for solar PV systems in Blacksburg's commercial sector is estimated using the same approach described for the residential sector. Existing commercial roof space is estimated to be 282,000 m^2, and is estimated to grow by 20 percent by the year 2050 (AAGR of 0.46 percent). As most commercial buildings have flat roofs, it's estimated that a large percentage of the roof space would be available for PV. The potentials for these solar scenarios are in Table 5-9 and Figure 5-14.

Table 5-9. Installed Solar PV, Capacities, and Savings According to Level of Application

	Percentage of Roof Space with PV (by year 2050)	Area of Installed PV (m^2)	Installed Capacity (MW)	Electricity Generated (million kWh/yr)	Energy Saved (MBtu/yr)	CO_2-e Emissions Reductions (metric tons/yr)
Conservative	10%	33,840	4.15	7.54	25,682	5,470
Intermediate	25%	84,600	10.36	18.86	64,205	13,676
Aggressive	44%	149,316	18.29	33.29	113,319	24,137

Figure 5-14. Solar PV Electricity Generation in Commercial Sector



Under the maximum scenario, approximately 33 million kWh of electricity would be generated. This is the equivalent of 113,000 million Btu. Figure 5-15 shows the GHG savings under the three scenarios.

Figure 5-15. Solar PV GHG Emissions Savings in Commercial Sector

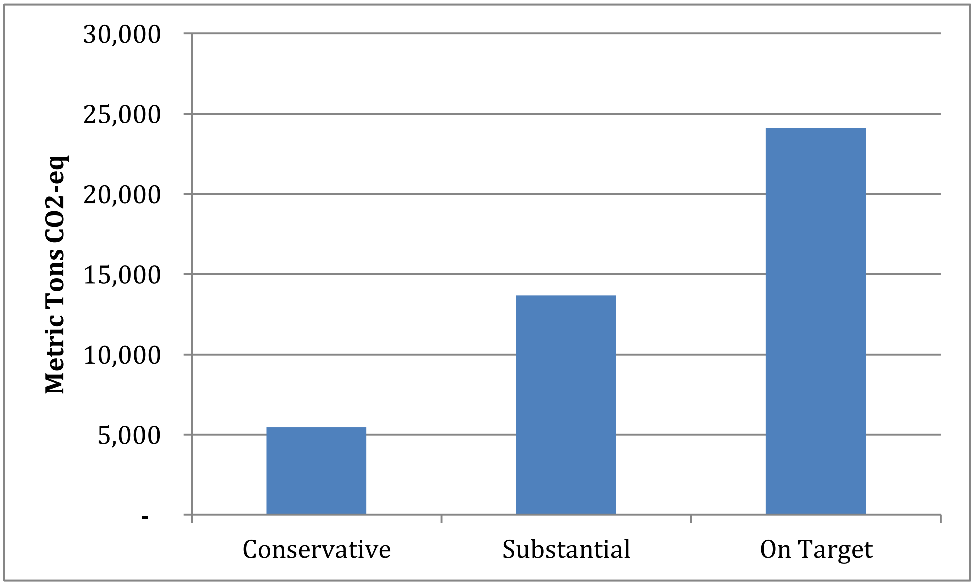
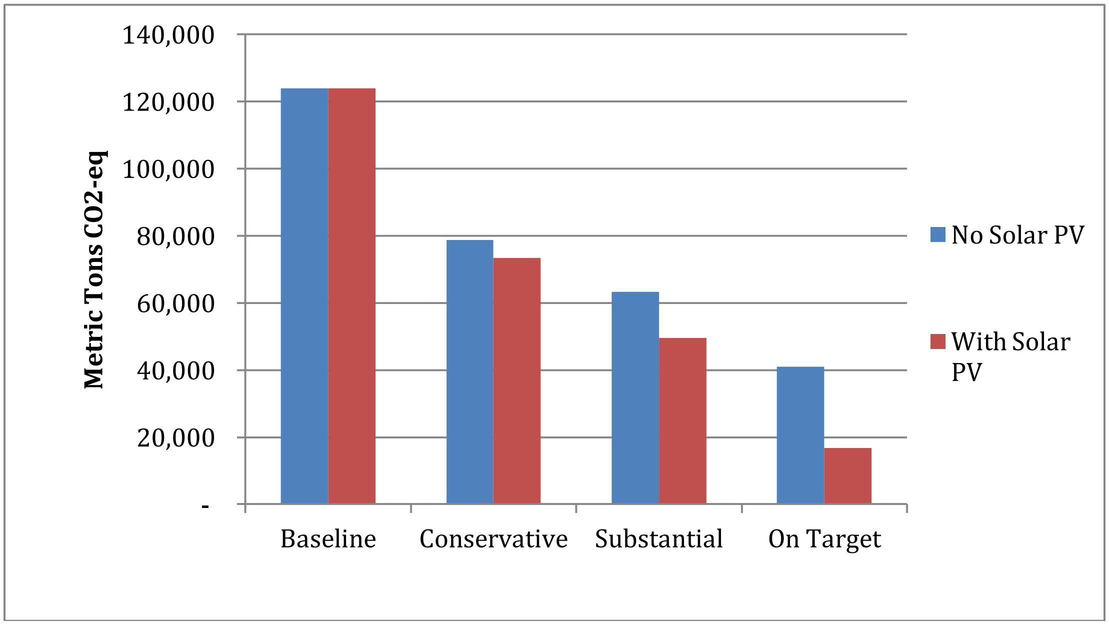


Figure 5-15 presents the amount of GHG emissions that would be saved by using PV-generated electricity, replacing traditional coal-fired electricity. The maximum scenario would reduce GHG emissions by 24,100 metric tons CO_2-e. Under the conservative and aggressive scenarios, GHG emissions would be reduced by 5,500 and 13,700 metric tons CO_2-e, respectively.

Before accounting for solar, the estimated energy use under the maximum scenario is 260,700 million Btu. The maximum scenario for commercial PV could supply 113,300 million Btu, or about 15 percent of the baseline energy demand in the commercial sector by 2050. Figure 5-16 compares the baseline GHG projection in 2050 to the three scenarios, both with and without the solar savings.

Figure 5-16. PV Impact on Commercial Sector GHG Emissions (tons CO_2-e)



Before accounting for solar, our estimated GHG emissions in 2050, under the maximum scenario, are 40,900 metric tons CO_2-e/yr. When the maximum PV scenario is included, emissions are further reduced to 16,800 tons CO_2-e/yr. This total is 87 percent below the estimated baseline emissions in 2050.

5.4. Potential Energy and GHG Savings from Industrial Buildings

Table 5-10 compares the three scenarios for potential future energy and GHG emissions for Blacksburg's industrial sector in 2050.

Table 5-10. Energy and GHG Reductions (2050)

	Percent GHG Reduction	Energy Consumption (mmBtu)	GHG (metric tons CO_2-e)	GHG Savings (metric tons CO_2-e)
Baseline	-	644,446	78,157	NA
Conservative	30%	451,112	54,710	23,447
Aggressive	60%	257,778	31,263	46,894
Maximum	88%	86,029	10,739	67,418

The conservative scenario represents a 30 percent reduction in GHG emissions, which would reduce energy use from a baseline of 644,000 million Btu to 451,000 million Btu. The aggressive scenario assumes an overall reduction in GHG emissions by 60 percent. In this scenario energy use falls to 258,000 million Btu. The maximum scenario assumes additional, technological improvements and a 88 percent decrease in GHG emissions by 2050. This would result in energy consumption of 86,000 million Btu. Figure 5-17 compares energy consumption under each scenario.

Figure 5-17. Projected Industrial Sector Energy Consumption (2050)

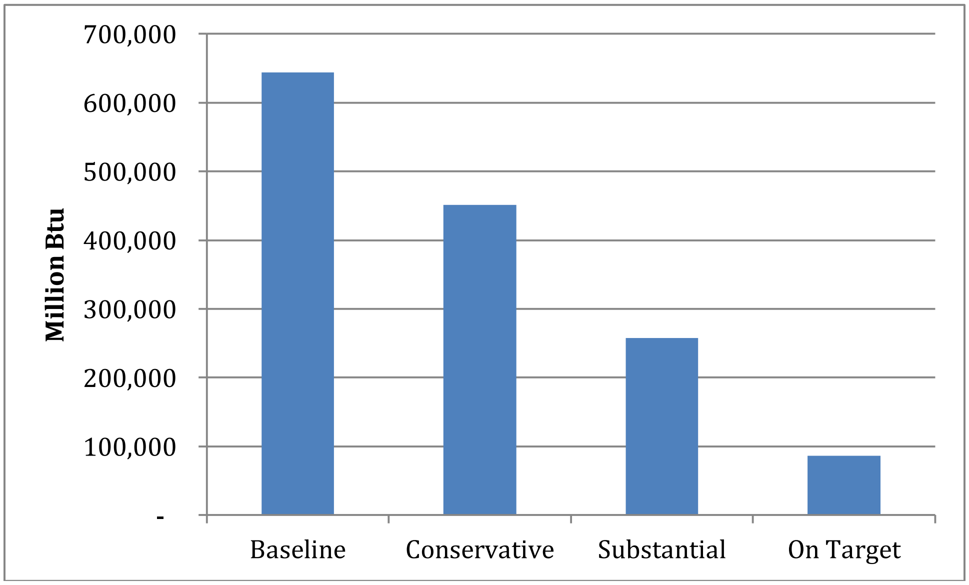
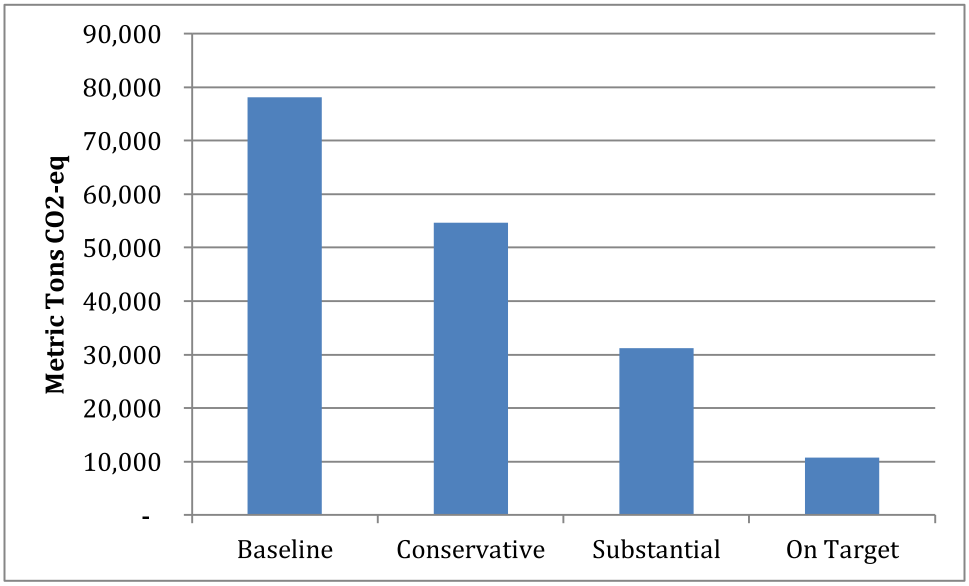


Figure 5-18 compares the GHG emissions under the three scenarios for the Blacksburg industrial sector in 2050. The conservative scenario represents a 30 percent reduction. Emissions drop from a baseline of 78,200 metric tons CO_2-e to 54,700 tons CO_2-e. The aggressive scenario assumes an overall reduction of GHG emissions by 60 percent. Emissions fall to 31,300 metric tons CO_2-e. The maximum scenario envisions even more substantial technological improvements and that by 2050 GHG emissions have fallen 88 percent. This would result in GHG emissions of 10,700 metric tons CO_2-e.

Figure 5-18. Projected Industrial Sector GHG Emissions (2050)



5.5. Combined Commercial and Industrial Sector GHG Savings

This section summarizes the combined commerical and industrial GHG savings realized in each of the scenarios described above.

Figure 5-19. Combined GHG Emissions Savings from Conservative Scenarios

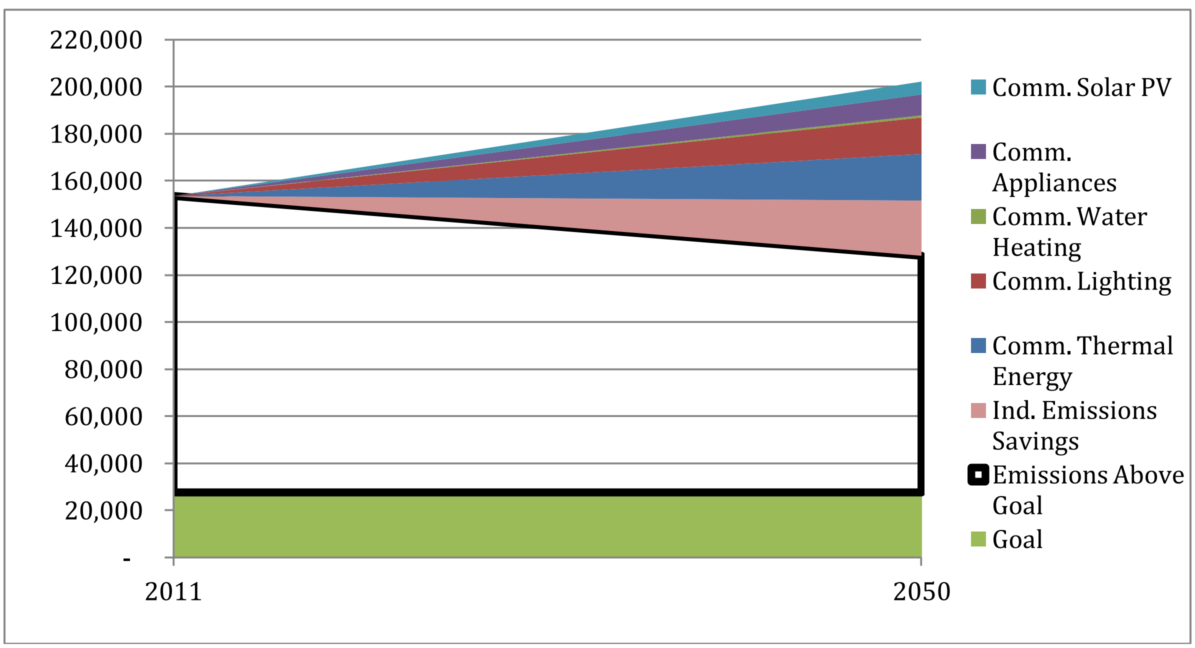
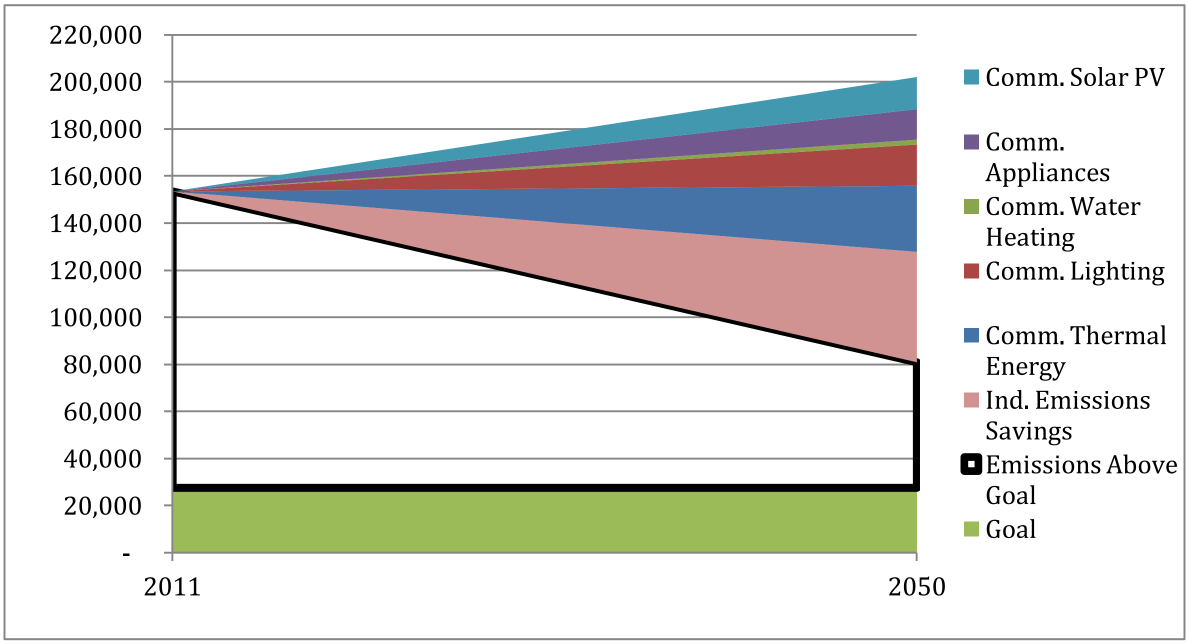
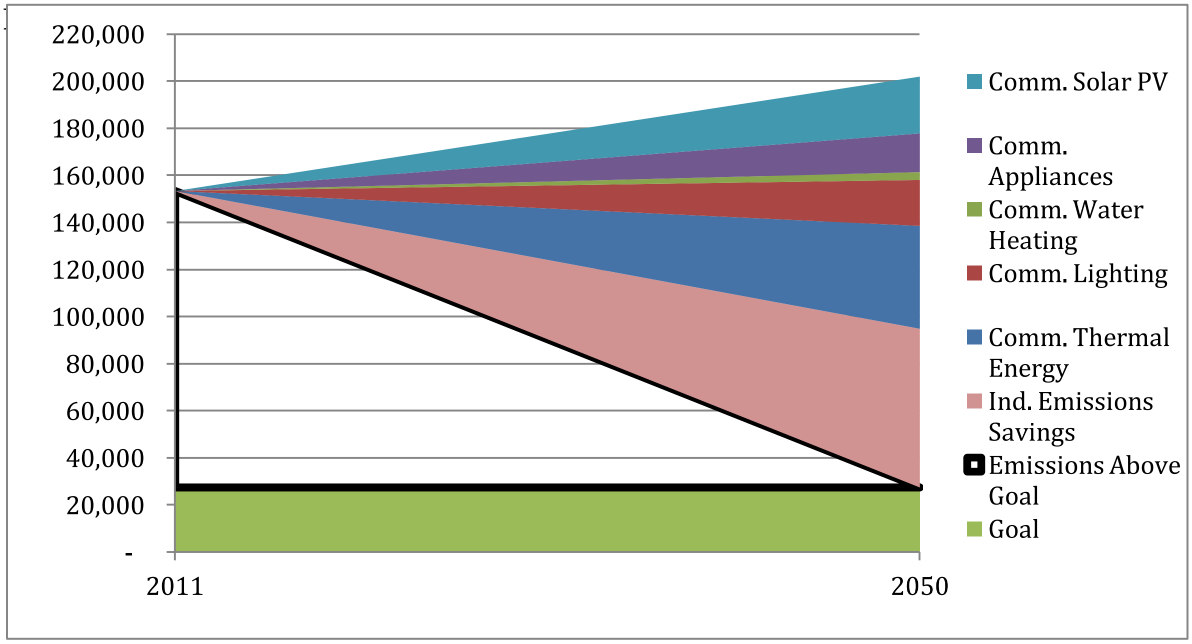


Figure 5-19 displays the GHG savings under the conservative scenario. Emissions are reduced significantly from the combined baseline projection of 202,000 metric tons CO2-eq to only 128,000 metric tons CO2-eq, a 37% improvement. However this figure is still 100,000 metric tons above the goal of 27,500 metric tons CO2-eq, which represents an 80% drop from Blacksburg's estimated 1990 emissions total.

Figure 5-20. Combined GHG Emissions Savings from Substantial Scenarios



Under the substantial scenario, GHG emissions are further reduced to 80,900 metric tons CO2-eq. This represents a 60 percent reduction from the baseline projection, but still falls 53,400 metric tons short of the 2050 goal.



The on target scenario describes the actions necessary to reach our 2050 emissions goal. Under this scenario, 86 percent of baseline emissions are avoided through more efficient commercial and industrial technologies, and the extensive use of solar photovoltaic systems on the roofs of commercial buildings.

5.6. Goals, Objectives, and Strategies: Commercial and Industrial Sectors

Goal 1: Establish programs and incentives to reduce greenhouse gas emissions from commercial and industrial buildings by 45% by 2050.

Objective 1-A: Reduce greenhouse gas emissions from existing commercial and industrial buildings.

Community Strategies

Strategy 1: Create a local green business certification program that recognizes local businesses that have achieved energy efficiency improvements.

a. Provide commercial buildings with a tiered certification system, where higher tiers provide more advertising incentives to businesses making the upgrade to energy-efficient appliances.

b. Provide stickers with the Go Green NRV, or the Town of Blacksburg logo to put on store windows to advertise certification.

c. Provide space in the NRV News or Topix to recognize participating businesses.

Strategy 2: Implement power management programs to assist commercial buildings with appliance energy reductions.

Strategy 3: Encourage Virginia Tech Electric and Appalachian Electric Power (AEP) to implement Demand Side Management (DSM) for local businesses.

<u>Government Strategies</u>

Strategy 1: Apply for federal grants to fund rebate and replacement programs to support energy efficiency upgrades and reach a 5% participation rate in said efficiency program.

Strategy 2: Establish a program to provide free energy audits to commercial property owners or developers who are committed to investing in energy-efficient retrofits.

Strategy 3: Pursue grant funds that may be used to provide low or zero-interest loans to incentivize investments in energy-efficient retrofits and help commercial buildings meet the up-front cost of appliance upgrades.

Strategy 4: Consider reducing property tax liability for businesses that have made energy-efficient retrofits.

Strategy 5: Sponsor or create an appliance trade-in program to assist with the transition to more energy-efficient appliances.

Strategy 6: Create a water heating efficiency improvement fund that can be used to generate educational resources and to distribute rebates and/or grants to commercial consumers.

Objective 1-B: Reduce greenhouse gas emissions from new commercial and industrial buildings.

<u>Community Strategies</u>

Strategy 1: Encourage new commercial and industrial businesses to participate in local green business certification programs.

<u>Government Strategies</u>

Strategy 1: Apply for grant programs to provide zero (or low) interest loans to help commercial buildings meet the up-front cost of appliance upgrades.

Strategy 2: Develop an incentive program for projects certified to the U.S. Green Building Council LEED-NC (new construction) program.

Strategy 3: Implement density bonuses to encourage designs that provide solar and other energy saving measures.

Goal 2: Increase the use of renewable energy in the commercial/industrial sector.

Objective 2-A: Meet 2.5% of commercial energy demand with on-site solar photovoltaic (PV) systems by 2020 and 10% by 2050.

Community Strategies

Strategy 1: Identify commercial rooftops with the capability to support solar PV systems.

Strategy 2: Introduce a certification system to reward businesses that derive power from solar PV systems.

Strategy 3: Take advantage of existing federal tax credits and potential future state incentives to reduce the upfront costs of installing a PV system.

Strategy 4: Explore opportunities for renter businesses to work with commercial property owners to install solar PV systems on the spaces they lease.

Strategy 5: Identify collaborative financing options for large-scale systems, such as privately owned and operated joint ventures.

Government Strategies

Strategy 1: Provide tax incentives for owners of commercial buildings or rental units who install solar PV systems, such as property tax waivers on all PV equipment.

Strategy 2: Identify all potential regulatory barriers at the town-level for the installation of solar PV systems, such as those associated with obtaining necessary permits.

Strategy 3: Streamline the application and approval process for solar PV systems.

Strategy 4: Consider a fast-track permitting program for solar PV applications.

Strategy 5: Entertain possibilities for public/private partnerships in which both the town and private citizens combine resources to establish a large PV system.

Strategy 6: Consider implementing a public loan program for businesses to purchase solar PV equipment from the Town and pay back the loan through property tax assessments.

Goal 3: Reduce energy use and GHG emissions associated with other aspects of commercial and industrial operations.

Objective 3-A: Reduce energy use and GHG emissions from industrial processes.

Community Strategies

Strategy 1: Take advantage of the Department of Energy Industrial Technology Program, which sponsors energy audits for manufacturing plants.

Strategy 2: Foster collaborations among area industrial businesses to share information on energy efficiency improvements and pool resources to purchase energy-efficient materials or equipment.

Government Strategies

Strategy 1: Provide education and assistance programs that encourage industrial facilities to take advantage of federal and state programs like the DOE's Industrial Technology Program.

Objective 3-B: Reduce energy use and GHG emissions associated with transportation in the commercial and industrial sector.

Community Strategies

Strategy 1: Encourage employers to provide incentives to employees who regularly bicycle or walk to work.

Strategy 2: Use a local green business certification program to encourage business owners to provide employees with more bicycle racks, secure parking, showers, and bicycle repair facilities.

Strategy 3: Demonstrate that at least 10% of employers encourage and/or provide incentives for employees to use alternative transportation to commute, adopt a flexible schedule, or telecommute.

Strategy 5: Provide parking or financial benefits to employees who use alternative/efficient vehicles.

Strategy 6: Encourage local businesses to offer improved parking places for efficient or alternatively fueled vehicles.

Government Strategies

Strategy 1: Establish an "Adopt-A-Stop" campaign in which local organizations and businesses sponsor a bus station, thus encouraging bus commuting.

Strategy 2: Develop and implement a comprehensive bicycle parking program throughout Town and in coordination with Blacksburg Transit to install bicycle racks at public sites and commercial locations.

Strategy 3: Utilize public transportation to stimulate economic development in the community, including telecommunications. *(Comprehensive Plan; Transportation; Mass Transit; R)*

a. Continue to work with area developers and community businesses to ensure public transportation accessibility and bus stops are included in their development plans.

b. Support expansion of public transportation to better serve citizens who commute to and from work.

Objective 3-C: Reduce waste from Blacksburg businesses and require recycling for all Blacksburg businesses/industry.

Community Strategies

Strategy 1: Encourage businesses/industry to purchase products with less packaging materials and buy in bulk.

Strategy 2: Discourage the use of Styrofoam take out containers and cups and other non-recyclable containers in restaurants.

Strategy 3: Encourage restaurants to provide compostable take-out containers.

Government Strategies

Strategy 1: Continue work to implement a downtown business recycling program

Strategy 2: Expand recycling services to other businesses and industries in the community.

Objective 3-D: Provide opportunities for all Blacksburg businesses/industry to compost organic waste, particularly for restaurants.

Community Strategies

Strategy 1: Promote food diversion and composting in the community, including business donations of usable but non-saleable food items to local pantries.

Strategy 2: Educate local businesses/industry about the value of composting.

Strategy 3: Encourage businesses/industry to contract for composting services.

Government Strategies

Strategy 1: Continue to compost organic waste at town-sponsored events.

Strategy 2: Begin offering composting at town facilities.

Goal 4: Establish education and outreach programs to encourage commercial/industrial energy efficiency.

Objective 4-A: Provide business owners/industrial facility operators with information on opportunities to reduce space heating and cooling energy consumption.

Community Strategies

Strategy 1: Raise/lower temperature set points to reduce cooling/heating demand.

Strategy 2: Install programmable thermostats to reduce heating/cooling demand when building has low occupancy.

Strategy 3: Improve building envelope performance.

a. Seal exterior cracks and leaks with caulk, spray foam, or weather stripping.

b. Install/upgrade insulation in basements, crawl spaces, ceilings, floors, exterior walls, and foundations.

c. Install a vapor barrier or vapor barrier diffusion retarder to control moisture in basements, crawl spaces, ceilings, floors, walls, and foundations.

d. Install ENERGY STAR rated or energy-efficient roofing materials.

e. Install awnings, shades, storm windows, window treatments, or coverings to reduce winter heat loss and summer heat gain.

f. Replace current windows, skylights, and exterior doors with ENERGY STAR-rated or other energy-efficient models.

Strategy 4: Upgrade current heating, ventilating, and air-conditioning (HVAC) systems to ENERGY STAR rated or other energy-efficient systems.

Strategy 5: Reduce lighting requirements or improve lighting systems to reduce air-conditioning loads.

Strategy 6: Track energy usage monthly to see if there are peak months for energy usage, and then find ways to reduce consumption during those months.

Strategy 7: Encourage behavioral change that reduces unnecessary heating and cooling energy consumption (e.g. wear a sweater instead of turning up the heat).

Government Strategies

Strategy 1: Provide public facilities that serve as examples of the desired development quality in Town. Design and construct new government buildings that are LEED certified. As older existing buildings are renovated, design and construct the renovations to achieve LEED certification.

Objective 4-B: Provide business owners/industrial facility operators with lighting energy reduction suggestions.

Community Strategies

Strategy 1: Replace traditional lighting with more efficient lighting technologies.

a. Install LED lighting in office and retail buildings, which have the greatest lighting demand in the commercial sector.

b. Install CFL ligh bulbs in remaining commercial buildings (i.e. lodging, restaurants).

Strategy 3: Install motion sensors and/or dimmers to reduce unnecessary energy usage.

a. Install dimmers in restaurant and lodging settings.

b. Install motion sensors in retail and office spaces.

Strategy 4: Reduce lighting demand during periods of non-use.

a. Have janitorial staff in schools, churches, office buildings, etc finish most of their duties during normal work hours rather than after hours.

b. Turn off lights in retail stores and other commercial buildings after hours.

Strategy 5: Attend Go Green NRV workshops and information sessions in the community to find out more about lighting upgrades.

Government Strategies

Strategy 1: Partner with Go Green NRV to create lighting upgrade workshops for business owners in the commercial sector.

Strategy 2: Offer commercial buildings potential cost savings analysis for their particular building.

a. Use potential cost savings as a tool to interest commercial building owners in lighting upgrades.

b. Tailor savings to specific building types and use.

Strategy 3: Create and distribute pamphlets, flyers, or mailers that explain the significant energy and cost savings available from lighting upgrades.

Objective 4-C: Provide business owners/industrial facility operators with appliance energy reduction suggestions.

Community Strategies

Strategy 1: Replace inefficient appliances with ENERGY STAR products wherever possible.

Strategy 2: Turn off nonessential office equipment when not in use.

Strategy 3: Apply smart metering for appliances/office equipment to cut down on non-essential, off-peak energy usage.

Strategy 4: Maintain and repair all appliances to ensure optimal performance and reduce energy losses.

Strategy 5: Use the Sustainable Blacksburg website to share information about the energy savings that can be achieved by upgrading to ENERGY STAR appliances.

a. Include an energy savings calculator that can show potential savings by upgrading appliances.

b. Include graphs that show average energy savings over time as a function of the initial cost of the appliance.

c. Include business/industry relevant ENERGY STAR devices/appliances on the website.

d. Continue to provide the most up-to-date material on new device/appliance technologies and conservation strategies.

Strategy 6: Encourage Go Green NRV to host educational seminars for local businesses/industry focused on efficient appliances.

Government Strategies

Strategy 1: Update the Town of Blacksburg's website to include resources for commercial/industrial appliance upgrades.

a. Provide links to relevant community web pages, including Sustainable Blacksburg and Go Green NRV's appliance resources.

b. Continue to provide the most up-to-date material on new appliance technologies and conservation strategies.

Strategy 2: Hold educational seminars instructing businesses/industry on the benefits of making appliance upgrades and applying energy conservation techniques.

Strategy 3: Distribute flyers to businesses/industry with quick facts about efficient appliances and conservation strategies.

Objective 4-D: Provide business owners/industrial facility operators with water heating energy reduction suggestions.

<u>Community Strategies</u>

Strategy 1: Encourage behavioral change that reduces unnecessary hot water consumption; i.e. use cold water for dishwashing.

Strategy 2: Ensure that low-flow fixtures are installed to reduce water demand in commercial/industrial buildings.

Strategy 3: Reduce water heating energy use in the commercial/industrial sector by retrofitting inefficient water heating systems.

Strategy 4: Repair leaks in pipes to minimize wasted water in commercial buildings/industrial facilities.

Strategy 5: Wrap hot water tanks and pipes with insulation blankets to reduce heat loss.

Strategy 6: Upgrade inefficient water heaters with more efficient models.

a. Replace gas-fired water heaters with more efficient gas-condensing or electric models.

b. Install ground source heat pumps where appropriate.

c. Install solar water heaters to supplement or replace traditional water heating technologies.

Strategy 7: Use the Sustainable Blacksburg website to share information about the energy savings that can be achieved by upgrading inefficient water heating systems.

a. Include an energy savings calculator that can show savings related to water heating upgrades.

b. Include graphs that show average energy savings over time as a function of the initial cost of the system upgrade.

c. Provide a comprehensive list of potential water heating system upgrades.

d. Provide a list of practical water conservation strategies.

Strategy 8: Encourage Go Green NRV to host educational seminars for local businesses/industry focused on water heater efficiency.

Government Strategies

Strategy 1: Encourage a hot water consumption audit as part of a comprehensive energy audit.

Strategy 2: Update the Town of Blacksburg's website to include resources for commercial/industrial hot water upgrades.

a. Provide links to websites that describe various water heating technologies, including the websites for Sustainable Blacksburg and Go Green NRV.

b. Provide information on water conservation strategies.

c. Continue to provide the most up-to-date material on new water heater technologies and water conservation strategies.