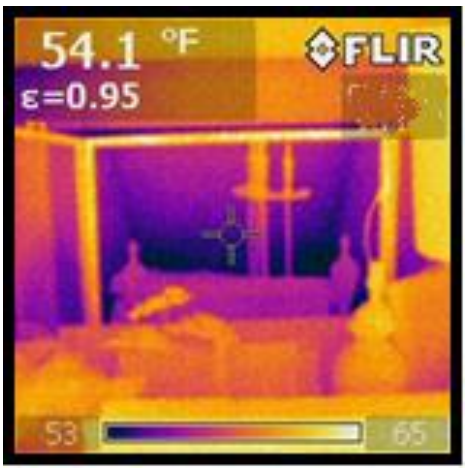
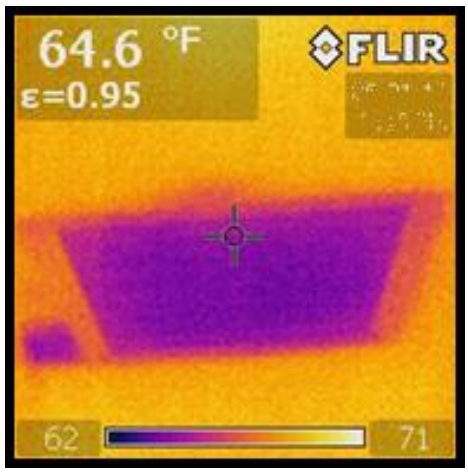
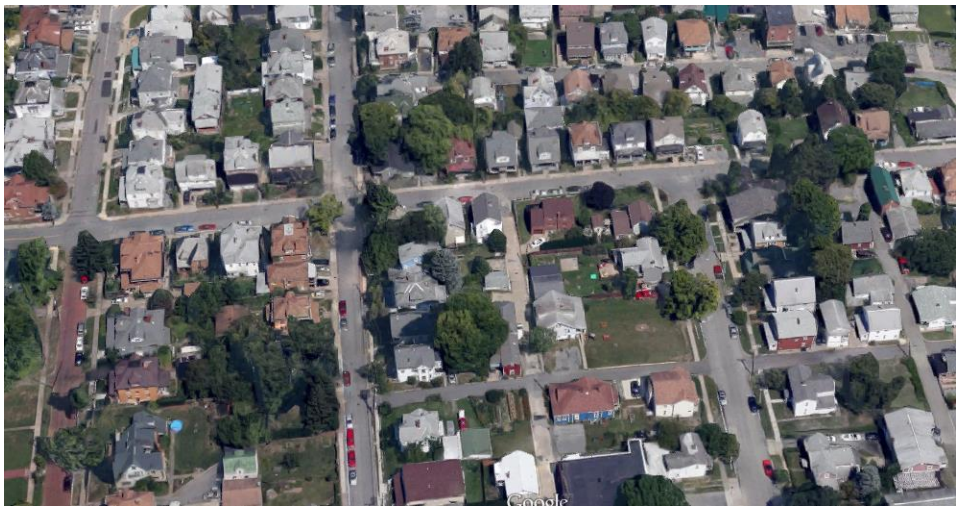
Opportunities for Reducing Commercial and Residential Greenhouse Gas Emissions in Morgantown, West Virginia







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Appalachian Stewardship Foundation

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Opportunities for Reducing Commercial and Residential Greenhouse Gas Emissions in Morgantown, West Virginia

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ABBREVIATIONS

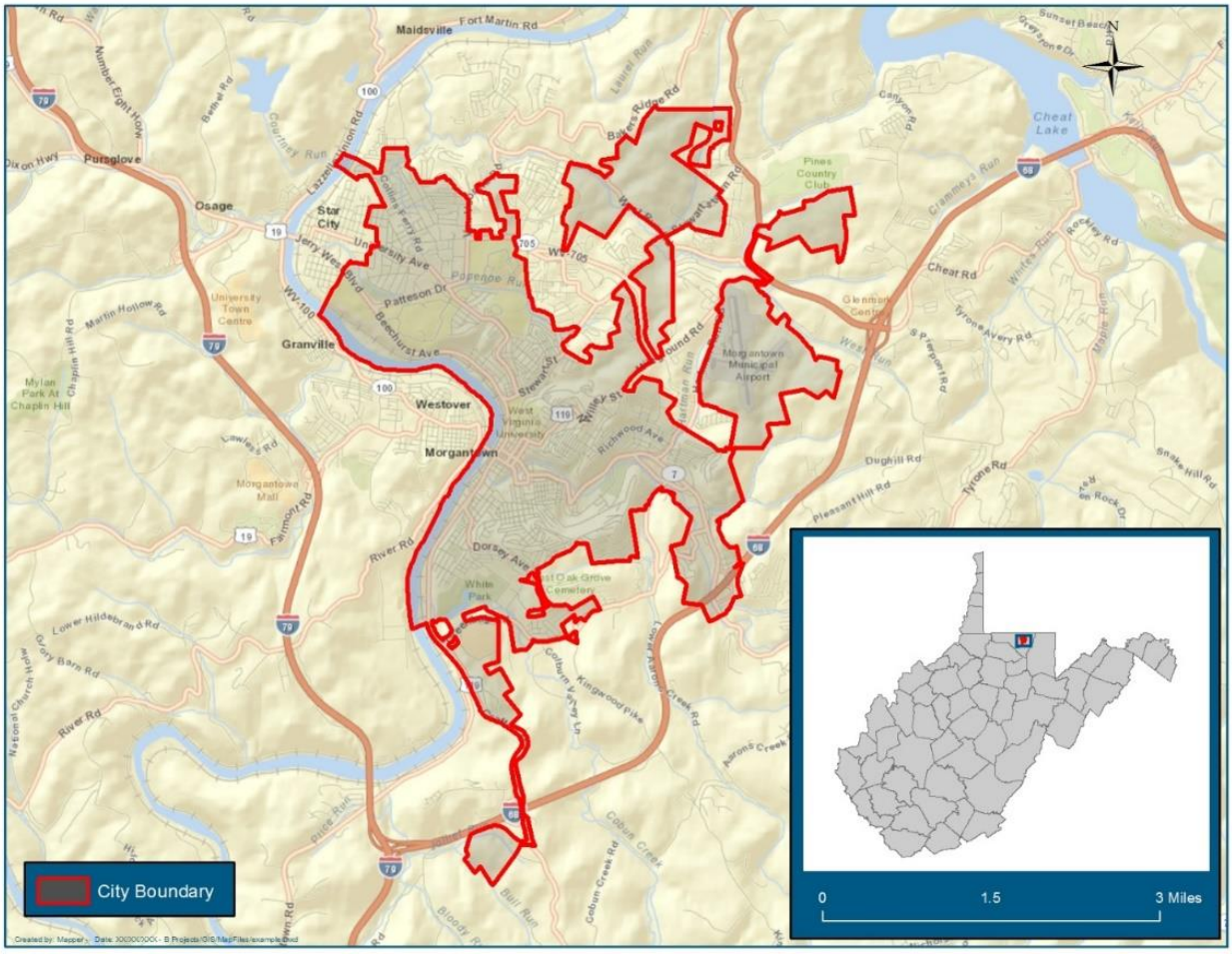
CFL	compact fluorescent
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
GHG	greenhouse gas
HVAC	heating, ventilation, and air conditioning
IRP	integrated resource planning
kWh	kilowatt-hour
LED	light-emitting diode
LEED	Leadership in Energy and Environmental Design
LTI	Leonardo Technologies, Inc.
Mon Power	Monongahela Power Company
MMBtu	million British thermal units
MT	metric ton
MW	megawatt
NREL	National Renewable Energy Laboratory
PV	photovoltaic
USDOE	United States Department of Energy
USEIA	United States Energy Information Administration
USEPA	United States Environmental Protection Agency
WVPSC	West Virginia Public Service Commission
WVU	West Virginia University

1. INTRODUCTION

Morgantown, a small city in north-central West Virginia that is home to West Virginia University (WVU), emits a significant quantity of greenhouse gases (GHG). According to a 2012 baseline inventory, the Morgantown community emitted over 800,000 metric tons of carbon dioxide equivalents (MT CO_2e)[1] (See (See Figure 1 and Table 1).

Within the built environment, the commercial sector is responsible for 72% of emissions—mostly from the use of electricity. The residential sector is responsible for an additional 25% of emissions in the built environment (See next-to-final column in Table 2).

Figure 1: City of Morgantown



[1] For a given mixture and amount of GHGs, CO_2e is the amount of CO_2 that would have the same global warming potential over a specified timescale.

When compared to all emissions—including the built environment and other sectors—commercial emissions make up 40% of the total, and residential emissions make up 14% of the total (See final column in Table 2).

In this report, we identify promising energy-saving projects that Morgantown business owners and homeowners can implement to save money while reducing GHG emissions and other associated pollution. This is the second of a three-phase project that aims to reduce GHG emissions in Morgantown; the first phase produced a baseline GHG emissions inventory, and the third phase is now focusing on implementation.

Table 1: Summary of emissions in Morgantown (2012, MT CO_2e)

Sector	Emissions
Built environment	
Electricity	347,434
Natural gas and other stationary fuels	96,314
Subtotal, built environment	443,748
Other sectors	
Water and wastewater	6,982
Solid waste	9,656
Transportation	345,308
Total	**805,694**

Source: Simcoe et al. (2014). Note: This table shows activity-based and not source-based emissions.

Table 2: Emissions in Morgantown from the built environment, by sector and fuel (2012, MT CO_2e)

Sector	Electricity	Natural gas	Other stationary fuels	Total	Percent of built environ. emissions	Percent of total emissions
Commercial	276,395	44,930	0	321,325	72%	40%
Residential	64,505	44,922	537	109,964	25%	14%
Other sectors	6,534	5,925	0	12,459	3%	2%
Total	**347,434**	**95,777**	**537**	**443,748**	**100%**	**55%**

Source: Simcoe et al. (2014). Note: This table shows activity-based and not source-based emissions. Totals do not match due to rounding.

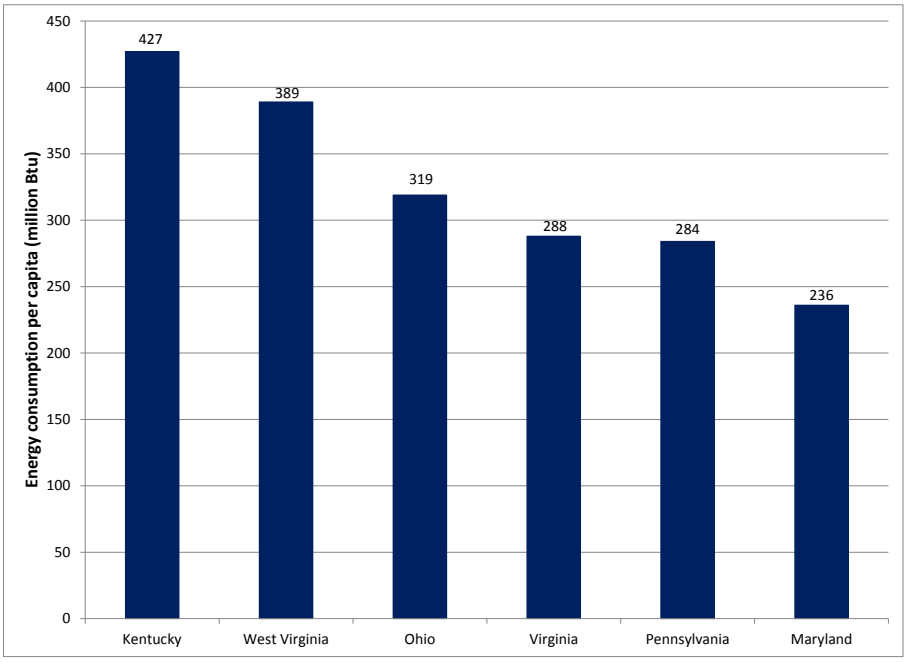
The Monongahela Power Company ("Mon Power"), a subsidiary of FirstEnergy, provides electricity to the city of Morgantown. FirstEnergy is an investor-owned utility company that operates in six states, serves 6 million customers, and maintains approximately 18,000 megawatts (MW) of generating capacity. Recently, Mon Power acquired the 40-year-old Harrison Power Station. This purchase cost will be recouped by raising customer rates by up to $858 million (Ward, 2013). In addition, Morgantown's customer rates have and will continue to be affected by rising coal prices, CO_2 mitigation costs, storm damage repair costs, increased tree trimming costs, and other factors.

Dominion Hope, the local natural gas utility company, serves all of West Virginia and is a subsidiary company of Dominion. Dominion has a portfolio of approximately 24,600 MW of generation capacity; 12,400 miles of natural gas transmission, gathering, and storage pipeline; and 6,455 miles of electric transmission. Additionally, it operates one of the nation's largest natural gas storage systems, with 949 billion cubic feet of storage capacity. Dominion serves retail energy customers in 12 states. (Dominion, 2015)

West Virginia is a net exporter of electricity and a national leader in interstate electricity sales. In 2012, the state generated 233% of the electricity consumed within its borders (USEPA, 2014a). Approximately 95% of the electricity produced in West Virginia comes from coal-fired power plants (USEIA, 2015a). Despite its relatively low rates, West Virginians pay disproportionately high energy bills. The state has the highest residential electricity consumption per household among the 13 Appalachian states (Van Nostrand, 2013a) and the fifteenth-highest total energy consumption per capita in the nation (USEIA, 2015b). West Virginia's

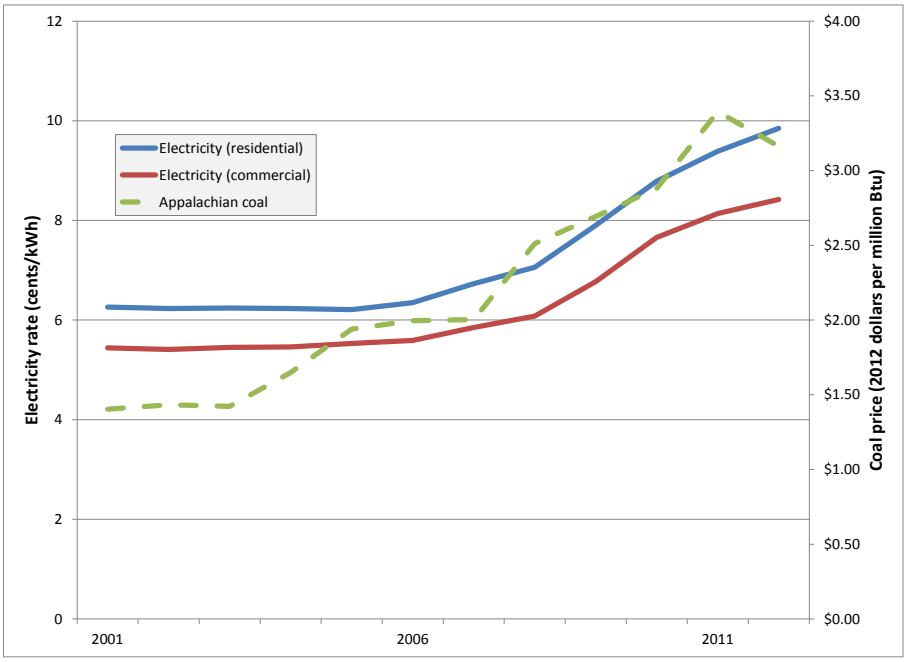
per capita energy consumption is greater than four of five neighboring states—all except Kentucky (See Figure 2). The dominance of coal in West Virginia's electricity generation portfolio means that electricity rates closely track coal prices, which have increased recently and are projected to continue increasing in the future (See Figure 3).

Figure 2: Energy consumption per capita



Source: USEIA (2015b).

Figure 3: Historic electricity and coal prices



Sources: Coal prices from USEIA (2014a). Electricity rates from USEIA (2015c).

2. BACKGROUND

This project builds upon and supports the City's participation in the Mayors Climate Protection Agreement, the Morgantown Comprehensive Plan, and the Morgantown Planning and Zoning Code (See Sections 2.1 through 2.3). In addition, statewide building codes for residential and commercial construction (See Section 2.4) and Mon Power's energy efficiency programs (See Section 2.5) dovetail with the findings and recommendations in this report.

2.1 Mayors Climate Protection Agreement

In 2005, as a response to the Kyoto Protocol to the United Nations Framework Convention on Climate Change, the United States (US) Conference of Mayors drafted the Mayors Climate Protection Agreement. The City of Morgantown signed the Agreement in 2007 and is one of over a thousand municipalities across the country to have done so. The Agreement urges the federal government to reduce GHG emissions by 7% from a 1990 baseline year by 2012. It requests that Congress pass bipartisan GHG-reduction legislation with clear timetables and emissions limits and a flexible, market-based system of tradable allowances among emitting industries. Additionally, by signing the agreement, Morgantown has agreed to meet the Kyoto Protocol goals and targets on a local scale. (US Conference of Mayors, 2005)

In 2007, after Morgantown signed the Mayors Climate Protection Agreement, the Morgantown City Manager established the Morgantown Municipal Green Team. The Green Team serves as an advisory committee to help guide public policy, planning, and evaluation of energy and environmental affairs within the city (City of Morgantown, 2015a).

In 2008, with help from the Green Team, The City of Morgantown began working towards the Mayors Climate Protection Agreement's goals and began taking steps to decrease energy consumption. The City hired a private firm to implement an energy savings performance contract to decrease energy consumption at City-owned buildings and facilities. The firm installed retrofits that, as of 2013, had saved the city more than $500,000. (City of Morgantown, 2015b)

In addition, the City began transitioning its fleet of vehicles. Code Enforcement Department vehicles were switched to smaller, more efficient vehicles, and Planning Department vehicles are scheduled to be switched soon. (Mikorski, 2015)

While these two projects have undoubtedly reduced energy consumption and GHG emissions, they were undertaken before a GHG inventory was completed.

2.2 Morgantown Comprehensive Plan

A well-articulated, decisive community plan is essential for identifying and achieving a community's goals for itself. Morgantown's most recent Comprehensive Plan, released in 2013, recognizes the benefits of setting energy and environmental goals. Building on recommendations from the Green Team, the Comprehensive Plan established Objective 5: Promoting energy conservation and green building. This objective is broken into five attainment measures:

- update zoning and building codes to accommodate alternative energy generation;
- create a Green Building Program that provides incentives for use of "green" building techniques that are energy efficient and environmental friendly;
- design and construct future city buildings and facilities using [Leadership in Energy and Environmental Design, or] LEED standards;
- incorporate LEED standards into renovations of City buildings and facilities; and

- meet regularly with WVU to remain informed, provide input, and collaborate on strategies identified in WVU's Sustainability Strategic and Action Plan (City of Morgantown, 2013a, p. 72).

Throughout the public input period, participants provided many recommendations pertaining to energy conservation and efficiency measures. Residents called for clean energy, access to alternative energy resources, and a decrease of GHG emissions. In fact, city residents voted Objective 5 as the highest environmental priority. (City of Morgantown, 2013b)

2.3 Morgantown Planning and Zoning Code

The Morgantown Planning and Zoning Code contains very limited language related to energy consumption and efficiency. First, pursuant to the Sunnyside-Up Comprehensive Revitalization Plan (Environmental Planning and Design, 2004), the Code notes that, within the Sunnyside neighborhood:

> "building materials which promote energy efficiency and sustainability should constitute a minimum of thirty-five (35) percent of the total materials used to construct a [new] building."[2]

Additionally, the Code states that:

> "plantings should be arranged to promote energy conservation wherever practicable; e.g. use of tall deciduous trees on the south and west sides of buildings to provide shade from the summer sun and planting evergreens on the north of buildings to dissipate the effect of winter winds."[3]

Data collected in this project will provide city leaders with more information with which to make informed planning and zoning considerations.

2.4 Statewide building codes

The State of West Virginia adopted the 2009 International Energy Conservation Code in 2012, and it has been in effect since 2013. This building code is expected to save the average West Virginia homeowner $1,996 over the lifetime of a 30-year mortgage (USDOE, 2012). This building code has many requirements, which include:

- the building must be properly sealed, including any necessary caulking or weather stripping to minimize unregulated air infiltration;
- all ducts must be properly sealed and insulated;
- 50% of the permanently installed lighting in the home must be high-efficiency; and
- an efficiency measure certificate must be placed on or near the electric breaker box, with information about specific efficiency improvement measures carried out in the home, including insulation ratings, U-values of windows and doors, and information about the heating, ventilation, and air conditioning (HVAC) systems (International Code Council, 2009).

The State of West Virginia also adopted the ASHRAE 90.1-2007 commercial building energy code in 2012, and it has been in effect since 2013. This code contains energy standards similar to those in the residential building energy code; however, it contains significantly more language related to facility lighting, refrigeration, and HVAC systems.

[2] City of Morgantown Planning and Zoning Code, 2015, Article 1361.03.
[3] City of Morgantown Planning and Zoning Code. 2015. Article 1367.06.

2.5 Mon Power's energy efficiency programs

Mon Power initiated its energy efficiency programs in 2012. The programs are expected to achieve "an aggregated amount of energy efficiency reductions of 0.5% of distribution sales in the delivery year ending May 31, 2018"—a reduction of 0.1% per year (WVPSC, 2011). This is less than levels being achieved in 40 other states and what is actively being achieved by other subsidiaries of FirstEnergy (Van Nostrand, 2013b).

Currently, Mon Power provides one program for commercial businesses and two residential energy efficiency programs. For commercial businesses, the Lighting for Business Program provides performance-based incentives of 5 cents per kilowatt-hour (cents/kWh) saved through use of efficient lighting equipment and controls—as calculated via a FirstEnergy calculator tool. Both new construction and retrofits are eligible for this incentive. (FirstEnergy, 2015a)

For homes, the Home Energy Analyzer tool helps residential electricity consumers evaluate major sources of energy use, identify ways to save energy, take steps to improve efficiency and ultimately save money (FirstEnergy, 2015b).

In addition, the Low Income Home Check-Up Program provides eligible low-income households with in-home energy assessments. Households enrolled in this program receive an energy-savings plan, and in some cases they receive energy-saving home improvements. (FirstEnergy, 2015c)

3. COMMERCIAL SECTOR

Nationwide, small businesses spend more than $60 billion per year to keep the lights on and the temperature controlled (USEPA, Undated(a)). In Phase 1, Morgantown's commercial sector[4] was identified as the largest contributor to GHG emissions and the largest consumer of energy from fossil fuels. As shown above in Table 2, the commercial sector is responsible for 72% of emissions from the built environment and 40% of all emissions from the Morgantown community.

Table 3 further subdivides these emissions into direct and indirect emissions. Direct emissions include those generated at the point of fuel combustion: at a power plant for electricity use and at the commercial site where natural gas is burned.

Indirect electricity emissions include those associated with the electricity that is lost to heat when transmitted through power lines and upstream emissions: those from the energy consumed in order to extract, process, and deliver fuels to electricity generation facilities.

Indirect natural gas emissions account for the leakage of natural gas as well as emissions associated with secondary fuels that are used in the natural gas supply chain.

In total, the commercial sector was responsible for 321,325 MT CO_2e in 2012 (Table 3). This total, however, includes not just private businesses, but also the City of Morgantown and WVU. After subtracting the emissions from the City of Morgantown and WVU, emissions from commercial establishments totaled 220,104 MT CO_2e in 2012 (Table 4).

In this chapter, we investigate the energy and cost savings and GHG emission reductions that could be achieved via implementation of energy efficiency recommendations at commercial establishments in Morgantown, and we compare the calculated emission reductions against this total.

Table 3: Commercial emissions in Morgantown (2012, MT CO_2e)

Fuel	Direct emissions	Indirect emissions	Total emissions
Electricity	237,374	39,021	276,395
Natural gas	36,506	8,423	44,930
Total	**273,880**	**47,444**	**321,325**

Source: Simcoe et al. (2014). Note: This table shows activity-based and not source-based emissions. Totals do not match due to rounding.

Table 4: Commercial emissions in Morgantown from the City of Morgantown, West Virginia University, and commercial establishments (2012, MT CO_2e)

Fuel	Total	City of Morgantown	West Virginia University	Commercial establishments
Electricity	276,395	1,568	87,200	187,627
Natural gas	44,930	4,750	7,702	32,477
Total	**321,325**	**6,318**	**94,902**	**220,104**

Source: Simcoe et al. (2014). Note: This table shows activity-based and not source-based emissions. Totals do not match due to rounding.

[4] Commercial GHG emissions are accounted for separately from industrial GHG emissions in the Phase 1 report.

3.1 Commercial energy assessment results

From 2010 through 2014, the WVU Industrial Assessment Center and Downstream Strategies conducted energy assessments for 250 small businesses across West Virginia. Assessment reports for each business included specific recommendations, energy savings estimates, implementation costs, and potential CO_2 emission reductions. Nearly 90 of these assessments were conducted within Morgantown. The Morgantown assessments included almost 140 efficiency improvement recommendations. In many cases, efficiency retrofits were cost-effective, meaning that the potential savings on utility bills would pay for the retrofits in a few years or, in some cases, a matter of months. (WVU Industrial Assessment Center and Downstream Strategies, 2010-2014)

For this analysis, we compiled data from these commercial energy assessments into a comprehensive database, which provides insight on the benefits of energy efficiency measures, including energy savings, payback periods, and subsequent GHG reductions.

In this report, assessment recommendations are analyzed by fuel because they will reduce the consumption of electricity, natural gas, or both. In the following section, we explore the average electricity savings, cost savings, annual GHG emission reductions, retrofit cost, and payback period of each recommendation. In general, these recommendations are divided into three categories: lighting, HVAC, and windows.

Table 5: Electricity-only recommendations

Recommendation	Rec. count	Average electricity savings (kWh/yr)	Average electricity cost savings ($/year)	Average GHG emission reductions (lbs CO_2e/year)	Average retrofit cost ($)	Average payback period (years)
Lighting						
Lighting retrofits	88	6,790	579	11,950	1,148	2.1
Exit sign retrofits	11	631	34	1,110	82	2.5
Occupancy sensors	1	5,886	589	10,359	120	0.2
HVAC						
Programmable thermostat	3	6,474	500	11,394	463	1.0
Windows						
Double-pane glass windows	2	12,028	1,169	21,169	23,980	16.4
Total	**105**	**6,227**	**531**	**10,959**	**1,441**	**2.4**

Source: WVU Industrial Assessment Center and Downstream Strategies (2010-2014). Note: Counts are counts of recommendations and not of businesses. Recommendations are omitted that are not representative of opportunities at a broad range of businesses. Average payback periods in each row are averages of the payback periods calculated individually for each recommendation in that row. GHG emission reductions include direct and indirect emissions of CO_2 and other GHGs, and are calculated in a manner consistent with the Phase 1 Morgantown GHG inventory (Simcoe et al., 2014).

Table 6: Natural gas-only recommendations

Recommendation	Rec. count	Average natural gas savings (MMBtu/yr)	Average natural gas cost savings ($/year)	Average GHG emission reductions (lbs CO_2e/year)	Average retrofit cost ($)	Average Payback period (years)
Lighting						
None						
HVAC						
Programmable thermostat	17	62	479	8,952	554	1.5
Setback point reduction	1	47	404	6,778	0	0.0
Windows						
None						
Total	**18**	**61**	**475**	**8,831**	**523**	**1.5**

Source: WVU Industrial Assessment Center and Downstream Strategies (2010-2014). Note: Counts are counts of recommendations and not of businesses. Recommendations are omitted that are not representative of opportunities at a broad range of businesses. Average payback periods in each row are averages of the payback periods calculated individually for each recommendation in that row. GHG emission reductions include direct and indirect emissions of CO_2 and other GHGs, and are calculated in a manner consistent with the Phase 1 Morgantown GHG inventory (Simcoe et al., 2014).

Table 7: Electricity and natural gas recommendations

Recommendation	Rec. count	Average natural gas savings (MMBtu/yr)	Average electricity savings (kWh/yr)	Average energy cost savings ($/year)	Average GHG emission reductions (lbs CO_2e/year)	Average retrofit cost ($)	Average Payback period (years)
Lighting							
None							
HVAC							
Programmable thermostat	3	194	3,310	1,794	33,850	725	0.4
Setback point reduction	1	30	3,666	396	10,778	0	0.0
Windows							
Double-pane glass windows	2	38	1,407	377	7,955	10,384	31.9
Total	**6**	**115**	**2,735**	**1,089**	**21,373**	**3,824**	**10.8**

Source: WVU Industrial Assessment Center and Downstream Strategies (2010-2014). Note: Counts are counts of recommendations and not of businesses. Recommendations are omitted that are not representative of opportunities at a broad range of businesses. Average payback periods in each row are averages of the payback periods calculated individually for each recommendation in that row. GHG emission reductions include direct and indirect emissions of CO_2 and other GHGs, and are calculated in a manner consistent with the Phase 1 Morgantown GHG inventory (Simcoe et al., 2014).

3.1.1 *Lighting*

Lighting technology has evolved rapidly in recent years. In commercial buildings, significant reductions in energy use can be achieved by installing energy-efficient lamps, fixtures, and controls. As described above, Mon Power offers an incentive of 5¢/kWh saved to businesses that utilize energy-efficient lighting technologies through its Lighting for Business Program. Energy savings are calculated utilizing FirstEnergy's calculator tool, which is available on its website. Table 5 summarizes the lighting recommendations provided to Morgantown businesses, because all lights utilize electricity.

Lighting retrofits

A large number of commercial businesses assessed in Morgantown utilize T12 fluorescent lamps with magnetic ballasts, which regulate the voltage and current provided to fluorescent lamps. The US Department of Energy (USDOE) estimates that over 1 billion T12 fluorescent tubes were in use in the country in 2012 (Independence LED Lighting, 2015). Almost two-thirds of the efficiency recommendations in the Morgantown commercial energy assessments were some variation of a lighting retrofit, and the majority involved upgrades from inefficient T12 lamps and magnetic ballasts.

The lighting retrofit recommendations generally had very short payback periods. In total, the 88 lighting retrofit recommendations would cost, on average, $1,148 to implement. Because they would generate, on average, $579 in annual savings, they would pay for themselves in about two years (See Table 5).

Full implementation of these 88 recommendations would reduce electricity consumption by approximately 600,000 kWh and would decrease emissions by approximately 1.1 million pounds CO_2e per year.

Exit sign retrofits

Lighting retrofits also address exit signs, which must be continuously illuminated (Occupational Safety & Health Administration, 2015). Switching incandescent exit-sign lamps with light-emitting diode (LED) lamps was recommended 11 times. These retrofits would cost, on average, $82 each and would produce estimated yearly electricity cost savings of $34. The payback period for exit sign retrofits, 2.5 years, is somewhat higher than for lighting retrofits, but the total cost of each retrofit is much less. Implementing these 11 exist sign retrofits could achieve cumulative electricity savings of almost 7,000 kWh and emission reductions of more than 12,000 pounds CO_2e per year.

Occupancy sensors

The installation of occupancy sensors was explored for an office where lights were kept on for 24 hours every day. Installing two occupancy sensors at this office would cost approximately $120, but would generate savings of $589 per year. These occupancy sensors would pay for themselves in approximately 0.2 years—or 2-3 months. They would reduce electricity consumption by almost 6,000 kWh and emissions by more than 10,000 pounds CO_2e per year.

3.1.2 *HVAC*

All HVAC systems require some type of a thermostat. Like most technologies, thermostats have improved dramatically over the last century. Deploying the most modern programmable thermostat technologies can provide considerable savings. Because HVAC systems may use electricity or natural gas, HVAC recommendations are included in Table 5, Table 6, and Table 7.

Programmable thermostat

There are many different HVAC configurations. The majority of the systems we observed were powered solely with natural gas, but some were powered with electricity. A number of the natural gas HVAC units utilized an electric heat pump. There are special programmable thermostats for systems that utilize heat pumps (USDOE, 2015a).

Approximately one-third of the assessed commercial buildings have HVAC systems with manual thermostats. During certain periods of the year, these systems may operate up to 24 hours each day. Significant savings can be achieved by replacing existing thermostats with programmable thermostats with time-of-day and day-

of-week programming to automatically change the set-point to an efficient temperature when the business is not open.

Programmable thermostats were recommended for 23 Morgantown businesses (See Table 5, Table 6, and Table 7). Payback periods for these thermostats are short and range from 0.4 years for electricity and natural gas (Table 7) to 1.5 years for natural gas only (Table 6).

The installation and proper use of programmable thermostats at these businesses would save approximately 29,000 kWh/year of electricity and 1,600 million British thermal units per year (MMBtu/year) of natural gas and would achieve emissions reductions of almost 290,000 pounds CO_2e per year.

Setback point reduction

In some cases, businesses were not taking advantage of the timed setback technology in already-installed programmable thermostats. These businesses can obtain significant energy savings at no additional cost. We evaluated reprogramming existing programmable thermostats on heating units at two businesses. For both businesses, we recommended reducing the setback point during non-operating hours to 50 °F. Energy savings can be expected to vary based on HVAC equipment, hours of operation, and pre-existing setback temperature; however, both businesses are projected to realize savings of around $400 per heating season (October-April) at zero cost. Collectively, these two businesses would reduce emissions by almost 18,000 pounds CO_2e per year.

3.1.3 *Windows*

In 2003, the US Energy Information Administration (USEIA) estimated that approximately 1.4 million commercial buildings had single-pane windows (Renovate by Berkowitz, Undated). Heat losses in cooler months and heat gains in the warmer months are larger in buildings with single- versus double-pane windows; this leads to higher year-round energy consumption and bills. Many businesses in Morgantown currently have single-pane windows. We explored complete window replacements in four businesses. Installing energy-efficient windows can reduce a building's base energy consumption. However, this improvement is considerably more expensive than other energy efficiency strategies and requires special consideration.

A complete window replacement was explored in these four businesses (See Table 5 and Table 7). These window replacements would cost, on average, approximately $24,000 for the electricity-only recommendations in Table 5 and approximately $10,000 for the electricity and natural gas recommendations in Table 7. The payback periods for these window replacements, 16.4 years for the electricity-only recommendations and 31.9 years for the electricity and natural gas recommendations, are significantly higher than the payback periods for the other recommendations.

Still, if these long-term investments were made, it would result in significant energy savings and a reduction of more than 58,000 pounds CO_2e yearly.

3.2 Greenhouse gas reduction scenarios

As identified in the Section 3.1, commercial energy assessments conducted in Morgantown have identified significant opportunities for cost-effective energy savings and GHG emission reductions. In this subsection, we apply the results from the energy assessments to calculate commercial GHG reduction scenarios for Morgantown.

These scenarios answer "what if" questions, such as: What if 100 businesses achieved the savings found to be cost-effective in the recent energy assessments? What if 1,000 businesses achieved the savings found to be

costs-effective in these assessments? What percentage of the city's commercial GHG emissions could be saved?

Answering these questions requires a calculation of the average energy and GHG savings that can be realistically achieved at each business; therefore, Table 8 combines the per-recommendation results in Table 5, Table 6, and Table 7 and presents potential savings per assessed business. We find these to be most appropriate results to use in the scenario because many businesses can benefit from more than one recommendation, and our scenarios are based on the number of businesses that implement energy-saving recommendations and not on the total number of recommendations installed.

Table 8: Recommendations averaged by business

	Number of businesses	Cost savings ($/year)	GHG emission reductions (lbs CO_2e/year)	Retrofit cost ($)	Payback period (years)
Electricity only					
All recommendations	80	697	14,384	1,892	2.7
All recommendations except windows	78	684	14,210	1,326	1.9
Natural gas only					
All recommendations	18	475	8,831	523	1.1
All recommendations except windows	18	475	8,831	523	1.1
Electricity and natural gas					
All recommendations	6	1,089	16,560	3,824	3.5
All recommendations except windows	4	1,444	5,983	544	0.4
Total					
All recommendations	**85**	**833**	**16,577**	**2,161**	**2.6**
All recommendations except windows	**85**	**797**	**15,191**	**1,353**	**1.7**

Source: WVU Industrial Assessment Center and Downstream Strategies (2010-2014). Note: Recommendations are omitted that are not representative of opportunities at a broad range of businesses. Average payback periods in each row are calculated as the average retrofit cost divided by the average cost savings. GHG emission reductions include direct and indirect emissions of CO_2 and other GHGs, and are calculated in a manner consistent with the Phase 1 Morgantown GHG inventory (Simcoe et al., 2014).

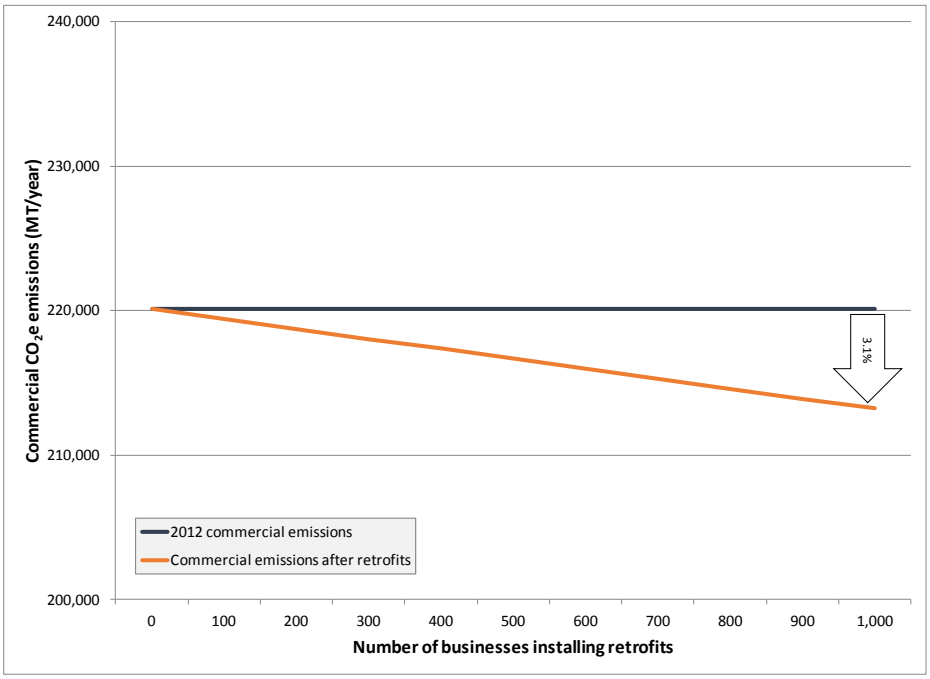
As shown in Table 8, the assessed businesses, on average, would save $833 on energy costs each year if they invested $2,161 in retrofits, for an average payback period of 2.6 years. These averages, however, include all recommendations, including those related to windows that, by far, are the most expensive and have the longest payback periods. Without the window-related recommendations, businesses would only need to invest $1,353 on average, and the payback period would drop substantially—to 1.7 years. We use these per-business averages, which include all recommendations except windows, in the scenarios that follow.

Calculating savings that are achievable by Morgantown businesses requires an estimate of the total number of businesses that can realistically install energy efficiency measures. A total of 4,515 active businesses are registered with the West Virginia Secretary of State with a Morgantown address (West Virginia Secretary of State, 2015); however, many of these businesses are located outside of the city limits. The City of Morgantown does not keep counts of businesses located within city limits. Even without a firm count of the total number of commercial establishments in Morgantown, our scenarios can still be instructive by providing "what if" results for a range of numbers of businesses that achieve the average energy and GHG reductions.

As summarized above in Table 4, emissions from commercial establishments in Morgantown totaled 220,104 MT CO_2e. If 100 Morgantown businesses implemented the retrofits identified in this analysis, those emissions would decrease to 219,415 MT CO_2e/year—a 0.3% reduction from 2012 (See Figure 4). If 1,000 Morgantown

businesses did so, then emissions would decrease further, to 213,213 MT $CO2_e$/year—a 3.1% reduction from 2012.

Figure 4: Achievable commercial establishment energy efficiency emission reductions in Morgantown



Source: 2012 emissions from Simcoe et al. (2014). Emissions after retrofits calculated in this report.

4. RESIDENTIAL SECTOR

During Phase 1 of this project, we found that the residential sector produces the second-highest percentage of GHG emissions: 25% of emissions from the built environment and 14% of total emissions from the Morgantown community (See Table 2, above).

Table 9 further subdivides these emissions into direct and indirect emissions. Direct emissions include those generated at the point of fuel combustion: at a power plant for electricity use and at the home where natural gas or other fuels such as LPG, fuel oil, or kerosene are burned.

Indirect electricity emissions include those associated with the electricity that is lost to heat when transmitted through power lines and upstream emissions: those from the energy consumed in order to extract, process, and deliver fuels to electricity generation facilities.

Indirect natural gas emissions account for the leakage of natural gas and other fuels as well as emissions associated with secondary fuels that are used in the supply chain for these fuels.

In total, the residential sector was responsible for 109,964 MT CO_2e in 2012.

Table 9: Residential emissions in Morgantown (2012, MT CO_2e)

Fuel	Direct emissions	Indirect emissions	Total emissions
Electricity	55,398	9,107	64,505
Natural gas	36,500	8,422	44,922
Other residential fuels	454	83	537
Total	**92,352**	**17,612**	**109,964**

Source: Simcoe et al. (2014). Note: This table shows activity-based and not source-based emissions. Other residential fuels include bottled, tank, or LPG and fuel oil or kerosene.

In this chapter, after reviewing results from our Morgantown Residential Energy Consumption Survey and home energy assessments, we investigate the energy cost savings and GHG emission reductions that could be achieved via implementation of energy efficiency recommendations at residences in Morgantown.

4.1 The Morgantown Residential Energy Consumption and Efficiency Survey

A Morgantown Residential Energy Consumption and Efficiency Survey was conducted between August and October 2014. This survey was needed because USEIA's national Residential Energy Consumption Survey, which includes information on housing unit characteristics, household demographics, and energy usage patterns, does not allow data from West Virginia, let alone Morgantown, to be extracted (USEIA, 2011).

Questions in the Morgantown Residential Energy Consumption and Efficiency Survey were borrowed from—or formulated similarly to—questions in the national survey and asked about housing typology, energy consumption, appliance saturation, and efficiency (See Appendix A for questions and detailed results). The primary goal of the survey was to identify patterns of energy consumption and efficiency across different Morgantown neighborhoods. This information was then used to inform the GHG reduction scenarios for the residential sector described in Section 4.4.

A total of 110 respondents from different households within Morgantown city limits completed the survey. It was promoted via neighborhood association meetings, the Morgantown Housing Advisory Commission, social media, and a number of community newsletters. While we consider the number of respondents sufficient to draw preliminary conclusions regarding energy use, expenditures, and related issues, the results are influenced by the respondent population demographics and may not be representative of residents across the entire city.

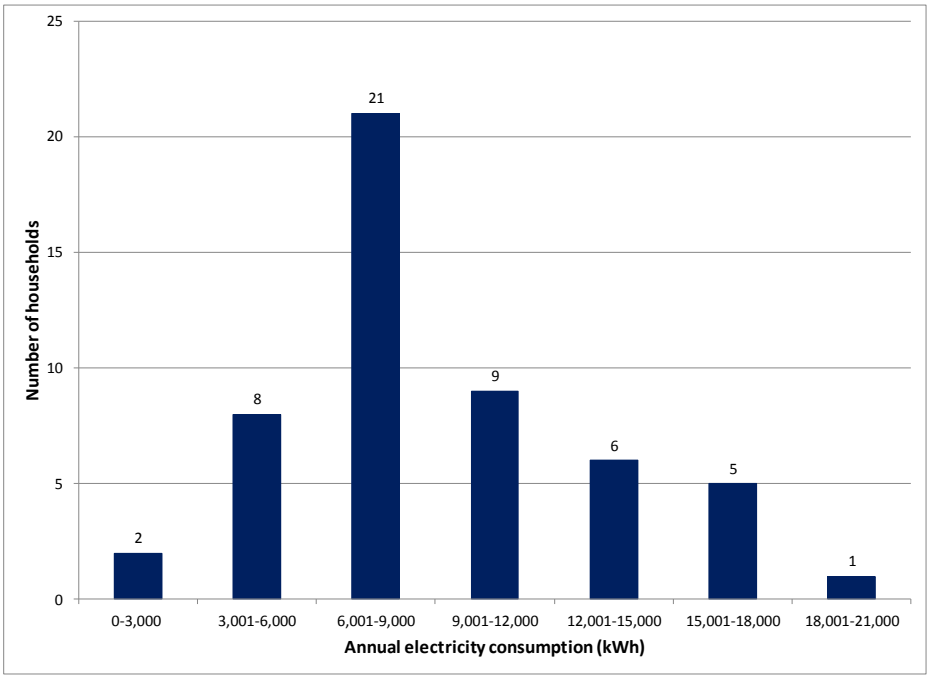
Survey respondents are from the First Ward, Greenmont, South Hills, South Park, Suncrest, Wiles Hill, Highland Park, Jerome Park, and Woodburn neighborhoods. The largest number of responses came from the South Park and Suncrest neighborhoods.

Most respondents live in single-family detached housing (92%), have household incomes of $50,000 or higher (79%), hold at least a bachelor's degree (91%), and consider themselves knowledgeable of general home efficiency and energy-saving practices (84%).

Respondents have an average household size of 2.4 people—the same as the state average (US Census Bureau, 2015a). Just over half (53%) live in homes built before 1940, and 88% of respondents live in homes built before 1980. Half of all respondents' homes have three bedrooms, and an additional 27% have four bedrooms. These homes range in size from less than 500 to greater than 4,000 square feet.

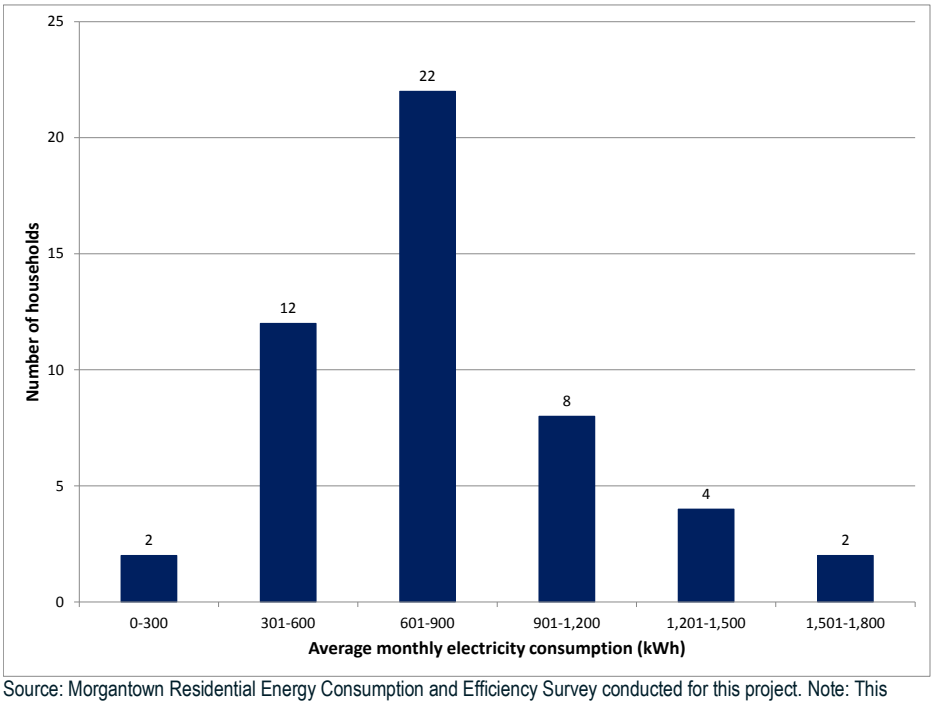
Electricity consumption was compiled in two ways. As shown in Figure 5, the total amount of electricity consumed in the previous year varied widely among respondents. The average monthly electricity consumption over the lifetime of respondents' accounts varied in a similar manner (See Figure 6). Almost half of the homes consumed between 601-900 kWh per month. The average monthly electricity consumption, 794 kWh, is less than the national average of 909 kWh (USEIA, 2015d). Most respondents also use natural gas: 86% as the main space heating fuel and 84% for water heating.

Figure 5: Annual electricity consumption in previous year



Source: Morgantown Residential Energy Consumption and Efficiency Survey conducted for this project. Note: This chart only includes electricity consumption for respondents who have lived in their home for at least one calendar year.

Figure 6: Average monthly electricity consumption in previous year



Source: Morgantown Residential Energy Consumption and Efficiency Survey conducted for this project. Note: This chart only includes electricity consumption for respondents who have lived in their home for at least one calendar year.

4.1.1 *Heating and cooling*

For decades, space heating and cooling accounted for the majority of residential energy consumption and related expenditures in the US; however, this is no longer the case (USEIA, 2013). Heating and cooling a home now require less energy, due in large part to the increasing efficiency of HVAC equipment, better insulation, and increasingly widespread knowledge of the benefits of proper home sealing. An HVAC system's air filter plays an important role in maintaining proper air quality in a home, and it has a large influence on the operational efficiency of the equipment (SparkEnergy, 2015). A dirty filter will result in the system working harder to pump air throughout a house. Depending on the type of HVAC system, the air filter should be changed or cleaned every three months (USEPA, 2015a).

Of those with applicable equipment, 83% of survey respondents have changed their air filter in the past six months, and 67% have conducted service or maintenance in the last two years. Despite following these best practices, 44% of respondents use some type of secondary heating equipment in the winter months.

There are two types of air exchanges in every home. The first, ventilation, is controlled. Every home needs a certain amount of ventilation to regulate moisture, odors, and harmful pollutants. Ventilation is an essential and necessary part in home construction across all climate regions (USDOE, 2010).The second, air infiltration, is the uncontrolled seeping of air through cracks and holes in the home envelope. This is often referred to as a home's draftiness.

More than half (56%) of survey respondents found their homes to be too drafty at least some of the time during the cooler months of the year. In extreme cases, this air infiltration can cause condensation buildup in the walls and ceiling that can destroy insulation and other building materials. Even worse, condensation caused by air infiltration can harm the home's electrical wiring. Fortunately, the process to correct issues with air infiltration is fairly easy and low-cost (Minnesota Department of Commerce, 2015). Homes can save up to 40% on their yearly heating and cooling costs by addressing infiltration issues (USEPA, 2015b).

Approximately two-thirds of respondents have tried to reduce air infiltration with caulk and weather stripping in at least some portion of their home.

In addition to air infiltration and ventilation, a home's temperature and air quality are greatly affected by its insulation levels. More than one-third of respondents state that their homes are poorly insulated or have no insulation at all, and almost all of these homes were built prior to 1970. Interestingly, while most respondents who self-reported insulation issues lived in older homes, our focused energy assessments found numerous insulation issues with newer homes (See Section 4.2).

The 2009 International Energy Conservation Code, described above in Section 2.4, includes insulation requirements based on climate (Table 10). However, these requirements only apply to new buildings, remodels, renovations, and additions to buildings (USDOE, 2009).

Table 10: 2009 International Energy Conservation Code insulation requirements for Morgantown

Building component	R-value
Ceiling	38
Wood frame wall	20
Mass wall	13/17
Floor	30
Basement wall	10/13
Slab	10
Crawl space wall	10/13

Source: International Code Council (2009).

In summary, the Morgantown Residential Energy Consumption and Efficiency Survey identified significant opportunities for improving energy efficiency related to heating and cooling. The residential scenarios described in Section 4.4 focus on these opportunities.

4.1.2 *Lighting*

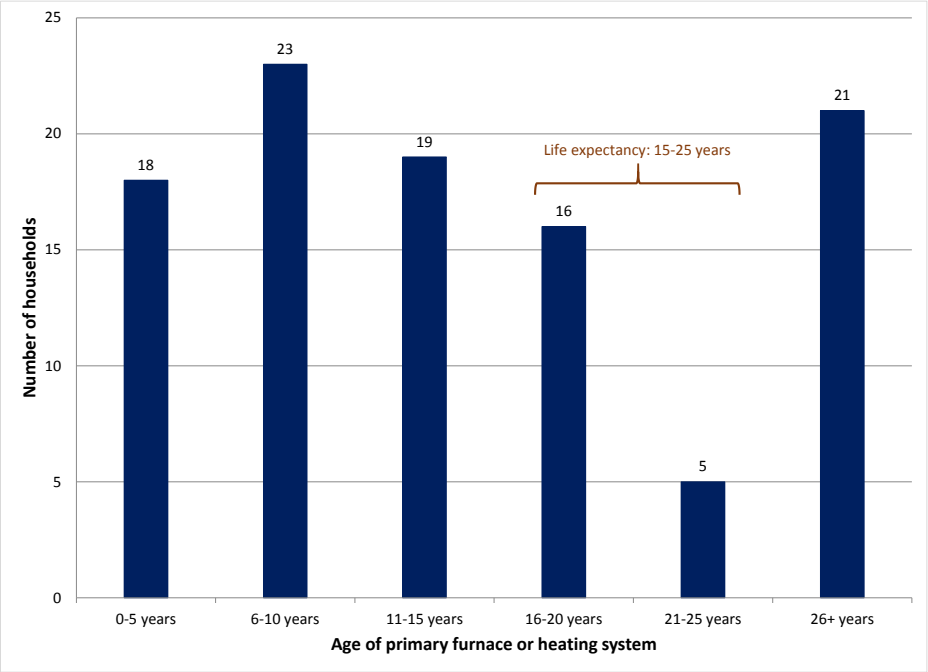
USEIA estimates that residential lighting accounted for over 14% of residential electricity consumption in 2012 (USEIA, 2015e). The federal Energy Independence Act of 2007 aimed to push the US closer to energy independence by phasing out inefficient technologies, promoting energy efficiency, and increasing the production of clean renewable fuel sources.[5] A large component of this Act is the systematic phase-out of inefficient incandescent lamps. In January 2014, two of the most popular incandescent lamps, the 40- and 60-watt bulbs, began to be phased out (Wade, 2010). In Morgantown, survey respondents use a mixture of incandescent, compact fluorescent (CFL), and LED lamps. Approximately two-thirds of respondents said that they use mostly CFL or mostly LED lamps; however, nearly one-third still use mostly incandescent lamps in their homes.

4.1.3 *Appliances*

Appliances significantly influence a household's baseline energy consumption. If a home has old and inefficient appliances, it may be cost-effective to upgrade. Households can often reduce consumption and save up to 30% on energy expenses by purchasing Energy Star appliances (USEPA, Undated(b)). According to the Morgantown survey, a large portion of respondents are using appliances that are at or near the end of their life expectancies (See Figure 7 through Figure 10).

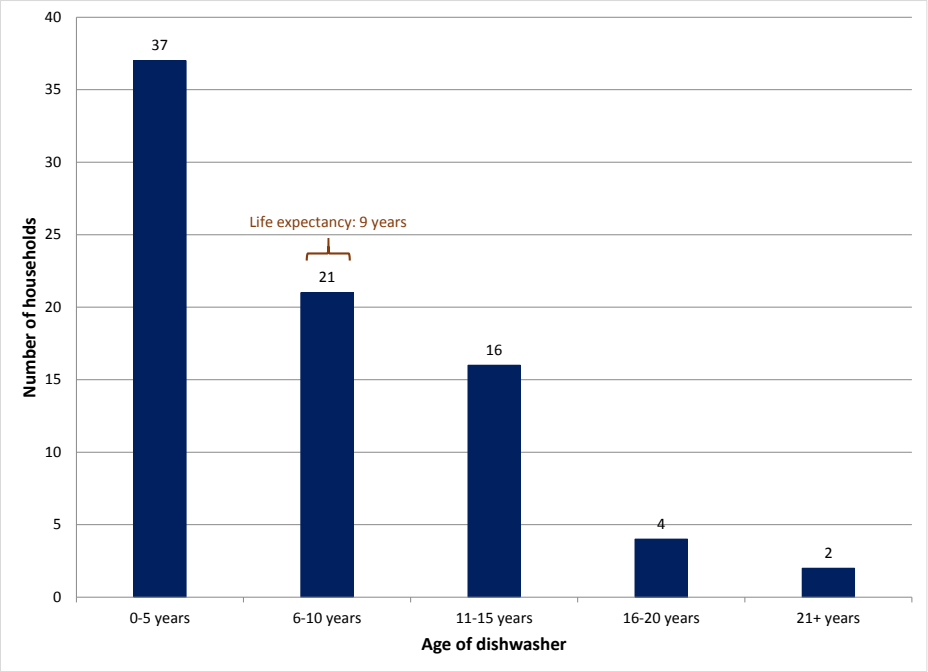
[5] See http://www.gpo.gov/fdsys/pkg/BILLS-110hr6enr/pdf/BILLS-110hr6enr.pdf.

Figure 7: Furnace age versus life expectancy



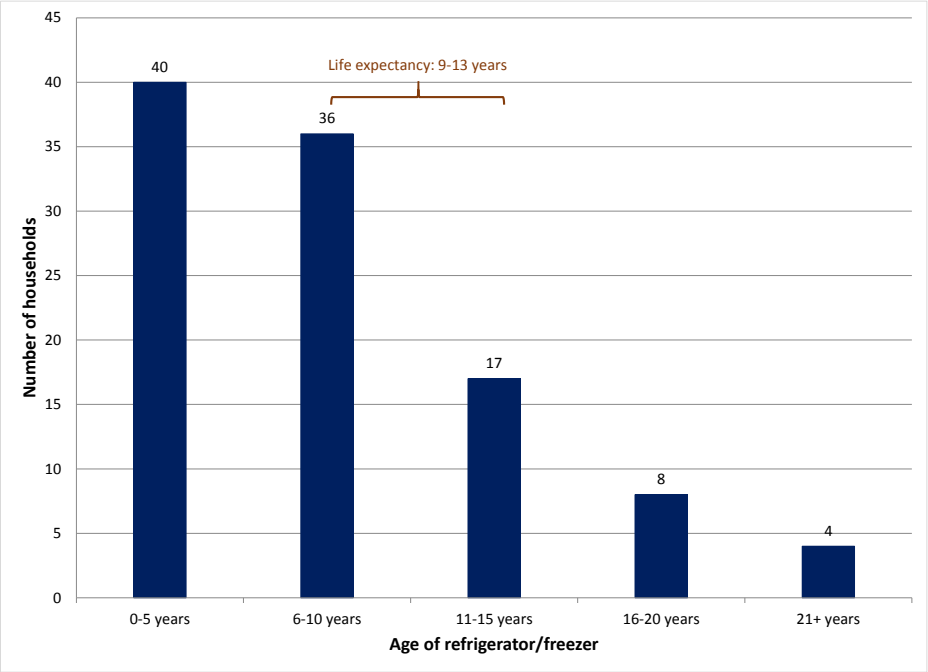
Sources: Life expectancy from International Association of Certified Home Inspectors (2015). Number of households from this report.

Figure 8: Dishwasher age versus life expectancy



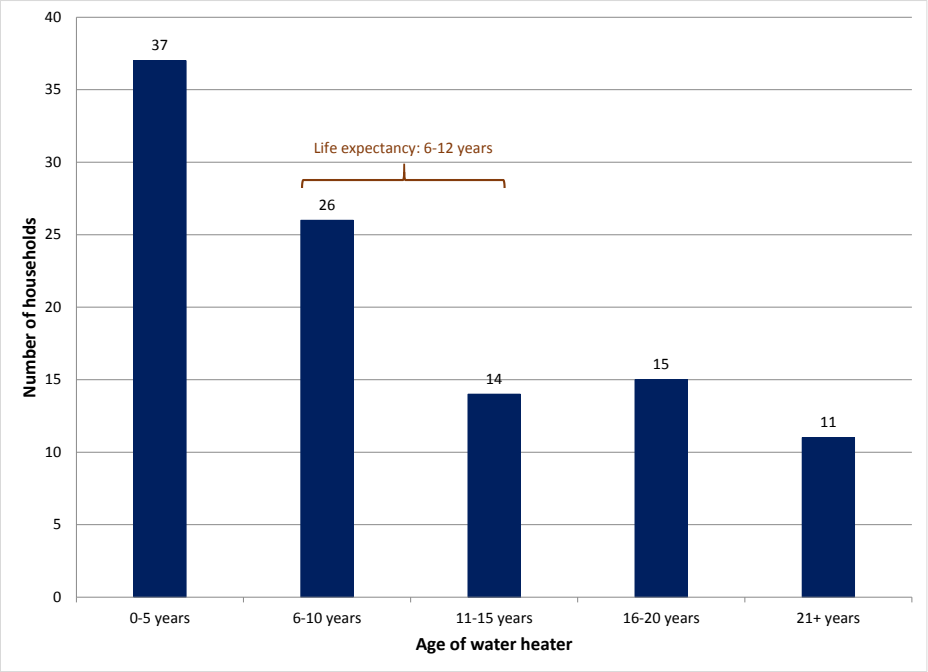
Sources: Life expectancy from International Association of Certified Home Inspectors (2015). Number of households from this report.

Figure 9: Refrigerator/freezer age versus life expectancy



Sources: Life expectancy from International Association of Certified Home Inspectors (2015). Number of households from this report.

Figure 10: Water heater age versus life expectancy

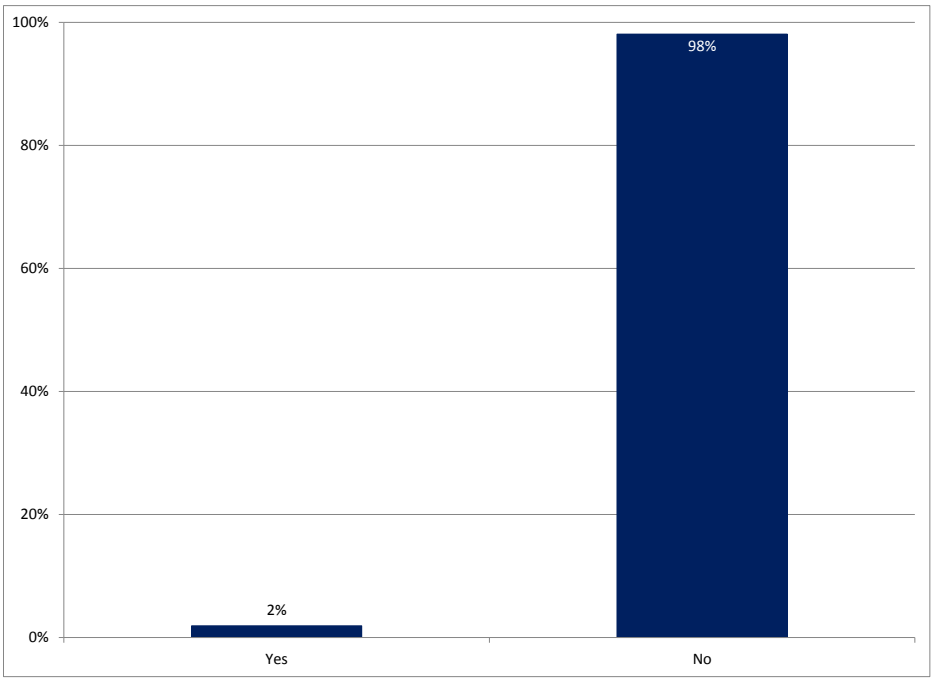


Sources: Life expectancy from International Association of Certified Home Inspectors (2015). Number of households from this report.

4.1.4 *Efficiency and assistance program participation*

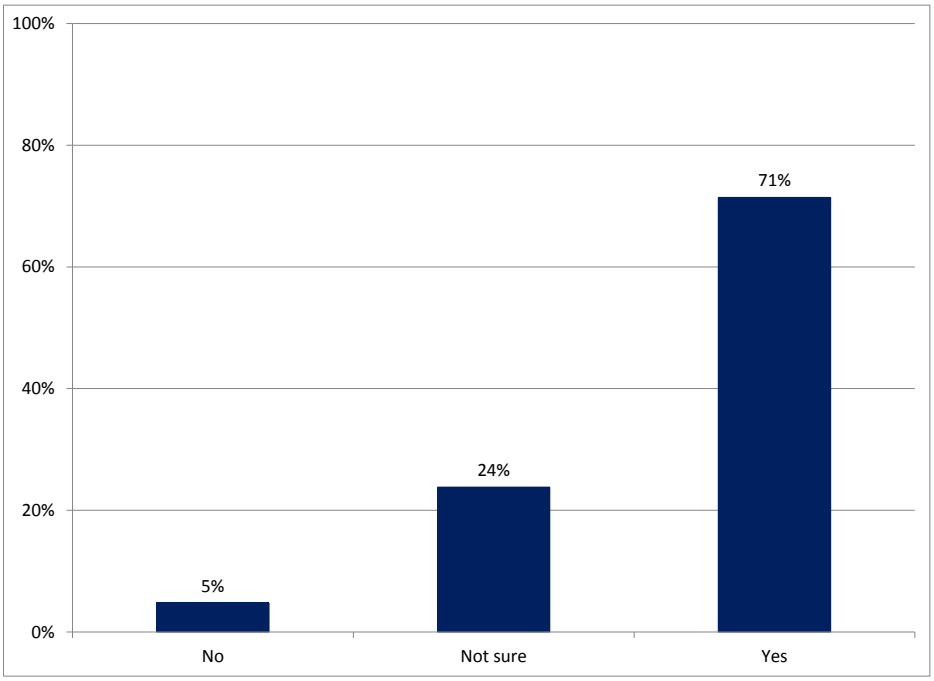
Despite interest in energy-saving programs, the majority of respondents had neither heard of, nor participated in, Mon Power's residential energy efficiency programs. Only 2% of respondents participated in Mon Power's Home Energy Analyzer Program (See Figure 11), and none participated in the Low Income Home Check-up Program.

Figure 11: Participation in Mon Power's Home Energy Analyzer Program



When asked, "If there was a program available in Morgantown that was designed to help residents reduce their energy costs as well as reduce greenhouse gas emissions, would you participate?", 71% of respondents said that would participate, and only 5% said they would not. The rest were unsure (See Figure 12). Clearly, there is a significant opportunity for Mon Power to sign up new participants in Morgantown.

Figure 12: Willingness to participate in an energy savings program



4.2 Focused home energy assessments

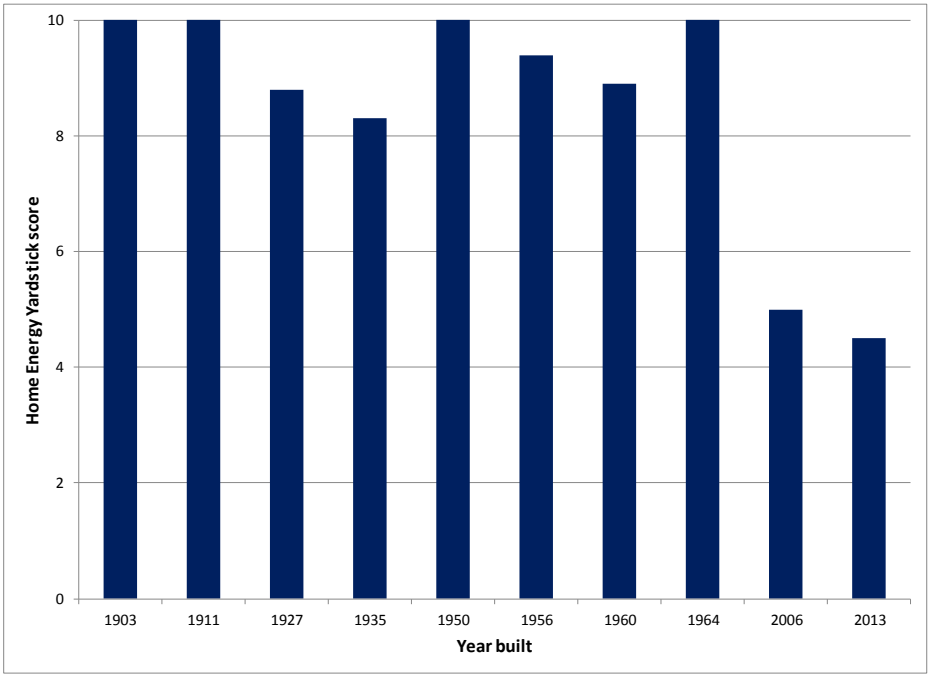
More than one-half of survey respondents identified that they were interested in focused home energy assessments. To further inform our GHG reduction scenarios, 10 focused home energy assessments were conducted on a diverse set of houses. Leonardo Technologies, Inc. (LTI), a firm with broad professional experience on energy efficiency and weatherization, conducted the assessments.

4.2.1 *Home Energy Yardstick*

Data for each home were collected and entered into the Home Energy Yardstick online tool, a standard assessment created by USEPA to allow homeowners and renters to compare their homes' energy performance to other homes nationwide (USEPA, 2015c). Using statistical algorithms that take into account climate, weather, home size, and home occupancy, homes are rated on a scale of one to ten. A rating of one is assigned to a home with high energy demand, high carbon emissions, and low efficiency, and a rating of ten is assigned to a home with low energy demand, low carbon emissions, and high efficiency. This system allows homes of various typologies and classes to be compared against each other. Additionally, it provides standard recommendations based on homes' specific typologies and a lighting calculator that estimates potential savings by switching from incandescent lamps to CFLs or LEDs. Appendix B contains observations and recommendations for all 10 homes.

Of the 10 homes inspected, the Home Energy Yardstick score averaged 8.5, which is significantly higher than the national average score of 5. As illustrated in Figure 13, four of the homes scored a 10, and the lowest score was a 4.5. Interestingly, the scores for two assessed homes built in the last decade were much lower than those for the older homes.

Figure 13: Home Energy Yardstick scores by year built



4.2.2 *Thermal imagery*

In addition to applying the Home Energy Yardstick tool, the project team conducted visual inspections of the homes with an infrared camera to identify unwanted heat losses and/or gains. As shown in Figure 14A, thermal imagery identified significant energy losses through unsealed fireplace flues. In fact, we found that all assessed homes with fireplaces would benefit from temporarily sealing their fireplace's flue when it is not in use. These homes could be losing as much as 1,000 cubic feet of conditioned air through the fireplace every minute (Sulski, 2000). This can be easily fixed by installing a chimney balloon when the fireplace is not in use.

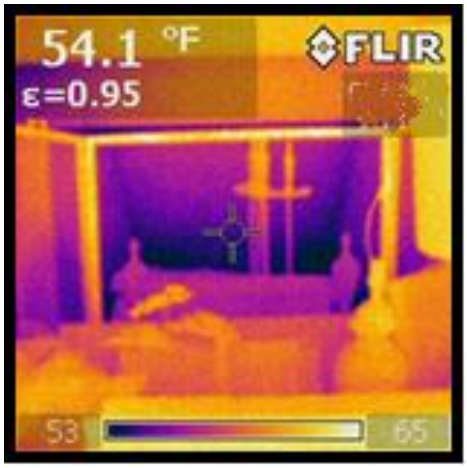
Many of the assessed homes used whole-house fans with louvered vents. While these fans can provide significant benefits in the summer, they are a source of significant energy loss in the winter. Many whole-house fans installed in the last century have insulation installed in the attic space around them but are not directly insulated (See Figure 14B). For fans of this type, it is recommended that homeowners install a temporary insulation box or shutter cover. This is a cheap and easy retrofit that will result in a space that is more efficiently heated in the winter.

While nine of the 10 assessed homes had insulation, in many cases the insulation had not been installed properly (See Figure 14C and D). Flaws included gaps, tucks, or folds, which, in addition to allowing air transfer, can promote condensate in walls and can lead to serious mold and air quality issues.

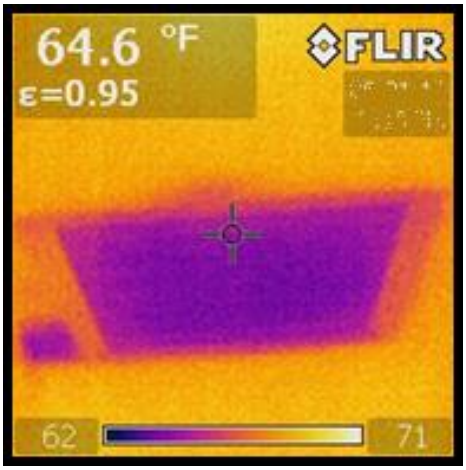
In Figure 14C, a scan of a south-facing wall, the homeowner had paid the builder to insulate the whole house. Clearly, this wall had not been insulated. The temperature gradient had promoted condensate in the walls, which in turn caused the house's exterior paint to peel off. In Figure 14D, a scan of a vaulted ceiling, the purple areas show sizeable gaps where the insulation was compacted.

Figure 14: Thermal images for assessed homes

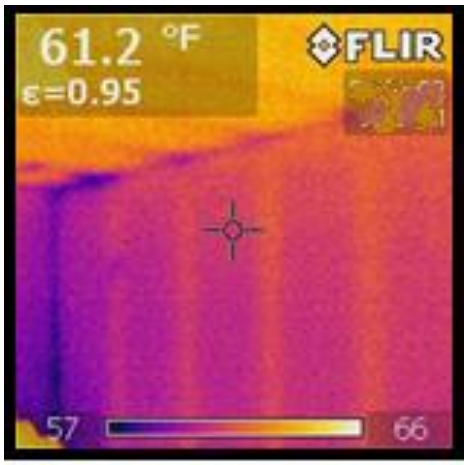
A: Heat loss from a fireplace



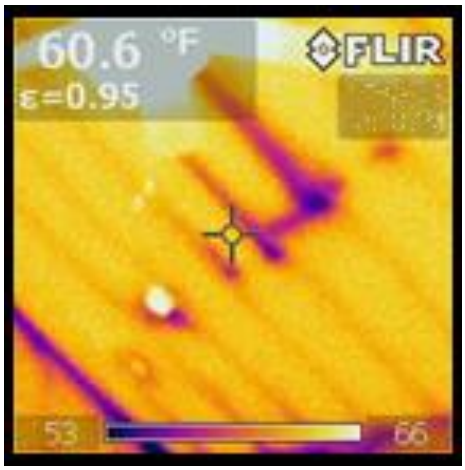
B: Heat loss from an uninsulated whole-house fan vent



C: Heat loss from improper wall insulation



D: Heat loss from compacted ceiling insulation



While it might be expected that older homes, constructed prior to any building codes, would be leakier and less efficient than newer homes, our energy assessments did not bear this out. The two newest homes had the lowest Home Energy Yardstick scores (Figure 13), and even the newest homes had issues with energy losses identified by thermal imagery.

In one case, homeowners purchased a brand new house and were told that it was built to LEED specifications. The home had comparatively high energy consumption when compared to homes of similar typology and like occupants. Infrared imagery detected gaps and compaction in the envelope—signs of improper insulation installation. Overall, the home was well built, but the homeowners' experience underscores the importance of pre-sale home energy assessments—something that has become law in other states. Even simple infrared scans can expose problem areas in building envelopes and prevent future issues. Additionally, home energy assessments can help hold builders and contractors accountable, especially if they are marketing a new home built to LEED specifications.

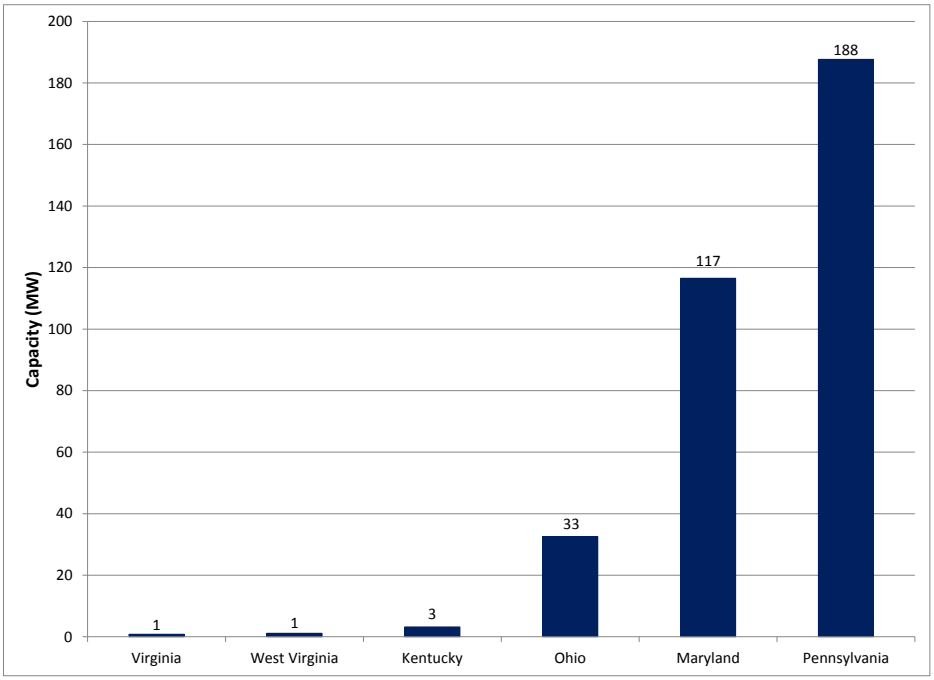
In summary, the focused home energy assessments identified significant opportunities for improving energy efficiency related to heating and cooling—consistent with the results from the Morgantown Residential Energy Consumption and Efficiency Survey. The residential scenarios described in Section 4.4 focus on these opportunities.

4.3 Solar opportunities

As the cost of solar photovoltaic (PV) installations has steadily decreased, the US market has experienced unprecedented growth in the number of rooftop solar arrays (Barbose et al., 2013). Solar is now cheaper than electricity from the grid in 42 out of the largest 50 cities in the US (Pyper, 2015).

In West Virginia, state leaders have done little to promote the installation of distributed renewable energy systems such as rooftop solar. As shown in Figure 15, with only roughly 1 MW of total installed solar generation capacity, West Virginia ranks last when compared to its surrounding states. Section 5.2.1 provides state-level policy recommendations that would lead to a drastic increase in the number of solar PV systems.

Figure 15: Total installed solar capacity in West Virginia and surrounding states



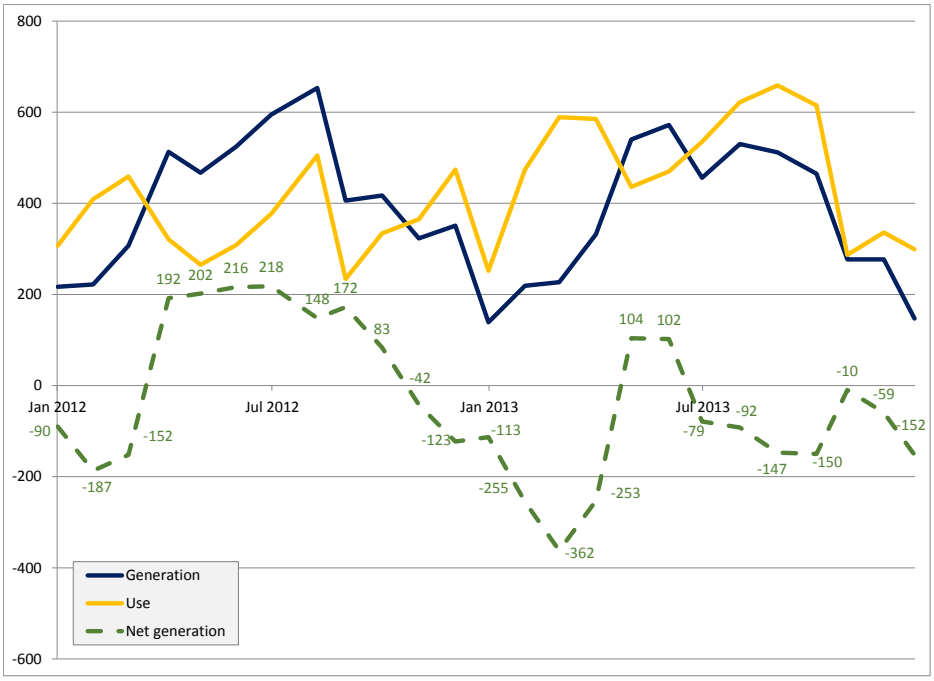
Source: NREL (2015).

Morgantown residents and businesses have voiced an interest in distributed energy sources (City of Morgantown, 2013a and b). An estimated 22% of all residential roof area and 65% of all commercial roof area are viable for solar in the cool climate zone of the US—in which Morgantown is located (Denholm and Margolis, 2008). In fact, the National Renewable Energy Laboratory (NREL) has estimated that West Virginia has 4 GW of technical potential for rooftop solar PV installations (Lopez et al., 2012), approximately 4,000 times more than is currently installed.

At one of the ten homes for which focused home energy assessments were conducted, a 4,000-watt rooftop solar system had been installed approximately five years ago. Generation varied considerably by month, but electricity use also varied. As illustrated by the dashed green line in Figure 16, net generation was positive in some months, meaning that the home generated more electricity than it used. In other months, net generation was negative.

In 2012, generation exceeded use, and this homeowner bought no electricity from Mon Power in accordance with West Virginia's net metering policy. In 2013, the homeowner bought electricity from Mon Power, but only the amount by which use exceeded generation.

Figure 16: Electricity production and use from a solar array installed at a Morgantown home, 2012-13



For the other nine homes for which focused home energy assessments were conducted, we analyzed the potential for rooftop solar PV. On average, these homes had approximately 420 square feet of south-facing roof space, which is large enough for a 5,280-watt system.[6] For seven of the nine homes, systems that fit on the south-facing roof would be large enough to displace over one-half of the home's electricity consumption. In one case, the system that fits on the south-facing roof has the potential to displace the home's entire electricity consumption.

At 10 cents/kWh, an approximation of the current residential electricity rate, the assessed homes would save an average of $15,500 over 25 years. Rates have increased in recent years (See Figure 3, above) and will likely continue to increase in the future. If rates increased an average of 15% over the next 25 years, these homeowners could expect an average savings of close to $17,900.[7] These nine solar installations could offset more than 98,000 pounds of CO_2e per year.

The reduction in GHG emissions that could be achieved by installing this average system is incorporated into the GHG reduction scenarios in the following section.

[6] Solar calculations are based on panels with power densities of 135 watts per square meter.
[7] Payback periods would be impacted not just by these savings, but also by the installation costs and incentives, which were not modeled for this analysis.

4.4 Greenhouse gas reduction scenarios

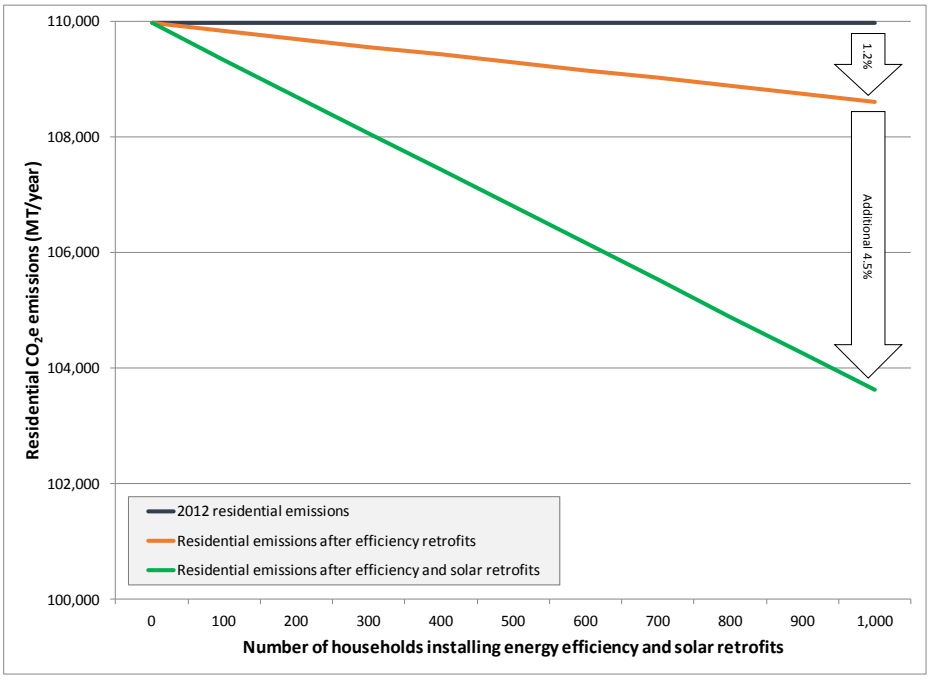
As identified in the Morgantown Residential Energy Consumption and Efficiency Survey (Section 4.1), the focused home energy assessments (Section 4.2), and the analysis of solar opportunities (Section 4.3), Morgantown residents have significant opportunities for reducing GHG emissions by installing energy efficiency retrofits and rooftop solar. In this subsection, we apply these results to calculate residential GHG reduction scenarios for Morgantown.

These scenarios answer "what if" questions, such as: What if 100 homeowners improved energy efficiency to address heating and cooling in their homes? What if 1,000 homeowners did so? What if similar numbers of homeowners installed rooftop solar on their homes?

Answering these questions requires an estimate of the average energy and GHG savings that can be realistically achieved at each residence. The residential energy efficiency results presented in this chapter cannot be used to directly calculate potential energy efficiency savings per household; therefore, results from USDOE are used to estimate these savings. Homes in the climate zone that includes Morgantown, on average, can reduce their total energy consumption by 12% by addressing air sealing and insulation issues (USDOE, 2015b). Because the Morgantown Residential Energy Consumption and Efficiency Survey and focused energy assessments found numerous issues with home envelopes, we apply this 12% average in order to estimate the average energy savings and GHG reductions that can be achieved by addressing air sealing and insulation problems. There were an estimated 9,776 households in Morgantown in 2013 (US Census Bureau, 2015b).

As summarized above in Table 9, residential emissions in Morgantown totaled 109,964 MT CO_2e. If 100 Morgantown households implemented energy efficiency retrofits to address their home envelopes, residential emissions would decrease to 109,829 MT CO_2e/year—a 0.1% reduction from 2012 (See orange line in Figure 17). If 1,000 Morgantown households did so, then emissions would decrease further, to 108,613 MT $CO2_e$/year—a 1.2% reduction from 2012.

Figure 17: Achievable residential energy efficiency and solar emission reductions in Morgantown



Source: 2012 emissions from Simcoe et al. (2014). Residential emissions after retrofits calculated in this report.

Households can do more than just improve efficiency, however. Our analysis above identified the potential to install 5,280-watt solar systems on roofs; these systems would generate approximately 6,244 kWh per year, which would offset a considerable amount of electricity now generated primarily by coal. If 1,000 Morgantown households also installed solar systems at this size, emissions would decrease an additional 4.5%, to 103,628 MT $CO2_e$/year (See green line in Figure 17).

The total GHG emission reduction, 5.8%, could be achieved by homes that both improve energy efficiency and install solar, or homes that install only one type of retrofit. So long as 1,000 homes, in total, install retrofits as described here, residential emissions will decrease as calculated.

5. CONCLUSIONS AND RECOMMENDATIONS

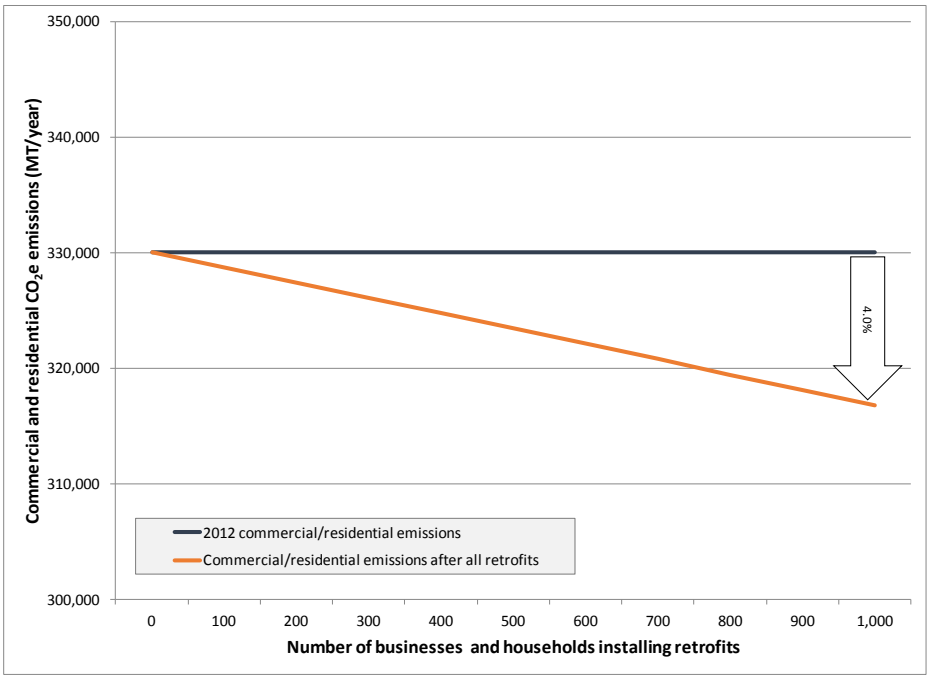
5.1 Greenhouse gas reduction scenario conclusions

Sections 3.2 and 4.4 explore scenarios in which commercial establishments and households install retrofits to save electricity and natural gas, and thereby reduce GHG emissions. As shown in Figure 18, which combines these scenarios, commercial establishments and households emitted 330,068 MT $CO2_e$/year in 2012, but these emissions can be decreased by 4.0% if 1,000 businesses and 1,000 homes install the retrofits identified in this analysis.

For businesses, most retrofits involve installing more efficient lighting; these retrofits have very short payback periods. For homes, retrofits involve addressing air sealing and insulation issues and installing rooftop solar.

Not considered in these scenarios are a wide variety of additional steps that businesses and residents can take to reduce GHG emissions. For example, as identified above in Section 3.1, commercial establishments can install double-pane windows. And as identified above in Section 4.1, many appliances in Morgantown homes are past their life expectancy and are less efficient than those on the market now.

Figure 18: Achievable commercial establishment and residential energy efficiency and solar emission reductions in Morgantown



5.2 Recommendations

Achieving these GHG emission reductions will require actions by individual business owners and homeowners. However, a supportive state policy environment, and well-publicized programs from Mon Power, would significantly help people learn about, finance, and reap the benefits of energy efficiency and solar electricity generation.

5.2.1 *For businesses owners and homeowners*

Participate in Mon Power's efficiency programs. More than half of survey respondents had not heard of Mon Power's Home Energy Analyzer or the Low Income Home Check-Up programs, and only 2% of respondents were participating in the Home Energy Analyzer Program. Business owners should also participate in Mon Power's Lighting for Business Program.

Address issues with building envelopes. All buildings need a certain amount of ventilation to regulate moisture, odors, and harmful pollutants; however, unregulated air infiltration can lead to higher energy bills and damage. As discussed above, there are significant opportunities to lower heating and cooling bills by addressing air infiltration.

Properly maintain HVAC systems. If applicable, air filters on HVAC systems should be changed every three months to keep the systems running efficiently. Also, systems connected to leaky ducts work up to 20% harder to pump air. Properly sealing ducts can save up to $140 annually in heating and cooling costs (USEPA, 2015a).

Install programmable thermostats. Savings can be realized by commercial and residential utility customers by installing programmable thermostats and setting efficient setback temperatures at times when buildings are unoccupied. Programmable thermostats must be compatible with the building's HVAC system configuration. Also, HVAC systems that utilize heat pumps require special programmable thermostats to optimize efficiency.

Install efficient lights. Many opportunities have been identified, both in the commercial and residential sectors, to upgrade lighting to more efficient technologies. The federally mandated lighting technology phase-outs have significantly lowered the cost of efficient lamp replacements and lighting retrofits.

Conduct an energy assessment. There are many different types of energy assessments. Some go into great detail and require work by a professional energy assessor or weatherization expert, and others can be completed by untrained building occupants at no charge. Assessments help prioritize efficiency improvements and building upgrades, which will help business owners and homeowners decide which actions to take to improve energy efficiency and lower energy costs.

5.2.2 *For Mon Power*

Promote efficiency programs like FirstEnergy subsidiaries have done in different states. The demand-reduction benefits of an energy efficiency program can only be realized if it is adopted by consumers. Furthermore, according to the Morgantown Residential Energy Consumption and Efficiency Survey, most respondents had neither heard of, nor participated in, Mon Power's efficiency programs. Almost all respondents are interested in programs that could reduce energy consumption and save money.

5.2.3 *For state government*

With supportive state policies, business owners and homeowners would be more likely to install energy efficiency retrofits and solar PV systems. Many state energy policies, however, are designed to support coal's disproportionate share of West Virginia's energy portfolio, which limits the adoption of alternatives, including renewable energy sources.

Develop an all-of-the above strategy for implementing the Clean Power Plan in West Virginia. According to the draft Clean Power Plan rule released by the USEPA in 2014, CO_2 emissions from coal-fired power plants will need to be reduced. If the final rule, which is expected to be released in summer 2015, mirrors the draft rule, states will be provided with great flexibility in designing plans that include, among other things, demand-side energy efficiency and renewable energy development. The West Virginia Department of Environmental Protection should develop a plan that makes use of an all-of-the-above approach and that includes incentives for business owners and homeowners to implement the GHG emission reduction strategies identified in this analysis. (Van Nostrand et al., 2015)

Adopt an Energy Efficiency Resource Standard. House Bill 2210, which would have established an Energy Efficiency Resource Standard, was proposed in 2013 but was not passed by the West Virginia Legislature. It included energy efficiency savings goals and directed the West Virginia Public Service Commission (WVPSC) to oversee the implementation of energy efficiency programs by the state's utilities. The Legislature should reconsider this bill and ensure that West Virginia consumers receive the same opportunity to access energy efficiency savings as utility customers in neighboring states.

Pass a Renewable Portfolio Standard with a solar carve-out. Approximately 95% of the electricity produced in West Virginia comes from coal-fired power plants (USEIA, 2015a). West Virginia enacted an Alternative and Renewable Energy Portfolio Standard in 2010, but that law was repealed in 2015. The 2010 Standard required utilities to meet increasing percentages of their electricity supply through either "alternative" or "renewable" energy sources. But utilities could meet the standard with "alternative" resources including some types of coal and natural gas and had no actual incentive to develop renewable electricity sources. Enacting a true Renewable Portfolio Standard with a solar carve-out would provide meaningful incentives not just for utilities, but also for business owners and homeowners who could team up with utilities to help them meet their goals.

Issue revised integrated resource planning (IRP) requirements for electric utilities. IRP requires utilities to evaluate a full range of supply- and demand-side resource alternatives for meeting future electricity demand in order to provide adequate and reliable service to customers at the lowest system cost. Utilities must consider demand-side resources such as energy efficiency and nontraditional supply-side resources such as rooftop solar PV on the same footing as traditional, large, utility-owned power plants (Van Nostrand, 2012). In 2014, the West Virginia Legislature required utilities to engage in IRP, and in 2015, WVPSC issued an order requiring utilities to submit their first resource plans by January 1, 2016 (WVPSC, 2015). Neither the 2014 legislation nor the WVPSC order requires integration of supply-side and demand-side resources, and many other elements commonly included as part of the IRP process in most other states are missing. WVPSC should therefore issue a second order that provides specific IRP development guidelines.

6. NEXT STEPS

This investigation of GHG reduction opportunities was the second phase of a broader three-phase project to identify energy-saving opportunities in Morgantown that, when implemented, will save money, reduce GHG emissions, and show progress toward initiatives that the City of Morgantown supports.

Phase 3, the Sustainable Morgantown Initiative, has been funded by the Appalachian Stewardship Foundation. This initiative will include four linked programs to promote investments in energy efficiency and renewables:

1. **Solar cooperative for single-family homes.** Partnering with Community Power Network, the Green Team, and the City of Morgantown, we are implementing a solar cooperative that will provide steep discounts for solar PV systems to city residents. Community Power Network has successfully implemented 28 solar coops in Washington, DC; Maryland; Virginia; and West Virginia, which boast 2,169 members, 481 installed systems, and over 2.6 MW of solar installed.
2. **Demand response, efficiency, and solar at multifamily residences.** Partnering with Solar Holler and Mosaic Power, we will install demand-response systems on hot water heaters, which automatically turn the heaters off when grid demand is high, without disrupting service. The $100 annual payments for each system will help make efficiency and solar projects affordable. We will target two types of multifamily residences in Morgantown: low-income housing and WVU student housing.
3. **Sustainable small business designation.** Partnering with the Green Team, the City, and regional stakeholders, we will explore the potential for establishing a Sustainable Business Designation Program modeled after Sustainable Pittsburgh's program. Businesses that take certain steps, including actions to improve energy efficiency or to install renewables, will qualify for designation.
4. **Energy assessments.** We will leverage the technical expertise of LTI to market energy assessments alongside the other Sustainable Morgantown programs. LTI provides professional weatherization, engineering, and energy efficiency solutions to public and private clients.

Phase 3 will also include a unified public relations effort for all four programs in the Sustainable Morgantown Initiative. This will include social media and Web-based information that is disseminated by Downstream Strategies, the Green Team, the City, and other partners.

For each of these programs, we will track energy savings and GHG reductions. At the end of the project, we will produce a report that documents the GHG reductions accomplished via the Sustainable Morgantown Initiative.

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APPENDIX A: DETAILED MORGANTOWN RESIDENTIAL ENERGY CONSUMPTION SURVEY RESULTS

A total of 117 respondents submitted online responses to this survey. After excluding responses from people living outside the city limits of Morgantown, blank submissions, and duplicative household responses, a total of 110 respondents remained. Some respondents did not answer every question.

1. In general, would you consider yourself knowledgeable of general home efficiency and energy saving practices?

	No. responses	Percentage
Yes	92	84%
No	9	8%
Not sure	9	8%
Total	**110**	

2. Some homeowners participate in government or energy supplier assistance programs that help pay for energy efficiency or weatherization upgrades in their home. Are you aware of these types of programs?

	No. responses	Percentage
Yes	65	60%
No	44	40%
Total	**109**	

3. If you answered yes to question #2, which of the following have members of your household used? (select all that apply)

	No. responses	Percentage
I was aware of different types of assistance but opted not to receive assistance	20	31%
Tax credit	18	28%
Manufacturer or retailer rebate	17	26%
Utility or energy supplier rebate or program	6	9%
Other	5	8%
Not applicable	15	23%
Total	**81**	

4. Mon Power is the local electricity utility, and they offer programs such as the Home Energy Analyzer or the Low Income Home Check-Up Program designed to help homeowners conserve energy. Are you aware of these programs?

	No. responses	Percentage
Yes	45	41%
No	66	59%
Total	**111**	

5. If you answered yes to question #4, have you or anybody in your household participated in these programs?

	No. responses	Percentage of yes	Percentage of total
Home Energy Analyzer	2	4%	2%

6. If there was a program available in Morgantown that was designed to help residents reduce their energy costs as well as reduce greenhouse gas emissions, would you participate?

	No. responses	Percentage
Yes	79	71%
No	5	5%
Not sure	27	24%
Total	**111**	

7. Which neighborhood do you call home?

	No. responses	Percentage
South Park	36	33%
Suncrest	27	25%
Greenmont	15	14%
Woodburn	11	10%
First Ward	12	11%
Wiles Hill/Highland Park	4	4%
Other	4	4%
Total	**109**	

8. Including yourself, how many people occupy your residence?

	No. responses	Percentage
One	23	21%
Two	51	46%
Three	14	13%
Four	15	14%
Five	4	4%
Six	3	3%
Total	**110**	

9. Do you or members of your household own or rent your present home?

	No. responses	Percentage
Own	102	93%
Rent	8	7%
Total	**110**	

10. Which of the following, do you believe, best describes your home?

	No. responses	Percentage
Apartment building with 2 to 4 units	3	3%
Apartment building with 5 or more units	1	1%
Single-family attached house	3	3%
Single-family detached house	101	92%
Other	2	2%
Total	**110**	

Note: Single-family attached house is defined as a condominium, duplex, townhouse, etc. Single-family detached house is defined as a dwelling that does not share an inside wall with any other structure.

11. About when was the structure built?

	No. responses	Percentage
Before 1940	58	53%
1940 to 1949	6	5%
1950 to 1959	14	13%
1960 to 1969	17	15%
1970 to 1979	2	2%
1980 to 1989	3	3%
1990 to 1999	3	3%
2000 to 2014	4	4%
Not sure	3	3%
Total	**110**	

12. How many bedrooms do you have in your home? (include bedrooms in finished attics or finished basements)

	No. responses	Percentage
One	1	1%
Two	14	13%
Three	55	50%
Four	29	27%
Five	7	6%
More than five	3	3%
Total	**109**	

13. What is the total square footage of your home? (include basement if one is present, include attics or attached garage only if those areas are heated or cooled)

	No. responses	Percentage
Fewer than 500	1	1%
500 to 999	8	7%
1,000 to 1,499	17	16%
1,500 to 1,999	30	28%
2,000 to 2,499	26	24%
2,500 to 2,999	13	12%
3,000 to 3,499	3	3%
3,500 to 3,999	2	2%
4000 or more	2	2%
Not sure	7	6%
Total	**109**	

14. From one of your Mon Power electricity bills under the usage history section (see graphic below), please find and enter your last 12 months' use and your average monthly use.

Last 12 months' use

	No. responses	Percentage
0-3,000	2	4%
3,001-6,000	8	15%
6,001-9,000	21	40%
9,001-12,000	9	17%
12,001-15,000	6	12%
15,001-18,000	5	10%
18,001-21,000	1	2%
Total	**52**	

Average monthly use

	No. responses	Percentage
0-300	2	4%
301-600	12	24%
601-900	22	44%
901-1,200	8	16%
1,201-1,500	4	8%
1,501-1,800	2	4%
Total	**50**	

15. Dominion Hope provides natural gas service to the Morgantown area, and they offer a budget plan, which allows customers to pay the same amount each month for natural gas service. Do you participate in a natural gas budget plan with Dominion Hope?

	No. responses	Percentage
Yes	48	46%
No	54	51%
Not applicable	3	3%
Total	**105**	

16. If you answered yes to question #15, what is your monthly budget amount?

	No. responses	Percentage
$1.00 to $29.99	1	2%
$30.00 to $59.99	8	17%
$60.00 to $89.99	19	40%
$90.00 to $119.99	6	13%
$120.00 to $149.99	4	8%
$150.00 to 179.99	6	13%
$180.00 or greater	1	2%
Don't know	3	6%
Total	**48**	

17. If you are not on a natural gas budget plan, what do you estimate your average monthly cost for natural gas consumed in your home to be?

	No. responses	Percentage
$1.00 to $29.99	1	2%
$30.00 to $59.99	11	20%
$60.00 to $89.99	18	33%
$90.00 to $119.99	8	15%
$120.00 to $149.99	4	7%
$150.00 to 179.99	1	2%
Don't know or Not applicable	11	20%
Total	**54**	

18. Approximately, what is the total yearly cost for energy consumed within your home? (Include costs for electricity, natural gas, propane, wood, kerosene, etc.)

	No. responses	Percentage
$500 or less	1	1%
$501 to $1,000	8	8%
$1,001 to $1,500	19	20%
$1,501 to $2,000	25	26%
$2,001 to $2,500	18	19%
$2,501 to $3,000	13	14%
$3,001 to $3,500	6	6%
$3,501 to $4,000	3	3%
$4,001 to $4,500	1	1%
$4,501 to $5,000	1	1%
More than $5,000	1	1%
Total	**96**	

19. What is the most common type of light bulb used within your home today?

	No. responses	Percentage
Incandescent	14	13%
A mix but mostly incandescent	19	18%
CFL	37	34%
A mix but mostly CFL	23	21%
LED	5	5%
A mix but mostly LED	4	4%
Don’t know	6	6%
Total	**108**	

20. Regarding the insulation in your home’s walls and attic, overall, would you say your home is:

	No. responses	Percentage
No insulation	11	10%
Poorly insulated	29	27%
Adequately insulated	43	39%
Well insulated	21	19%
Don’t know	5	5%
Total	**109**	

21. How often have you or other members of your household found your home too drafty during the cooler months of the year?

	No. responses	Percentage
Never	44	41%
Some of the time	39	36%
Most of the time	14	13%
All of the time	8	7%
Don't know	3	3%
Total	**108**	

22. Caulking and weather stripping is often used to seal windows, doors, and ducts. Has any portion of your home/apartment been caulked or weather stripped in order to seal air leaks since you moved in?

	No. responses	Percentage
Yes	70	65%
No	31	29%
Don't know	6	6%
Total	**107**	

23. Which of the following is the main space heating fuel for your home?

	No. responses	Percentage
Natural gas	94	86%
Electricity	11	10%
Wood	2	2%
Other	2	2%
Total	**109**	

24. Approximately how old is the primary furnace or heating equipment used in your home?

	No. responses	Percentage
Less than 5 years old	18	17%
More than 5 and less than 10 years old	23	21%
More than 10 and less than 15 years old	19	17%
More than 15 and less than 20 years old	16	15%
More than 20 and less than 25 years old	5	5%
More than 25 years old	21	19%
Don't know	7	6%
Total	**109**	

25. Have you or a professional replaced the air filter on your furnace or main heating equipment in the last 6 months?

	No. responses	Percentage of total	Percentage of applicable
Yes	73	67%	83%
No	14	13%	16%
Don't know	1	1%	1%
Not applicable	21	19%	
Total	**109**		

26. Have you or a professional conducted service or maintenance (other than changing the air filter) on your furnace or heating equipment in the last 2 years?

	No. responses	Percentage of total	Percentage of applicable
Yes	71	65%	67%
No	32	29%	30%
Don't know	3	3%	3%
Not applicable	3	3%	
Total	**109**		

27. Do you use secondary heating equipment? (Anything to supplement the main heating equipment in any portion of your home)

	No. responses	Percentage
Yes	47	44%
No	60	56%
Don't know	1	1%
Total	**108**	

28. Which fuel does your household use for heating water?

	No. responses	Percentage
Natural gas	91	84%
Electricity	16	15%
None	1	1%
Total	**108**	

29. Approximately how old is your water heater?

	No. responses	Percentage
Less than 2 years old	13	12%
More than 2 and less than 5 years old	24	22%
More than 5 and less than 10 years old	26	24%
More than 10 and less than 15 years old	14	13%
More than 15 and less than 20 years old	15	14%
More than 20 years old	11	10%
Not applicable	1	1%
Don’t know	5	5%
Total	**109**	

30. Has the main water heater in your home ever been insulated using a water heater blanket?

	No. responses	Percentage
Yes	18	17%
No	82	75%
Not applicable	5	5%
Don't know	4	4%
Total	**109**	

31. What fuel does your oven or stove use?

	No. responses	Percentage
Natural gas	66	61%
Electricity	42	39%
Total	**108**	

32. Do you have more than one refrigerator/freezer?

	No. responses	Percentage
Yes	61	57%
No	46	43%
Total	**107**	

33. What is the approximate age of your primary refrigerator/freezer?

	No. responses	Percentage
Less than 2 years old	20	18%
More than 2 and less than 5 years old	20	18%
More than 5 and less than 10 years old	36	33%
More than 10 and less than 15 years old	17	16%
More than 15 and less than 20 years old	8	7%
More than 20 years old	4	4%
Don’t know	4	4%
Total	**109**	

34. Does your household use an automatic dishwasher?

	No. responses	Percentage
Yes	79	72%
No	30	28%
Total	**109**	

35. Approximately how old is the dishwasher your household uses?

	No. responses	Percentage
Less than 2 years old	21	20%
More than 2 and less than 5 years old	16	15%
More than 5 and less than 10 years old	21	20%
More than 10 and less than 15 years old	16	15%
More than 15 and less than 20 years old	4	4%
More than 20 years old	2	2%
Don't know	4	4%
Not applicable	22	21%
Total	**106**	

36. Which of the following categories best describes your employment status?

	No. responses	Percentage
Disabled, not able to work	3	3%
Not employed, not looking for work	5	5%
Not employed, looking for work	3	3%
Employed, part-time	7	6%
Employed, full-time	66	61%
Retired	25	23%
Total	**109**	

37. What is the highest education level obtained by any member of your household?

	No. responses	Percentage
High school diploma or GED	1	1%
Some college	6	6%
Associates degree	3	3%
Bachelor's degree or above	98	91%
Total	**108**	

38. Do you or does anyone in your household work from home more than 20 hours a week?

	No. responses	Percentage
Yes	25	23%
No	83	77%
Total	**108**	

39. Which category best describes the total combined yearly income of all members living in your household?

	No. responses	Percentage
$10,000 to $14,999	1	1%
$15,000 to $19,999	3	3%
$20,000 to $29,999	5	5%
$30,000 to $39,999	6	6%
$40,000 to $49,999	6	6%
$50,000 to $74,999	30	30%
$75,000 to $99,999	20	20%
$100,000 or more	29	29%
Total	**100**	

APPENDIX B: FOCUSED HOME ENERGY ASSESSMENT RESULTS

Close to 55% of Morgantown Residential Energy Consumption and Efficiency Survey respondents were interested in a home energy assessment. Ten homes were chosen to receive focused home energy assessments.

Home 1

Observation	Recommendation
Four occupants	Insulate louver covered whole house fan
Split-level design	
Built in 1964	
More than five bedrooms	
1,500-1,900 square feet	
Primary heating unit is 5-15 years old	
Water heater is 5-15 years old	

Home 2

Observation	Recommendation
Two occupants	Replace incandescent lamps with CFL or LED
Two-story dwelling	
Built in 2006	
Three bedrooms	
2,000 square feet	
Primary heating unit is less than five years old	
Water heater is less than five years old	

Home 3

Observation	Recommendation
Two occupants	Address gaps and voids in insulation
Split-level design	Replace incandescent lamps with CFL or LED
Built in 1960	Insulate attic hatch
Three bedrooms	Add fiberglass batts to attic to achieve R-38 to R-50
2,000 square feet	
Primary heating unit is less than 10 years	
Water heater is more than five years old	

Home 4

Observation	Recommendation
Two occupants	Insulate the building
Two-story brick building	Seal fireplaces when not in use
Built in 1903	
Four bedrooms	
4,700 square feet	
Primary heating unit is greater than 20 years old	
Water heater is between 10 and 12 years old	

Home 5

Observation	Recommendation
Two occupants	Address gaps and voids in insulation
Two-story brick building	Replace gas and incandescent lamps with CFL or LED
Built in 1911	Seal fireplace when not in use
Four bedrooms	
3,000-3,499 square feet	
Primary heating unit is 10-15 years old	
Water heater is between 15-20 years old	

Home 6

Observation	Recommendation
Three occupants	Address gaps and voids in insulation
Two-story frame building	Insulate ducts in garage
Built in 1927	Insulate and weather strip garage doors
Four bedrooms	
5,400 square feet	
Primary heating unit is 10-15 years old	
Water heater is less than 10 years old	

Home 7

Observation	Recommendation
Two occupants	Address insulation compaction
Two-story frame building	Weather strip garage door
Built in 2013	Replace incandescent lamps with CFL or LED
Three bedrooms	Weather strip rear doors
1,000-1,499 square feet	
Primary heating unit is less than five years old	
Water heater is less than five years old	

Home 8

Observation	Recommendation
Four occupants	Address gaps in insulation
Split-level building	Insulate and weather strip garage doors
Built in 1950	Replace incandescent lamps with CFL or LED
Three bedrooms	Insulate louvered attic vent during winter months
2,000-2,499 square feet	Seal fireplaces when not in use
Primary heating unit is greater than 15 years old	
Water heater is less than two years old	

Home 9

Observation	Recommendation
Two occupants	Insulate south walls of home
Split-level building	Insulate and weather strip garage doors
Built in 1956	Replace incandescent lamps with CFL or LED
Three bedrooms	Seal fireplace when not in use
2,000-2,499 square feet	
Primary heating unit is greater than 15 years old	
Water heater is less than two years old	

Home 10

Observation	Recommendation
Three occupants	Insulate garage door
Two-story frame building	Insulate and seal attic access hatch
Built in 1935	Seal fireplace when not in use
Three bedrooms	
2,000 square feet	
Primary heating unit is less than 10 years old	
Water heater is less than 10 years old	