Focusing the Use of Incentives on Maximizing Greenhouse Gas Emissions Reductions for Existing Homes in Montgomery County, Maryland

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Abstract

This project evaluates the incentives provided by Montgomery County Maryland, to encourage homeowners to purchase energy efficient appliances, equipment, and modifications for existing residential properties. The methods used included participation, as a stakeholder member, in the Montgomery County Department of Environmental Protection (DEP) Working Group tasked to develop energy efficiency incentives for existing residential properties, a review of the literature, and gathering information on the approaches used by other jurisdictions. The project reviewed the existing information and considered it from a different perspective than the existing DEP approach. The energy efficiency actions were evaluated to determine the resulting amount of greenhouse gas (GHG) emissions reduction each action would provide per dollar cost. This resulted in recommendations to develop incentives that target actions providing the largest GHG emissions reductions for the incentive dollars spent and those actions requiring lowest purchase cost by consumers, in support of low- and moderate-income homeowners.

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Introduction

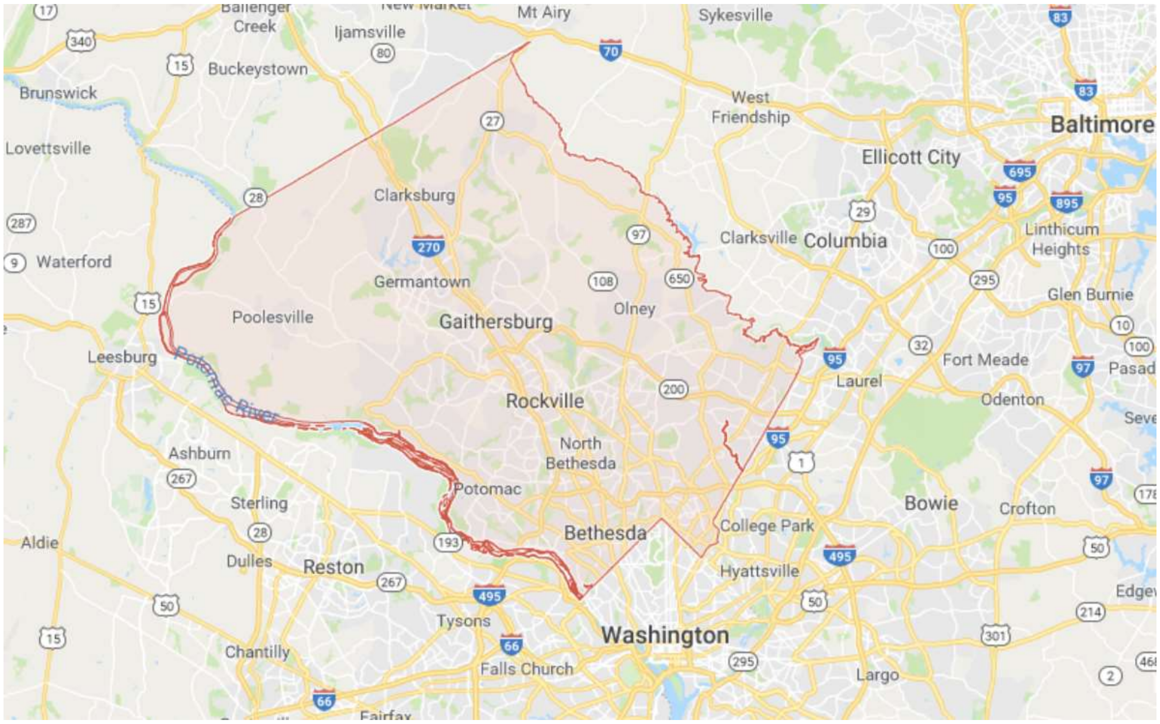

Figure 1. Montgomery County, Maryland ("Montgomery County Map," n.d.)

Policy Contexts

Maryland State Actions

Maryland, which is bordered by both the Chesapeake Bay and the Potomac River, is considered particularly sensitive to the effects of increasing greenhouse gas (GHG) concentrations in the atmosphere and the resulting impacts of climate change, which include sea level rise, water intrusion along the shoreline, and shore erosion ("Maryland's Greenhouse Gas Reduction Plan - October 2013," 2013).

These impacts, along with other effects of climate change – including extreme weather events, heat stress, and impacts on ecosystems – led to the state's issuance of the "Healthy Air Act" in 2006, which established a baseline of 106.93 million-metric tons (MMT) of carbon dioxide equivalent (CO_2e) annual gross greenhouse gas (GHG) emissions, the first of many such actions to be taken by the state ("Maryland Greenhouse Gas Emissions Inventory Documentation - Base Year Projection Years," 2011).

Maryland passed the "EmPOWER Maryland Energy Efficiency Act" in 2008, which established cooperative energy efficiency programs, developed by the Maryland Energy Administration and managed by the local utilities (Baltimore Gas and Electric Company, Potomac Edison Company, Delmarva Power & Light, Potomac Electric Power Company, Southern Maryland Electric Cooperative, and Washington Gas Light Company). These programs focused on promoting reduced energy consumption in residential properties and commercial and industrial facilities through the use of various incentives provided in the form of utility bill rebates ("EmPOWER Maryland," n.d.).

In 2009, the State issued the "Greenhouse Gas Reduction Act of 2009," which established the initial goal of a reduction of 25% in the State's GHG emissions, relative to the 2006 baseline emissions, by the year 2020 ("Greenhouse Gas Emissions Reduction Act of 2009 - HB315/SB278," 2009). In 2016, Maryland issued the "Greenhouse Gas Reduction Act of 2016," which renewed the 2009 law and expanded the goals to a 40% reduction in GHG emissions, relative to the 2006 baseline emissions, by the year 2030 ("Greenhouse Gas Emissions Reduction Act - Reauthorization," 2016).

Maryland currently uses two methods to encourage energy reduction activities – regulation and building codes (to require) and incentives (to promote). The State also sponsors education and awareness efforts that encourage voluntary actions ("Maryland's Greenhouse Gas Reduction Plan - October 2013," 2013). The Maryland Energy Administration website lists all the currently available incentives to State homeowners including utility-sponsored programs, loans, grants, and tax credits ("Maryland Energy Administration Incentives," n.d.).

Montgomery County Actions

In 2017, Montgomery County, Maryland, took a significant action to address the primary man-made cause of climate change, greenhouse gas emissions. The County was among the first in the United States to support the Climate Mobilization organization's position as follows ("Drafting and Passing Climate Emergency Policy," n.d.):

> “By declaring that we are in a climate emergency and committing to addressing it in time to avoid the worst outcomes, local governments can become leaders of the climate emergency movement, and inspire others to do the same.”

Maryland’s Montgomery County Council issued an “Emergency Climate Mobilization,” resolution on December 5, 2017, which documented the Council’s position that urgent, additional action was required to reduce the County’s greenhouse gas (GHG) emissions in response to the emerging threats from climate change. The resolution, which is more ambitious than Maryland’s goals, specified an acceleration from the then current County goals for reduction in GHG emissions (an 80% reduction by the year 2050) to, instead, an 80% reduction in GHG emissions by 2027 combined with a 100% reduction by 2035 (“Emergency Climate Mobilization - County Council For Montgomery County, Maryland Resolution No. 18-974,” 2017).

Maryland’s most populous, Montgomery County is home to approximately 1.04 million residents. In 2008, the County had determined that additional actions were needed to further address the its contribution to the reduction in GHG emissions in support of the state goals (“Montgomery County MD - Quick Facts,” n.d.). The Montgomery County Council adopted Bill No. 32-07, “Environmental Sustainability – Climate Protection Plan,” which established a County goal of an 80% reduction in GHG emission by the year 2050. In addition, the County took the position in 2017 to reaffirm its support of the international Paris Climate Agreement (“Montgomery County Reaffirms Commitment to Meeting Goals of the Paris Climate Agreement - Resolution No. 18-846,” 2017) and, as discussed previously, issued the Climate Emergency resolution.

Figure 2. Typical 1950 Vintage Residential Properties in Montgomery County, Maryland, representative of mean square footage ("Montgomery County House," n.d.)

Incentivizing Beneficial Response

County Support for Energy Reduction in Residential Properties

In addition to the state and County legislation and bills, Montgomery County has also adopted other approaches to addressing greenhouse gas emissions. The Montgomery County Department of the Environment (DEP) and the Montgomery County Council have enlisted single-family residential property owners as partners in reducing energy use and corresponding GHG emissions. The emissions are a result of the County's current reliance on electrical energy production facilities (primarily coal and natural gas) that produce GHG emissions as a byproduct and the direct use of natural gas at residential properties ("Maryland Greenhouse Gas Emissions Inventory Documentation - Base Year Projection Years," 2011).

Montgomery County has limited authority to mandate residential activities (such as requiring modifications to existing, privately owned properties). The County has instead used education, outreach programs, and financial incentives – primarily property tax credits – to influence consumers to make energy efficient purchases and modifications that might not otherwise occur on a strictly volunteer basis (Shaw, 2017).

The "My Green Montgomery" website is directed towards the residents of Montgomery County, listing of currently available State and County energy efficiency incentives ("Incentives and Programs," 2018). The incentives apply to the approximately 187,00 existing detached homes and townhomes, accounting for 48% of the County's existing housing stock and usually receive a combination of electric power and natural gas energy (Reed, 2014)

The most recently offered set of incentives (Shaw, 2017) consists of property tax reductions that are available to owners of existing residential homes for a variety of purchases that would reduce the amount of energy consumed, and therefore the corresponding greenhouse gas emissions. These incentives were specifically developed in support of Montgomery County's established goals for the reduction in greenhouse gas (GHG) emissions ("Emergency Climate Mobilization," 2017).

To What Extent are Incentives Correlated to Reduced Energy Consumption and GHG Emissions?

The Montgomery County Department of Environmental Protection established a Working Group to assess existing consumer incentives and to consider new types of incentives and purchases (energy efficient appliances, equipment, and modifications for existing homes) that would most efficiently and effectively reduce energy consumption in support of the County's GHG emissions reduction goals (Shaw, 2018)

The DEP periodically develops new incentive packages – primarily consisting of previously included equipment and modifications – and then assigns monetary incentives generally proportional to the cost of the necessary equipment or modifications. For example, an efficient clothes washer might receive a $50 incentive while a more expensive Energy Star geothermal heat pump would receive up to $2000.

Therefore, two of the areas addressed in this project report consider the consequences of assigning incentive value based on consumer cost and potential alternatives available, which are possibly better aligned with County GHG emissions reduction goals and equitable participation in the program by homeowners.

(1) The energy efficient purchases and modifications, and the corresponding incentives, are not being evaluated with respect to any reduction in energy use or GHG emissions, (which is beyond the current scope of the DEP Working Group). A quantitative correlation between incentive costs and the amount of energy reduction resulting from the energy efficient purchases and modifications is necessary to measure the reduction in energy use per dollar of incentive spent. The absence of this measurement constrains DEP's ability to optimally manage its limited incentive resources, ideally applied to purchases resulting in the largest reductions in energy use per incentive dollar. Having that measurement would provide the DEP the information necessary to maximize the amount of reduction of energy use for specific incentives. This would also provide information on GHG emissions reduction that could be used to determine the incentive's support for the County GHG emission reduction goals.

(2) The process and results determining incentive value addresses the aspect of the social equity of the incentives in a limited manner. The incentive program for a 100% reimbursement of a wide range of energy efficiencies is aimed at lower cost incentives and is currently capped at $250 (Shaw, 2017). However, purchases and modifications of larger costs – more expensive purchases and modifications – typically require a larger consumer contribution than is affordable to low and middle-income homeowners. Therefore, these homeowners are constrained from full benefits of reduced utility costs via increased energy efficiency, and from contributing to County goal fulfillment.

<u>Correlating Reductions in Energy Consumption and GHG Emissions</u>

To achieve the stated energy reduction goals, the State, County, and the applicable energy suppliers should instead consider both sides of the "demand to capacity ratio" (as shown in Figure 3) in order for energy demand to become less than, or equal to, the capacity of the energy supplied by non-GHG producing sources. As energy demand is reduced, and as non-GHG sources are simultaneously developed, the more quickly the non-GHG energy capacity will meet the energy demand as demonstrated in Figure 3. The accurate crediting of energy use reduction may contribute to identification of the point where non-GHG energy source capacity meets the State and County's energy demand, identify the point where the need for maintain GHG emitting energy sources has been reduced or eliminated.

Measurement (or an approximation) of the amount of energy reduction for each incentivized purchase or modification of a residential property would allow for the aggregation of the collective GHG emissions reductions that resulted from the purchases and modifications made in accordance with the total incentives budget. This would provide an understanding of the contribution of the incentives program to the County's total decrease in energy demand. This could then provide useful information for modifying the incentive budget when compared to other energy reduction incentives (such as those not related to residential properties).

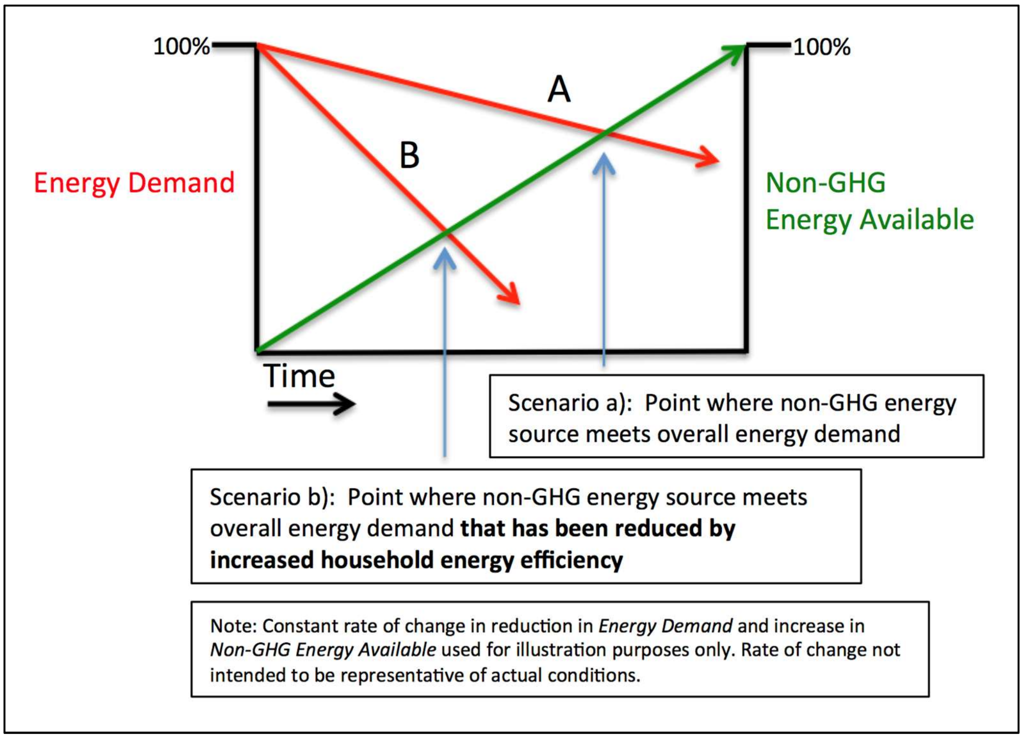

Figure 3. Differing Durations Required for Non-GHG Energy Capacity To Meet Reductions In Energy Demand

Methods

Incentives for Energy-Reduction: Applying Lessons from Other Locales

The initial stage of the research into these questions was to identify the set of incentives and incentivized purchases and modifications that have been used in the localities adjacent to

Montgomery County – Virginia, Delaware and the District of Columbia (D.C.) – and in other selected areas, such as the State of California, in order to identify those that might be applicable for use in Montgomery County (the sources of this information are shown in the **Incentive – Sources of Information** text box, which identifies corresponding program names and links).

The information obtained from the other locations contributed to a consolidation of regional incentives for consideration of applicability to Montgomery County. The results of this activity provided a set of incentives and incentivized purchases and modifications that could be considered for the various attributes that follow below.

Literature reviewed for this study identified incentive types and values to which consumers have consistently responded. For example, the Environmental Protection Agency (EPA) provided extensive information on the use and promotion of market based incentives including subsidies, permits, and voluntary actions to promote environmental protection ("The United States Experience with Economic Incentives for Protecting the Environment," 2001). Incentive types include those previously offered by the County such as property tax deductions, but also those that have proved successful in other jurisdictions such as items as county income tax deductions, sales tax reduction, rebates, and low loan interest rates. These would include low cost incentives that the consumers repeatedly use (an example of this would be a $250 dollar tax credit per year available for a variety of energy efficient home modifications (for example a programmable thermostat or LED light bulbs), which could be used for a different type of modification each year) (Shaw, 2017).

Incentives – Sources of Information

The District of Columbia – DC.gov – Department of Energy and Environment website for Washington D.C. residents ("Residential Green Incentives," n.d.)

Delaware – Delaware.gov – Energy and Climate website for Delaware residents ("Renewable Energy Assistance," n.d.)

Virginia – Virgina.gov – Division of Energy website for Virginia residents ("Energy Incentives," 2015)

California – DSIRE – Database of state incentives ("Database of State Incentives for Renewables & Efficiency (DSIRE)," n.d.)

Each incentivized purchase and modification was assigned an incentive cost in U.S. dollars based on Montgomery County market conditions and current prevailing retail costs. Secondly, the anticipated reduction in energy consumption was determined based for each incentivized activity and typical energy consumption for Montgomery County residential properties.

The energy sources provided to Montgomery County residential properties were then reviewed to determine the GHG emissions per kWh of electricity (1.1 lbs CO_2e) ("Maryland Environmental Information for Standard Offer Service," 2017) and delivered natural gas (0.4 lbs CO_2e) ("U.S. Energy Information Administration - Frequently Asked Questions," n.d.). Market prices were assigned to a kWh of electricity and a therm of natural gas. This set of data was the basis for relating the number of dollars of incentive spent for the reduction in the amount of energy consumed to the reduction in GHG emissions at the energy source and at a residential property (in the case of directly-delivered natural gas).

The amount of GHG emissions produced by the consumption of a kWh and therm of energy used in the residential properties was calculated using the currently supplied energy sources of electricity. The sources are (10% renewable non-GHG emitting, 44% nuclear, and 26% coal, 20% natural gas-fired power plants) ("Maryland Profile Analysis," 2018) and natural gas that is directly supplied to residential properties. The GHG emission per unit of energy reduction for each incentivized purchase and modification were determined using this information.

Measurement of GHG Emissions Reduction per Dollars of Incentive Each of the set of available incentives and incentivized purchases and modifications, with the costs and GHG emissions determined, was then calculated resulting in a measurement of the reduction in GHG emissions per dollar of incentive spent (GHG emissions reduction (CO_2e)/incentive cost ($)).

Management of the Application of Incentives The GHG emissions reduction (CO_2e)/incentive cost ($) was used then as a factor for identifying those incentives that would align most closely with the Montgomery County reduction in energy use and GHG emissions stated goals. The GHG reduction (CO_2e)/incentive cost ($) calculation then allows the County to better manage the limited available incentive resources for application on purchases that would result in the largest reductions in GHG emissions per dollar of incentive spent.

Maximization of the Impact of Incentives The informed management of the incentive resources would provide the County with the ability to maximize the amount of reduction of energy use and GHG emissions in order to support the County GHG emissions reduction goals.

Considerations of Social Equity and Affordable Incentivized Purchases and Modifications

Social equity of incentive availability was addressed using a tiered approach that groups incentivized purchases and modifications into categories based on cost such as low cost, medium cost, and high cost (consumer contribution). Using the "GHG emissions reduction per dollar incentive cost" calculation allows ranking within each tier in order to focus on those lower cost purchases and modification that provide the largest amount of reduction in GHG emissions per dollar of incentive. A weighting factor, based on the item cost relative to the incentive budget, was applied to provide **a balance between targeting maximized GHG emissions reduction and maximizing community participation** in the incentive program. Additionally, at certain low income levels, it may be appropriate to continue to use incentive resources to completely cover the cost of purchases and modifications that would (1) result in a benefit to County in the form of reduced energy use and GHG emissions and to provide the consumer with a reduction in utility costs and (2) have a secondary impact in the form of education and outreach on the impacts of reducing energy consumption and the associated costs.

Summary

The implementation of the incentives outlined in the report are bounded by the maximum value of the incentive, type of incentive (*property tax credit*, *sales tax credit*, *rebate*), timing of incentive, consumer awareness and actions, alignment with existing regulatory structure and goals, and governing body approval. Therefore, it is important, considering the limited availability of incentive resources, to provide consumer incentives **that maximize the contribution to the stated goals relative to a reduction in energy consumption and GHG emissions**.

The methods discussed, along with the results and conclusion, are presented in additional detail within the following section of this paper. The pertinent information identified through the literature review and informed by the author's activities in the Montgomery County residential incentive Working Group, is collected in Appendix 1.

Montgomery County, Maryland, periodically develops new combinations of energy efficiency incentives for existing residential properties in order to further changes in energy reduction goals set at the County or State level. The development of incentives and incentivized behaviors by consumers provides an opportunity to reconsider which incentives types and amounts are most effective, and which energy efficiencies are to be included in an updated incentive package.

The County incentive package usually consists of groupings of energy efficiency measures (for example, installation of attic insulation) that are supported by a County property tax rebate, which is a percentage of the consumer's cost for the energy efficiency. In this example the dollar amount of the incentive is directly proportional to the cost of installing the measure and is, therefore, often accompanied by a cap (for example, $2000) to limit the amount of an individual incentive (Shaw, 2017). A second type of incentive is available to a broader group of energy efficiencies (for example, programmable thermostats), which is in the form of a cash rebate to consumers that is 100% of the purchase price. This is currently (2018) capped at $250 (Shaw, 2017).

The use of property tax rebates, in lieu of cash rebates, is the preferred type of incentive to be proposed by the Montgomery County Department of Environmental Protection. Incentives that reduce a residential property tax cause a reduction in the amount of property tax to be collected for that specific property the next year following the incentive, such that the County collects no money to implement the incentive. Therefore, once approved, property tax rebates are specific to the County energy efficiency incentive program and no longer subject to further County budgeting considerations (Shaw, 2018). However, to obtain fund for cash rebates, the DEP requests funds that are allocated according to the County's yearly taxing, fund collection, budgeting, and re-allocation processes. Requesting and obtaining funds, on a yearly basis from the County budget is an additional activity with less predictable outcome requiring competition for County funds with other departments and programs (Shaw, 2018). The DEP Working Group activities provided an opportunity to evaluate the current processes and incentives for increased energy efficiency to identify changes that would result in increased alignment with the County's GHG emissions reductions goals.

This project included an examination of a broad view of environmental, economic, and social aspects of energy efficiencies for existing residential properties, the types and costs of these incentives, reductions in energy use they may give, reduction in greenhouse gas (GHG) emissions they represent, the availability of their energy efficiencies, and the corresponding reduction in energy costs to low and middle income (LMI) residents of Montgomery County. It also examined the need for targeted marketing.

The incentives are developed by the Montgomery County Department of Environmental Protection (DEP), managed as a portion of the County budget, and approved by the Montgomery County Council. Currently, the consumer actions being encouraged are actions to encourage energy efficiency such as the purchase of appliances, equipment, or modifications in, existing residential properties, that will reduce the amount of energy consumption and therefore, ultimately, reduce the amount of GHG emissions (Shaw, 2018).

Environmental Factors

This project was focused on correlation observed between the reduction in GHG emissions and incentive costs prompting energy efficiency actions for existing residential properties. This correlation is seen, here, as a management improvement tool for County officials with limited incentive resources available for maximizing GHG emissions reduction in support of the County's stated goals (Shaw, 2018).

Prior to, and during the research and performance of the methods employed for this project, the author participated as a stakeholder member in the Montgomery County, Maryland, Department of Environmental Protection Working Group. The Working Group was assembled to review the current set of incentives for energy reduction purchases and modifications for existing residential properties in support of the County's recently declared "climate change emergency," which modified the County's GHG emission goals as previously discussed in the Introduction section above ("Emergency Climate Mobilization," 2017). Participation in the Working Group provided the author insight into the mechanisms, processes, and limiting factors of incentive development and, ultimately the choice for incentivized energy reduction activities.

Surveying the literature from representative communities (adjacent and selected) enabled initial identification and cataloguing of three items: (1) the types of energy efficiency actions currently used for existing residential properties, (2) the incentive types used to encourage consumers to perform the energy efficiency actions, and (3) the monetary value of the incentives provided to encourage consumers to perform the desired energy efficiency actions. The communities subject to the literature survey were the District of Columbia (Washington D.C.) ("Residential Green Incentives," n.d.), and the States of Virginia ("Energy Incentives," 2015), Delaware ("Renewable Energy Assistance," n.d.), and California ("Energy Efficiency Programs," 2018). The survey resulted in identifying energy efficiency incentives provided at several governmental levels: city, county and state. The results of this survey were compiled in an spreadsheet (included as Appendix 1, "Energy Efficiency Actions Data"), which was further expanded and modified during the performance of the additional portions of the methods that follow.

These cataloged energy efficiency actions were then reviewed in order to identify those actions that could be applicable or suitable for existing residential properties–single family homes and townhomes–and the identified actions were then sorted (from the multiple duplications of similar action from various communities) in order to compile a single set of energy efficiency actions considered appropriate for Montgomery County. For each energy efficiency actions, the various community's incentive types and values were then cataloged.

The energy reduction of the energy efficiency action was typically provided as a percentage reduction of the initial energy being consumed (prior to the efficiency action), and was converted to estimations of actual energy amounts in kWh (energy expressed in therms was converted to kWh for consistency). This was accomplished through additional literature research that provided information specifically for the Montgomery County housing stock ("Barlett et al.," 2016) or, as necessary, by considering the variations of in housing size and energy consumption and then calculating the existing energy consumption along with the expected percentage energy reduction due to the energy efficiency actions ("AP 42, Fifth Edition Compilation of Air Pollutant Emissions Factors, Volume 1: Stationary Point and Area Sources," 2009).

The local energy sources available to Montgomery County residential properties (electricity and directly supplied natural gas) were evaluated in order to determine the usual GHG emissions for these utility-supplied energy sources ("American Community Survey - Select Housing Characteristics 2012-2016 American Community Survey 5-Year Estimates - Montgomery County, Maryland," n.d.). The electricity available to County residents is sourced from coal, gas, or oil-fired power plants; and also renewable sources, primarily wind and solar; and a single nuclear power plant (Calvert Cliffs). Natural gas was a second energy source for many properties and was delivered directly to the residence to be combusted for use as a heating source ("Maryland Profile Analysis," 2018).

Maryland provides consumers a breakdown, on their energy bill, stating the portion of energy source types that supply electricity to the State (and County) and the resulting amount of GHG emissions per year ("Maryland Greenhouse Gas Emissions Inventory Documentation - Base Year Projection Years," 2011). In addition, the U.S. Energy Information Administration (EIA) provides a method to calculate the pounds of CO_2 created per kWh for fuel-specific energy generators a CO_2 emissions factor and identified state-specific data sets that could be used to make the necessary calculations ("U.S. Energy Information Administration - Frequently Asked Questions," n.d.).

The Washington Natural Gas Commission provides consumers information, on their energy bills, stating the GHG emissions produced during production and delivery of the natural gas to a residence (through delivery loss) ("WGL Achieves Two Major Carbon Emissions Reduction Goals Early - Fact Sheet & Infographic," 2016). The principle source of natural gas GHG emissions occurs during the combustion of the delivered natural gas at the residence. This was determined by using Environmental Protection Agency emissions factors for CO_2 per unit of combusted natural gas ("AP 42, Fifth Edition Compilation of Air Pollutant Emissions Factors, Volume 1: Stationary Point and Area Sources," 2009).

The reduction in energy consumption (in kWhs or therms) for the each selected energy efficiency action was then converted to a calculation of a reduction in GHG emissions (mass of CO_2e) using the amount of GHG emissions per kWh of electricity produced and the GHG emissions per therm of natural gas combusted at a residence.

Economic Factors

Developing the GHG emissions reduction factor and incentive cost provided the necessary information to correlate each energy efficiency action's GHG emissions reduction to an incentive amount, which could then be expressed as a reduction in GHG emissions per cost of the incentive (mass-CO_2e) / incentive cost (\$). This calculation allowed for a direct comparison of the value of various energy efficiency actions, using a common factor of GHG emissions reduction per the incentive cost for the each energy efficiency action.

The calculation of the GHG emissions reduction/per incentive cost provided an opportunity to reconsider the traditional order of implementing energy efficiences in residential properties in the County, such as sealing an attic, then installating roof, attic and ceiling insulation, followed by other energy efficiency measures ("Energy Savings at Home," n.d.). Alternatively, other measures combined could result in great energy saving at a lower incentive cost and, therefore, might be considered the first action that a homeowner should take. This lead to the development of an implementation plan based on a rank ordering of energy efficiency measures based on a the combination of the reduction in GHG emsissions calculated to be at the lowest incentive cost.

Social Factors

The information obtained and developed, at this point, contributed to an addressing of the environmental (identification of GHG emissions reduction for the energy efficiency action) and the economic factors (maximize reductions in GHG emission per cost) of the development of County energy efficiency incentives for existing residential properties. Additional research was required to identify the socio-economic factors to be considered for the development of the County incentives.

To do this, a literature review was performed to explore the efficiency of providing incentives to residents that were likely to make the purchases without any incentive (typically high- dollar projects), and whether this point of inflection, beyond which the purchase would occur could, be reliably identified. This was considered an important factor for the equitable distribution of incentives in that the unnecessary incentive expenditures rendered that amount of incentive unavailable for other homeowner energy efficiency actions where a consumer would not make the purchase without the availability of an incentive (Shogren, 2012).

Associated literature was reviewed was to determine the contribution point(s) at which low- and moderate-income (LMI) consumers were likely to make an energy efficinciency purchase. This was performed in order to consider whether a large, or total incentive (covering the complete cost of an energy upgrade), would more likely result in LMI residents' participation towards the County's goal of a reduction in GHG emissions and receiving thereby the benefit of reduced energy costs. In addition, the GHG emissions correlation to incentive cost calculation allowed for scaling the incentive amounts to more strongly encourage the choice of the energy efficiency actions for LMI residents that produced the greatest reduction in GHG emissions per incentive cost ("The United States Experience with Economic Incentives for Protecting the Environment," 2001).

Development of Incentive Recommendations

These methods, previously discussed, to evaluate the environmental, economic and social factors were chosen such that the results would provide policymakers sufficient information to balance the environmental and economic achievements of meeting GHG emissions reduction goals, while reducing a potential negative economic impact on the incentive budget by offering unnecessary incentives for higher income residents. This was done along with an evaluation of the consideration of the positive socio-economic impact of reduced energy costs and the participation in the support of County GHG reduction goals, for the LMI community.

With this information in hand, a set of County-specific energy efficiency action incentives for existing residential properties were rank-ordered using the factors considered in this analysis: the energy efficiency actions, incentive type, incentive costs, energy reduction amounts, and GHG emissions reduction amounts, with additional the factors of energy efficiency actions not requiring an incentive, energy efficiency actions requiring additional incentives to support LMI consumer participation, and the need for targeted marketing were all considered.

Results and Discussion

Incentives can be defined as financial benefits (*tax deduction, discounts, rebates*) used to encourage consumers to purchase energy efficient equipment and modifications. The value of County incentives had previously been based solely on the consumer cost of the energy efficiency action. Additional data was considered to develop incentives that address each of the three pillars of sustainability (*economic, environmental, and social*).

Identification of Energy Efficiencies and Incentives

The literature review of the energy efficiencies and the corresponding incentives for the jurisdictions adjacent to Maryland – Delaware, Virginia, Washington, D.C., and also the State of California (to include spatial diversity in the review) – provided data that were suitable for reviewing with respect to commonality and divergence.

The resulting catalog of energy efficiencies and corresponding incentives (see Appendix 1) was reviewed in order to verify that the set of energy efficiencies applicable to the existing residential properties in Montgomery County, Maryland, was consistent with the other jurisdictions (see Table 2, "Applicable Energy Efficiencies Identified Through the Literature Review"). It was noted that the energy efficiencies incentivized in each of the jurisdictions, including those previously incentivized in Montgomery County, were included in more than one jurisdiction, if not all. There were few regionally specific incentivized energy efficiencies (such as efficient swimming pool pumps in California) identified for existing residential properties that were unique to a single jurisdiction ("Database of State Incentives for Renewables & Efficiency (DSIRE)," n.d.).

Energy Efficiency Action	Energy Savings (kWh/year)	Greenhouse Gas Emissions (GHG) Reduction due to Energy Savings (CO_2e lbs/year) (see Note B)	Consumer Cost[28]	GHG Emissions Reduction (lbs CO_2e/year) per Consumer Cost of Energy Efficiency Action (dollars)	Number of Energy Efficiency Actions per Proposed County Budget ($500,000)	"Sustainability Factor" - GHG Emissions Reduction*Number of Energy Efficiency Actions per Proposed County Budget	Embodied Energy (kWh)	Incentives - California	Incentives - D.C.	Incentives - Delaware	Incentives - Virginia
Air conditioners (SEER 9 to SEER 14) (See *Note D.*) 8	1,886	2075	2300	0.90	217	196	1666 [30]	$450-900/unit			

Table 1. Detail of Appendix 1 - Energy Efficiency Actions with Varying Incentive Types and Costs

The incentives for residential properties in each jurisdiction, including Montgomery County, were similar in that the monetary value of the incentive applied to an amount of energy efficiency was proportional to the consumer purchase price of that energy efficiency, including Washington, D.C. ("Residential Green Incentives," n.d.), Virginia ("Energy Incentives," 2015), Delaware ("Renewable Energy Assistance," n.d.), and California ("Database of State Incentives for Renewables & Efficiency (DSIRE)," n.d.). Table 2 lists the energy efficiencies identified in the review that were also applicable to Montgomery County, Maryland,

Air conditioners Attic Insulation Clothes Dryer Clothes Washer Dishwasher Duct Sealing Exterior Wall Insulation Exterior Wall Sealing Freezer Furnace – Gas, Forced Air Heat Pump - Air Source	Heat Pump - Geothermal LED Lighting Replacement Programmable Thermostat Refrigerator Roof Water Heater – Gas Water Heater – Heat Pump Water Heater – Solar/Electric Water Heater – Solar/Gas Windows

Table 2. Applicable Energy Efficiencies Identified Through the Literature Review ("Database of State Incentives for Renewables & Efficiency (DESIRE)," n.d.)

<u>Economics</u>

The energy efficiencies in Table 2 were evaluated to determine the consumer cost, incentive types and costs, energy savings (relative to Montgomery County), GHG emissions reduction (relative to Montgomery County), and embodied energy in the modification. For the purpose of illustration of the results of this project, five energy efficiencies from Table 2 were considered, as shown in Figure 4 below, "Energy Efficiencies by Cost," ("National Residential Efficiency Measures Database," n.d.). Within cost-proportional incentives, "window replacement" would receive the largest incentive and "lighting replacement" (using LED bulbs) would be provided the smallest incentive. The rank order from largest to smallest cost and incentive would be:

<u>Rank 1 – Largest Cost</u>

1. Window Replacement
2. Seal/Insulate Attic
3. Water Heater Replacement
4. Dishwasher Replacement
5. Lighting Replacement

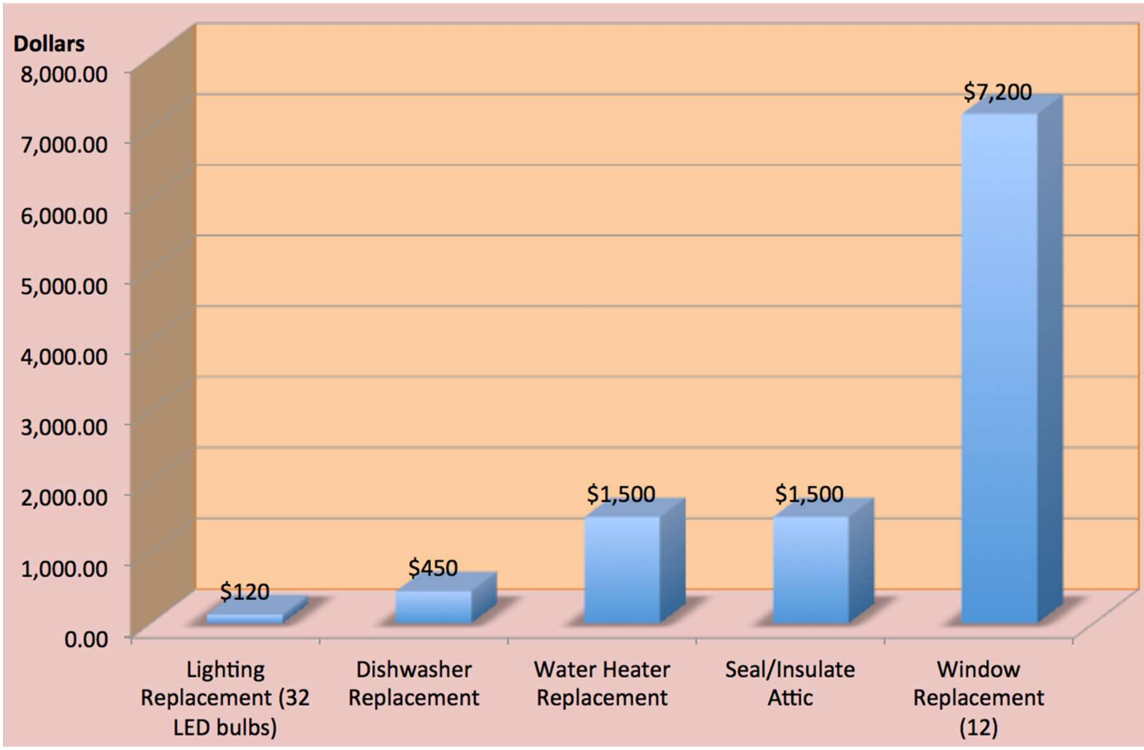

Figure 4. Energy Efficiency Options by Cost ("National Residential Efficiency Measures Database," n.d.)

<u>Environment</u>

Based on the literature review and supporting documentation, the energy efficiencies data were considered in an alternative manner and assessed on the effectiveness of the contribution to the stated goals of reducing energy consumption and GHG emissions. As shown in Figure 5, "Energy Efficiencies by GHG Emissions Reduction lbs/year," the five energy efficiencies' GHG emissions reductions do not correlate with the costs of the energy efficiency. In this case, the "water heater replacement" could be expected to result in a reduction of GHG emission of 2,200 lbs of CO_2 per year, while the more costly "window replacement" would achieve a 660 lbs reduction of CO_2 per year. In addition, the least costly energy efficiency – "lighting replacement" – resulted in a GHG emissions reduction of 1,045 lbs of CO_2 per year. The rank order from largest to smallest reduction in GHG emissions reductions per year would be:

<u>Rank 2 – Largest GHG Reductions per Year</u>

1. Water Heater Replacement
2. Lighting Replacement
3. Seal/Insulate Attic
4. Window Replacement
5. Dishwasher Replacement

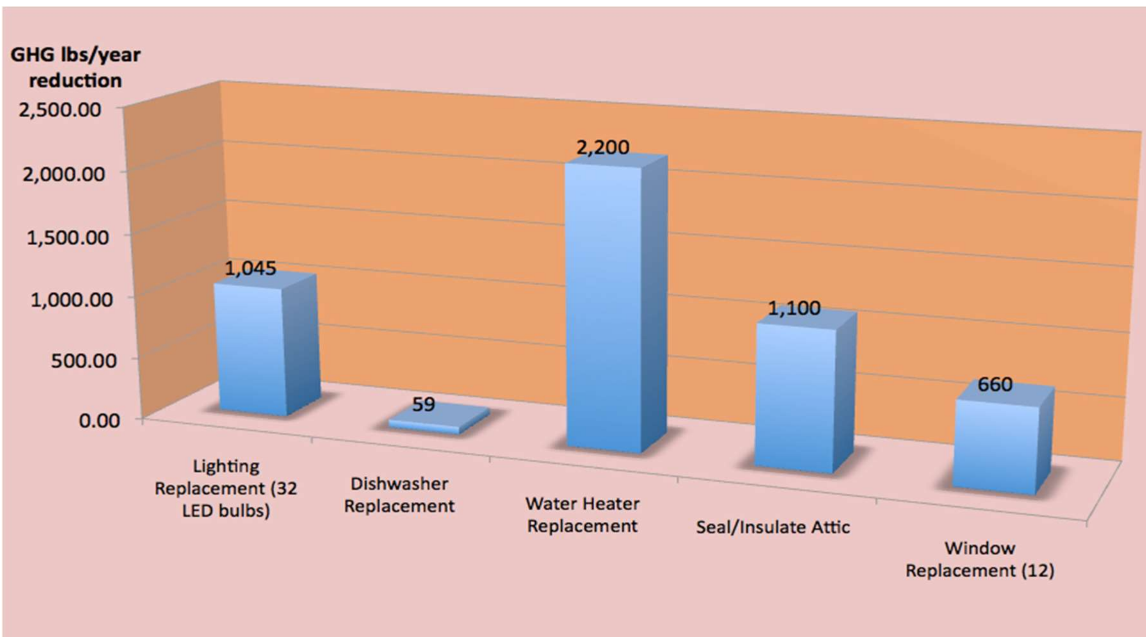

Figure 5. Energy Efficiencies by GHG Emissions Reduction lbs/year [References: Led Bulbs ("Energy Efficient Light Bulbs," n.d.), Dishwasher ("Dishwasher," n.d.); Water Heater ("Energy Star - Certified Heat Pump Water Heaters," n.d.); Attic ("Energy Star - Attic Insulation," n.d.); Window ("Energy Star - Residential windows, Doors, and Skylights," n.d.)]

Correlating the GHG emissions reduction to the consumer cost (which is proportional to the incentive value) provides insight to the relationship between the cost/incentive values to the GHG emissions reduction goal as shown in Figure 6, "Energy Efficiencies by GHG Emissions Reduction and Cost (lbs/year/dollar cost)." The data indicate that installing efficient LED bulbs results in the largest GHG emissions reduction per dollar cost at 8.71 CO_2 lbs per year per dollar cost. The most expensive energy efficiency, the window replacement, provides a reduction of only 0.09 CO_2 lbs per year per dollar cost. The rank order from largest to smallest reduction in GHG emissions per year per dollar cost would be:

Rank 3 – Largest GHG Emissions Reduction per Dollar Cost

1. Lighting Replacement
2. Water Heater Replacement
3. Seal/Insulate Attic
4. Dishwasher Replacement
5. Window Replacement

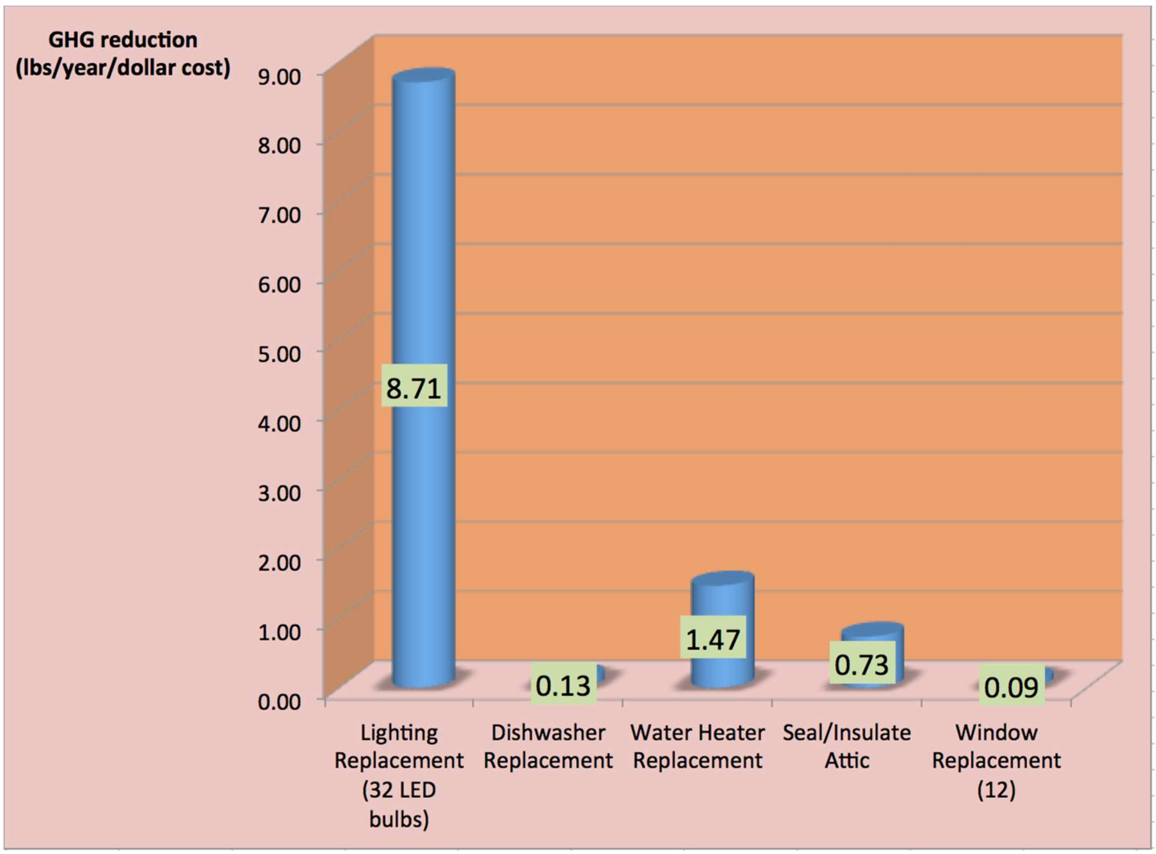

Figure 6. Energy Efficiencies by GHG Emissions Reduction and Cost (lbs/year/dollar cost)

Table 2, "Energy Efficiencies Ordered by Cost, GHG Emissions Reduction, GHG Emissions Reduction/Cost," demonstrates how the factors can be used to rank order energy efficiencies when considering incentive values and how that can affect the results. Incentives based on the cost of the energy efficiency would assign a greater value to "window replacement" than "lighting replacement." However, if the GHG emissions reduction (without consideration of cost) were considered, the "water heater replacement" would be assigned the greatest value, followed by "lighting replacement," with "window replacement" assigned an even lower value. If GHG emissions reduction per cost is made the primary factor – which reflects maximizing support of the County goal (lower energy consumption and GHG emissions) with the least cost, "lighting replacement" at 8.71 lbs GHG emissions reduction per dollar is found to be the most cost effective energy efficiency and "the best value" to incentivize. Alternatively, the "window replacement" at 0.09 lbs GHG emissions reduction per dollar cost is the least cost effective energy efficiency and "the worst value" to incentivize.

Greatest Cost	**Largest GHG Emissions Reduction**	**Largest GHG Emissions Reduction Reduction/Cost**
Window Replacement	Water Heater Replacement	Light Replacement
Seal/Insulate Attic	Light Replacement	Water Heater Replacement
Water Heater Replacement	Seal/Insulate Attic	Seal/Insulate Attic
Dishwasher Replacement	Window Replacement	Dishwasher Replacement
Light Replacement	Dishwasher Replacement	Window Replacement

Table 3. Energy Efficiencies Ordered by Cost, GHG Emissions Reduction, and GHG Emissions Reduction/Cost

Social

Considering that the energy efficiencies have been evaluated according to the corresponding GHG emissions reduction, and the purchase cost, two pillars of sustainability have been addressed: environmental and economic. To address the third pillar of sustainability – social equity – the data required additional consideration in order to identify a process that would maximize the number of residents able to participate in the incentive offering, with a focus on low- and moderate-income (LMI) residents.

In this analysis, the initial step was a determination of the maximum number of energy efficiencies that could be supported by the County incentive budget (proposed $500,000 for FY 2019), for each specific energy efficiency. Again, for the purpose of illustration of the conclusions, five energy efficiencies, a subset of the population of energy efficiencies listed in Table 2 and as shown in Figure 7, were used.

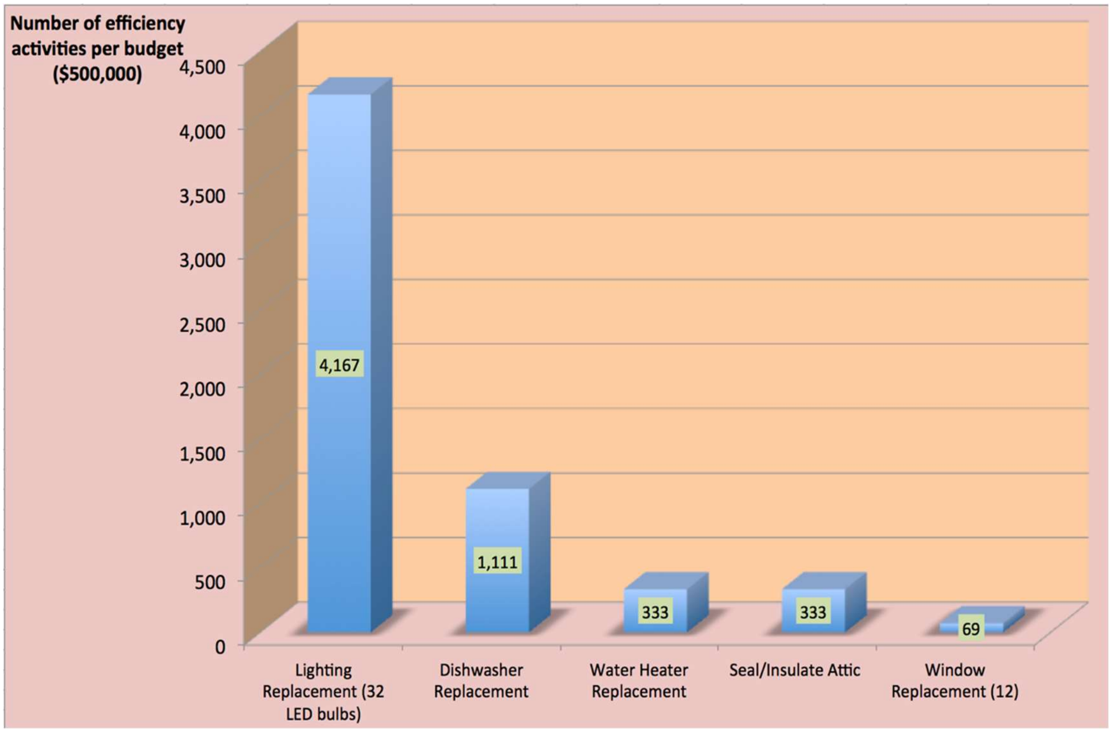

Figure 7. Number of Energy Efficiencies Per the County Incentive Budget (proposed $500,000)

Figure 7, "Number of Energy Efficiencies per the County Incentive Budget (proposed $500,000)," is a reverse order of the cost curve in Figure 4 and demonstrates that a "lighting replacement" energy efficiency could be provided, at cost, to 4,167 properties within a $500,000 budget. The most costly energy efficiency in this group, "window replacement" could only be provided to sixty-nine residences within a $500,000 budget. This indicates that, for example, an LED light bulb retrofit could include the participation of 4,098 additional residents when compared to the "window replacement." The rank order from largest to smallest reduction in GHG reductions per year per dollar cost would be:

<u>Rank 4 – Largest GHG Emissions Reductions/Year</u>
<u>per Number of Efficiency Actions per Budget</u>

1. Lighting Replacement
2. Dishwasher Replacement
3. Water Heater Replacement
4. Seal/Insulate Attic
5. Window Replacement

The information on the amount of the cost of the energy efficiencies relative to the budget (the number of residents that could potentially participate) can be weighted by the reduction in the amount of GHG emissions per year to develop a "sustainability factor," which can provide insight on maximizing both the number of participating residents and the amount of GHG emissions reduction per year. The "sustainability factor" can be expressed mathematically as (GHG Emissions Reduction/Cost (lbs/year/dollar))*(Number of Energy Efficiency Actions per Budget).

The "sustainability factor," provides a final rank order of effective energy efficiencies that result in maximizing GHG emissions reductions at a low cost, which could be more readily available to LMI residents. Developing this method of rank ordering and applying incentives values that encourage consumers to follow the rank order of energy efficiencies, would allow for greater potential participation of the LMI residents due to the low cost of entry, while supporting the County's GHG emissions reduction goals. It is important to note, that the rank order of energy efficiencies per "sustainability factor" may not result in the absolute maximum for either reduction of GHG emissions or consumer participation, but rather provides a perspective to allow for a balance between the largest GHG emissions reduction with the largest consumer participation.

<u>Rank 5 – Greatest "Sustainability Factor" (GHG Emissions Reduction/Cost (lbs/year/dollar))*(Number of Energy Efficiency Actions per Budget)</u>

1. Lighting Replacement
2. Water Heater Replacement
3. Seal/Insulate Attic
4. Dishwasher Replacement
5. Window Replacement

The "sustainability factor" also addresses another aspect of the underlying inequities that may occur without considering how to maximize homeowner participation. When Montgomery County initially developed consumer incentives for energy efficiencies the use of caps on the incentive value were much higher. This resulted in large-scale projects receiving a disproportionally large amount of the total incentive budget. In addition, while the incentive values were large, the portion that the consumer would pay was also larger, potentially shutting out portions of the LMI community. In that case, while the GHG emissions reductions might have been large, it may have come at the expense of limiting the distribution of incentives to a smaller number of individuals and to those that had the ability to pay the larger homeowner contribution.

Beyond Montgomery County

Previously we've considered the development of energy efficiency incentives in the context of the three pillars of sustainability – economic, environmental, and social, as applicable to the GHG emissions goals of Montgomery County and the owners of existing residential properties within the County. It is more effective for goal of reduction GHG emissions in the broader sense, to have a more complete accounting of the total GHG emissions associated with the purchase of appliances, equipment or a home modification when incentivizing those activities. The embodied energy in the energy efficiencies, as measured through a life cycle analysis of the appliances, equipment, and home modifications that includes the materials, production, transportation, and disposal, describe an energy debt that comes with the purchase of energy efficiencies. The energy debt, and the corresponding GHG emissions debt, is effectively paid back over a period of time through the purchaser's reduction in energy use and corresponding GHG emissions reductions, as shown in Figure 8, "Energy Efficiencies by Embodied Energy (kWh) with GHG Emissions Reduction Payback Period (years)." The rank order from shortest to the longest embodied energy/GHG emissions payback period would be:

Rank 6 – Energy Efficiencies by Shortest Embodied Energy Payback Period

1. Lighting Replacement
2. Window Replacement
3. Water Heater Replacement
4. Seal/Insulate Attic
5. Dishwasher Replacement

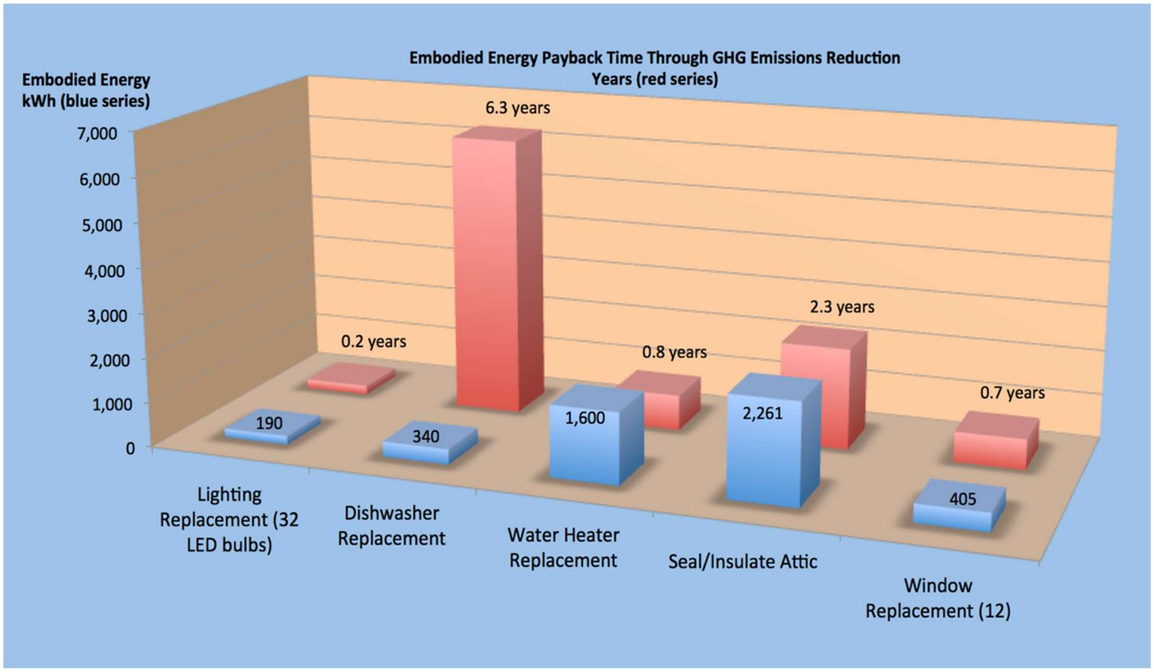

Figure 8. Energy Efficiencies by Embodied Energy (kWh) with GHG Emissions Reduction Payback Period (years) [References: LED Bulbs ("Life-Cycle Assessment of Energy and Environmental Impacts of LED Lighting Products," n.d.); Dishwasher (Alter, 2015); Water Heater (Crawford & Treloar, n.d.); Attic ("Embodied Energy of Insulating Materials," n.d.); Window (Asif, Davidson, & Muneer, 2001)]

Determining whether an appliance, equipment or home modification should be incentivized should include and evaluation of whether the embodied energy in these actions will be "paid back" by a more energy efficient purchase.

Consider an energy efficient action that does not last through the "payback period," for example, a dishwasher is required to be replaced in 5.3 years, one year less than the 6.3 years needed to "pay for" the amount of energy needed to create a new dishwasher (see Figure 7). In this case, 59 lbs of GHG emissions of the embodied energy have not been yet been realized by operation of the dishwasher, resulting, in effect, a 59 lbs GHG emissions "debt" that would carry forward to the replacement dishwasher. This indicates that if energy efficient actions do not remain in place longer than the embodied energy "payback period," incentives should not be directed toward that particular energy efficiency.

The performance of the literature review performed for this project indicated that information on the embodied energy of many types of equipment and home modifications is not readily available. Information on embodied energy was found on fifteen of the twenty-one energy efficiency actions identified as applicable for Montgomery County (see Appendix 1). This in area that would benefit from additional research that might determine and compile embodied energy information for use in evaluating whether a appliance or system should be replaced with one of greater efficiency or would be more effective in not contributing to additional GHG emissions by being retained in service for a longer period.

Similar to the concept of embodied energy payback, advances in technology can result in increases in energy efficiency that may result in energy efficiency actions that become less desirable after a short period of time. For example, consider the availability of compact fluorescent lights (CFL) prior to light emitting diode lights (LED). Currently (2018) twelve Watt LED bulbs that last approximately 25,000 hours at an operating cost of $1.00 per years are a similar-costing alternative to the earlier available fifteen Watt CFL bulbs that last approximately 10,000 hours at an operating cost of $1.20 per year ("National Residential Efficiency Measures Database," n.d.). The appropriateness of providing incentives to rapidly changing technologies warrants additional evaluation.

Conclusions

Recommendations

The evaluation of the energy efficiencies in local jurisdictions and in the State of California, determined that Montgomery County, Maryland, has an appropriate set of energy efficiency actions, available for use with incentives, for existing residential properties that would serve a diverse set of homeowners, including the low- and moderate-income community.

However, the values of the incentives provided for the energy efficiency actions should be based on the expected reduction in GHG emissions that result from the action, as opposed to being based solely or primarily on the consumer cost of the action, as is now done.

Incentive values should also target those energy efficiency actions such that have a large GHG emissions reduction per dollar of incentive.

Incentives should be targeted to energy efficiency actions that are of lower cost, in order to provide greater access to participation by the low- and moderate-income community.

The incentives should consider the embodied energy of the energy efficiency actions and the time required for the energy saving to equal the embodied energy.

The incentives should evaluate energy efficiency actions periodically to ensure that outdated, less energy efficient technology is not being incentivized.

Implementation of Recommended Energy Efficiency Action and Incentives For Montgomery County, Maryland

The twenty-one energy efficiencies identified as suitable for Montgomery County, Maryland, as listed in Table 2, were evaluated using the concepts previously discussed to identify a preferred order for application of incentives.

The rank order shown in Table 4 (sourced from the information contained in Appendix 1) is based on the "sustainability factor" - (GHG Emissions Reduction/Cost (lbs/year/dollar))*(Number of Energy Efficiency Actions per Budget), which provided preference to the energy efficiency actions with largest GHG emissions reduction per cost weighted by the lowest cost (efficiency actions per budget).

Applying incentives in this preferential manner to develop a rank order is intended to result in the largest reduction in GHG emissions in existing homes, while including the largest number of energy efficiency actions, and participating homeowners, within the confines of the proposed County incentive budget of $500,000.

Energy Efficiency Action	Greenhouse Gas Emissions (GHG) Reduction due to Energy Savings (CO2 lbs/year)	GHG Emissions Reduction (lbs CO_2e/year) per Consumer Cost of Energy Efficiency Action (dollars)	Number of Energy Efficiency Actions per Proposed County Budget ($500,000)	"Sustainability Factor" - GHG Emissions Reduction*Number of Energy Efficiency Actions per Proposed County Budget
1. Programmable Thermostat	3300	16.50	2500	41250
2. LED Lighting	1045	8.71	4167	36285
3. Exterior Wall Sealing	1100	4.40	2000	8800
4. Water Heater - Heat Pump	2200	1.47	333	489
5. Water Heater - Gas	234	0.39	833	326
6. Duct Sealing	1386	0.92	333	308
7. Attic Insulate	1100	0.73	333	244
8. Air conditioners	2075	0.90	217	196

9. Clothes Dryer – Electric	165	0.25	769	195
10. Freezer	33	0.11	1667	183
11. Dishwasher	59	0.13	1111	147
12. Furnace - Gas	1160	0.55	238	132
13. Refrigerator	495	0.35	357	126
14. Clothes Dryer/Gas	68	0.09	667	60
15. Heat Pump - Geothermal	3300	0.44	67	29
16. Roof	3300	0.44	67	29
17. Clothes Washer - Electric	33	0.04	667	29
18. Heat Pump - Air Source	660	0.18	139	25
19. Water Heater - Solar/Electric	1210	0.15	63	9
20. Windows	660	0.09	69	6
21. Water Heater - Solar/Gas	102	0.01	63	1

Table 4. Recommended Rank Order of Energy Efficiency Actions for Montgomery County, Maryland [References: See Appendix 1 for source information and references]

The rank order of energy efficiencies in Table 4 was evaluated to pair recommended incentive types and values to support the goal of maximizing GHG emissions reduction with increased access to the incentives to a larger portion of Montgomery County homeowners. The type of incentives used in the current DEP model – a cash rebate of 100% up to a fixed value for lower cost energy efficiency actions and a varying percentage up to a fixed value for higher cost energy efficiency actions fit well with the rank order of Table 4 based on the "sustainability factor." In addition, the DEP model was consistent with those used by the jurisdictions included in the literature review (see Appendix 1).

However, the primary focus of the proposed incentive values presented in Table 5, "Recommended Rank Order of Energy Efficiency Actions for Montgomery County, Maryland Including Recommended Incentive Types and Values for Energy Efficiency Actions," (sourced from the information contained in Appendix 1) is to apply incentives in a weighted manner. This provides a focus of resources on a combination of those energy efficiency actions that provide the maximum GHG emissions reduction for lower cost energy in order to provide greater access to participation by the low- and moderate-income community

The first category highlighted in green in Table 5 (Items 1, 2, and 3, bordered in green) provides very large GHG emissions relative to cost. Using the information shown, a set of one each of Items 1, 2, and 3, (that is one Item 1, one Item 2, and one Item 3) at a cost of $570, could provide approximately 5,445 lbs CO_2e of GHG emissions reduction per year.

The second category bordered in yellow in Table 5 (Items 4-9 and 12-13), for a set of one of each of the items (eight items total) at a cost of $11,500, could provide approximately 8,815 lbs CO_2e of GHG emissions reduction per year.

This difference in GHG emissions reduction per consumer cost indicated that the first category should be more heavily incentivized than the second. Accordingly, the recommendation for Items 1, 2, and 3 is to provide a cash rebate of 100% up to $250, which is intended to provide the items at no effective cost to the consumer.

The recommended incentive type and value for Items 4-9 and 12-13, which are substantially more expensive and provide less GHG emissions reduction per consumer cost than Items 1-3, have recommended incentive types and values that require more financial contribution from the homeowner. The reason for this it that large County contributions to more costly energy efficiency actions producing proportionally less GHG emissions reduction per dollar is a less efficient use of a limited County budget than those costing less and producing more emissions reduction.

The third category of efficiency actions bordered in red in Table 5, Items 10-11 and 14-21, are either more costly, or provide low GHG emissions reduction relative to consumer costs that the first two categories. Therefore the “sustainability factor” value is small, and it is recommended that the limited County incentive budget should be directed towards the first and second categories rather than the third.

The recommended incentive types and values are in general alignment with those currently offered by Montgomery County and, accordingly, should be able to be implemented. However, compared to the current DEP model, the recommended incentives are alternatively weighted towards those providing the largest reductions in GHG emissions reduction at a lower cost for both the consumer and the County. It is recommended that as the participation in the first category be prioritized in the incentive budget for an initial period of time, for example the first six months of the FY hear, with the remaining incentive funds be made available to both the first and the second categories in the second six months of the year. It is recommended that incentives not be offered in the third categories until participation in the first two categories is at a minimum.

Energy Efficiency Action	Greenhouse Gas Emissions (GHG) Reduction due to Energy Savings (CO_2e lbs/year)	"Sustainability Factor" - GHG Emissions Reduction*Number of Energy Efficiency Actions per Proposed County Budget	Consumer Cost (Dollars)	Recommended Incentive Types and Values
1. Programmable Thermostat	3300	41250	200	Cash Rebate - 100% of cost up to $250. When cash rebate portion of the budget is exhausted provide the same value in the form of a property tax rebate.
2. LED Lighting	1045	36285	120	Cash Rebate - 100% of cost up to $250. When cash rebate portion of the budget is exhausted provide the same value in the form of a property tax rebate.
3. Exterior Wall Sealing	1100	8800	250	Cash Rebate - 100% of cost up to $250. When cash rebate portion of the budget is exhausted provide the same value in the form of a property tax rebate.
4. Water Heater - Heat Pump	2200	489	1500	Property Tax Rebate - 50% of cost up to $1000

5. Water Heater - Gas	234	326	600	Property Tax Rebate - 50% of cost up to $1000
6. Duct Sealing	1386	308	1500	Property Tax Rebate - 50% of cost up to $1000
7. Attic Insulate	1100	244	1500	Property Tax Rebate - 50% of cost up to $1000
8. Air conditioners	2075	196	2300	Property Tax Rebate - 50% of cost up to $1000
9. Clothes Dryer – Electric	165	195	650	Property Tax Rebate - 50% of cost up to $1000
10. Freezer	33	183	300	No Incentive Recommended at This Time
11. Dishwasher	59	147	450	No Incentive Recommended at This Time
12. Furnace - Gas	1160	132	2100	Property Tax Rebate - 50% of cost up to $1000
13. Refrigerator	495	126	1400	Property Tax Rebate - 50% of cost up to $1000
14. Clothes Dryer/Gas	68	60	750	No Incentive Recommended at This Time
15. Heat Pump - Geothermal	3300	29	7500	No Incentive Recommended at This Time
16. Roof	3300	29	7500	No Incentive Recommended at This Time
17. Clothes Washer - Electric	33	29	750	No Incentive Recommended at This Time
18. Heat Pump - Air Source	660	25	3600	No Incentive Recommended at This Time
19. Water Heater - Solar/Electric	1210	9	8000	No Incentive Recommended at This Time
20. Windows	660	6	7200	No Incentive Recommended at This Time
21. Water Heater - Solar/Gas	102	1	8000	No Incentive Recommended at This Time

Table 5. Recommended Rank Order of Energy Efficiency Actions for Montgomery County, Maryland Including Recommended Incentive Types and Values for Energy Efficiency Actions
[References: See Appendix 1 for source information and references]

Summary

The development of incentive values, typically proportional to the consumer cost of the energy efficiency action, can be further refined by considering additional information. The expected reduction in greenhouse gas emissions should be a primary consideration of whether to provide an incentive for each action and also the value of the incentive should be proportional. In addition, the amount of reduction in GHG emissions should be weighted by consideration of the number of homeowners that are able to participate in the incentives program, with a focus on the LMI community. This can be accomplished by using incentives to direct consumer participation towards those energy efficiency actions that have the largest GHG emissions reductions to cost ratio. Future research could provide further insight to the impact of embodied energy on the actual net energy reductions for equipment and modifications.

The Montgomery County incentive program for existing residential properties is robust and is responsive the Climate Emergency Resolution issued in 2017. With more targeted incentives that specifically apply to equipment and modifications for existing homes that result in the largest reduction in GHG emissions and are available to a larger portion of the community, the County will more fully support the stated GHG emissions reduction goals.

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Appendix 1 Energy Efficiency Actions Data

Energy Efficiency Action	Energy Savings (kWh/year)	Greenhouse Gas Emissions (GHG) Reduction due to Energy Savings (CO_2e lbs/year) (see Note B)	Consumer Cost[28]	GHG Emissions Reduction (lbs CO_2e/year) per Consumer Cost of Energy Efficiency Action (dollars)	Number of Energy Efficiency Actions per Proposed County Budget ($500,000)	"Sustainability Factor" - GHG Emissions Reduction*Number of Energy Efficiency Actions per Proposed County Budget	Embodied Energy (kWh)	Incentives - California	Incentives - D.C.	Incentives - Delaware	Incentives - Virginia
Air conditioners (SEER 9 to SEER 14) (See *Note D.*) 8	1,886	2075	2300	0.90	217	196	1666 [30]	$450-900/unit			
Attic Insulate & Seal (See *Note E.*) [9]	1,000	1100	1500	0.73	333	244	2261	$0.15/sq ft, $0.20/sq ft, $0.30/sq ft, $4,000/house	n/a	n/a	n/a
Clothes Dryer - Electric [11]	150	165	650	0.25	769	195	n/a	$100-300	$150	$675-900 (blower test)	n/a
Clothes Dryer - Gas [11]	170	68	750	0.09	667	60	n/a	$250	$100-150	n/a	n/a
Clothes Washer - Electric [10]	30	33	750	0.04	667	29	2500 [31]	$35-300	$500 (replacing electric)	n/a	n/a
Dishwasher [13, 29]	54	59	450	0.13	1111	147	340 [29, 31]	$25-70	$300	$750-900	$225
Duct Sealing [14]	1,260	1386	1500	0.92	333	308	n/a	$350-500	n/a	$300-525	$300
Exterior Wall Sealing/Caulking [15]	1,000	1100	250	4.40	2000	8800	n/a	$200-800	n/a	$675	n/a
Freezer [16]	30	33	300	0.11	1667	183	n/a	$50-100	n/a	$300-500	$145-575
Furnace - Gas [17]	2,900	1160	2100	0.55	238	132	1111 [32]	n/a	50; $250 energy star	n/a	$50
Heat Pump - Air Source [18]	600	660	3600	0.18	139	25	1111 [32]	$450-900/unit	n/a	n/a	$25
Heat Pump - Geothermal [19]	3,000	3300	7500	0.44	67	29	1111 [32]	$450-900/unit	$50	n/a	$50
LED Lighting (32 8.5 W LED replace 32 60 W Incandescen)t [21]	950	1045	120	8.71	4167	36285	190	$5-10/bulb	n/a	n/a	$50
Programmable Thermostat [20]	3,000	3300	200	16.50	2500	41250	n/a		$50-75	n/a	$50
Refrigerator [22]	450	495	1400	0.35	357	126	5000	$50-100; $125 energy star	n/a	$1,500	$575
Roof (2,000 sq ft) [23]	3,000	3300	7500	0.44	67	29	24,482	$10-30/sq ft	n/a	n/a	n/a
Water Heater - Gas [24]	586	234	600	0.39	833	326	5775 [33]	$100-200; $200 energy star	$50-75	n/a	$50
Water Heater - Heat Pump [25]	2,000	2200	1500	1.47	333	489	1600 [33]	$750-1000	n/a	$400-675	$200-300
Water Heater - Solar/Electric [26]	1,100	1210	8000	0.15	63	9	19341 [33]	n/a	n/a	n/a	n/a
Water Heater - Solar/Gas [26]	254	102	8000	0.01	63	1	21,725	$1,000	n/a	n/a	$1/sq ft
Windows Replacement [27]	600	660	7200	0.09	69	6	405	$1-3/sq ft; $2,000/house	%100 rebate property tax	n/a	n/a

Appendix Table 1 - Energy Efficiency Actions and Data

Appendix 1 - Notes

Note A.	The CO_2 emissions from the combustion of natural gas is 117lbs CO_2 emitted per million British thermal units of natural gas.[5] 117 lbs/ MBTU*1 MBTU/10 therm*1 therm/29.3 kWh = 0.4 lbs/kWh
Note B.	GHG emissions savings were calculated based on 1.1 lbs CO_{2e}/kWh (electricity) [4] and 0.4 lbs CO_{2e}/kWh (natural gas) [5] per year times the energy savings in kWh per year
Note C.	Convert gas cost of $0.81 per therm to kWh - $0.81/therm*1 therm/23.9 kWh = $0.034/kWh of energy
Note D.	3 ton AC is upgraded from an installed SEER 9 (assumption) rated AC unit to the current minimum required standard for Montgomery County - SEER 14[6]
Note E.	1000 sq. ft. Attic is upgraded from R-19 bat insulation to a R-38[7]
Note F.	Yearly Energy Usage Electricity [4] 10,000 kWh Cost $1284 Gas [3] 26,000 therms Cost $884
Note G.	Energy Sources in Montgomery County[1] Electricity (kWh) Natural gas (kWh) delivered at $0.81 per therm 2017-2018 (See Note A)
Note H.	Energy Unit Costs in Montgomery County (dollars) Electricity 0.122 [2] Natural Gas 0.034 [3]
Note I.	CO_2 Emissions per unit energy (lbs CO_{2e})/kWh Electricity 1.1 [4] Natural Gas 0.40 [5]

Appendix 1 – References

Note that all references are included in the main body of the paper in the "References" section. They are repeated here with notations to the Appendix Table 1 information for efficiency.

1	(“Maryland Profile Analysis,” 2018)
2	(“State Electricity Profiles,” 2018)
3	(“Washington Gas Greenhouse Gas Emissions,” 2011)
4	(“Maryland Environmental Information for Standard Offer Service,” 2017)
5	(“U.S. Energy Information Administration - Frequently Asked Questions,” n.d.)
6	(“2017-01-06 Energy Conservation Program: Standards for Consumer Central Air Conditioners and Heat Pumps; Notice of proposed rulemaking,” n.d.)
7	(“Residential Energy Conservation Code,” 2016)
8	(“SEER Energy Savings Calculator,” 2018)
9	(“Energy Star - Attic Insulation,” n.d.)
10	(“Clothes Washer,” n.d.)
11	(“Energy Star Clothes Dryers,” n.d.)
12	(“Dehumidifiers,” n.d.)
13	(“Dishwasher,” n.d.)
14	(“Duct Sealing,” n.d.)
15	(“Methodology for Estimated Energy Savings from Cost-Effective Air Sealing and Insulating,” n.d.)
16	(“Freezers,” n.d.)
17	(“AC Doctor -Energy Calculator,” n.d.)
18	(“Air-Source Heat Pumps,” n.d.)
19	(“Geothermal Heat Pumps,” n.d.)
20	(“Proper Use Guidelines for Programmable Thermostats,” n.d.)
21	(“Energy Efficient Light Bulbs,” n.d.)
22	(“Refrigerators,” n.d.)
23	(“Oak Ridge National Laboratory - Cool Roof Calculator,” n.d.)
24	(“Energy.gov - Energy Cost Calculator for Electric and Gas Water Heaters,” n.d.)
25	(“Energy Star - Certified Heat Pump Water Heaters,” n.d.)
26	(“Energy.gov - Estimating the Cost and Energy Efficiency of a Solar Water Heater,” n.d.)
27	(“Energy Star - Residential windows, Doors, and Skylights,” n.d.)
28	(“National Residential Efficiency Measures Database,” n.d.)
29	(Alter, 2015)
30	(Dincer & Rosen, 2015)
31	(Gonzalez, Chase, & Horowitz, 2012)
32	(“Energy.gov - Furnaces and Boilers,” n.d.)
33	(Crawford & Treloar, n.d.)