

Executive Summary

The world's climate is changing and Pennsylvania, which is responsible for 1% of the planet's man-made greenhouse gas (GHG) emissions, is positioned to become a leader in the fight against this global threat. The Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC) concluded unequivocally that as a result of the substantial increase in atmospheric concentrations of carbon dioxide (CO₂) and other greenhouse gases (GHG) caused by human activity, the Earth's climate system is warming. The United Nations Environment Programme just released its *Climate Change Science Compendium 2009*¹, an analysis of the latest IPCC science and which provides a further wake-up call for the need to take immediate action. The report identifies impacts that are already underway and will be realized as a result of current atmospheric GHG concentrations including the following:

- Ocean acidification that will damage or destroy coral reefs and many species of marine life that live in or around or otherwise depend upon these ecosystems
- Sea Level Rise over the next millennium, with greater than 3 feet likely in the next century but with 5 or 10 times that in the following centuries
- Tropical and temperate mountain glacier loss that will disrupt irrigation systems, drinking water supplies and hydroelectric installations, as well as alter the socio-economic and cultural lives of perhaps 20-25 per cent of the human population.
- Shifts in the hydrologic cycle that will result in the disappearance of regional climates with associated ecosystem destruction and species extinction as drier regions shift towards the poles
- A global temperature increase of 2.4°C (4.3°F.) above pre-industrial temperatures, even if GHG concentrations had been held constant at 2005 levels

The scientific community is overwhelmingly in agreement that anthropogenic climate change is occurring and that mitigation and adaptation actions need to be implemented. This is not opinion and is further supported in the October 21, 2009 letter to the United States Senate signed by the American Association for the Advancement of Science, American Chemical Society, American Geophysical Union, American Meteorological Society, the American Statistical Association and numerous other scientific organizations. The letter is located at www.agu.org/sci_pol/pdf/Climate_Letter.pdf. A portion of the letter follows:

“Observations throughout the world make it clear that climate change is occurring, and rigorous scientific research demonstrates that the greenhouse gases emitted by human activities are the primary driver. These conclusions are based on multiple independent lines of evidence, and contrary assertions are inconsistent with an objective assessment of the vast body of peer-reviewed science. Moreover, there is strong evidence that ongoing climate change will have broad impacts on society, including the global economy and on the environment. For the United States, climate change impacts include sea level rise for coastal states, greater threats of extreme weather events, and increased risk of regional water scarcity, urban heat waves, western wildfires, and the disturbance of biological systems throughout the country. The severity of climate change impacts is expected to increase substantially in the coming decades.

If we are to avoid the most severe impacts of climate change, emissions of greenhouse gases must be dramatically reduced. In addition, adaptation will be necessary to address those impacts that are already unavoidable. Adaptation efforts include improved infrastructure design, more sustainable management of water and other natural resources, modified agricultural practices, and improved emergency responses to storms, floods, fires and heat waves.”

Our own National Academy of Sciences and the academies of science from numerous other countries share this common understanding. In fact, the department is not aware of any credible scientific body substantiating a different view.

The Climate Change Action Plan is based upon the most current scientific data available. The Advisory Committee and the department led a stakeholder-driven process which evaluated and recommended 52 work plans to mitigate greenhouse gases. All of the work plans were developed, discussed and analyzed with full participation of the Advisory Committee. The department has identified the diversity of viewpoints with regard to the language of each work plan. Appropriately, we have inserted the specific language provided to us by each of the subcommittee chairs within the “Subcommittee Comments” section of each individual work plan. This was done to provide a complete and transparent record and to allow the public and policy makers insight into the thoughts and concerns expressed by the Advisory Committee members.

The need to reduce GHG emissions is clear. The recommendations of this report identify opportunities that can reduce Pennsylvania’s GHG emissions by over a third. Many of these actions can be accomplished at no additional cost or may even result in a net savings.

On July 9, 2008, Governor Rendell signed the Pennsylvania Climate Change Act (Act 70). Among a number of goals, Act 70 required the preparation of this report. Working with the Climate Change Advisory Committee (CCAC) mandated under Act 70, the Department of Environmental Protection (Department) has prepared this Climate Change Action Report. Though not specifically referenced in Act 70, the department recognizes that no plan of action is complete without a stated goal (target) and a timeframe with which to accomplish the goal. Therefore, in order to frame the context of this climate change action plan and facilitate monitoring of progress towards reaching the recommended GHG reductions, it was necessary to establish three key elements: a baseline year, target year and a target.

- Baseline Year – the year by which total emissions reductions would be measured
- Target Year – the year for which forecasted emissions are projected and in which the emissions reduction target may be achieved
- Target (reduction target) – the percentage of GHG emissions reductions recommended

Considered together, these three elements frame the action plan. Upon consultation with the CCAC the department’s target recommendation is: **30 percent reduction in GHG emissions below year 2000 levels by 2020.** Furthermore, the recommendations of this report are expected to result in the net creation of 65,000 new full-time jobs and add more than \$6 billion to the Commonwealth’s gross state product in 2020.

¹ Climate Change Science Compendium 2009, September 24, 2009, United Nations Environment Programme, available at: <http://www.unep.org/compendium2009/>

The action plan identifies 52 specific work plans (recommendations) as well as several recent actions taken by Pennsylvania and the federal government that combined will provide GHG emissions reductions in Pennsylvania of 42 percent below 2000 levels in the year 2020. The 52 recommendations of this report, on their own, are anticipated to yield a 36 percent reduction in emissions by 2020, putting us well on the path to making the critical reductions needed to prevent further impacts on the world's climate. These values are within the range of reductions that is recommended by the Intergovernmental Panel on Climate Change (IPCC) as being necessary to stabilize the effects of climate change.

The recommendations of this action plan will have no impact on the ability of Pennsylvania to continue to meet all of its consumer's energy demands. Pennsylvania is the third largest producer of electricity in the nation producing more than 226 billion kilowatt hours of electricity. In that same year we produced 74,515 million kilowatt hours in excess of what we consume. That is the equivalent demand of 6.2 million homes, more than the 4.8 million occupied homes reported in the 2000 census of Pennsylvania and our population growth remains relatively flat. The generation potential from nuclear uprates can provide an additional 8,738 million kilowatt hours per year. With the recommendations of this plan to require additional cost-effective energy efficiency and conservation measures, the growth in renewable and natural gas-fueled electricity generation coupled with similar trends in neighboring states leads the department to conclude that there are no concerns with our continued ability to be a net exporter of electricity and therefore meet all of Pennsylvania's needs.

Overview of Pennsylvania Emissions and Projections

To support the work required under Act 70, the department prepared a GHG emissions inventory covering the period from 1990 to 2020. The inventory and a series of forecasts based on that data provided the department with a comprehensive picture of possible future GHG emissions. The inventory and forecast were provided to the CCAC to support its understanding of past, current, and possible future GHG emissions patterns. CCAC recommended changes were made to the forecasts for electricity generation, transportation and landfills.

The inventory and projections cover the six types of gases included in the United States (U.S.) Greenhouse Gas Inventory:

- Carbon dioxide (CO₂) from burning fossil fuels for electricity, heating and transportation;
- Methane (natural gas) from gas production, leakage in pipe line transportation and inefficient domestic and industrial processes;
- Nitrous oxide (N₂O) from internal combustion engine exhaust, nylon manufacture byproducts, use of agricultural nitrate fertilizers, and use as a aerosol can propellant;
- Hydro fluorocarbons (HFCs) used as replacement refrigerants, fire extinguishing and foam blowing agents for stratospheric ozone depleting chlorofluorocarbons (CFCs);
- Perfluorocarbons (PFCs) also used as a replacement for CFC refrigerants, used directly in medical and electronics manufacturing applications, and formed as a byproduct of aluminum smelting; and

- Sulfur hexafluoride (SF₆) used as a gaseous dielectric medium replacing liquid PCB (polychlorinated biphenol) containing substances, an inert gas in magnesium smelting and as an inert insulator in windows.

In explaining GHG emissions it is important to understand the fundamental concept of CO₂e or carbon dioxide equivalent. This measure is used, rather than carbon dioxide (CO₂) alone, because there are a number of gases that affect the world's climate. For example, natural gas (methane) has a climate changing impact that is 23 times that of an equal volume of CO₂. In order to make comparison possible, all climate changing gases are converted to their impact if they were CO₂.

In 2000, Pennsylvania emitted approximately 284 MMtCO₂e of gross emissions (consumption basis), an amount equal to about 4.0% of total U.S. gross GHG emissions (based on 2000 U.S. data).¹ On a net emissions basis (i.e., including carbon sinks such as forestlands), Pennsylvania accounted for approximately 263 MMtCO₂e of emissions in 2000, an amount equal to 4.1% of total U.S. net GHG emissions. On a per-capita basis, Pennsylvania residents emitted about 23 metric tons (t) of gross CO₂e in 2000, less than the national average of about 25 tCO₂e. Both Pennsylvania and national per capita emissions remained relatively flat from 1990 to 2000. In both Pennsylvania and the nation as a whole, economic growth exceeded emissions growth throughout the 1990–2000 period. From 1990 to 2000, emissions per unit of gross product dropped by 19% nationally, and by 35% in Pennsylvania.²

If no action other than the recent state and federal government actions is taken to reduce GHG emissions, we project that Pennsylvania's emissions will increase slightly to 295 MMtCO₂e by 2020, or about 1.8% above 2000 levels. This equates to a 0.1% annual rate of growth from 2000 to 2020. The most significant contributor to Pennsylvania's emissions growth is the electricity generation sector, two-thirds of which are the result of activities in residential and commercial buildings (primarily heating and cooling). Emissions from waste management and agriculture are modest contributors to future emissions growth, while emissions from all other sectors are expected to decrease or remain relatively constant from 2000 to 2020. These increases are driven in large part by the electricity sales projections from the electric distribution companies (EDCs) and further by applying their historic annual rates of growth for years 2014 through 2020. This methodology and data set was considered to be the best available state-specific source for Pennsylvania's emissions forecast associated with electricity consumption. Under these assumptions, it is anticipated that the most significant contributor to Pennsylvania's emissions growth is the electricity generation sector. However, the department believes that recent trends will alter this forecast, at least in terms of the magnitude of the emissions increase. Data reported by the PJM Interconnection indicates that electricity sales for the first six months of 2009 are down 5% below 2008 levels and that 2008 sales were 2.7% below 2007 levels.

¹ The national emissions used for these comparisons are based on 2005 emissions from *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006*, April 15, 2008, US EPA #430-R-08-005, (<http://www.epa.gov/climatechange/emissions/usinventoryreport.html>).

² Based on real gross domestic product (millions of chained 2000 dollars) that excludes the effects of inflation. U.S. Department of Commerce, Bureau of Economic Analysis. "Gross Domestic Product by State." Available at: <http://www.bea.gov/regional/gsp/>.

Data from the U.S. Environmental Protection Agency's (EPA) Division of Clean Air Markets confirms that CO₂ emissions from Pennsylvania's electric power plants have decreased. While this decrease is in large part due to recessionary impacts there also has been a shift to the utilization of more natural gas to displace coal for the generation of electricity in the Commonwealth. The department believes that natural gas will continue to play a more significant role in electricity production than was the case in 2000 and even 2005. Though the initial analysis incorporated EDC sales forecasts in an attempt to use the most state-specific data sources, the department believes the annual growth rate of electricity sales to be more modest. Specifically, the department believes that it is more likely that electricity sales will grow at a rate of about 1% per year rather than the historical rate of approximately 1.6%, which will have a profound and beneficial impact on GHG emissions by 2020. Assuming the department's assertions are correct, a sensitivity analysis indicates there will be an approximate 10% reduction in GHG emissions from electricity consumption forecasted in 2020.

Recommendations and Key Points about Micro-Economic Analyses

- The CCAC and PA DEP reviewed over 100 multi-sector GHG mitigation actions and approved for inclusion in this report a package of 52 work plan recommendations to reduce GHG emissions and address related energy and commerce issues in Pennsylvania. The recommended work plans cover a wide range of costs and GHG reduction potentials.
- The CCAC approved work plan recommendations are estimated to generate a net cumulative savings of about \$12 billion between 2009 and 2020.
- The approved work plan recommendations (if all are implemented) are estimated to reduce gross GHG emissions (consumption basis) by approximately 85 MMtCO₂e emissions in 2020, representing a 30% reduction in GHG emissions below 2000 levels. The combination of emission reductions associated with the work plan recommendations and recent state and federal actions suggest that Pennsylvania has the potential to reduce its annual GHG emissions in 2020 to about 39% below 2000 levels.

Figure ExS-1 compares the distribution of gross GHG emissions by sector in 2000 in Pennsylvania and the U.S. The principal sources of Pennsylvania's GHG emissions in 2000 are electricity consumption, industrial activities, and transportation, accounting for 30%, 28% and 24% of Pennsylvania's gross GHG emissions, respectively. The next largest contributor is the residential and commercial fuel use sectors, accounting for 14% of gross GHG emissions in 2000. However, a significant point of clarification needs to be made to better understand this data. These charts illustrate the direct source of emissions. For the Residential and Commercial Sector this includes the onsite combustion of fossil fuels for heating, hot water and cooking. Here electricity consumption is not attached to the end users; rather it reflects the contribution of electricity generation that is consumed within Pennsylvania. Residential and commercial buildings are responsible for sixty-six percent of all electricity consumed, as illustrated in Figure ExS-1a; the remaining one-third is consumed by all other sectors. Therefore, buildings are responsible for approximately 34% of all gross GHG emissions in PA.

Figure ExS-1. Gross GHG Emissions by Sector, 2000: Pennsylvania and U.S.

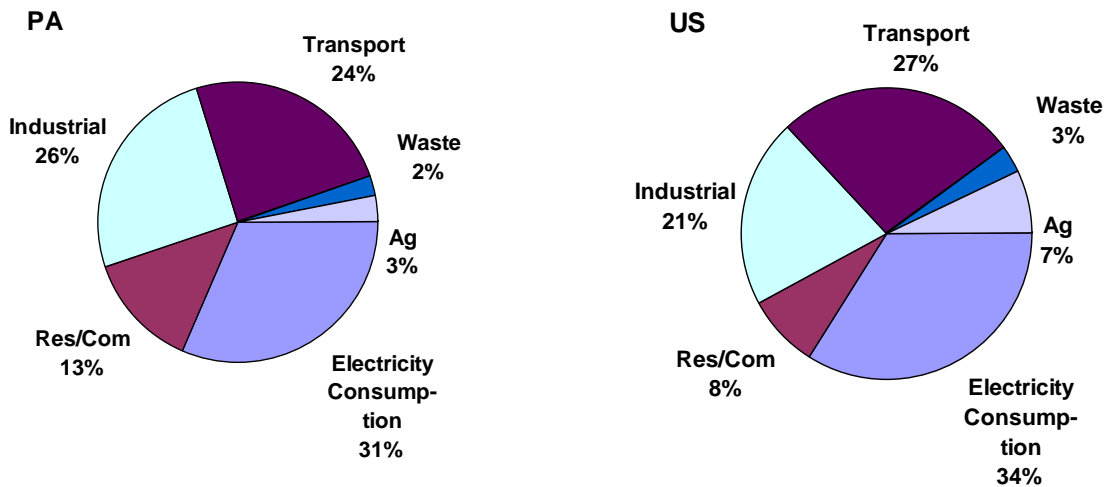
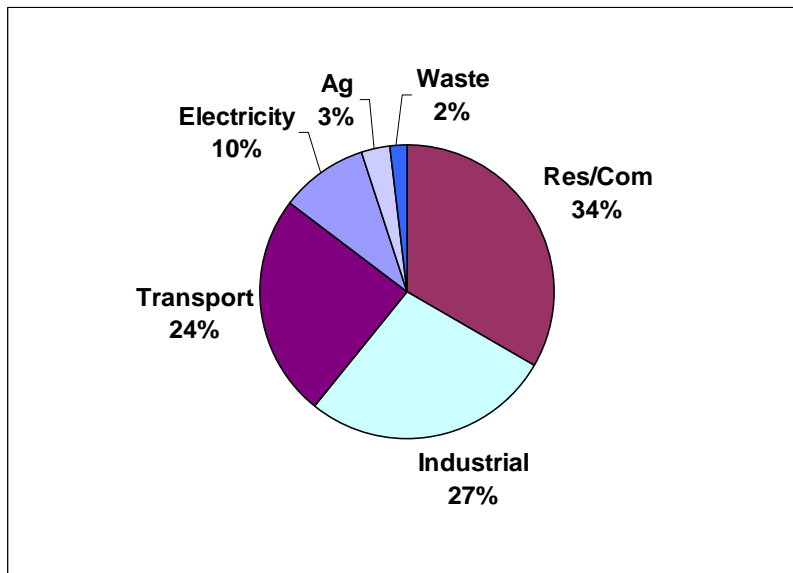


Figure ExS-1a. Gross GHG Emissions by Sector, 2000: Pennsylvania



Res/Com = residential and commercial sectors.

Recent State and Federal Actions

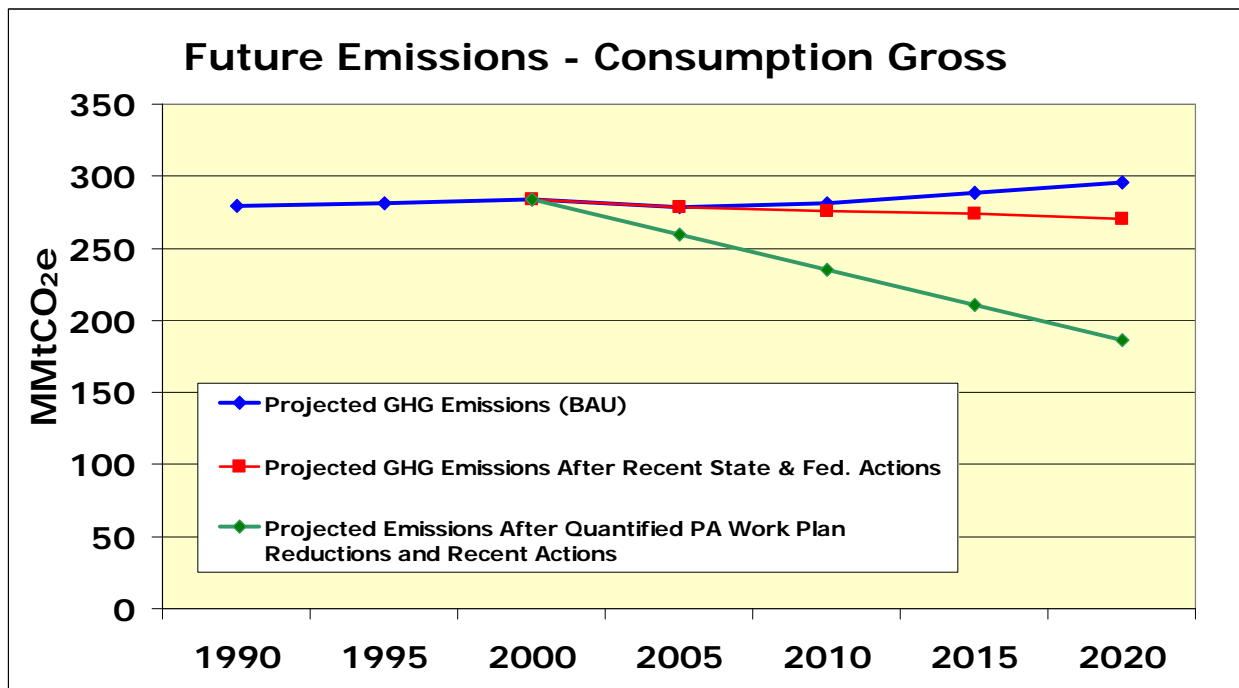
The significant overall reduction in GHG emissions predicted here would be significantly less without several actions already taken by Pennsylvania and the federal government. The report examines seven recent actions for their impact on emission reductions and costs. The result is a projected reduction of approximately 24.6 MMtCO₂e in 2020 or an 8.7% reduction in the state's GHG emissions below 2000 levels.

The most important impacts from policies already being implemented include:

- The renewable energy requirements in our Alternative Energy Portfolio Act (AEPS) and Act 129, mandating electric utility energy efficiency programs, will reduce emissions by 15 MMtCO_{2e}.
- Pennsylvania’s adoption of the 2008 Biofuel Development and In-State Production Incentive Act, the Diesel-Powered Motor Vehicle Idling Act, and the Pennsylvania Clean Vehicles (PCV) Program will reduce emissions by an additional 16 MMtCO_{2e}.
- Recently enacted federal appliance efficiency standards as well as improved efficiency for new light-duty vehicles. These will further reduce emissions by 5 MMtCO_{2e} by 2020.

The graph in Figure ExS-2 below depicts potential impacts on emissions. The top line shows emissions if nothing is done. Actions already under way, including Pennsylvania’s renewable portfolio requirement and federal appliance efficiency standards are shown in the middle line. The proposals in this report include a wide variety of actions many of which will have positive economic impacts and are represented by the bottom line. The actions recommended here will have a very significant impact on emissions.

Figure ExS-2. Annual GHG Emissions: Reference Case Projections, Recent Actions and Work Plan Recommendations (Consumption Basis, Gross Emissions)



MMtCO_{2e} = million metric tons of carbon dioxide equivalent; GHG = greenhouse gas; BAU = business-as-usual.

Recommendations

The department developed this Climate Action Report based on the recommendations of the Climate Change Advisory Committee (CCAC) as an initial step in establishing a basis for moving forward on the implementation of climate change actions in Pennsylvania. Evaluation of key factors such as cost effectiveness, economic impacts, and harmonization with other Pennsylvania programs and policies will be critical to the next stage of climate policy implementation. The following key elements and recommendations were identified by the CCAC during this initial process:

The CCAC and the department reviewed over 100 GHG mitigation actions covering a wide range of emissions impacts and cost-benefit results. 52 mitigation actions were recommended by the CCAC. Of these 52 recommendations, the CCAC approved 28 unanimously, 11 with only three or less not in support, and 13 plans were voted at least 13 in-support to eight not-in-support. These 52 recommendations or work plans that have the potential to reduce our GHG emissions by approximately 85 MMtCO₂e or by roughly 30% below 2000 while providing cumulative savings of about \$12 billion between 2009 and 2020. The weighted-average cost-effectiveness of these recommendations is estimated to be a savings of about \$21 per metric ton of carbon dioxide equivalent (tCO₂e) emissions reduced.

Pennsylvania has already undertaken steps to reduce GHG emissions associated with the generation of electricity and the use of fossil fuels for the transportation sector. In addition, recent federal programs for on-road vehicles and appliances will reduce GHG emissions. Analysis of these recent state and federal actions indicate that in 2020, they are estimated to reduce Pennsylvania's gross³ GHG emissions (consumption basis) by approximately 24.6 million metric tons of carbon dioxide equivalent (MMtCO₂e), representing an 8.7% reduction in GHG emissions below 2000 levels. The combination of emission reductions associated with the work plan recommendations and recent state and federal actions suggest that Pennsylvania has the potential to reduce its annual GHG emissions in 2020 to about 39% below 2000 levels. The results shown in Table ExS-1 indicate that the work plan recommendations support significant opportunities for Pennsylvania to reduce GHG emissions at a cost savings economy-wide. Although the cumulative results for the LUT sector indicate a significant cost, savings are expected to be realized on an annual basis by 2020.

³ Excluding GHG emissions removed due to forestry and other land uses and excluding GHG emissions associated with exported electricity.

Table ExS-1. Summary by Sector of Estimated Impacts Associated with Implementing All of the CCAC Work Plan Recommendations (cumulative reductions and costs/savings)

Sector	Annual Results (2020)			Cumulative Results (2009-2020)		
	GHG Reductions (MMtCO ₂ e)	Costs (Million \$)	Cost-Effectiveness (\$/tCO ₂ e)	GHG Reductions (MMtCO ₂ e)	Costs (NPV, Million \$)	Cost-Effectiveness (\$/tCO ₂ e)
Residential Commercial	32.3	-538	-\$17	214.5	-3,668	-\$17
Electricity Generation, Transmission, and Distribution	21.4	\$248	\$12	120.1	\$638	\$5
Industry	5.8	-\$365	-\$62	32.6	-\$1,072	-\$33
Waste	5.9	-\$49	-\$8	37.0	-\$298	-\$8
Land Use & Transportation	6.62	-\$494	-\$75	60.09	\$2,805	\$47
Agriculture	1.41	-\$62	-\$44	10.19	-\$380	-\$37
Forestry	11.35	-\$1,376	-\$121	97.62	-\$10,177	-\$104
Total (includes all adjustments for overlaps)	84.7	-\$2,636	-\$31	572.1	-\$12,151	-\$21

GHG = greenhouse gas; MMtCO₂e = million metric tons of carbon dioxide equivalent; \$/tCO₂e = dollars per metric ton of carbon dioxide equivalent.

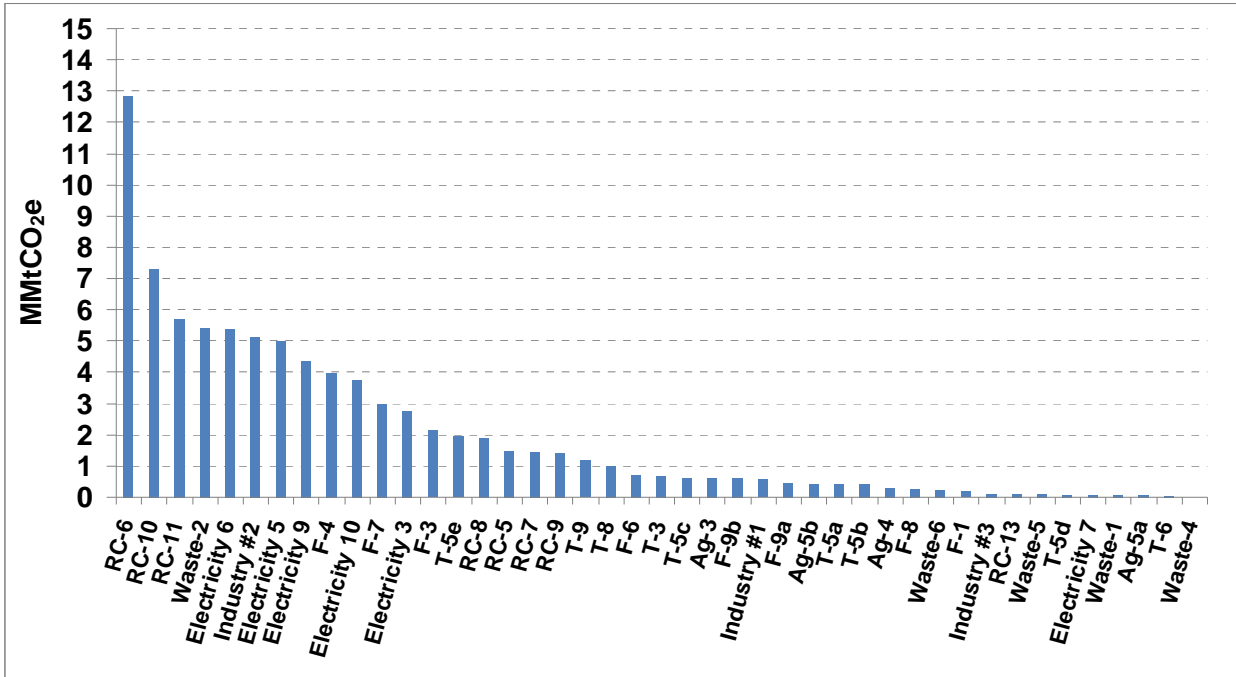
Negative values in the Net Present Value and the Cost-Effectiveness columns represent net cost savings associated with the policy options.

Within each sector, values have been adjusted to eliminate double counting for work plan recommendations or elements of work plan recommendations that overlap. In addition, values associated with work plan recommendations or elements of work plan recommendations within a sector that overlap with recommendations or elements of recommendations in another sector have been adjusted to eliminate double counting.

As explained previously, the CCAC considered the estimates of the GHG reductions that could be achieved and the costs or cost savings for the work plan recommendations that were quantifiable. Figure ExS-3 presents the annual GHG emission reductions in 2020 for each of the 42 work plan recommendations for which GHG emission reductions were quantified. Figure ExS-4 presents the estimated dollars-per-ton cost (or cost savings, shown as a negative number) for each of the 42 work plan recommendation for which emission reductions and costs or cost savings were quantified.⁴ The dollars per ton value is calculated by dividing the net present value of the cost of the work plan recommendation by the cumulative GHG reductions, all for the period 2009–2020.

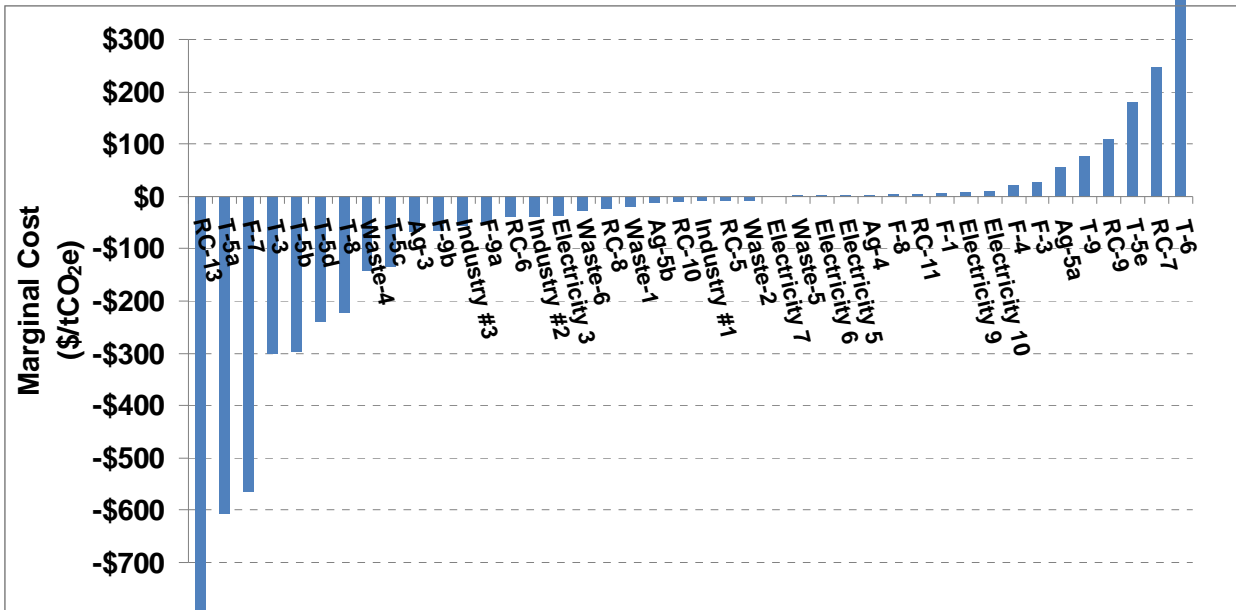
⁴ Costs were not quantified for Forestry 6 (Durable Wood Products) due to the lack of data.

Figure ExS-3. Work Plan Recommendations Ranked by 2020 GHG Reduction Potential After Adjusting for Overlaps



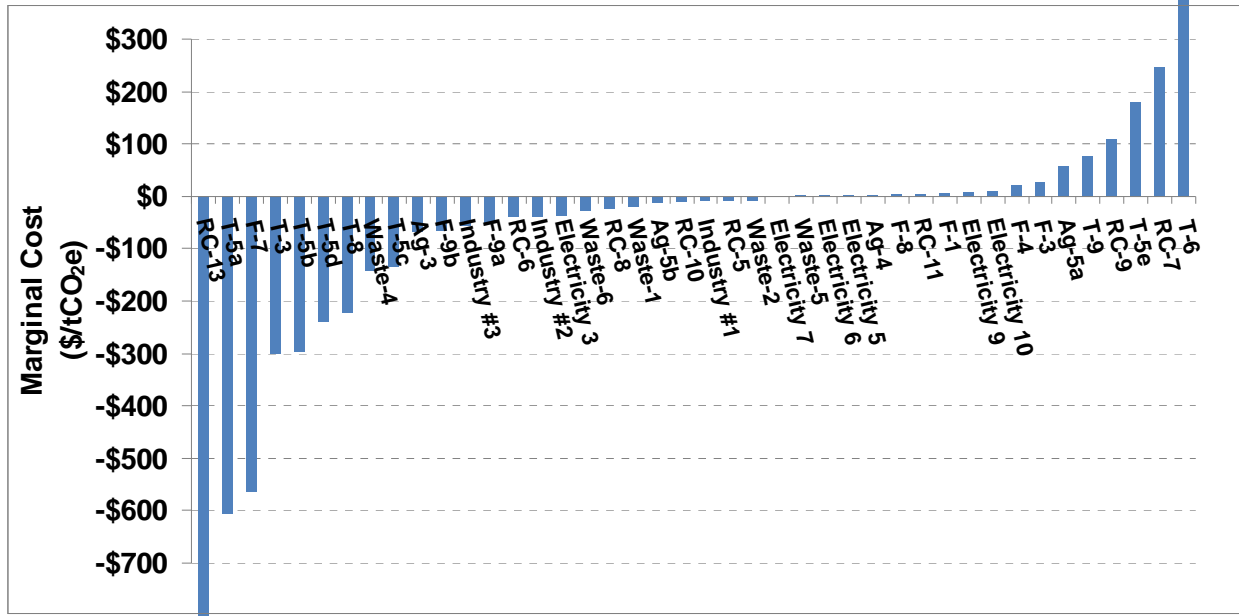
GHG = greenhouse gas; MMtCO₂e = million metric tons of carbon dioxide equivalent; Ag = agriculture; RC – residential commercial; F = forestry; T= land use and transportation.

Figure ExS-4. Work Plan Recommendations Ranked by Cumulative (2009–2020) Net Cost/Cost Savings per Ton of GHG Removed



GHG = greenhouse gas; MMtCO₂e = million metric tons of carbon dioxide equivalent; Ag = agriculture; RC – residential commercial; F = forestry; T= land use and transportation.

Figure ExS-4. Work Plan Recommendations Ranked by Cumulative (2009–2020) Net Cost/Cost Savings per Ton of GHG Removed



GHG = greenhouse gas; MMtCO₂e = million metric tons of carbon dioxide equivalent; Ag = agriculture; RC – residential commercial; F = forestry; T= land use and transportation.

Summary of Macroeconomic Modeling Results

Chapter 11 summarizes the macroeconomic analysis of the impacts of the recommended 52 work plans. Among these 52 work plans, 42 have been analyzed quantitatively in terms of GHG reduction potentials and associated costs or savings. Two work plans completely overlap with each other and those for which microeconomic data was not available were not included in the macroeconomic analysis.

Different from the microeconomic analyses of each work plan, the macroeconomic analysis considers the impact to Pennsylvania’s economy associated with the interrelationship of these work plans being implemented. The results of this analysis reveal a net present value (NPV) impact on total gross state product (GSP), for the period 2009-2020, of about \$5.13 billion dollars and that by year 2020 these measures will stimulate the creation of 54,000 new full-time jobs. Two recent actions taken by the Commonwealth, the passage of the Alternative Energy Portfolio Standard (AEPS) and electricity conservation measures approved with the passage of Act 129 of 2008 (Act 129) were also analyzed. These recent actions coupled with the work plan recommendations are expected to result in the net creation of 65,000 new full-time jobs and add more than \$6 billion to the Commonwealth’s GSP by 2020.

Need and Plan to Address Adaptation

The department believes a climate change action plan must address both mitigation and adaptation. Act 70 identifies the need for mitigation and prescribes the manner by which mitigation options should be developed however, it is silent on the matter of climate change

adaptation. The need to understand and plan for adaptation is equally as significant as our need to mitigate our contribution to the impacts.

Understanding climate change adaptation requires additional consideration because, as illustrated in the Pennsylvania Climate Change Impacts Assessment report, the issues are very far reaching and require comprehensive discussion. The department is very interested in coordinating these discussions but believes that it is not within the scope or timeline of Act 70 to facilitate such discussion until after this first action plan has been prepared and delivered. The department believes that a much broader group of stakeholders must be consulted, specific to the topical areas of discussion.

The natural resource agencies of the Commonwealth have already held informal discussions of adaptation but this must be expanded and many other topical areas must be properly addressed, too. For instance, at a minimum, separate focus groups should be established for public health, transportation and energy planning. The CCAC also agrees that adaptation is critical and a missing element of the requirements of Act 70 having raised concerns at various times throughout the current planning process. During the February 27, 2009 meeting of the CCAC, a motion was made and passed with unanimous support that the action plan include a recommendation to the Governor and the Pennsylvania General Assembly to address adaptation.

The department anticipates that it will begin the process of framing up potential pathways to identify the necessary focus groups and potential respective stakeholders to engage in future discussions. The department will solicit the opinions of the CCAC and further consult with other Commonwealth agencies to forge a path forward. The department expects that any recommendations will be reported to the CCAC for their consideration.