Pennsylvania Climate Change Action Plan Update

Presented to:
Governor Tom Corbett

Presented by:

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

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Executive Summary

The Pennsylvania Climate Change Act (Act 70 of 2008) requires the Department of Environmental Protection (DEP) to submit to the governor a Climate Change Action Plan that is revised every three years. This version is the first update to the original Climate Change Action Plan that was completed in 2009.

The Pennsylvania Climate Change Advisory Committee (CCAC) was tasked as consultants to DEP for the completion of this report. The CCAC was comprised of four subcommittees: Electricity Production, Transmission and Distribution; Residential, Commercial and Industrial; Land Use and Transportation; and Agriculture and Forestry. Each of the cost-effective strategies for reducing greenhouse gases (GHGs), the basis of this plan, were discussed with the subcommittees of the CCAC as well as the full committee and are included in the Appendix of this report. The Center for Climate Strategies also provided assistance to DEP by analyzing the work plans to account for potential costs and benefits provided to the gross state product and employment impacts.

Since the last report was prepared in 2009, there have been broad based changes to Pennsylvania's economy and energy portfolio. Many of the changes have resulted in fewer emissions of GHGs in Pennsylvania. These include, primarily, emissions of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6).

This action plan summarizes Pennsylvania GHG emissions and sinks for the base year 2000, 2010, and target year 2020. Throughout the document, emissions are provided in a CO_2 equivalent (CO_2e) for consistency. For gross emissions by sector, Pennsylvania's percentage of emissions by sector is lower than the U.S. percentage of emissions for the transportation, waste and agriculture sectors. Pennsylvania's percentage of emissions by sector is higher than the U.S. percentage of emissions by sector for the industrial and residential/commercial sectors.

Overall, Pennsylvania's gross GHG emissions are expected to be lower in 2020 than in 2000, with reductions in the residential, commercial, transportation, agriculture and waste sectors. The total statewide emissions sinks are also expected to increase, creating additional net GHG benefits through 2020. These benefits are mostly attributed to Pennsylvania's forestry sector.

In the electricity production, transmission and distribution sectors, there have been huge changes happening in Pennsylvania since 2009. Due to increasing federal regulations and the availability of natural gas, many coal-fired power plants have either retired, reduced run time, or are considering fuel-switching to natural gas.

Even with the anticipated voluntary coal plant retirements and shifts to natural gas, Pennsylvania remains a net exporter of electricity. Recently, EPA data has confirmed that the voluntary retirement of coal plants in Pennsylvania will result in an emissions savings of about 12 million metric tons of CO_2e (MMtCO2e) annually. The new generating capacity proposed for

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Pennsylvania will produce about 6.45 MMtCO2e in 2020, resulting in a total of 5.5 MMtCO2e savings[1].

Pennsylvania has also introduced measures to reduce emissions from oil and gas extraction activities, and compression and processing operations, including a revised General Plan Approval and or/General Operating Permit for Natural Gas Compression and/or Processing Facilities (GP-5). DEP has implemented revised permit exemption criteria for the oil and gas activities. The DEP Category No. 38 exemption criteria include practices such as Reduced Emission Completion or “green completion” instead of current practice of either venting or flaring. These permit conditions will require operators to employ leak detection and repair programs to reduce and control emissions of methane in a manner that is efficient and achieves results stricter controls over federal rules. This will have a significant impact on the reduction of methane emissions at these sources. DEP also adopted similar leak detection and repair requirements for the natural gas refueling stations.

Governor Corbett also signed Act 11 of 2012, allowing water and wastewater utilities, natural gas distribution companies, city natural gas distribution operations, and electric distribution companies to petition the Pennsylvania Utility Commission (PUC or Commission) for approval to implement a Distribution System Improvement Charge (DSIC). This will allow utilities to recover the reasonable and prudent costs incurred for the repair, improvement, or replacement of property to ensure efficient, safe and reliable services.

There have also been great strides since 2009 made in the alternative fuel vehicle sector. The Alternative Fuel Incentive Grant (AFIG) program remains a very popular grant program in Pennsylvania, as it has since it was first implemented in the early 1990s. AFIG continues to provide rebates for alternative fuel vehicles and also provided a $1 million grant for the installation of electric vehicle charging infrastructure at each of the rest stops along the Pennsylvania Turnpike.

In addition to this program, Act 13 of 2012 provided $20 million, funded by natural gas operator impact fees, over three years for the purchase or retrofit of heavy-duty vehicles to operate on natural gas. In the first grant round, 329 heavy-duty vehicles were purchased or converted to run on natural gas, which will support 16 new re-fueling stations in Pennsylvania. It is projected that these projects will displace 3.67 million gallons of gasoline each year.

With this report, DEP is recommending nine different actions of the Pennsylvania Legislature. These recommendations include addressing the long-term liability of carbon capture and sequestration, providing incentives for coal mine methane usage, evaluating Act 11 of 2012 (Utility DSIC), expanding access to natural gas utilities, providing incentives for alternative fuel vehicles, considering specifying legislation energy use profiling for commercial buildings, expanding competitive electricity markets to foster and encourage alternative and renewable energy suppliers to enter Pennsylvania’s market, supporting the implementation of the Alternative Energy Portfolio Standard (AEPS), and amending AEPS to include additional waste-to-energy facilities.

[1] US EPA, Clean Air Market Emissions Report – PA (2010).

Chapter 1. Introduction

The Pennsylvania DEP prepared this update to the Pennsylvania Climate Change Action Plan to fulfill the requirements of the Pennsylvania Climate Change Act (Act 70 of 2008).

Act 70 of 2008 was signed into law on July 9, 2008 and required DEP to:

1. Implement the establishment of the Climate Change Advisory Committee (CCAC)
2. Develop an impacts assessment report and revise the report every three years
3. Compile an annual inventory of Greenhouse Gas (GHG) emissions
4. Create a voluntary GHG registry
5. Develop an Action Plan and revise the plan every three years.

Climate Change Advisory Committee

To assist the DEP in meeting these obligations, Act 70 established the CCAC. Membership of the CCAC was to be based upon a person's interest, knowledge or expertise on climate change issues. The composition of the advisory committee was to include representatives that could offer a diversity of viewpoints from the scientific, business and industry, transportation, environmental, social, outdoor and sporting, labor and other affected communities. The act directed that 18 members would be appointed as follows and would further include three ex-officio members of the Department of Conservation and Natural Resources, Department of Community and Economic Development and the Public Utility Commission.

The CCAC began the deliberative process for this latest edition of the Pennsylvania Climate Change Action Plan (Action Plan) on May 20, 2010. The committee met in person a total of 15 times, with the final meeting held on Dec. 5, 2013. Multiple meetings were held by the individual sub-committees to review, create and update work plans for the Action Plan.

The four subcommittees considered information and potential mitigation actions for the following sectors:

- Electricity Production, Transmission and Distribution
- Residential, Commercial and Industrial
- Land Use and Transportation
- Agriculture and Forestry

The sub-committees served as advisors to the CCAC and consisted of CCAC members and additional individuals with interest and expertise. Members of the public were invited to observe and provide input at all meetings of the CCAC. The subcommittees assisted the CCAC by generating initial options on Pennsylvania-specific mitigation actions to be considered for analysis including existing state and federal actions. Where members of a subcommittee did not fully agree on the recommendations to the CCAC, the summary of their efforts was reported to the CCAC as a part of its consideration and endorsement decisions. The CCAC reviewed the subcommittee's proposals, modified the proposals, if necessary, and made final decisions on the items before them.

Action Plan Revisions

When Act 70 of 2008 was signed into law it required, among other actions, DEP submit to the governor, and revise every three years, a climate change action plan that:

1. Identifies GHG emission and sequestration trends and baselines in this commonwealth.
2. Evaluates cost-effective strategies for reducing or offsetting GHG emissions from various sectors in this commonwealth.
3. Identifies costs, benefits and co-benefits of GHG reduction strategies recommended by the climate change action plan, including the capability of meeting future energy demands within the commonwealth.
4. Identifies areas of agreement and disagreement among committee members about the Climate Change Action Plan.
5. Recommends to the General Assembly legislative changes necessary to implement the Climate Change Action Plan.

Since 2009, when the previous plan was prepared, there have been a number of changes related to GHG emissions in Pennsylvania. The most notable change has been the decrease in energy-related carbon dioxide emissions from the United States as a whole. In 2012, energy-related carbon dioxide emissions reached the lowest level since 1994 and are now down more than 12 percent since 2007. Half of the decrease in energy usage can be attributed to reductions from the residential sector

Energy efficiency, a shifting economy and a changing energy portfolio have accounted for the single biggest factor in the emissions reductions. In 2012, there was a 6.5 percent decrease in the energy intensity of the U.S. economy, which is the amount of economic value it acquires per unit of energy. This signifies that businesses and households have reduced energy waste, by shifting to an economy based on energy-light services and technology and away from energy-intensive manufacturing.

Increased production and use of natural gas, such as the gas extracted from the Marcellus and Utica shale formations in Pennsylvania, has also played a substantial part in reducing CO_2 emissions. Due to the abundant supply, the price of natural gas remained low from 2011 through 2013, contributing to a shift from coal use to lower-carbon intensive natural gas. Since 2011, deactivations of coal-fired power plants in Pennsylvania have resulted in a loss of nearly 4000 MW of generation with approximately 1700 MW of additional losses expected by the end of 2015. From 2000 through 2010, the carbon intensity of energy supply in Pennsylvania has decreased by more than 5 percent and with the additional and expected losses of coal-fired generation, that trend is expected to continue. The increased use of natural gas in high-efficiency combined cycle plants, plus moderate increases in wind energy generation have contributed to the overall decline in CO_2 emissions nationally, as well as in Pennsylvania.

This Climate Change Action Plan Update lists techniques and strategies that are not only cost-effective, but in many instances result in a cost savings, environmental benefit and positively impact Pennsylvania's economy.

This action plan represents the culmination of the work efforts of the CCAC and DEP through an informed process that also includes the above referenced requirements under Act 70.

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Chapter 2. Recent Initiatives that Reduce GHGs

2.1 Introduction

While this report identifies those actions that have taken place between 2010 through 2012, events related to the reduction of GHGs throughout Pennsylvania have accelerated. Initiatives that reduce GHGs have not only been initiated at the state level, but there have also been changes at the federal level and within the business community as well. Recently, a number of coal-fired electric generating plants have announced that they are either deactivating, co-firing with natural gas or converting to fire with natural gas. DEP has also implemented new requirements for the natural gas sector that will further reduce methane emissions, which is a potent GHG, and EPA has announced new regulatory initiatives related to reducing GHGs. As a result, this chapter will ensure that the public and General Assembly have the most up-to-date information regarding recent initiatives that reduce GHGs.

Pennsylvania is committed to addressing GHG emissions while keeping the economy strong. There is continued success at reducing GHGs, as carbon dioxide emissions from the fossil fuel-fired electric generating fleet in Pennsylvania have declined by 11.7 percent from 2005-2012 and are projected to decline by 22 percent from 2005 through 2020. Yet according the U.S. Bureau of Labor Statistics, Pennsylvania's unemployment rate has steadily improved from a high of 8.7 percent in 2010 to 7.5 percent in 2013.

Pennsylvania's holistic approach to managing environmental issues is the principal reason for the corresponding decline in GHG emissions and improved economic outlook. For instance, a robust and properly regulated natural gas industry is driving down fuel costs and is responsible, at least in part, for electric power plant conversions and deactivations. Recent DEP efforts like GP-5 for natural gas compressor stations and processing facilities assist in reducing GHGs from these operations. Pennsylvania's AEPS is expanding the electric market for renewable and alternative energy sources. These and other efforts are designed to complement each other in a strategic effort to provide for economic development and expand opportunities to reduce GHGs.

2.2 Electricity Production, Transmission, and Distribution

<u>Greenhouse Gas Tailoring Rule</u>

In June 3, 2010, EPA promulgated its *Prevention of Significant Deterioration and Title V Greenhouse Gas Tailoring Rule* which regulates greenhouse gases from new and modified air contamination sources. 75 Fed. Reg. 31514. Pennsylvania implements these greenhouse gas requirements through its Prevention of Significant Deterioration of Air Quality program under 25 Pa. Code Chapter 127, *Subchapter D* and Title V Operating Permits program under 25 Pa. Code Chapter 127, Subchapter G.

To date, DEP has issued 10 plan approvals that have GHG emission rates, which will reduce the growth of GHG emissions in Pennsylvania.

New Source Performance Standards

DEP incorporates EPA's New Source Performance Standards (NSPS) into its regulatory program under 25 Pa. Code Chapter 122 (relating to National Standards of Performance for New Stationary Sources). *See* 9 Pa. Bull. 1447, (April 28, 1979). As EPA develops greenhouse gas performance standards for stationary sources, these standards are automatically incorporated into Pennsylvania law.

For example, on September 20, 2013, EPA announced proposed new source performance standards for emissions of carbon dioxide for fossil fuel-fired electric utility generating units.[2] The rule will apply only to new fossil fuel-fired electric utility generating units (EGUs). For purposes of this rule, fossil fuel-fired EGUs include utility boilers, integrated gasification combined cycle (IGCC) units and certain natural gas-fired stationary combustion turbine EGUs that generate electricity for sale and are larger than 25 megawatts (MW). EPA is proposing to set separate standards for natural gas-fired stationary combustion turbines and for fossil fuel-fired utility boilers and integrated gasification combined cycle units. The rule also does not apply to: Liquid oil-fired stationary combustion turbine EGUs, new EGUs that do not burn fossil fuels (e.g., those that burn biomass only), and low-capacity factor EGUs that sell less than 1/3 of their power to the grid. EPA is proposing two limits for fossil fuel-fired utility boilers and IGCC units, depending on the compliance period that best suits the unit: 1,100 lb. CO2/MWh-gross over a 12-operating month period, or 1,000-1,050 lb. CO2/MWh-gross over an 84-operating month (7-year) period. EPA is proposing two standards for natural gas-fired stationary combustion units, depending on size: 1,000 pounds of CO2 per megawatt-hour (lb. CO2/MWh-gross) for larger units (>850 mmBTU/hr.) or 1,100 lb. CO2/MWh-gross for smaller units (≤850 mmBTU/hr.). Once finalized, these rules will be applicable in Pennsylvania for new EGUs.

To date DEP has issued four plan approvals for the construction of combined cycle natural gas turbine projects with best available technology emission rates consistent with the proposed New Source Performance Standards.

Electric Power Plant Conversions and Deactivations

There is a growing trend in the utility industry to convert existing coal-fired power plants to burn natural gas, deactivate, or reduce operations. This trend is driven by a number of factors, including state-level renewable portfolio standards; federal environmental regulations, like the Mercury and Air Toxics Standards Rule, consumer demand, deregulation of the industry in Pennsylvania, competition from regulated out-of-state generators, and an economic climate that contributes to the cost competitiveness of coal. The GHG emissions from a coal-fired power plant could be reduced significantly after the plant is converted to burn natural gas.

In Pennsylvania there are 12 projects that are proposed to be constructed as natural gas-fired electric generating stations. Moreover, there are 13 coal-fired electric generating stations that are either deactivated or slated for deactivation in the near term. The effect of this changing electric

[2] EPA proposal, September 20, 2013. http://www2.epa.gov/carbon-pollution-standards/2013-proposed-carbon-pollution-standard-new-power-plants.

generating station profile means that carbon dioxide emissions from the fossil fuel-fired electric generating fleet in Pennsylvania has declined by 11.7 percent from 2005-2012 and is projected to decline by 22.0 percent from 2005 through 2020.

The Pennsylvania Alternative Energy Portfolio Standard (AEPS)

AEPS requires that an annually increasing percentage of electricity sold to retail customers in Pennsylvania is from renewable and alternative energy sources. This act requires that electric distribution companies and electric generation suppliers include a specific percentage of electricity from alternative resources in the generation that they sell to Pennsylvania customers. The GHG reductions of this initiative are further discussed in Chapter 4 of this report.

Act 129 of 2008

Act 129 of 2008 requires electric distribution companies (EDC) to achieve certain energy efficiency and conservation programs. The EDCs have established goals and provide economic incentives to assist homeowner, business, and institutional energy users to reduce energy demand. Many of these programs are included in various work plans and their GHG reductions are discussed further in Chapter 4.

Air Quality Requirements for Oil and Gas Operations

Pennsylvania is the first state to require comprehensive leak detection and repair to minimize the fugitive emissions, including methane, from oil and gas operations and compressed natural gas fueling stations on a programmatic basis through a General Permit and Exemption Criteria.

Emissions Reporting

Pennsylvania has implemented an emissions inventory reporting requirement for the natural gas industry. The first emission inventory was reported for emissions released in 2011 and included unconventional natural gas operations and mid-stream compressor stations. The inventory was expanded for emissions released in 2012 to include conventional natural gas operations and to require the reporting of greenhouse gases. These emission inventories will be posted on the DEP Webpage.[3]

EPA has established mandatory greenhouse gas emission reporting for the oil and gas sector. Owners or operators of facilities that contain petroleum and natural gas systems and emit 25,000 metric tons or more of GHGs per year (expressed as carbon dioxide equivalents) report GHG data to EPA. Owners or operators collect GHG data; calculate GHG emissions; and follow the specified procedures for quality assurance, missing data, recordkeeping, and reporting.[4] EPA requires the following segments of the petroleum and natural gas industry to submit emissions data reports:

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[3] http://www.dep.state.pa.us/dep/deputate/airwaste/aq/emission/Emission_Inventory.htm.
[4] http://www.epa.gov/ghgreporting/reporters/subpart/w.html.

- Onshore petroleum and natural gas production
- Offshore petroleum and natural gas production
- Onshore natural gas processing plants
- Onshore natural gas transmission compression
- Underground natural gas storage
- Liquefied natural gas (LNG) storage
- Liquefied natural gas import and export equipment
- Natural gas distribution

Well Sites

On August 10, 2013, DEP finalized an amendment to the Air Quality Permit Exemption List for Category No. 38 (pertaining to oil and gas exploration, development, production facilities and associated equipment and operation). The final guidance for Category No. 38 provides flexibility by allowing each owner or operator to seek an air quality plan approval from DEP or demonstrate compliance with requirements for controls and work practices more stringent than the federal rules. The DEP Category No. 38 exemption criteria includes practices such as Reduced Emission Completion or "green completion" instead of current practice of either venting or flaring. The criteria also include a leak detection and repair program for the entire well pad and facility, rather than just the storage vessels as required by federal rules. This will have a significant impact on the reduction of methane emissions at these sources. The greenhouse emissions including leaks from all sources and associated air pollution control equipment located at a well site is limited to 100,000 tons expressed as carbon dioxide equivalent (CO2e) on a 12-month rolling sum basis.

Natural Gas Compression and Processing Facilities - General Permit (GP-5)

On February 2, 2013, DEP finalized revisions to a general plan approval and general operating permit for natural gas-fired engines and equipment at gas processing plants and compressor stations which help move gas from well sites into transmission pipelines. The revised general permit establishes requirements for best available technology and a comprehensive leak detection and repair program to minimize emissions including greenhouse gas emissions. The revised general permit also limits the greenhouse emissions including leaks from all sources and associated air pollution control equipment located at a natural gas compression and/or processing facility to 100,000 tons expressed as carbon dioxide equivalent (CO2e) on a 12-month rolling sum basis.

Public Utility Commission Efforts to Reduce Methane Leakage

There are two PUC programs that will contribute to fewer natural gas leaks and thus decrease fugitive methane emissions. The amount of emission reduction has not been calculated by the PUC as such a reduction is viewed as a co-benefit and not the main driver for either program. The two programs are Act 11 of 2012 (or Distribution System Improvement Charge (DSIC)) and

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the commission's April 4, 2013, final rulemaking at L-2012-2294746, regarding unaccounted-for-gas (UFG).[5]

On Feb. 14, 2012, Act 11 of 2012 was signed by Governor Tom Corbett and amended Title 66 (Public Utilities) of the Pennsylvania Consolidated Statutes to allow jurisdictional water and wastewater utilities, natural gas distribution companies, city natural gas distribution operations and electric distribution companies to petition the commission for approval to implement a DSIC. The DSIC must be designed to provide for "the timely recovery of the reasonable and prudent costs incurred to repair, improve or replace eligible property in order to ensure and maintain adequate, efficient, safe, reliable and reasonable services." 66 Pa.C.S. § 1353 (a).

Starting Jan. 1, 2013, public utilities were eligible to petition the commission for approval to establish a DSIC. A petition must contain the following elements: 1. initial tariff; 2. testimony and exhibits to demonstrate that the DSIC will ensure the provision of adequate, efficient, safe, reliable and reasonable service; 3. long-term infrastructure plan; 4. certification that a base rate case has been filed within the past five years; and 5. any other information required by the commission. Moreover, the petition must demonstrate that granting the petition and allowing the DSIC to be charged will accelerate the replacement of infrastructure. To date, Equitable, Peoples, Peoples TWP, PGW and Columbia Gas have filed DSIC petitions with the PUC.

The second program relates to unaccounted for natural gas (UFG). In general, UFG is defined as the difference between total gas supplies delivered to the natural gas distribution company (NGDC) and the amount of that gas the NGDC subsequently delivers to its retail, commercial and industrial customers, adjusted for company use, temperature, pressure variations or other allowed variables. As the name implies, UFG is gas that is "lost" during transport from supplier to customer. This PUC rulemaking establishes the uniform terminology of "unaccounted for gas," or UFG, to describe gas lost from an NGDC's system and determines that an end state UFG metric should be set at 3 percent for distribution system UFG.

2.3 Residential, Commercial, and Industrial

Residential and Commercial Energy Efficiency Standards

The federal appliance and lighting standards are a cost-effective way to reduce energy consumption, without requiring lifestyle changes, while achieving GHG reductions. The Energy Independence and Security Act of 2007 set new standards for equipment not previous covered by an energy efficiency standard, including lighting. In 2009, a Memorandum for the Secretary of Energy was issued requesting that the Department of Energy (DOE) finalize all outstanding efficiency standards and to prioritize the development of other efficiency standards that achieve the greatest energy savings.

The DOE has set a schedule for energy efficiency rulemaking activities for 2013 that include final rules for battery chargers and external power supplies and furnace fans. In 2014, DOE has

[5] http://www.pabulletin.com/secure/data/vol42/42-42/2028.html.

scheduled final rulemaking standards for efficiency for metal halide lamp fixtures, commercial refrigeration equipment, walk-in coolers and freezers, automatic ice makers, electric motors, commercial furnaces, commercial packaged air conditioners and heat pumps, commercial water heaters, Incandescent Reflector Lamps (IRLs), and general service fluorescent lamps and IRLs.

In *New York v. Bodman*, 05 Civ. 7807 (LAP), DEP and a number of other states secured a settlement agreement with DOE to establish energy efficiency standards for a range of consumer and commercial products that use large amounts of energy including electricity, natural gas, and home heating oil as required under the Energy Policy Conservation Act, 42 U.S.C. §§ 6291 *et seq*.

As part of that agreement, DEP and its litigation partners secured energy efficiency standards for 23 categories of sources including: room air conditioners; central air conditioners; water heaters; pool heaters; direct heating equipment; furnaces and boilers; small furnaces; mobile home furnaces; dish washers; clothes dryers; fluorescent lamp ballasts; gas kitchen products; gas and electric kitchen products; general service fluorescent lamps; IRLs; general service fluorescent and general service incandescent lamps; packaged terminal air conditioners and heat pumps; packaged boilers; instantaneous water heaters less than 10 gallons volume; electric motors; high intensity discharge lamps; electric distribution transformers; and small electric motors.

The improved energy efficiency standards will result in less energy usage and lower GHG emissions.

Appliance and lighting standards are a cost-effective way to reduce energy consumption, without requiring any lifestyle changes and to achieve GHG reductions. DOE is implementing new energy efficiency standards for a variety of equipment such as: dishwashers, clothes washers, microwave ovens, air conditioners, etc. Such standards are projected to reduce GHG emissions by 6.9 MMtCO_2e by 2020. Many of the electric distribution companies are offering incentives to encourage the transition to the more efficient appliances and lighting.

Industrial/Institutional Sources

On December 20, 2012, EPA finalized maximum achievable control technology (MACT) emissions standards for industrial boilers and process heaters. Existing affected boilers are required to comply with the MACT requirements by Jan. 31, 2016. In order to comply with these standards, several existing industrial and institutional coal fired boilers are in the process of converting them to burn natural gas which will result in additional GHG emission reductions.

2.4 Land Use and Transportation

Brownfields

For more than a decade, other states have looked to DEP's award-winning Land Recycling Program as a national model for the successful cleanup of underutilized and often abandoned industrial properties. DEP has 18 years of experience in cleaning up more than 4,760 brownfield sites.

Brownfields are underused properties where the presence or potential presence of hazardous substances, pollutants or contaminants complicates expansion, redevelopment or reuse of the properties. Pennsylvania's approach to brownfield redevelopment has proven to be a national model for transforming abandoned, idle properties into safer places that contribute to greater economic opportunity and revitalize communities. Under the Land Recycling and Environmental Remediation Standards Act (Act 2) of 1995, thousands of brownfield sites in Pennsylvania have been returned to productive use, providing jobs and tax revenues, and benefiting local communities. Existing infrastructure, historic buildings and close proximity to transportation are among the many cost-effective benefits for reuse of brownfields.

Brownfield site cleanup and development can restore the environment and provide significant economic benefit to Pennsylvania. Reuse of brownfields preserves Pennsylvania's forests and "green fields," helps reduce the growth of GHGs, and preserves the commonwealth's carbon sequestration capacity.

Natural Gas Energy Development Program

Act 13 of 2012 provides $20 million, funded by natural gas operator impact fees, over three years for the purchase or retrofit of heavy-duty vehicles to operate on natural gas. In the first grant round, 329 heavy-duty vehicles were purchased or converted to run on natural gas, which will support 16 new re-fueling stations in Pennsylvania. It is projected that these projects from the first round alone will displace 3.67 million gallons of gasoline each year.

Retail Vehicle-Fueling Operations at Industrial Facilities (Exemption Category No.33)

On August 10, 2013, DEP also finalized an amendment to the Air Quality Permit Exemption List for Category No. 33 (pertaining to retail gasoline dispensing facilities and similar vehicle-fueling operations at industrial facilities). The criteria also include a leak detection and repair program for the compressed natural gas fueling station to minimize greenhouse gas emissions. The greenhouse emissions including leaks from all sources and associated air pollution control equipment located at these facilities are limited to 100,000 tons expressed as carbon dioxide equivalent (CO2e) on a 12-month rolling sum basis.

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2.5 Agriculture and Forestry

Forest Management

Sustainably managed forests will store carbon for decades, and durable products made from wood may store carbon for even longer. As steward of Pennsylvania's 2.2 million acres of state forests, the Department of Conservation and Natural Resources (DCNR) strives to protect, enhance and promote these lands for use and enjoyment. Studies show that well-managed forests sequester carbon at higher rates then poorly managed forests. DCNR's long-term forest management plan ensures that this resource is held to the highest environmental standards.

In 2013, Pennsylvania state forests were once again certified as well managed by Scientific Certification Systems under the Forest Stewardship Council™ (FSC) standard. The FSC® is an independent organization supporting environmentally appropriate, socially beneficial, and economically viable management of the world's forests. For the 16th consecutive year, since 1998 when a team of scientists first began reviewing management of the 2.2 million acres of state forestlands, researchers lauded Pennsylvania's commitment to its forests, and exemplary practices and innovation in managing forest resources. This careful management ensures that DCNR's state forest system continues to sequester carbon at a steady rate.

In addition to ensuring the long-term health and sustainability of state forestland, DCNR also provides technical assistance to landowners to guide forest planting, encouraging responsible maintenance of private forestland.

Well-managed forests also yield a reliable supply of high-quality wood, which increases the likelihood that timber harvested from these forestlands over time are used to create durable wood products. Durable wood products prolong the length of time forest carbon is stored and not emitted to the atmosphere. Substituting products made from wood for products with higher embodied energy in building materials can reduce GHG emissions. DCNR's management activities and timber sales continue to promote and encourage the use of durable wood products.

Protecting Pennsylvania's Open Space

As Pennsylvania's population continues to increase, there is less land in the state that remains undeveloped and left for the public to enjoy. Because loss of forests and open space to development reduces the carbon sequestration potential of these lands, preserving them through protection and acquisition is an important GHG-reduction strategy. DCNR supports land conservation through a number of methods, including acquisition of lands that are added to state parks and forests, funding for acquisition of conservation lands by local government or nonprofit entities, and funding of the purchase of easements on privately held property. In state acquisition alone, DCNR has preserved 3,995 acres since 2011.

Act 13 of 2012, signed by Governor Corbett on February 14, 2012, provided the first infusion of money into the Growing Greener Program since 2005, as well as providing over $20 million annually in new park, open space, and recreation funding.

TreeVitalize

Planting trees in urban and suburban areas contributes to cleaner air and water, aesthetic benefits, and increases carbon sequestration. Trees also provide shade, which reduces the fossil fuel demand primarily for cooling. In April 2013, DCNR expanded the award-winning TreeVitalize community tree-planting and education program to communities across the state. The program, which previously had been a success in 13 major urban areas, has resulted in more than 360,000 new trees planted to make Pennsylvania's cities greener. Funded through DCNR's Bureau of Forestry grants and municipal, private agency and company involvement, TreeVitalize depends on community support to increase tree canopies across the state, and educate and engage citizens in the care and selection of these new trees.

Implementing New Energy Efficient Technology

In order to make our state forests and parks more energy efficient and reduce their carbon footprint, DCNR has incorporated new green technologies into construction of new buildings and retrofits of existing infrastructure. By implementing the latest green technology in construction and land use, and by utilizing new forms of alternative energy, such as solar and wind power, state parks are averaging a 25-33 percent decrease in yearly electrical bills. A recent study found that five state parks saved more than $27,000 in just three years merely by upgrading their lighting to more efficient bulbs and fixtures.

New construction at state parks and forests features LEED-certified buildings and landscapes to maximize efficiency and minimize future maintenance costs. Gold LEED Certification was awarded in 2011 to the Penn Nursery facility in Centre County as well as the Tiadaghton Forest Resource Management Center in Lycoming County. The construction of a new Resource Management Center in Weiser State Forest and a new visitor center at Jacobsburg Environmental Education Center are complete; and a visitor center at Ohiopyle State Park is under construction. All are pursuing LEED certification. In all, DCNR currently has 11 LEED-certified park and forest buildings.

No-Till Farming

No-till cropping systems sequester soil carbon that would otherwise be released to the atmosphere through conventional cultivation practices. No-till farming also reduces the amount of nitrogen-based fertilizer being applied therefore, providing reductions in N_2O emissions. No-till also results in reduced time spent preparing the fields such that diesel fuel consumption is reduced and therefore, provides a third source of greenhouse gas reductions.

Over the last several years, no-till practices have been increasing in Pennsylvania agriculture. In 2007, no-till was practiced on 50.4 percent of the major crop acreage and conventional tillage was used on 29.2 percent of the major crop acreage in Pennsylvania. Other conservation tillage practices were used on the remaining 20.4 percent. In 2012, USDA reports that no-till was practiced on 59.8 percent of the major crop acreage, and other conservation tillage practices were used on the remaining 22.5 percent in Pennsylvania. With more crop growers realizing potential advantages to no-till and other conservation tillage practices including reduced labor costs and increased water filtration, it is anticipated that no-till practices will continue to increase through 2020.

2.6 Inventory Efforts

DEP is now collecting more information related to GHGs. Each year, DEP compiles an emissions inventory of certain regulated air contamination sources as provided under 25 Pa. Code § 135.3 (related to reporting). Beginning in the 2012 calendar year, owners and operators of GHG sources are required to submit emissions data annually to DEP.

In addition, EPA has instituted a GHG reporting rule for many industry sectors. This GHG data can be found at the following web site: http://www.epa.gov/ghgreporting/index.html. These inventory efforts will allow DEP to develop more accurate GHG projections and will provide useful data for projecting and assessing future climate impacts.

2.7 Conclusion

Pennsylvania CO_2 emissions have fallen dramatically, in large part because Pennsylvania is generating more electricity with natural gas instead of coal. However, other factors, including improved energy efficiency standards from consumer products and automobiles have contributed to the decline in carbon emissions. Pennsylvania continues to be a leader in reducing methane emission from the natural gas industry and solid waste landfills. Moreover, further reductions are occurring, and future reductions will occur, through new regulatory requirements like the Tailoring Rule, NSPS, and MACT.

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Chapter 3. GHG Inventory

This chapter summarizes Pennsylvania's GHG emissions and sinks (carbon storage) for 2000 (historical), 2010 current available EPA data) and 2020 (projected EPA data forward). The DEP prepared Pennsylvania's GHG emissions inventory and reference case projections. The inventory and reference case projections (forecast) provided the DEP with an understanding of current and possible future GHG emissions (hereafter referred to as the I&F. The information in this chapter does not reflect the current emissions of GHG in the Commonwealth. It does however reflect the most recent EPA values of the GHG inventory and reference case projections available at the time of the writing of this report.[6]

In this Action Plan and the original 2009 plan, GHG emissions inventories were developed using the Federal Environmental Protection Agency's (EPA) State Inventory and Projection Tool (SIT) which is a set of generally accepted principles and guidelines for state GHG emission inventories, relying to the extent possible on Pennsylvania-specific data and inputs. The tool provides an aggregated total for each sector and does not include emissions for specific power plants, industrial facilities, or other point sources. It shows where Pennsylvania was, where Pennsylvania is currently, and where Pennsylvania is going with respect to GHG emissions with respect to the data available within the SIT. The reference case projections are based on a compilation of various existing projections of electricity generation, fuel use and other GHG-emitting activities, along with a set of simple, transparent assumptions.

The Inventory and Projections of GHG Emissions (I&P) covers the six types of gases included in the U.S. GHG inventory: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6). Emissions of these GHGs are presented using a common metric, CO_2 equivalence (CO_2e), which indicates the relative contribution of each gas, per unit mass, to global average radiative forcing on a global warming potential-weighted basis.[7]

It is important to note that the I&P estimates reflect the GHG emissions associated with the electricity sources used to meet Pennsylvania's demands in 2010, corresponding to a consumption-based approach to emissions accounting. Another way to look at electricity emissions is to consider the GHG emissions produced by electricity generation facilities in the state—a production-based method. They cover both methods of accounting for emissions, but for consistency, emissions for all sectors are reported as consumption-based.

[5] EPA, State Climate and Energy Program, State Inventory Tool, August 12,2013

[7] Changes in the atmospheric concentrations of GHGs can alter the balance of energy transfers between the atmosphere, space, land, and the oceans. A gauge of these changes is called radiative forcing, which is a simple measure of changes in the energy available to the Earth–atmosphere system. Holding everything else constant, increases in GHG concentrations in the atmosphere will produce positive radiative forcing (i.e., a net increase in the absorption of energy by the Earth). See: Boucher, O., et al. "Radiative Forcing of Climate Change." Chapter 6 in *Climate Change 2001: The Scientific Basis*. Contribution of Working Group 1 of the Intergovernmental Panel on Climate Change Cambridge University Press. Cambridge, United Kingdom. Available at: http://www.grida.no/climate/ipcc_tar/wg1/212.htm.

3.1 Pennsylvania GHG Emissions: Sources and Trends

Table 3-1 provides a summary of GHG emissions estimated by the EPA for Pennsylvania by sector for 2000, 2010 and 2020. As shown in this table, Pennsylvania is estimated to be a net source of GHG emissions (positive, or gross, emissions). Pennsylvania's forests serve as natural GHG emission sinks (removal and/or store negative emissions). The net emissions for Pennsylvania are calculated by subtracting the equivalent GHG reduction obtained from emissions sinks rom the gross GHG emission total. The following sections discuss GHG emission sources and sinks, trends, projections, and uncertainties. The following sections discuss GHG emission sources and sinks, trends, projections and uncertainties

3.2 Historical Emissions

According to EPA data in 2010, on a gross emissions consumption basis (i.e., excluding carbon sinks), Pennsylvania accounted for approximately 264 million metric tons (MMt) of CO_2e emissions, an amount equal to about 4.4 percent of total U.S. gross GHG emissions. On a net emissions basis (i.e., including carbon sinks), Pennsylvania accounted for approximately 230 $MMtCO_2e$ of emissions in 2010, an amount equal to 3.9 percent of total U.S. net GHG emissions.[8] Pennsylvania's GHG emissions decreased along with those of the nation as a whole.

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[8] The national emissions used for these comparisons are based on 2010 emissions from U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–200*, April 15, 2008, EPA430-R-12-00. Available at: http://www.epa.gov/climatechange/emissions/usinventoryreport.html.

[9] The national emissions used for these comparisons are based on 2010 emissions from U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–200*, April 15, 2008, EPA430-R-12-00. Available at: http://www.epa.gov/climatechange/emissions/usinventoryreport.html.

[10] During this period, population grew by 3.2 percent in Pennsylvania and by 9.7 percent nationally.

Table 3-1. Pennsylvania Historical and Reference Case Emissions, by Sector*

Sector / Emission Source ($MMtCO_2e$)	2000	2010	2020
Residential	**25.91**	**20.49**	**18.42**
Commercial	**12.83**	**10.58**	**11.19**
Industrial	**78.03**	**69.2**	**78.96**
Combustion of Fossil Fuels (CO_2, CH_4 & N_2O)	50.25	39.2	46.49
Industrial Processes (CO_2, N_2O, HFC, PFC & SF_6)	15.27	13.02	14.78
Coal Mining and Abandoned Coal Mines (CH_4)	9.58	10.1	9.49
Natural Gas and Oil Systems (CH_4)	2.93	6.88	8.2
Transportation	**69.49**	**66.88**	**65.04**
On-road Gasoline	44.58	44.81	37.19
On-road Diesel	10.8	15	19.23
Marine Vehicles	3	0.01	0.011
Natural Gas, LPG, Other	3.38	3.49	4.66
Jet Fuel and Aviation Gasoline	7.78	4.68	4.69
Electricity (Consumption)	**90.19**	**87.25**	**98.08**
Electricity Production (in-state)	**122.74**	**123.32**	**134.48**
Coal (CO_2, CH_4 & N_2O)	*115.47*	*106.93*	*116.95*
Other (CO_2, CH_4 & N_2O)	*0.34*	*1.41*	*1.54*
Natural Gas (CO_2, CH_4 & N_2O)	*2.125*	*13.9*	*15.2*
Oil (CO_2, CH_4 & N_2O)	*4.3*	*0.57*	*0.21*
MSW/LFG (CO_2, CH_4 & N_2O)	*0.5*	*0.51*	*0.58*
Net Imported (Exported) Electricity (CO_2, CH_4 & N_2O)	-32.55	-36.07	-36.04
Sector / Emission Source ($MMtCO_2e$)	**2000**	**2010**	**2020**
Agriculture	**8.38**	**6.12**	**6.29**
Enteric Fermentation	3	3.01	2.91
Manure Management	1.55	1.14	1.24
Agricultural Soil Management	3.82	1.97	2.14
Burning of Agricultural Crop Waste	0.01	0.006	0.004
Waste Management	**5.57**	**3.59**	**4.26**
Municipal Solid Waste (CO_2, CH_4 & N_2O)	2.74	2.12	2.77
Industrial Landfills	0.19	0.051	0.05
Waste Combustion	1.61	0.51	0.58
Wastewater (CH_4 & N_2O)	1.03	0.91	0.86
Total Statewide Gross Emissions (Consumption Basis)	**290.4**	**264.11**	**282.24**
Increase relative to 2000		*-9.05%*	*-2.80%*
Increase relative to 2010			*6.42%*

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Total Statewide Gross Emissions (Production Basis)	**322.95**	**300.18**	**318.64**
Increase relative to 2000		*-7.05%*	*-1.33%*
Increase relative to 2010			5.79%
Forestry and Land Use	**-21.25**	**-34.43**	**-33.99**
Total Statewide Net Emissions (Consumption Basis) (including F&LU sinks)	**269.15**	**229.68**	**248.25**
Increase relative to 2000		*-14.67%*	*-7.77%*
Increase relative to 2010			*7.48%*
Total Statewide Net Emissions (Production Basis) (including F&LU sinks)	**301.7**	**265.75**	**284.65**
Increase relative to 2000		*-11.92%*	*-5.65%*
Increase relative to 2010			*6.64%*

MMtCO_2e = million metric tons of carbon dioxide equivalent; MSW = Municipal Solid Waste; LFG = Landfill Gas; LPG = Liquefied Petroleum Gas; CH_4 = Methane; N_2O = Nitrous Oxide.
* Totals may not equal exact sum of subtotals shown in this table due to independent rounding. NA = information was not available.

The principal sources of Pennsylvania's GHG emissions in 2010 were electricity consumption, followed by the industrial sector and then the transportation sector. Each of these accounted for 33 percent, 26 percent and 25 percent of Pennsylvania's gross GHG emissions, respectively, as shown in Figure 3-2. The next largest contributor is the residential/commercial fuel use sector, accounting for 12 percent of gross GHG emissions in 2010.

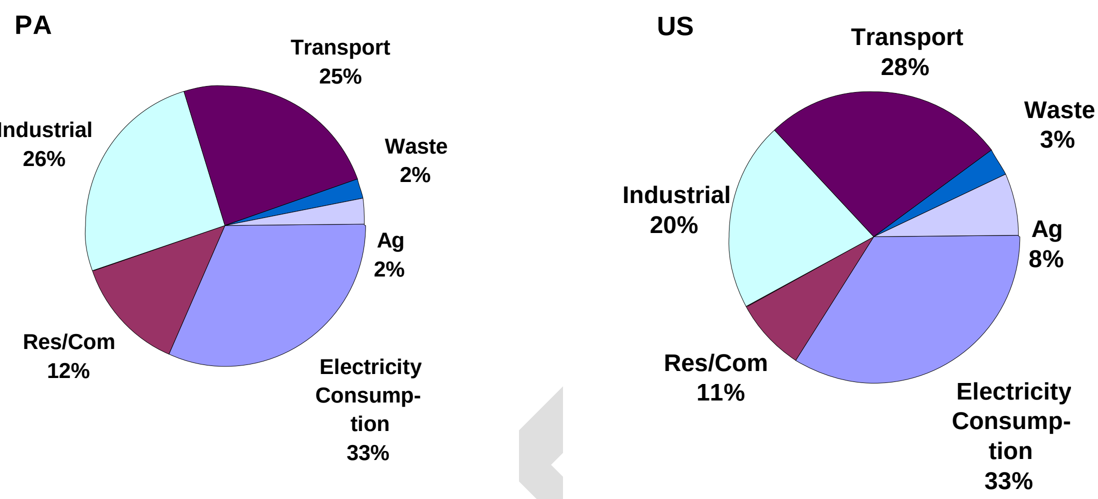
Figure 3-1 also shows that the emissions from the agricultural sector accounted for 3 percent of the gross GHG emissions in Pennsylvania in 2010. These CH_4 and N_2O emissions primarily come from agricultural soils, enteric fermentation, manure management and agricultural soil cultivation practices. Also, landfills, waste combustion and wastewater management facilities produce emissions that accounted for 2 percent of total gross GHG emissions in Pennsylvania in 2010.

Forestry emissions refer to the net CO_2 flux[11] from forested lands in Pennsylvania, which account for about 58 percent of the state's land area.[12] Pennsylvania's forests are estimated to be net sinks of CO_2 emissions in the state, reducing GHG emissions by 34.4 MMtCO_2e in 2010.

[11] "Flux" refers to both emissions of CO_2 to the atmosphere and removal (sinks) of CO_2 from the atmosphere.

[12] Total forested acreage in Pennsylvania is 16.5 million acres. The total land area in Pennsylvania is 28.7 million acres (http://www.statemaster.com/state/PA-pennsylvania/geo-geography).

Figure 3-1. Gross GHG Emissions by Sector, 2010: Pennsylvania and U.S.



Notes: Res/Com = Residential and commercial fuel use sectors. Emissions for the residential fuel use sector are associated with the direct use of fuels (natural gas, petroleum, coal and wood) to provide space heating, water heating, cooking and other energy end-uses. The commercial sector accounts for emissions associated with the direct use of fuels by, for example, hospitals, schools, government buildings (local, county and state) and other commercial establishments. The industrial sector accounts for emissions associated with manufacturing, emissions from fossil fuel processing and emissions included in the industrial fuel use sector. The transportation sector accounts for emissions associated with fuel consumption by all on-road and non-highway vehicles. Non-highway vehicles include jet aircraft, gasoline-fueled piston aircraft, railway locomotives, boats and ships. Emissions from non-highway agricultural and construction equipment are included in the industrial sector. Electricity = Electricity generation sector emissions on a consumption basis, including emissions associated with electricity imported from outside of Pennsylvania and excluding emissions associated with electricity exported from Pennsylvania to other states.

3.3 Reference Case Projections

Relying on a variety of sources for projections, a simple reference case projection of GHG emissions through 2020 was developed. As shown numerically in Table 3-1, under the reference case projections, Pennsylvania's gross GHG emissions are projected to increase slightly to about 282 $MMtCO_2e$ by 2020, or 2.8 percent below 2000 levels and 6.4 percent above 2010 levels. This equates to a 0.64 percent average annual rate of growth in emissions from 2000 to 2020. Relative to 2010, the share of emissions associated with electricity consumption increases from 32 percent to 35 percent by 2020. It is note worth at this point to take into consideration that this older data does not reflect future factors in the electricity generation sector that will ultimately lower emissions from this sector. The anticipated closure of coal fired electricity generating stations along with the construction of new natural gas fired stations and possible fuel switching from coal to natural gas will have a profound effect on Green House Gas emissions in the commonwealth.

The share of emissions from the industrial sector increases to 28 percent by 2020. The shares of emissions from the residential/commercial fuel use sectors and the transportation sector both decrease 4.7 percent and 2.75 percent respectively from their relative share of emissions in 2010. The share of emissions from the waste management and agriculture sectors increase slightly in 2020 relative to their shares in 2000. Once again it is reasonable to surmise that the current data does not recognize the projected emissions reductions possible from the waste sector's Landfill Gas to Energy (LFGTE) programs growing in Pennsylvania. Currently LFGTE projects are generating about 150 MW of power while reducing methane emissions from the commonwealth's permitted landfills.

Emissions associated with electricity consumption are projected to be the largest contributor to future GHG emissions growth by far; emissions from waste management and agriculture are modest contributors to future emissions growth as shown in Figure 3-2, while emissions from all other sectors decrease from 2010 to 2020. Table 3-2 summarizes the growth rates that drive the growth in the Pennsylvania reference case projections, as well as the sources of these data.

The industrial sector accounted for 26 percent of Pennsylvania's gross GHG emissions in 2010, higher than the national average of 21percent. This is not surprising given Pennsylvania's history of heavy industry. Fuel combustion to provide space heating, water heating, process heating, cooking, and other energy end-uses makes up the majority of industrial emissions. Emissions from industrial processes account for 19 percent of the state's industrial emissions in 2020. These emissions include: the use of HFCs and PFCs as substitutes for ozone-depleting chlorofluorocarbons,[13] CO_2 released by cement and lime manufacturing; CO_2 released during soda ash, limestone, and dolomite use; CO_2 released during iron and steel production; SF_6 used in electricity transmission and distribution systems; and HFCs, PFCs, and SF_6 released during semiconductor manufacturing. The fossil fuel production sector accounts for the remaining 25 percent of emissions from the industrial sector. These emissions come primarily from coal mining, although there are also emissions associated with the natural gas industry

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[13] Chlorofluorocarbons are also potent GHGs; however, they are not included in GHG estimates because of concerns related to implementation of the Montreal Protocol on Substances That Affect the Ozone Layer.

Figure 3-2. Sector Contributions to Gross Emissions Growth in Pennsylvania, 2000–2020: Reference Case Projections

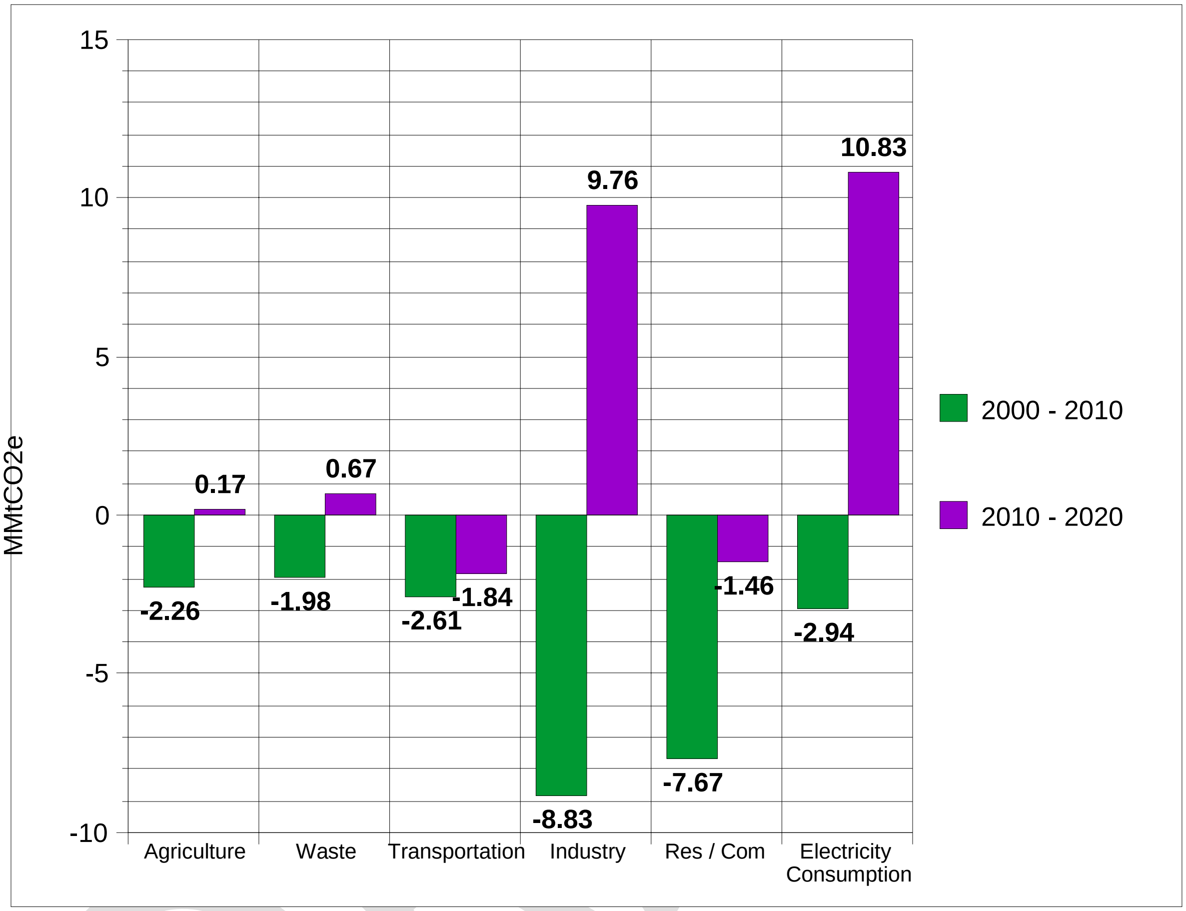

Table 3-2. Key Annual Growth Rates for Pennsylvania, Historical and Projected

	2000-2010	2010-2020	Sources
VMT	-2.01%	-1.06	Based on Pennsylvania Department of Transportation Roadway Management System Data and Forecasted Growth Rates
Population	3.43%	0.67%	
Electricity Sales	10.15%	-2.72%	For 2000-2010, the average annual growth rate is calculated from actual PA sales. For 2010-2020, the average annual growth rate is based on PA sales over the period 2007 to 2011.

EIA = Energy Information Administration; SIT = State (GHG) Inventory Tool; VMT = vehicle miles traveled.

3.4 A Closer Look at the Three Major Sources of GHG Emissions: Electricity Supply, Industrial Sector, and Transportation Sector

As shown in Figure 3-2, electricity use in 2010 accounted for 33 percent of Pennsylvania's gross GHG emissions (about 84 $MMtCO_2e$), which was slightly lower than the national average share of emissions from electricity consumption (34 percent).[14] On a per-capita basis, Pennsylvania's GHG emissions from electricity consumption are lower than the national average (in 2010, 7.57 tCO_2e per capita in Pennsylvania, versus 8.02 tCO_2e per capita nationally).

Electricity Supply

According to the latest data from the EPA, in 2010, emissions associated with Pennsylvania's electricity consumption (87.25 $MMtCO_2e$) were about 36 $MMtCO_2e$ lower than those associated with electricity production (123.32 $MMtCO_2e$). The higher level for production-based emissions reflects GHG emissions associated with net exports of electricity to other states to meet their electricity demand.[15] Emissions from electricity exports are projected to increase to a level of about 38 $MMtCO_2e$ by the year 2020. The reference case projection indicates that production-based emissions (associated with electricity generated in-state) will increase by about 11 $MMtCO_2e$, and consumption-based emissions (associated with electricity consumed in-state) will increase by about 11 $MMtCO_2e$ from 2010 to 2020. Electricity generation in Pennsylvania is dominated primarily by units powered by coal and nuclear fuel. However, the onset of natural gas production in the state is resulting in a greater share in natural gas fired power generating stations and reducing the share of coal generated electricity.

Projections of electricity sales for 2010 through 2020 indicate that Pennsylvania will remain a net exporter of electricity. Projected increases for in-state sales are driven in large part by reports provided by the electric distribution companies (EDCs) to the Public Utility Commission and further, by applying historic annual rates of growth for each EDC

While estimates are provided for emissions from both electricity production and consumption, unless otherwise indicated, tables, figures and totals in this report reflect electricity consumption emissions. The consumption-based approach can better reflect the emissions (and emission reductions) associated with activities occurring in the state, particularly with respect to electricity use (and efficiency improvements), and is particularly useful for decision making. Under this approach, emissions associated with electricity exported to other states would need to be covered in those states' inventories in order to avoid double counting or exclusions.

[14] For the U.S. as a whole, there is relatively little difference between the emissions from electricity use and emissions from electricity production, as the U.S. imports only about 1 percent of its electricity, and exports even less.

[15] Estimating the emissions associated with electricity use requires an understanding of the electricity sources (both in-state and out-of-state) used by utilities to meet consumer demand.

Industrial Sector

The industrial sector accounts for 26 percent of Pennsylvania's gross GHG emissions in 2010, higher than the national average of 21percent. This is not surprising given Pennsylvania's history of heavy industry. Fuel combustion to provide space heating, water heating, process heating, cooking and other energy end-uses makes up the majority of industrial emissions.

Emissions from industrial processes account for 19 percent of the state's industrial emissions in 2020. These emissions include: the use of HFCs and PFCs as substitutes for ozone-depleting chlorofluorocarbons,[16] CO_2 released by cement and lime manufacturing; CO_2 released during soda ash, limestone and dolomite use; CO_2 released during iron and steel production; SF_6 used in electricity transmission and distribution systems; and HFCs, PFCs and SF_6 released during semiconductor manufacturing. The fossil fuel production sector accounts for the remaining 25 percent of emissions from the industrial sector. These emissions come primarily from coal mining, although there are also emissions associated with the natural gas industry.

Using the currently available data, under the reference case projections, GHG emissions from the industrial sector are projected to increase by 13.36 percent from 2010 to 2020, to 78.96 $MMtCO_2e$ in 2020.

Transportation

GHG emissions from transportation fuel use have decreased from 2000 to 2010 at an average annual rate of 9.36 percent. In 2010, gasoline-powered on-road vehicles accounted for about 66 percent of transportation GHG emissions; on-road diesel vehicles for 22 percent; jet fuel and aviation gasoline for 7 percent and marine vessels, rail and other sources (natural gas- and liquefied petroleum gas-fueled vehicles used in transport applications) for the remaining 5 percent.

Overall emissions from the transportation sector are expected to decline at a rate of about 0.1 percent annually from 2010 to 2020 to 65$MMtCO_2e$. This overall decrease is driven by the decrease in on-road gasoline emissions, declining at a rate of 0.7 percent per year from 2000 to 2020, reaching 39 $MMtCO_2e$ in 2020. In contrast, the vehicle miles traveled by gasoline vehicles is expected to increase at a rate of 1.4 percent per year in the same time period. The decrease in on-road gasoline emissions is driven by the assumed increase in vehicle fuel economy resulting from the Energy Independence and Security Act of 2007 which increase Corporate Average Fuel Economy (CAFE) standards. Emissions from on-road diesel vehicles are projected to increase by 2.5 percent annually from 2010 to 2020.

[16] Chlorofluorocarbons are also potent GHGs; however, they are not included in GHG estimates because of concerns related to implementation of the Montreal Protocol on Substances That Affect the Ozone Layer.

3.5 Key Uncertainties

Historically, the key component of Pennsylvania's GHG emissions has been the electricity sector; primarily coal fired generating stations, which have accounted for about 50 percent of all PA electricity generation for many years. Recently, the availability of increased natural gas supplies, resulting from the Marcellus Shale play, has been shifting the state's power generation share away from coal-fired to natural gas-fired generation stations. Coal's share has declined over the past few years because of growing competition from more efficient natural gas-fired plants, new federal emissions standards, subsidized electricity and AEPS.

From the currently available data presented in Table 3.1, the electricity sector share of GHG emissions is projected to increase to about 98.08 $MMtCO_2e$ by 2020 (consumption basis), or 8 percent above 2000 levels and 11 percent above 2010 levels. The same data also shows an increase of 8.6 percent in coal emissions above 2010 levels and an increase of 1.3 percent above 2000 levels. The EPA data captured in the 2020 projection does not represent the emissions reductions that could be gained by the closure of 13 Pennsylvania coal-fired generating plants by 2016. It is representative of the business as usual use of coal-fired generating stations for the production of electricity.

Recent data from the EPA[17] indicates that with the suggested coal plant closings, the cumulative CO_2e emissions reductions will be in the neighborhood of 13 $MMtCO_2e$ and a capacity reduction of 6500 MW. In the same time frame, the PJM proposed new generating capacity for Pennsylvania is 11,659 MW. This new capacity is resultant from new natural gas-fired generation plants. The new natural gas generated electricity will produce about 6.45 $MMtCO_2e$ in 2020, resulting in a negative offset of 7.0 $MMtCO_2e$ to the projected 2020 electricity GHG emissions as noted in Table 3.1. This will reduce the projected increases to 3.72 percent below 2000 levels and 3.26 percent below 2010 levels.

DEP believes that natural gas will continue to play a more significant role in electricity generation in Pennsylvania. However, emissions associated with electricity consumption are still projected to be by far the largest contributor to future GHG emissions growth.

Key tasks for future refinement of this inventory and forecast include review and revision of key drivers, such as the transportation, electricity demand, and industrial and residential/commercial fuel use growth rates that will be major determinants of Pennsylvania's future GHG emissions

Pennsylvania's Electrical Generation

Along with the GHG inventory in this report that was developed by DEP's Bureau of Air Quality prepared a CO_2 emissions trend analysis for Electric Generating Units (EGU) operating in Pennsylvania projected to the year 2016, using EPA's State Inventory Tool. In preparing the analysis the following assumptions were used:

- A 0.9 percent per year growth of electricity demand (U.S. EIA, AEO May 2013)

[17] US EPA, Clean Air Market Emissions Report – PA 2010

- All proposed new power projects were added
- All EGU's that are scheduled to be shutdown were removed.
- All other data was extracted from the U.S. EPA Clean Air Markets Division database.[18]

Table 3-3: CO_2 Emissions Trend from All EGUs Projected to 2016

Year	CO2 (tons)	CO2 (10^6 tons)	Heat Input (MMBtu)	Gross Load (MW-h)	Gross Load (10^6 MW-h)	Average lbs/MWh
2000	121,409,680	121.41	1,206,528,839	142,254,370	142.25	1707
2001	125,402,320	125.40	1,180,119,246	143,184,791	143.18	1752
2002	124,854,653	124.85	1,251,865,327	136,215,651	136.22	1833
2003	129,509,485	129.51	1,292,537,172	138,653,840	138.65	1868
2004	133,263,467	133.26	1,356,529,559	145,464,463	145.46	1832
2005	136,691,667	136.69	1,383,442,193	150,458,619	150.46	1817
2006	134,546,579	134.55	1,362,254,850	149,364,836	149.36	1802
2007	138,832,451	138.83	1,424,203,567	155,042,650	155.04	1791
2008	134,714,655	134.71	1,381,296,576	150,455,844	150.46	1791
2009	127,645,017	127.65	1,353,775,190	146,679,469	146.68	1740
2010	137,014,082	137.01	1,445,867,861	156,273,105	156.27	1754
2011	129,419,962	129.42	1,395,662,942	152,683,792	152.68	1695
2012	120,696,891	120.70	1,347,762,894	147,450,917	147.45	1637
2020 (projected)	106,626,251	106.63	1,447,914,193	158,407,889	158.41	1346

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Table 3-3 shows historical CO_2 emissions data from 2000 to 2012 and the projected emissions for 2016. The historic date demonstrates a 0.71 percent decrease in CO_2 emissions between 2000 and 2012. The projected 2016 data shows a 9.14 percent decline in emissions from 2012 levels and a decrease in CO_2 of 9.6 percent below 2000 CO_2 levels. The resulting decrease in EGU CO_2 emissions is a result of two contributing factors: 1. the shutdown of coal-fired EGUs across the state and 2. the conversion of other existing coal fired EGUs to cleaner burning natural gas.

Although CO_2 emissions trends from EGUs show a decline through 2016, PA's EGUs continue to increase gross load above 2000 levels. A 7.44 percent increase can be seen in Table 3-3 and Figure 3-3.

[18] http://ampd.epa.gov/ampd/QueryToolie.html. Data accessed Nov. 8, 2013.

Figure 3-3: CO_2 emission trend 2000-2016 from EGUs located in Pennsylvania

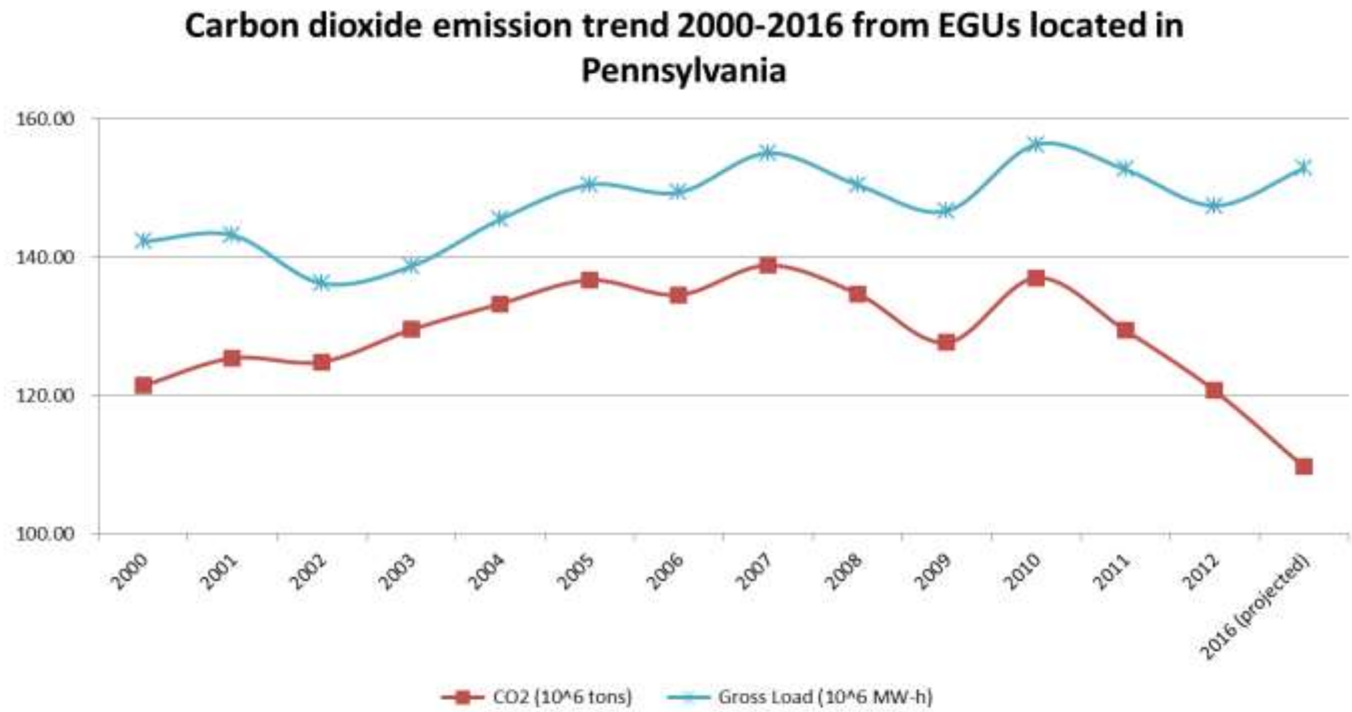

Figure 3-4: Output based emission rate of CO2 2000-2016

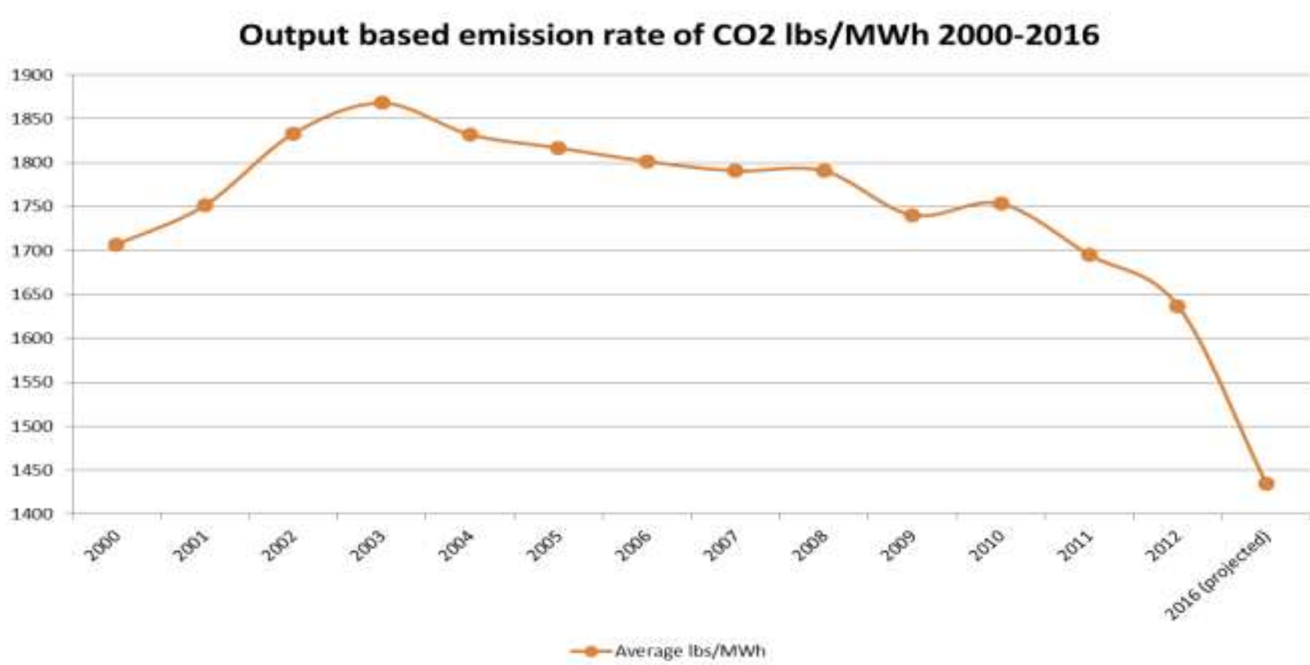

Figure 3-4 also shows a decline in the emission rate of CO_2 projected from 2000 to 2020. As can be seen on the graph, the emissions rate declines from about 1700 Lbs./MWh in 2000 to about 1350 lbs/MWh in 2020. This is approximately a 21.1 percent decrease in the CO_2 emissions rate from PA's EGUs over the projected 20 year period. The emissions rate reduction is also attributed to the planned retirement of coal-fired EGUs across the commonwealth and the planned conversion of other existing coal-fired EGUs to cleaner burning natural gas.

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Chapter 4. Cost-Effective Strategies For Reducing Or Offsetting GHG Emissions

The following sections of this chapter outline a list of options and initiatives for consideration to reduce GHG emissions in Pennsylvania. The options are organized by sector and include an overview with the challenges and opportunities of each sector. Each of these options should be weighed in consideration with Pennsylvania's neighboring states and other competitors around the world, so as not to shift the economic activity to a different locale, thereby not reducing greenhouse gas emissions, but only shifting them to another region.

Many of the cost-effective strategies for reducing or offsetting GHGs result in an overall savings to the economy, but in place of those that do not result in a cost-savings, market-based solutions should be sought. Non-market based approaches, such as government mandates on electric generation portfolio standards should be avoided.

4.1 Electricity Production, Transmission, and Distribution Overview

The electricity production, transmission and distribution (EPTD) sector includes GHG emissions from all production, transmission and distribution of electricity. Pennsylvania power plants are anticipated to continue to produce more electricity than is consumed in the state for residential, commercial and industrial uses while also providing electricity to meet the demands of other Mid-Atlantic States, making Pennsylvania a net exporter of electricity.

Electricity generation in Pennsylvania expanded at a modest annual rate of 1.3 percent from 2000 to 2010. From 2000 to 2017, the average annual growth rate is expected to be 0.8 percent. Efficiency gains in the commercial and residential sectors have helped to slow the increasing demand for electricity, a trend which will continue.

The EPTD sector is the largest source of GHG emission in the state. In 2000, on an electricity production basis, the sector contributed about 122.74 MMtCO_2e emissions (about 38 percent) to Pennsylvania's total statewide gross GHG emission. On a consumption basis, in 2000 the sector contributed about 90.19 MMtCO_2e of emissions (about 31 percent) to Pennsylvania's total gross GHG emissions.

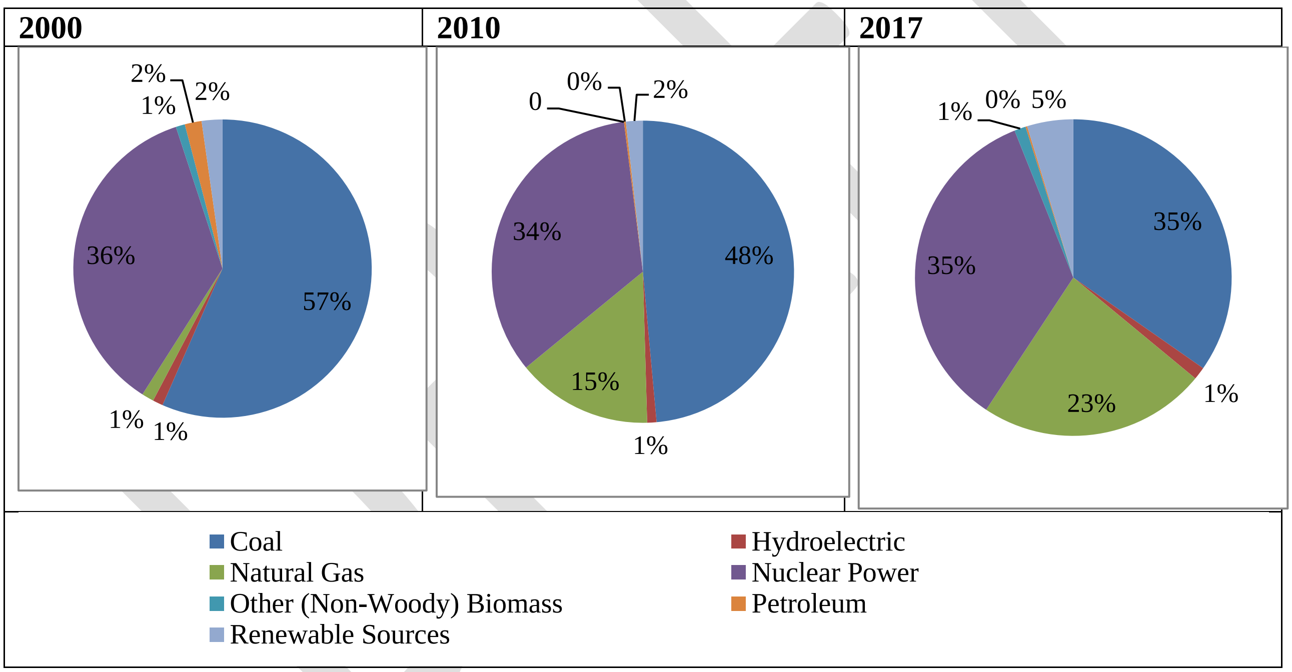
Overall, emissions for the sector are expected to increase 8 percent on a consumption basis between 2000 and 2020, based on forecasts using the EPA State Inventory Tool. Specifically, the production-based GHG emissions associated with Pennsylvania's electricity sector increased by only 0.58 MMtCO_2e between 2000 and 2010. On a consumption basis, GHG emissions associated with the energy sector increased by 8.3 MMtCO_2e between 1990 and 2000, accounting for 11 percent of the growth in GHG emissions. By 2020, consumption-based emissions are expected to increase from 2000 levels by approximately 8.7 percent, from roughly 90.19 MMtCO_2e in 2000, to about 98.08 MMtCO_2e in 2020. However, as discussed in Section 3.5, a reduction in 2020 GHG projected emissions are expected to decrease due to the shutdown of coal-fired electricity generating units and conversions to natural gas generation.

Challenges and Opportunities for Energy Production, Transmission and Distribution

Traditionally, coal-fired power plants have been the main source of GHGs from this sector. Coal production has been declining since 2000 and is expected to decline until at least 2017 and likely beyond. By 2017, coal production in Pennsylvania is projected to be 73 percent of the production levels in 2000. Due to increased federal regulations, as well as the availability of natural gas, many coal-fired power plants have either retired, reduced run time, or are exploring fuel-switching to natural gas. When fired, natural gas has a lower GHG potency than coal.

Since the last Climate Change Action Plan was completed in 2009, a shift in energy generation in Pennsylvania has occurred due to the availability of lower-cost natural gas. Natural gas use can lead to reductions of not only CO_2, but also SO_2 and NOx emissions, providing a flexible response to emissions requirements and seasonal fuel prices.

Figure 4-1. Shares of electricity generation by fuel type in Pennsylvania



Source: Pennsylvania Public Utility Commission, Energy Information Administration

Methane

Natural Gas

In 2011, methane (CH_4) accounted for about 9 percent of all U.S. greenhouse gas emissions from human activities. Methane is also emitted by natural sources such as livestock. CH_4 can be removed through natural processes in soil and chemical reactions in the atmosphere. Methane's lifetime in the atmosphere is much shorter than carbon dioxide (CO_2), but CH_4 is more efficient at trapping radiation than CO_2.According to the EPA, when methane, the major component of natural gas, is emitted into the atmosphere, it is approximately 21 times more potent a greenhouse gas than carbon dioxide[19]. Methane losses from natural gas extraction and delivery accounted for 32 percent of U.S. methane emissions and 3 percent of the total U.S. GHGs in 2009. Reducing these losses will provide significant environmental benefit through the reduction of greenhouse gas emissions. In 2012, EPA adjusted their estimates on methane losses from natural gas by 50 percent. [20]

The natural gas resources from within Pennsylvania, particularly from deep shale formations such as the Marcellus and Utica, offer opportunity for economic prosperity and renewed optimism for greater energy independence and security. The potential climate impact that may result from replacing other fossil fuels with methane depends largely on the type of fuel being replaced. When estimating the net climate change implications of fuel-switching strategies, outcomes must be based on the complete fuel cycle, a Life Cycle Analysis, and account for changes in the radiative forcing effects (warming) of the relevant GHGs.

Beginning in 2015, EPA regulations will require natural gas operators to employ green completion technology to prevent gas from escaping into the atmosphere after the well has been hydraulically fractured, since this is typically when the most methane is released. Many unconventional operators in Pennsylvania are already employing this type of technology when feasible. “Green completion” technology captures the gas and condensate that is released during the flowback period after hydraulic fracturing. By implementing green completions, emissions are expected to be reduced by up to 95 percent. The new federal regulation also includes requirements for other sources of emissions in the oil and gas industry, including storage vessels.

Pennsylvania has also introduced measures to reduce emissions from gas and oil operations that include a revised General Operation Permit for compressor stations and processing operations that meet emission standards set by DEP. These facilities will use leak detection and repair program (LDAR) to reduce and control emissions of methane. Operating permit exemptions such as Exemption 33 and Exemption 38 are also available to gas and oil operations that meet the criteria set by DEP.

Practices such as LDAR for the entire well pad and facility, rather than just the storage vessels, as required by federal rule, are more stringent than the federal rules. Any leaks must be repaired within 15 days unless the operator shuts the site down or is in the process of acquiring replacement parts. Emissions of volatile organic compounds and hazardous air pollutants must also be controlled beyond levels required by the federal rules. DEP guidance also requires that emissions of nitrogen oxides be less than 100 pounds per hour, half a ton per day and 6.6 tons per year. The federal rules do not address or limit such emissions.

The EPA has also encouraged natural gas operators to join the Natural Gas STAR Program. This program was first developed in 1993 and provides operators with information on cost-effective

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[19] EPA. http://www.epa.gov/climatechange/ghgemissions/gases/ch4.html
[20] EPA. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2011* (April 2013) http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2013-Main-Text.pdf

methane emission reduction technologies and practices and requires participating operators to submit annual reports describing the actions they've taken to reduce their emissions. As more and more shale wells are drilled and hydraulically fractured each year, programs like this will become more important at controlling methane leakage from natural gas production and distribution.

Other Sources of Methane

In addition to being the main component of natural gas, there are a number of other sources of methane in Pennsylvania, including the biodegradation of trash in landfills, coal bed methane, and fermentation of organic matter (such as manure). Capturing this methane before it is emitted into the atmosphere is not only beneficial to reducing GHGs, but it is also an opportunity for additional energy generation. Many of the cost-effective strategies outlined in this section of the report focus on the capture and use of methane.

Around the world, the most popular method of waste disposal is in landfills. When the organic material disposed of in landfills breaks down anaerobically, it releases landfill gas (50 percent - 60 percent methane, 40 percent – 45 percent CO_2) into the atmosphere. Depending on local conditions, a small amount of the carbon in organic waste placed in landfills may be sequestered there indefinitely. However, placing waste in landfills does not reduce GHGs from waste management, unless the landfill gas is managed properly. Many landfills in Pennsylvania are using the landfill gas to their benefit by using it to generate electricity or heat, or by liquefying it for use as a transportation fuel. This renewable source of energy, which would otherwise be flared off into the atmosphere, can be used to off-set other power sources.

In 2013, a public/private initiative was unveiled in Franklin County, where PPL Renewable Energy and the borough of Chambersburg have partnered to use landfill gas for electricity generation. The 6.4 MW power generation systems captures methane from decomposing trash at the IESI Blue Ridge Landfill and harnesses it to generate 50 million kilowatt-hours per year of electricity. This electricity generation is enough to power 4,000 homes, or roughly one-third of the borough's electric customers. This one partnership project has to potential to save more than 40,000 tons of CO_2 emissions each year in addition to saving consumers money on their electric bill each month.

Methane gas can also be released from coal mines. Like landfill methane, coal mine methane can be collected before, during, and after mining, and condensed into a fuel resembling the properties and heat content of natural gas.[21] About 75 percent of the methane produced by active projects in the state is used for power generation. These active projects resulted in the generation of almost 900 million kilowatt hours of electricity. This amounts to roughly one-third of one percent of the total electricity generated in Pennsylvania in 2011.

[21] U.S. Department of Energy, Energy Efficiency and Renewable Energy. "Combined Heat and Power Market Potential for Opportunity Fuels." August 2004.

Utility DSIC

There are two PUC programs that will contribute to fewer natural gas leaks and thus decrease fugitive methane emissions. The amount of emission reduction has not been calculated by the PUC as such a reduction is viewed as a co-benefit and not the main driver for either program. The two programs are Act 11 of 2012 (or Distribution System Improvement Charge (DSIC)) and the commission's, April 4, 2013, final rulemaking at L-2012-2294746, regarding unaccounted-for-gas (UFG).

On Feb. 14, 2012, Act 11 of 2012 was signed and amended Title 66 (Public Utilities) of the Pennsylvania Consolidated Statutes to allow jurisdictional water and wastewater utilities, natural gas distribution companies, city natural gas distribution operations and electric distribution companies to petition the commission for approval to implement a DSIC. The DSIC must be designed to provide for "the timely recovery of the reasonable and prudent costs incurred to repair, improve or replace eligible property in order to ensure and maintain adequate, efficient, safe, reliable and reasonable services." 66 Pa.C.S. § 1353 (a).

Starting Jan. 1, 2013, public utilities were eligible to petition the commission for approval to establish a DSIC. A petition must contain the following elements: 1. initial tariff; 2. testimony and exhibits to demonstrate that the DSIC will ensure the provision of adequate, efficient, safe, reliable and reasonable service; 3. long-term infrastructure plan; 4. certification that a base rate case has been filed within the past five years; and 5. any other information required by the commission. Moreover, the petition must demonstrate that granting the petition and allowing the DSIC to be charged will accelerate the replacement of infrastructure. To date, Equitable, Peoples, Peoples TWP, PGW and Columbia Gas have filed DSIC petitions with the PUC.

The second program relates to UFG. In general, UFG is defined as the difference between total gas supplies delivered to the natural gas distribution company (NGDC) and the amount of that gas the NGDC subsequently delivers to its retail, commercial and industrial customers, adjusted for company use, temperature, pressure variations or other allowed variables. As the name implies, UFG is gas that is "lost" during transport from supplier to customer. This PUC rulemaking establishes the uniform terminology of "unaccounted for gas," or UFG, to describe gas lost from an NGDC's system and determines that an end state UFG metric should be set at 3 percent for distribution system UFG.

Peak Demand

Act 129 of 2008 was signed into law on Oct. 15, 2008, and became effective on Nov. 14, 2008. Among other things, the act created an Energy Efficiency and Conservation (EE&C) Program, codified in the Pennsylvania Public Utility Code at Sections 2806.1 and 2806.2, 66 Pa. C.S. §§ 2806.1 and 2806.2. In one aspect of Act 129, electric distribution company (EDC) peak demand was to be reduced by a minimum of 4.5 percent of the EDC's annual system peak demand in the 100 hours of highest demand by May 31, 2013.

By November 30, 2013, the commission was required compare the total costs of the peak demand reduction portion of the EE&C plans to the total savings in energy and capacity costs, as well as other costs determined by the commission, incurred by retail customers in the state. If the commission determines that the benefits of the peak demand reduction program exceed the costs, the commission must set additional incremental requirements for reduction in peak demand for the 100 hours of greatest demand or an alternative peak reduction program approved by the commission.

With its November 14, 2013, tentative order, the commission released for comment an amended Act 129 demand response study, which included a preliminary wholesale price suppression and prospective TRC analysis prepared by the commission's Act 129 statewide evaluator, and an assessment of the cost-effectiveness of the Act 129 2012 peak demand reduction program. In addition, the tentative order seeks comments on an alternative peak demand reduction program to be studied for inclusion in a subsequent phase of the Act 129 EE&C Program. Comments to the order are expected by January 2014. A final commission order should be issued by March 2014.

Overview of Energy Production, Transmission and Distribution Work Plan Recommendations and Estimated Impacts

The following strategies were discussed with the Energy Production, Transmission and Distribution Subcommittee of the Pennsylvania CCAC. Table 4-1 provides a summary of all of the GHG reductions, costs and cost-effectiveness of all the work plans for the Energy Production, Transmission and Distribution sector work plans. A negative cost number indicates and overall savings to the economy. All individual work plans, including assumptions and calculations, are included in Appendix D.1.

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Table 4-1. Summary Results for Energy Production, Transmission and Distribution Sector Work Plan Recommendations

Work Plan Name	Annual Results (2020) GHG Reductions ($MMtCO_2e$)	Annual Results (2020) Costs (Million $)	Annual Results (2020) Cost-Effectiveness ($/$tCO_2e$)	Cumulative Results (2013-2020) GHG Reductions ($MMtCO_2e$)	Cumulative Results (2013-2020) Costs (Million $)	Cumulative Results (2013-2020) Cost-Effectiveness ($/$tCO_2e$)	CCAC Voting Results (Yes/No/Abstained)
Act 129 of 2008	8.9	-1,139	-127	19.1	$-2,033	-106	10-3-0
Coal Mine Methane Recovery	Costs and GHG reductions are considered in the Coal Mine Methane Recovery Work Plan						12-0-0
Combined Heat and Power	3.8	-178	-47	17.1	$-544	-32	13-1-0
Reducing Methane Leakage from Natural Gas Infrastructure	1.12	-43	-38.4	11.94	-424	-31.76	13-0-0
Waste-to-Energy Digesters	0.13	1.06	8.14	0.48	$4.25	8.91	14-0-0
Beneficial Use of Waste	Costs and GHG reductions are considered in the Beneficial use of Waste Work Plan						13-0-0
Nuclear Uprates	5.4	840	155.25	30.4	$3,553	117	11-3-0
Manure Digesters	0.0139	.441	31.73	0.0529	$1.5	28.36	13-0-0
Sulfur Hexafluoride Emissions Reductions	0.11	0.07	0.64	0.86	$0.34	0.40	13-0-0

Act 129 of 2008, Phases I, II, and III

Act 129 of 2008 was signed into law on October 15, 2008 and requires electricity reduction measures. The PUC has primary implementation responsibility and has established an energy efficiency and conservation program implementation order. This order requires all EDCs to develop and implement cost-effective energy efficiency and conservation plans to reduce consumption and peak load within their service territories.

Phase I of the act required a reduction of 1 percent below consumption levels for the period of June 1, 2019, through May 31, 2010, in total electricity consumption by May 31, 2011. Phase I also required a 3 percent reduction in total electricity consumption by May 31, 2013, from the same period benchmark. Phase II of Act 129 requires a reduction in total electricity consumption from June 1, 2012, through May 31, 2016, equal to 3,313,246 MWh, which equates to about 1,104,415 MWhs per year. Through the years 2017 to 2020, annual reductions equal to 0.75 percent of projected electricity consumption is required.

For phase 2, the chart below outlines the energy efficiency reductions that each EGU has achieved.

Utility Territory	Three-Year % of Energy Efficiency Reductions
Duquesne	2.0
Met-Ed	2.3
Penelec	2.2
Penn Power	2.0
PPL	2.1
PECO	2.9
West Penn	1.6
AVERAGE	**2.2**

Source: PUC

Coal Mine Methane Recovery

When coal is mined and processed for use, substantial amounts of methane gas are released. Coal bed methane is methane contained within coal formations that may be extracted by gas exploration methods or released as part of coal mining operations. This work plan deals with coal mine methane (CMM), the methane within the coal that can be vented or recovered prior to mining, during mining and immediately after mining the coal as some gas escapes to the surface through post-mining vents or boreholes. Methane gas that remains sequestered within an abandoned underground coal mine does not contribute to GHG emissions, but could be, and sometimes is, recovered by subsequent gas exploration operations.

A CMM recovery initiative would encourage owners/operators of current longwall mines, and of any new gassy underground coal mines that are mined by any method, to capture 10 percent of the estimated total coal mine methane that is released into the atmosphere before, during, and immediately after mining operations. At this time it is not feasible to capture methane liberated by high velocity ventilation systems. This means the proposed and encouraged 10 percent capture of total coal mine methane from gassy underground coal mines would have to be realized from pre-mining surface drill holes, horizontal drill holes within the mine, or for a brief time from surface drill holes into the post mining gob area.

Combined Heat and Power (CHP)

CHP is a term used to describe scenarios in which waste heat from energy production is recovered for productive use. The theory of CHP is to maximize the energy use from fuel consumed and to avoid additional GHG's by the use of reclaimed thermal energy. This initiative encourages distributed CHP systems to reduce fossil fuel use and GHG emissions.

Reductions are achieved through the improved efficiency of CHP systems, relative to separate heat and power technologies, and by avoiding the losses associated with moving power from central generation stations to distant locations where electricity is used.

The reclaimed thermal energy can be used by other nearby entities (e.g., within an industrial park or district steam loop) for productive purposes. Generating stations in urban areas may have existing opportunities or may benefit from the co-location of new industry. For Pennsylvania, the largest source of new, cost-effective CHP potential is in industrial facilities that have continuous thermal loads for domestic hot water and process heating[22].

By 2020, the goal of this initiative is to use 64 million MMBtu of natural gas and 7 million MMBtu of biomass in CHP applications. This initiative would cumulatively reduce GHG emissions by 17.1 $MMtCO_2e$ by 2020 at a cost of $544 million. This initiative has high front-end costs and cost savings will potentially be realized after 2020.

Reducing Methane Leakage from Natural Gas Infrastructure

In recent years, the U.S. natural gas industry has been developing more technologically advanced methods for extraction that have resulted in increased drilling of new wells in unconventional reserves. Natural gas is released to the atmosphere through fugitive and vented emissions. Fugitive emissions are methane leaks often through pipeline and system components, such as compressor seals, pump seals and valve packing. Vented emissions are methane leaks from a variety of equipment and operational practices, such as well completion activities, and are directly attributed to an organization's actions but also through accidental line breaks and thefts.

On August 16, 2012, federal regulations were promulgated by the EPA for the oil and gas sector. These regulations, New Source Performance Standards Subpart OOOO (NSPS), are designed to regulate and reduce volatile organic compounds and SO_2 emissions from oil and gas exploration, production, processing and transportation facilities. Subpart OOOO does not directly regulate methane or CO_2 emissions. However, significant collateral emissions reductions of methane will result from the capture and control of fugitive natural gas emissions required by this subpart.

EPA's Natural Gas STAR Program is a voluntary initiative to reduce fugitive emissions from all aspects of natural gas production, transmission and distribution. Much of the industry's knowledge regarding the supply and costs of mitigating fugitive methane emissions comes from this program, and appears to be the foundation for the NSPS.

Natural Gas STAR partners have reported that performing reduced emissions completions (RECs) recovers most of the gas that is normally vented or flared during the well completion process. RECs is a gas recovery process that involves installing portable equipment that is specifically designed and sized for the initial high rate of water, sand and gas flowback during well completion. The objective is to capture and reintroduce this gas back into the system to avoid venting or flaring. There has been a 78 percent reduction in emissions from the production sector as a result of Best Management Practices (BMPs) such as RECs[23].

[22] (ACEEE et al., 2009)
[23] *US EPA. (2007). Project Opportunities Study for Partner X. Natural Gas Star Program*

As part of normal operation, pneumatic control devices release or bleed natural gas to the atmosphere and as a result are a major source of methane emissions. In the transmission sector there are an estimated 85,000 pneumatic control devices and the actual emissions level, or bleed rate, largely depends on the design of the device. Reduced methane emissions can be achieved by the following methods either alone or in combination:

- Replacing high-bleed devices with low-bleed devices having similar performance capabilities,
- Installing low-bleed retrofit kits on existing operating devices,
- Performing enhanced maintenance, cleaning and tuning, repairing or replacing leaking gaskets, tubing fittings and seals.

By reducing methane emissions from high-bleed pneumatic control devices, significant economic and environmental benefits can be achieved.

Waste-to-Energy (WTE) Digesters

This initiative encourages an expansion of regional digesters that can offer larger-scale and higher technology treatment for a mixture of feedstocks including organic municipal solid waste (MSW), organic residual waste, manure, and biosolids. Thermophilic anaerobic digestion is the preferred strategy for future digestion facility planning, rather than the common mesophilic technologies that are predominate on U.S. farms and wastewater treatment plants. Technologies common in Europe provide for mixed feedstocks, yield more gas and are more efficient than manure-only digesters. The effluent (digestate) is closely monitored and can yield precision-agriculture soil amendment with a guaranteed nitrogen-phosphorus-potassium analysis for fertilizer application. Depending on the exact technology/vendor selected for these digesters, about 50 percent of the input is manure, and the remainder is some combination of food residues, crop residues, yard wastes, organic fraction of MSW or sewage sludge. The European model for centralized digestion relies on processes that digest waste that has a moisture content of less than 25 percent. Using drier feedstocks provides for a higher biogas yield and allows for a more stable digestion process that requires less mixing and disposal of wastewater.

Building four additional waste-to-energy digesters in Pennsylvania by 2020 would eliminate about 0.33 $MMtCO_2e$ over the period.

Beneficial Use of Waste

Pennsylvania is second in the country in terms of generation of the amount of electricity from landfill-gas-to-energy projects, and the state's WTE facilities also contribute to greenhouse gas reductions through the production of up to 276.5 MW, and generated of 1,604,742 MWh in 2011 based on US EIA's database. This strategy would ensure that all MSW generated or disposed of within the state is disposed of at a permitted waste disposal facility and increase the amount of energy generated by existing waste disposal facilities.

US EPA's Landfill Methane Outreach Program reports that as of July 2013, 43 out of 51 landfills in Pennsylvania have operating LFGTE projects, a rate that significantly exceeds California's rate and is in the top-4 nationally. Despite all of these successes, only 59 percent of collected landfill gas at Pennsylvania landfills was used for beneficial use in 2011.[24] The annual generating capacity of the 42 active plants in Pennsylvania exceeds 37 billion cubic feet. If all currently planned projects were developed, this generating capacity would increase to over 40 billion cubic feet per year by 2015. An additional 28 projects with a total capacity of over 17 billion cubic feet per year are described as "potential projects." These potential projects would not come online until approximately 2017. Clearly, there are significant opportunities to improve the rate of LFGTE generation in the Commonwealth.

The six WTE facilities in Pennsylvania generated approximately 1,604,742 MWh of electricity in 2011, directly offsetting consumption of other fuels for electricity generation. Electricity generated using WTE facilities are assumed to have a GHG emission value of 1843 lbs/MWh. Co-locating facilities that require process heat will generate GHG emission reductions. Each 1 mmBTU of fossil fuel generation from waste heat reduces GHG emissions by 0.0003 million metric tons per year, and as average waste heat usage rate of 2 mmBTU per hour for 4000 hours per year, combined industry-wide, would yield an additional annual GHG reduction of 2.4 million metric tons per year. The potential GHG emission reductions of this strategy could total just less than 3.2 million metric tons per year.

Nuclear Capacity Uprates

Using data from the PJM planning queue and data from the EIA's 860 database, DEP estimates 551 MW of additional potential capacity at Pennsylvania's nuclear power plants (Limerick, Peach Bottom, Susquehanna, Three Mile Island), as compared to nameplate capacities in 2008. The data also suggests that since the year 2000, the baseline year from which GHG reductions are being compared in the Pennsylvania action plan, a total of 1,000 MW may be online before 2020.

Typically, to increase the power output of a reactor, a more highly enriched uranium fuel is added. This enables the reactor to produce more thermal energy and therefore more steam, driving a turbine generator to produce electricity. To accomplish this, components like pipes, valves, pumps, heat exchangers, electrical transformers and generators must be able to accommodate the conditions that would exist at the higher power level. For example, a higher power level usually involves higher steam and water flow through the systems used in converting the thermal power into electric power. These systems must be capable of accommodating the higher flows.

In some instances, facilities will modify and/or replace components to accommodate a higher power level. Depending on the desired increase in power level and original equipment design, this can involve major and costly modifications to the plant, such as the replacement of main turbines. All of these factors must be analyzed by the facility as part of a request for a power uprate, which is accomplished by amending the plant's operating license. The analyses must demonstrate that the proposed new configuration remains safe and that measures continue to be

[24] Based on an analysis of 2011 Annual Reports on file at DEP's Bureau of Solid Waste.

in place to protect the health and safety of the public. Before a request for a power uprate is approved, the Nuclear Regulatory Commission must review these analyses.

Manure Digesters

Anaerobic digestion is a biological treatment process that reduces manure odor, produces biogas, which can be converted to heat or electrical energy, and improves the storage and handling characteristics of manure. There are currently 26 manure digesters in Pennsylvania and three more under construction, 14 of which have been funded in part through DEP and other commonwealth-supported financing programs. These digesters are converting the effluent from more than 14,000 dairy cows and 29,000 hogs into useable thermal energy and electricity. A goal of installing 25 additional anaerobic digesters on dairy farms of 500 or more cows and 10 additional digesters at swine operators with more than 3,000 animals by 2020 will reduce GHG by 0.1 $MMtCO_2e$ and cost $1.5 million through 2020.

Sulfur Hexafluoride (SF6) Emission Reductions from the Electric Power Industry

SF_6 is identified as the most potent non-CO_2 GHG, with the ability to trap heat in the atmosphere 23,900 times more effectively than CO_2. About 80 percent of SF_6 gas produced is used by the electric power industry in high-voltage electrical equipment as an insulator or arc-quenching medium. SF_6 is emitted to the atmosphere during various stages of the equipment's life cycle, and leaks also increase as equipment ages. The gas can also be accidentally released at the time of equipment installation and during servicing. From 2000 to 2009 there has been a decreasing trend of about 2.8 percent of SF_6 emissions annually.

According to the EPA[25], there are several categories of GHG reduction measures including: recycling equipment, leak detection and repair, equipment replacement and accelerated capital turnover, and advanced leak detection technologies. The most promising options for reducing SF_6 emissions are recycling (10 percent reduction) and leak detection and repair (20 percent reduction). By employing these two techniques, from 2013 through 2020 GHGs could be reduced by 0.86 $MMtCO_2e$ and cost approximately $340,000 through the period.

4.2 Residential, Commercial and Industrial (RCI) Overview

In 2000, the total GHG emissions from the RCI sectors was 116.77 $MMtCO_2e$, or about 40 percent of total statewide GHG emissions on a consumptive basis. These GHG emissions declined to 100.27 $MMtCO_2e$ in 2010 (about 38 percent of total GHG consumptive emissions), most likely due to the economic downturn and reductions in manufacturing. GHG emissions are expected to increase slightly through 2020 in these sectors to 108.57, but still remain less than the 2000 emission rate.

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[25] US EPA. Final Report on U.S. High Global Warming Potential (High GWP) Emissions 1990-2010: Inventories, Projections and Opportunities for Reductions. Chapter 3: Cost And Emission Reduction Analysis Of Sf6 Emissions From Electric Power Transmission and Distribution Systems in the United States. http://www.epa.gov/highgwp/pdfs/chap3_elec.pdf

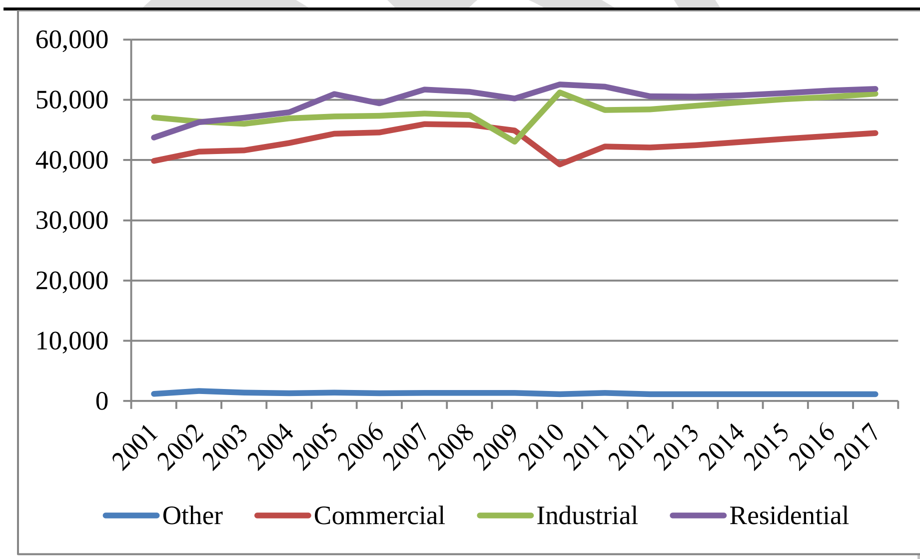
These emissions are associated primarily with energy use in homes and non-residential buildings, including institutional buildings, but also include energy use for other services such as street lighting, sewage and water treatment services. Therefore, the state's future GHG emissions will depend heavily on future trends in the consumption of electricity and other fuels in the building sectors.

There are two categories of RCI emissions – direct and indirect. In 2010, about 33 percent of total statewide gross GHG emissions are direct emissions from the RCI sector, which is the on-site combustion of natural gas, oil and coal. The electricity use by the RCI sector is considered the indirect emissions. Two-thirds of all electricity consumed (or about 50 percent of all electricity produced) in Pennsylvania is consumed by this sector. This electricity consumption accounts for about 17 percent of the total statewide gross GHG emissions.

Between 2000 and 2017, total energy consumption from all sources in Pennsylvania is projected to fall at an average rate of 0.3 percent annually. Industrial consumption is anticipated to fall faster than other sectors (an average of 0.4 percent per year), while commercial consumption is expected to experience the smallest average decline over this period. Residential consumption is projected to decline, on average, at rates consistent with the overall state rate. These trends reflect a complex mix of shifting technologies (e.g., more energy efficient manufacturers), consumer behavior and the impacts of public policy in striving to reduce energy utilization (e.g., green construction).[26]

While total energy consumption is declining over the period, consumption of electricity is expected to grow at very modest rates from 2001 through 2017. Growth is expected to average 0.6 percent annually as indicated by Figure 4-2 below.

Figure 4-2. Pennsylvania electricity consumption trends (gigawatt hours)



Average annual growth rate	
Other	-0.2%
Commercial	0.7%
Industrial	0.5%
Residential	1.1%
Total	0.6%

Source: Pennsylvania Public Utility Commission, Electric Power Outlook for Pennsylvania

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[26] Commonwealth Economics, *Energy in Pennsylvania: Past, Present, and Future* (2013)

The flat trend lines in sector-specific electricity consumption over time are consistent with the larger national picture. Residential and commercial rates of growth have steadily declined for decades with the switch to more energy efficient options of equipment and appliances. This trend has offset much of the growing demand arising from population growth and long-term increases in disposable income. Shifts in manufacturing towards goods requiring less-energy intensive production also tends to lessen that sector's demands.

Challenges and Opportunities for RCI Sector

Residential

Natural gas, the most commonly consumed fuel in the residential sector, is expected to experience a modest decline in use from 2000 to 2017. Part of the projected decline in natural gas consumption is attributed to projections of gradually increasing temperatures with their impact on demands for heating, a primary use of natural gas in the residential sector.[27] More importantly, a combination of more efficient appliances and household equipment working in conjunction with shrinking unit sizes will likely be associated with diminished residential natural gas consumption. Electricity use is expected to have a modest growth over that period, due in part to greater presence of appliances and personal devices that use electricity. All other fuel types are projected to have negative growth, particularly the use of coal.

A major opportunity for Pennsylvania would be to expand natural gas distribution lines to unserved areas of Pennsylvania. Due to Pennsylvania's long history with natural gas production in the northwestern part of the state, pipelines are more prevalent in that area than in the rest of Pennsylvania. With the increase in deep shale drilling activity in the southwestern and northeastern parts of Pennsylvania, pipelines are being built in those areas to carry the fuel to markets. However, while there is increasing activity in pipeline construction, there is still a large portion of Pennsylvania residents who do not have access to natural gas as a heating and cooking source through local distribution lines.

In addition to offsetting electric generation through expanded use of natural gas, energy efficiency and conservation programs can also lower energy demand. Initiatives such as the utility sponsored Low Income Usage Reduction Program, which involves 15 of the largest energy providers in Pennsylvania, have provided millions of dollars for weatherization and energy efficiency improvements.

Commercial

Commercial consumption is dominated by electricity and natural gas, which are both expected to register relatively slight growth over the 2000-2017 period. All other fuel types in the commercial consumption sector are expected to have negative growth in this period. Overall, the sector is expected to reduce consumption at an average annual rate of 0.2 percent from 2000 to

[27] Commonwealth Economics 2013. "Energy in Pennsylvania: Past, Present, and Future."

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2017, largely as a result of improved efficiencies in equipment, lighting, and other facets of commercial operations.

Industrial

Industrial energy consumption shows some variability from 2000 to 2017. Coal, the dominant fuel type in 2000, shows the greatest reduction in consumption (-2.8 percent per year) while natural gas and petroleum are expected to experience positive growth with natural gas showing significant growth starting in 2009 with the advent of Marcellus Shale production and a subsequent sharp drop in natural gas prices. Electricity consumption is virtually unchanged and the consumption of wood declines on average from 2000 to 2017.

Overview of RCI Work Plan Recommendations and Estimated Impacts

The following strategies were discussed with the RCI Subcommittee of the CCAC. Table 4-2 provides a summary of all of the GHG reductions, costs and cost-effectiveness of all the work plans for this sector. A negative cost number indicates and overall savings to the economy. All individual work plans, including assumptions and calculations, are included in Appendix D.2.

Table 4-2. Summary Results for RCI Sector Work Plan Recommendations

Work Plan Name	Annual Results (2020)			Cumulative Results (2013-2020)			CCAC Voting Results (Yes/No/Abstained)
	GHG Reductions ($MMtCO_2e$)	Costs (Million $)	Cost-Effectiveness ($/t$CO_2e$)	GHG Reductions ($MMtCO_2e$)	Costs (Million $)	Cost-Effectiveness ($/t$CO_2e$)	
Building Commissioning	1.3	-57.68	-44.37	8.7	-298	-34.10	13-0-0
DSM – Natural Gas	9.24	Costs and cost-effectiveness are discussed in the Demand Side Management of Natural Gas Work Plan					12-1-1
DSM – Water	0.1	-135	-1225	0.4	-576	-1,440	9-3-1
High Performance Buildings	21.7	-362.9	-16.7	86.1	-2542	-29.5	13-1-0
Industrial Electricity BMPs	4.0	-446	-111	9.5	$-989	-104	12-1-0
Re-Light PA	10.3	-1486	-144	71.1	-8153	-114.7	13-0-1
Re-Roof PA	0.8	1110	1387.5	2.4	2786	1160.8	9-4-0
Heating Oil Conservation and Fuel	5.2	-22	-4.23	23.3	-142	-6.09	13-0-0

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Switching							
Improved Efficiency at Wastewater Treatment Facilities	.0007	-0.503	-583	.006	-3.1	-3575	13-0-0
Increased Recycling Initiative	2.19	-13.6	-5.63	11.43	-82.1	-6.5	13-0-0

Building Commissioning

GHGs could be reduced by promoting the common practice of performing building commissions and retro-commissioning processes on newly constructed and renovated buildings to ensure optimal performance of building systems. Commissioning is tuning a building to operate as it was intended and it requires testing, monitoring and adjusting the building systems to operate at optimum efficiency. It is similar to having your car tuned-up.

This work plan sets a goal to commission or retro-commission non-commonwealth new and renovated commercial buildings greater than 25,000 sq.ft. within 8 years and, commission or retro-commission commonwealth new and renovated buildings greater than 25,000 sq.ft. within 5 years.

This could be done by promoting the common practice of performing commissioning processes on newly constructed and/or renovated buildings for the purpose of ensuring optimal performance of building systems. The Energy Efficient Building Hub at the Philadelphia Navy Yard has been promoting this type of activity by testing new and innovative technologies and practices. Building project teams are currently familiar with American Society of Heating, Refrigerating and Air- Conditioning Engineers standards, which cite building commissioning as good practice (Guideline 0-2005). It could also be accomplished by expanding existing training for building operators to include energy management training. Building operators, such as maintenance technicians, lead custodians and plant engineers currently have little formal training in building efficiency.

Demand-Side Management – Natural Gas

Substandard natural-gas fired appliances that may be leaky or wasteful can contribute significantly to GHG emissions, prompting need for upgrades to make these appliances operate more efficiently. This initiative analyzes the replacement of older, less efficient household appliances that utilize natural gas with more energy-efficient models, while at the same time, looks for improvements in overall system efficiency for heating and hot water heating. This work plan also recommends that the PUC should evaluate potential demand side mechanisms to reduce natural gas consumption.

Programs like this which improve pilot lights, improve space heating and cooling areas, and provides alternatives like solar water heaters, have existed for more than 30 years in other states

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and have proven successful, showing that conservation of natural gas and savings on energy use can be increased through natural gas efficiency plans. The technologies needed to increase efficiency are currently available. Increasing efficiency can be achieved in Pennsylvania through encouragement of natural gas utilities to engage in consumer education initiatives dealing with the efficient technologies and the PUC should evaluate mechanisms to reduce natural gas consumption through demand-side management.

Demand-Side Management – Water

Landscaping, toilet flushing, showers, sinks and washing machines are the most significant contributors to building water loads. These water costs have measurable GHG implications (4 percent of all energy use) because of the processing energy costs and the pumping energy costs. Faucets and washing machines also have hot water loads, gas or electric, with GHG implications.

As a result, water-conserving alternatives benefit building owners both in water cost savings and in domestic hot water heating cost savings. Conservation can be achieved through commonwealth efforts to promote rain capture for landscaping, dual-flush toilets, low-flow faucets and shower heads, and high-efficiency washing machines. This can be achieved by point-of-sale education and EPA WaterSense product performance standards, elimination of code barriers and utility-managed programs that combine certified installers with equitable utility rate financing.

Geothermal Heating and Cooling

This strategy capitalizes on the energy-effectiveness of geothermal or ground source heat pumps (GSHPs) in Pennsylvania's climate, the accompanying reductions in carbon emissions, and in demand for peak generation and transmission. Pennsylvania is already ranked as one of the top-tier states for experienced and competitive installation of GSHPs in its urban centers. This strategy would build on that strength, expanding the network of trained drillers and installers throughout the state. This strategy advocates GSHP installations for individual buildings and in district systems. Warren, Pa., hosts one of the few district GSHP systems in the United States, and this strategy supports further development of such systems for their energy and environmental benefits and for economic revitalization.

The goals of this initiative would include 20 percent of new residential dwellings and 2 percent of existing dwellings and 40 percent of new commercial buildings and 12.5 percent of existing commercial buildings installing GSHPs for heating and cooling through either an individual building basis or serving multiple dwellings through district systems.

This initiative was not voted on by the CCAC due to concerns over the cost analysis conducted in the work plan. It will be revisited in future updates to the Climate Change Action Plan.

High-Performance Buildings

Buildings are a major source of demand for energy and materials that produce by-product greenhouse gases. It will require immediate and significant action in the building sector to slow the growth rate of greenhouse gas emissions in Pennsylvania.

Recently, Architecture 2030 has issued The 2030 Challenge asking the global architecture and building community to adopt the following targets:

- All new buildings, developments and major renovations shall be designed to meet a fossil fuel, GHG-emitting, energy consumption performance standard of 50 percent of the regional (or country) average for that building type, as defined in The 2030 Challenge.
- At a minimum, an equal amount of existing building area shall be renovated annually to meet a fossil fuel, GHG-emitting, energy consumption performance standard of 50 percent of the regional (or country) average for that building type, as defined in The 2030 Challenge.
- Architecture 2030 established the following fossil fuel reduction standard for all new buildings and major renovations:
    - 60 percent of buildings in 2010,
    - 70 percent of buildings in 2015,
    - 80 percent of buildings in 2020.

Industrial Natural Gas and Electricity Best Management Practices

This initiative considers the possible reductions in electricity consumption in the industrial sector through increased efficiency and increased coordination between DEP's Office of Pollution Prevention and Energy Assistance, industrial resource centers at various universities and the DOE.

The DOE, through their Industrial Technology Program BMPs has determined that electricity efficiency improvements can result in a 20 percent reduction in consumption from the projected electricity use by the year 2031 are possible. This is consistent with the supply of industrial electricity efficiency opportunities identified in the ACEEE (2009) report through the year 2025. Industrial electricity consumption in Pennsylvania is expected to increase by about 0.4 percent by 2020, according to data from the Energy Information Administration's 2012 Annual Energy Outlook.

Re-Light Pennsylvania

This initiative is a critical building technology that accelerates replacement of less efficient outdoor and indoor lighting systems, including maximizing use of day-lighting in indoor settings. It applies to residential and commercial buildings, as well as parks, streetlights and parking facilities. This initiative actively invests in Pennsylvania manufacturing, sales, green-collar jobs and green-building infrastructure by relamping, re-fixturing and upgrading lighting systems, windows and control systems. This would also measurably improve the pastoral and remarkable qualities of the state, the quality of light delivered, and the health and safety of residents.

Re-Roof Pennsylvania

This initiative would mandate standards of thermal resistance for all new roofing projects. The goal of this initiative would be to replace 75 percent of commercial building roof areas with more energy-efficient roofing at the time of regular replacement. Green roofs should be promoted with incentives for benefits to cooling, carbon sequestration and storm water management. Skylights for day-lighting should be encouraged for roof replacements in buildings lower than four stories, that have deep sections that result in windowless spaces for occupants. Shading or insulation from renewable energy systems as secondary goals should be explored. Alternatively, amending the Pennsylvania Uniform Construction Code so high reflectivity is mandatory for all commercial buildings to minimize cooling loads should also be considered. In addition, adopting the latest version of International Construction Code so thermal resistance standards (R/U factors) minimize both cooling and heating loads should also be considered.

Heating Oil Conservation and Fuel Switching

This initiative aims to replace or upgrade inefficient household appliances using fuel oil with more energy-efficient models. One goal of this initiative would be a 37 percent reduction from reference case oil consumption in 2020 for the residential sector. Another goal would be a 26 percent reduction from reference case oil consumption in 2020.

Fuel switching to natural gas can also yield significant reductions in GHG emissions and has increased dramatically with the significant decrease in natural gas prices and is expected to continue. This initiative would also encourage air sealing and insulation, increased furnace and boiler efficiency, solar domestic hot water heaters and instantaneous hot water heaters.

Improved Efficiency at Wastewater Treatment Facilities

This initiative would improve efficiency at wastewater treatment facilities through outreach programs based on sustainable infrastructure principles. By assisting 50 percent or more treatment plants per year to improve efficiency, this outreach initiative would reduce GHGs through reduction of energy consumption. Facilities would be encouraged to utilize EPA's *Energy Management Handbook for Wastewater and Water Utilities* and available baseline assessment software as part of the outreach program.

Increased Recycling Initiative

This initiative supports the increased recycling of MSW sufficient to achieve an additional, cumulative reduction (i.e. 2013 through 2020) in GHG emissions of 5.0 $MmtCO_2e$ by improving the efficiency of existing programs and maximizing collections within mandated communities including expansion of single-stream recycling, focusing on increasing collection of those materials with the greatest GHG emission reductions per ton recycled and consideration of expanding mandatory recycling requirements to currently non-mandated communities.

Since 2005, a significant increase in recycling in the commonwealth has come from the growth of single-stream recycling. Single-stream recycling, providing convenience, cost effectiveness and immediate increases in the amount of recycled materials, accounted for more 43 percent of recycled residential materials in 2009, up from only 6 percent in 2005. Pennsylvania now hosts six privately-owned and funded, single-stream recycling facilities, and at least two more are scheduled to come online in the near future. When single-stream recycling service is provided to a curbside collection community, the amount of material recycled increases by about 45 percent.

The single-biggest boon to recycling rates is making curbside, single-stream recycling widely available. As published on DEP’s website, while at least 94 percent of the state’s population has access to recycling, only 79 percent have convenient access to recycling through curb-side pickup programs (although not discussed on the website, a significant portion of that 79 percent does not have access to single-stream recycling). The city of Philadelphia’s recent initiative to increase its recycling rate was very successful; with single-stream recycling at the core of the initiative, the recycling rate quadrupled.

4.3 Land Use and Transportation Overview

The Land use and Transportation (LUT) Sector includes light- and heavy-duty (on-road) vehicles, aircraft, rail engines and marine engines which cause GHG emissions when they burn gasoline or diesel fuel. In 2000, the LUT sector was the third largest source of GHG emissions in Pennsylvania with 69.49 MmtCO_2e, or about 24 percent on a consumptive basis, with on-road gasoline as the largest contributor to these emissions, followed behind on-road diesel. In 2010, LUT emissions share of GHGs increased slightly to 25 percent of the state’s total consumption.

The states future GHG emissions will depend significantly on future trends in the consumption of gasoline and diesel fuel by onroad sources. The contribution of other sources to total LUT emissions include aviation (11 percent), marine (4 percent) and rail and other nonroad sources (5 percent). By 2020, GHGs from the transportation sector is expected to decrease to 65.04 MmtCO_2e, or 23 percent of statewide GHGs on a consumptive basis.

Land Use

Brownfields redevelopment can be considered a sustainable practice because existing infrastructure is often re-used. Buildings, water and sewer services are already in place, so the need for new manufactured materials is reduced. The use of brownfields for housing and new industrial or commercial uses decreases “greenfield” development, which often results in loss of vegetation and trees. Greenhouse gases are reduced when “greenfields” are kept green. Communities that promote the growth of public transportation and alternative walking/biking modes of travel would see a reduction in greenhouse gases due to less vehicle traffic and reduced emissions.

Pennsylvania’s award-winning Land Recycling Program aims to reduce land consumption and encourages the transformation of abandoned, idle properties into economic opportunities. Since the program’s inception in 1995, 5,800 sites have entered into the Land Recycling Program and

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$590 million in grants have been awarded to facilitate cleanups through DCED, DEP, and PENNVEST programs. The Pennsylvania Land Recycling Program has become a national model. Roughly 100,000 jobs have been created or retained because of the business opportunities that have been recognized and realized in Pennsylvania's abandoned, idle properties.

Transportation

Policy is an important factor in trends in transportation energy consumption. Vehicle fuel economy improvements are scheduled for the period up to 2025, as mandated by the federal CAFÉ standards. From 2000 to 2017, Pennsylvania's total consumption of energy by transportation is expected to decrease at a rate of 0.3 percent per year. Natural gas consumption is expected to have the highest average growth rate (1.2 percent). The fastest growing transportation fuel is expected to be electricity, in part due to the increase in electric vehicles, such as the Nissan Leaf and the Chevy Volt[28]. Electricity, however, is a miniscule portion of the overall fuel mix for transportation, amounting to roughly 0.3 percent of all transportation energy values in 2017.[29] See Figure 4.4.

Act 124 of 2008 enacted restrictions on diesel idling in Pennsylvania. Under this this law, diesel vehicles with a gross weight of 10,001 pounds or more that are engaged in commerce may not idle their engines for more than five minutes in any 60-minute period unless a specific exception applies. Exceptions include motor homes, farm equipment and certain cases where health or safety is an issue. The act also requires owners of parking lots with 15 or more spaces for qualifying vehicles to post and maintain a sign informing drivers of the law. By decreasing the amount of idle time, GHGs from diesel emissions have been reduced.

Since 2009, Pennsylvania has been making significant strides with respect to alternative fuel usage in the transportation sector. There are two notable programs for alternative fueled vehicles in Pennsylvania: AFIG and the Act 13 of 2012 Natural Gas Vehicles Program.

Pennsylvania's AFIG Program allows for organizations, non-profit agencies, for profit companies, commonwealth or municipal authorities and local transportation organizations to apply for grant funding for alternative fueled vehicles. This program allows eligible applicants to propose projects which will convert or purchase natural gas vehicles weighing less than 14,000 pounds, as well as convert or purchase electric, propane, or other alternative fuel vehicles of any size. The program also provides grants for innovation in alternative fuel transportation, including non-road vehicles, such as natural gas-powered trains or marine vessels.

Most recently, the AFIG Program awarded 33 different projects that are expected to result in the deployment of 351 natural-gas-fueled vehicles and 337 propane fueled vehicles. The vehicles deployed in this grant round will support 15 new and 30 existing fueling stations. The AFIG program has also deployed a very successful rebate program, providing Pennsylvania consumers with 376 rebates for plug-in hybrid electric vehicles (PHEVs), 87 rebates for PHEV with smaller battery capacities, natural-gas-fueled vehicles, or propane-fueled vehicles.

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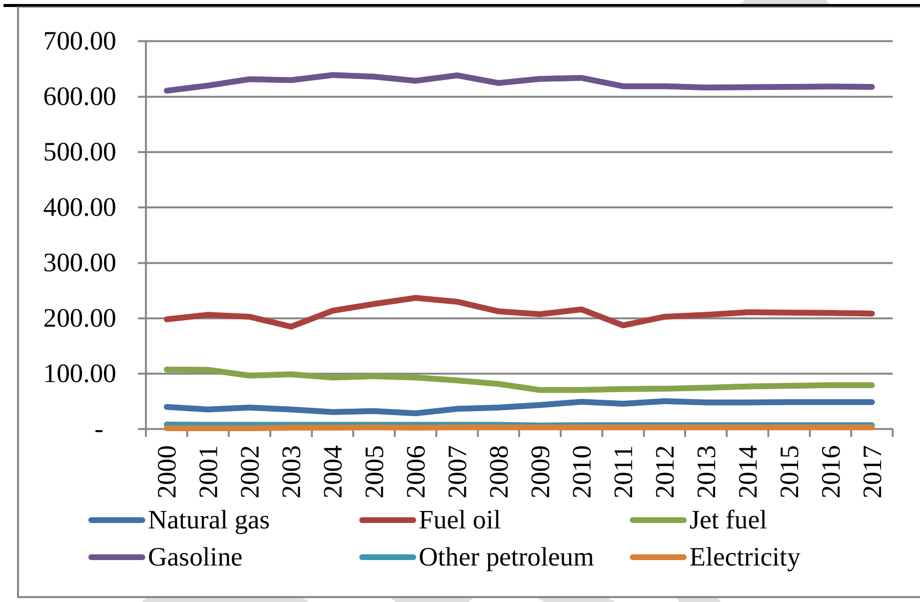
[28] Commonwealth Economics, "Energy in Pennsylvania: Past, Present, and Future." (2013)
[29] Commonwealth Economics, "Energy in Pennsylvania: Past, Present, and Future." (2013)

Act 13 of 2012 provided $20 million over three years, out of impact fees paid by natural gas operators, for the purchase or retrofits of large fleet vehicles 14,000 pounds or less to operate on Compressed Natural Gas (CNG) or Liquefied Natural Gas (LNG). In the first year of the grant, 329 vehicles were converted to CNG or LNG, which supported the construction of 16 new natural gas fueling facilities. Of these new facilities, four have full public availability, 10 have limited public availability, and two are private facilities. The first year of this three year program will account for 3.54 million gallons of gasoline displaced each year.

Figure 4-3. Pennsylvania transportation sector consumption by fuel type (trillions of BTUs) (2000 – 2017)



Average annual growth rate	
Natural gas	1.2%
Fuel oil	0.3%
Jet fuel	-1.8%
Gasoline	0.1%
Other petroleum	-1.2%
Electricity	5.0%

Source: Energy Information Administration

Challenges and Opportunities for Land Use and Transportation

Pennsylvania has huge opportunities to reduce transportation emissions and GHGs from this sector. With the influx of natural gas supply in Pennsylvania, a low-cost, cleaner burning fuel is easily accessible with the proper infrastructure.

Similar to the Energy Production, Transmission and Distribution sector, the challenge of using natural gas as a transportation fuel is reducing the methane leakages. If natural gas can displace some gasoline and diesel emissions, GHGs from this sector could be reduced. Another challenge of using natural gas is consumer accessibility to refueling infrastructure. There are currently 46 natural gas refueling stations in Pennsylvania, but only 22 are publicly accessible. There are also technologies being developed that would allow consumers to refuel their natural gas vehicles in their own home, if they have access to CNG. However, as previously mentioned, many Pennsylvania residents do not have access to natural gas distribution lines.

Hybrid electric vehicles (HEV) also present an opportunity for Pennsylvania, especially transit fleets that traditionally run on diesel. Several of Pennsylvania's transit organizations use diesel-hybrid buses. Studies indicate the HEV busses experience a 37 percent improvement in fuel economy compared to a standard diesel bus. In addition, a DOE study has demonstrated that NOx emissions from diesel-hybrid busses were 30 to 40 percent lower than conventional diesel units. Diesel-hybrid busses also exhibited the lowest carbon monoxide emissions of any bus tested including CNG powered units.

Statewide land use and transportation policies that follow more sustainable "smart growth" principles that generate fewer private auto trips, promote the use of transit and non-motorized modes, and protect open spaces could minimize the generation of associated GHGs. Smart growth seeks to create more compact communities throughout the state, featuring walkable communities of concentrated development and a mixture of land uses that generate less vehicle traffic while being more supportive of auto trip-reduction measures, such as transit, non-motorized modes and TDM programs, such as car sharing, carpooling, etc. Smart growth also sites commercial and industrial facilities and growth with ready access to an efficient, multimodal freight transportation system.

Investing in growth recognizes that public transportation is first and foremost a public service, and that the sustainability of transit systems and services is dependent on demonstrating sound management practices and prudent use of public funding to attract and retain riders.

As the state's overall and special-needs populations increase, efficient and effective personal mobility are increasingly necessary in the present and emerging economies. When high-occupancy modes are provided efficiently and used effectively, they decrease GHGs and other harmful emissions. Land development plans and implementations that provide sufficient density and connectivity for the institution of efficient and effective transit services are integral to system and ridership growth.

Local or intra-city transit ridership growth potential is most likely in the larger urbanized areas with the highest population densities. These areas can provide the most efficient, cost-effective high-quality transit services that attract riders, including fixed-guideway modes, such as bus rapid transit (BRT), priority corridors, rail, etc. Transit services in the Philadelphia and Pittsburgh areas, for example, currently comprise more than 90 percent of total Pennsylvania transit ridership. Similarly, key intercity markets exist and may continue to emerge, as travelers continue to seek lower cost, higher quality, and more dependable travel modes. An example is the Keystone Corridor (commuter rail between Harrisburg and Philadelphia), but may include other intercity pairs inadequately or not served by rail or air modes.

Investment is necessary to better serve the state's present citizens and provide attractive service to populations in future residential areas, employment areas and other activity centers. This investment, made wisely, will significantly increase transit ridership and the proportion of total trips served by transit, *at a minimum* reducing the projected growth of vehicle-related GHG emissions, reducing highway vehicle-related GHG emissions from current projections, and working to reduce vehicle-related carbon emissions.

All transportation investments must be appropriate to the existing and planned environment to ensure implementation of smart transportation approaches. There are other more cost-effective approaches that can be implemented, such as:

- Workplace Incentives for Public Transit Use: To encourage public transit use by employees at workplaces with access to public transit systems, the state and local governments could work with businesses to provide incentives for their employees to use public transit for their work commute. Such programs should also include state workers, and incentives could include free/discounted bus or train tickets, transit ticket purchase with pre-tax dollars or vouchers for discounts at businesses in the area.
- Workplace Incentives for Carpooling: State and local governments could work with businesses to provide incentives for their employees to carpool for their work commute. Such incentives could include free/discounted parking, matching up riders or vouchers for discounts at businesses in the area.
- Telecommuting in the Private Sector: By working from home, workers can avoid vehicle trips and their resulting GHG emissions. Actions to encourage more telecommuting in the private sector include business tax incentives for employers to provide telecommuting as an option to their employees (could include local wage tax adjustments), and funding for regional telecommuting centers (which provide an office-like environment for workers in a given area closer to home and away from their employer's office).
- Telecommuting in the Public Sector: To help set the example and establish some of the regional telecommuting centers, the state should offer telecommuting as an option for employees wherever appropriate, and set clear targets and timelines for the number of employees using the telecommuting option.

Overview of Land Use and Transportation Work Plan Recommendations and Estimated Impacts

The following strategies were discussed with the Land Use and Transportation Subcommittee of the CCAC. Table 3-3 provides a summary of all of the GHG reductions, costs and cost-effectiveness of all the work plans for this sector. A negative cost number indicates and overall savings to the economy. All individual work plans, including assumptions and calculations, are included in Appendix D.3.

Table 4-3. Summary Results for Land Use and Transportation Sector Work Plan Recommendations

Work Plan Name	Annual Results (2020)			Cumulative Results (2013-2020)			CCAC Voting Results (Yes/No/Abstained)
	GHG Reductions ($MMtCO_2e$)	Costs (Million $)	Cost-Effectiveness ($/$tCO_2e$)	GHG Reductions ($MMtCO_2e$)	Costs (Million $)	Cost-Effectiveness ($/$tCO_2e$)	
Alternative Fueled Public Transit Bus	.020			0.12	590.5	4,921	8-5-0

Fleet (HEV)							
Alternative Fueled Public Transit Bus Fleet (CNG) [30]	.003	131.8	39847.5	0.01	525.3	52,532	
Alternative Fueled Taxi Cabs (HEV)	.014	-33	--2373	.067	-42	-634	11-2-0
Alternative Fueled Taxi Cabs (CNG)	.007	-.29	-4392	.0.37	-25.8	-619	
Cutting Emission from Freight Transportation	Costs and GHG reductions are considered under different scenarios in the Cutting Emissions from Freight Transportation Work Plan						10-1-2

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Alternative-Fueled Public Transit Fleets

This initiative would transition 25 percent of Pennsylvania's existing transit buses to alternative fuels/hybrid technology by the year 2020 through facilitation of replacement and/or conversion of the existing bus fleet to cleaner burning CNG and/or more fuel-efficient HEV technology for diesel-hybrid buses.

This could be achieved by encouraging transit authorities to use alternative fuel vehicles and alternative fuel technology buses, especially HEV diesel buses, when replacing transit buses that are scheduled for normal replacement; keeping transit authorities updated on available financial state and federal alternative fuel vehicle incentives; offering special state grant solicitations for transit authorities to install alternative fuel infrastructure; and offering special state grant solicitations to assist transit authorities with the incremental cost associated with the purchase of HEV diesel and dedicated CNG buses.

Alternative-Fueled Taxi Cabs

This initiative would transition 25 percent of Pennsylvania's existing taxi cab fleet to CNG, HEV or a combination of the two by 2020. Data compiled from the Pennsylvania Department of Transportation indicates that there were 3,150 taxi cabs in service in the Pennsylvania in 2010. Hybrid automobiles and CNG automobiles are capable of reducing CO_2 emissions by as much as 25 percent when compared to conventional gasoline powered automobiles. A DOE, National Renewable Energy Laboratory Taxicab study comparison of 10 conventional gasoline powered Ford Crown Victoria taxis and 10 CNG powered Ford Crown Victoria taxis demonstrated that CNG exhaust emissions are significantly lower than their gasoline counterparts.[31] In addition, the testing demonstrated that although both the gasoline and CNG vehicle emissions fell within

[30] This analysis assumes that there is a less than 1 percent leakage rate in natural gas systems.
[31] *NREL, 1999: Barwood Cab Fleet Study Summary, May, 1999.*

the EPA's applicable standards, the CNG vehicles had significantly lower levels of non-methane hydrocarbon, carbon monoxide and oxides of nitrogen.

The data in the analysis of this work plan supports that there could be significant reductions in GHG emissions realized with the adoption of either CNG taxis or HEV taxis to replace existing gasoline-powered units. Cost effectiveness of the fuel mode selected along with availability of the technologies at the present will dictate the early choice for pioneer taxi fleets. Looking toward the future when CNG and HEV/EV OEM vehicle and public and private fueling infrastructure are more readily available, taxi fleets will be able to select from multiple alternative fuel modes to fit their individual needs and goals.

This initiative could be achieved by encouraging taxi fleet owners to using alternative fuel vehicles and alternative fuel technology when replacing taxis that are scheduled for normal replacement; keeping taxi fleet owners updated on available state and federal alternative fuel incentives; providing special state grants to assist taxi companies with the incremental cost associated with the purchase of dedicated alternative fuel vehicles.

Cutting Emissions from Freight Transportation

This initiative presents an array of specific measures that can be adopted to decrease GHG emissions from the state's freight transportation sector, which is forecast for continued growth. Primarily, these measures aim to improve the efficiency of vehicle trips, reduce large diesel engine idling and emissions, and shift freight from trucks to other modes.

Possible modes of improving trucking efficiency are to expand EPA SmartWay Truck Transport and provide more productive truck combinations. Modes to expanding rail freight and improving efficiency include promoting low-emission locomotives, electric cranes, and battery power locomotives; reducing locomotive engine idling; and expanding or upgrading existing rail.

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4.4 Agriculture and Forestry Overview

Agricultural sector GHG emissions include non-energy methane (CH_4) emissions from livestock (i.e. enteric (intestinal) fermentation),[32] and CH_4 and nitrous oxide (N_2O) emissions from the storage and treatment of livestock manure (e.g.; compost piles or anaerobic treatment lagoons),[33] N_2O emissions and net fluxes of CO_2 associated with the management of agriculture soils,[34] and CH_4 and N_2O emissions associated with agriculture residue burning. Relative to all other sectors, Pennsylvania's agriculture sector contributes relatively low amounts of GHG emissions to total statewide emissions. In 2000, agriculture sector emissions accounted for 8.38 $MMtCO_2e$. Through 2020, agriculture GHG emissions are expected to decrease to 6.29 $MMtCO_2e$, accounting for less than 2 percent total emissions.

Pennsylvania's forestry sector is responsible for sequestering moderate amounts of carbon. In 2000, the sequestration in Pennsylvania from land use and forestry was about 21 $MMtCO_2e$, which is about 7.5 percent of the state's gross GHG emissions from a consumptive basis of all sectors. The forestry sector is expected to increase as a net carbon sink through 2020, to sequester 34 $MMtCO_2e$, which would be about 12 percent of the state's expected gross GHG emissions from a consumptive basis of all sectors.

Challenges and Opportunities for Agriculture and Forestry

Agriculture

Opportunities for GHG mitigation in the agricultural sector include measures that can reduce emissions within this sector and measures that can reduce emissions in other sectors. Within the agricultural sector, changes in crop cultivation can reduce GHG emissions by building soil

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[32] Methane emissions from enteric fermentation are the result of normal digestive processes in ruminant and non-ruminant livestock. Microbes in the animal digestive system breakdown food and emit CH_4 as a by-product. More CH4 is produced in ruminant livestock because of digestive activity in the large fore-stomach.

[33] Methane and N_2O emissions from the storage and treatment of livestock manure (e.g., in compost piles or anaerobic treatment lagoons) occur as a result of manure decomposition. The environmental conditions of decomposition drive the relative magnitude of emissions. In general, the more anaerobic the conditions are, the more CH4 is produced because decomposition is aided by CH_4 producing bacteria that thrive in oxygen-limited aerobic conditions. Under aerobic conditions, N_2O emissions are dominant. Emissions estimates from manure management are based on manure that is stored and treated on livestock operations. Emissions from manure that is applied to agricultural soils as an amendment or deposited directly to pasture and grazing land by grazing animals are accounted for in the agricultural soils emissions.

[34] The management of agricultural soils can result in N_2O emissions and net fluxes of CO_2 causing emissions or sinks. In general, soil amendments that add nitrogen to soils can also result in N_2O emissions. Nitrogen additions drive underlying soil nitrifications and de-nitrification cycles, which produce N_2O as a by-product. Agricultural soils emissions also account for decomposition of crop residues, synthetic and organic fertilizer application, manure application, sewage sludge, nitrogen fixation, and histosols (high organic soils, such as wetlands or peatlands) cultivation. Both direct and indirect emissions of N_2O occur from the application of manure, fertilizer, and sewage sludge to agricultural soils. Direct emissions occur at the site of application and indirect emissions occur with nitrogen leaches to groundwater or in surface runoff and is transported off-site before entering the nitrification/denitrification cycle.

carbon or through more efficient nutrient applications. In addition to the potential cost savings and GHG benefit from the work plan recommendations, the implementation of these measures may serve to enhance the viability of farming in Pennsylvania by improving the quality of the soil.

The biggest challenge facing the implementation of the initiatives in the agricultural sector is breaking any economic barriers that may exist that would prevent farmers in Pennsylvania from undertaking these measures.

Forestry

Pennsylvania has the opportunity to increase carbon sequestration in the forestry sector by protecting forest land, promoting management practices that will increase carbon sequestration, planting new forests and using wood for durable products and energy. Establishing new forests (afforestation) and enhanced stocking in existing forests can lead to higher levels of carbon sequestration in the state's forests. Additionally, slowing land conversion will provide opportunities for additional carbon sequestration. Actions taken within the forestry sector can also lead to GHG reductions in other sectors (e.g., urban forestry projects can reduce energy consumption by providing shade and wind protection to buildings).

The biggest challenge within the forestry sector is balancing the implementation of forest protection and promotion strategies with development and economic growth in the state. It is important that Pennsylvania provide adequate land space for development to encourage economic growth, which makes Pennsylvania's award winning Brownfields Program integral at helping to reduce GHGs and increase carbon sequestration. Pennsylvania's Brownfields Program reduces the need for the development of open space.

CO_2 capture and sequestration (CCS) could play an important role in reducing GHG emissions, while enabling low-carbon electricity generation from power plants, including coal- and natural-gas-fired power plants, as well as other stationary CO_2 emitters like ethanol processing plants. Two potential sources of sequestration in Pennsylvania are geologic sequestration and forest management. The former is when CO_2 emissions from stationary sources are captured, transported and stored in underground geologic formations, while the latter deals with restocking understocked forests and/or increasing the acreage under certified management.

The concerns of geologic sequestration are the transportation of CO_2 through pipelines, injection and long-term storage, and liability of leakage. The leakage liability stems from the question of who will be liable for the possible loss of CO_2 and subsequent contamination, resulting in harm to human health, the environment or property. Specifically, if the private sector took financial responsibility of the storage formation, then the liability and unforeseen costs would be likely to deter industry from CO_2 storage. To address and mitigate these concerns, the commonwealth could develop protocols for siting and operating geologic sequestration projects and/or develop a pilot project(s) to demonstrate sequestration in different geologic regions of Pennsylvania. These options could provide opportunity for expansion of regulatory framework and valuable technical information for future projects, but legislation to address the long-term liability issues is necessary.

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As for forest management, atmospheric carbon is reduced through afforestation, planting and regeneration of vegetation statewide and a number of other forest management strategies like enhancing forest growth and decreasing biomass loss. Implementation attempts to increase CCS in vegetation and soils and increase the amount of land used for CCS. Forest management practices have been implemented and tested to show which options and combinations of techniques produce the best results and need only to be executed in Pennsylvania on a larger scale.

Overview of Agriculture and Forestry Work Plan Recommendations and Estimated Impacts

The following strategies were discussed with the Agriculture and Forestry Subcommittee of the CCAC. Table 4-4 provides a summary of all of the GHG reductions, costs and cost-effectiveness of all the work plans for this sector. A negative cost number indicates and overall savings to the economy. All individual work plans, including assumptions and calculations, are included in Appendix D.4.

Table 4-4. Summary Results for Agriculture and Forestry Sector Work Plan Recommendations

Work Plan Name	Annual Results (2020)			Cumulative Results (2012-2020)			CCAC Voting Results (Yes/No/Abstained)
	GHG Reductions ($MMtCO_2e$)	Costs (Million $)	Cost-Effectiveness ($/$MMtCO_2e$)	GHG Reductions ($MMtCO_2e$)	Costs (Million $)	Cost-Effectiveness ($/$MMtCO_2e$)	
Afforestation	Costs and GHG reductions are considered under different scenarios in the Afforestation Work Plan						10-0-0
Durable Wood Products	Costs and GHG reductions are considered under different scenarios In the Durable Wood Products Work Plan						2-11-0
Forest Protection Initiative – Easement	0.294	1.22	4.17	2.231	11.72	$5.25	9-4-0
Forest Protection and Avoided Conversion Acquisition	Costs and GHG reductions are considered under different scenarios In the Forest Protection and Avoided Conversion - Acquisition Work Plan						8-5-0
Urban Forestry	Costs and GHG reductions are considered under different scenarios in the Urban Forestry Work Plan						10-0-0
No-Till Farming	0.30	-22.83	-76.39	1.3	-112.4	-85.97	10-0-0

Afforestation

Afforestation increases the amount of carbon in biomass and soils compared to pre-existing conditions. Planting and afforestation can take place on land not currently experiencing other

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uses, such as abandoned mine lands (AMLs), oil and gas well sites, marginal agricultural land and riparian areas. The success of an initiative like this to reduce GHGs depends on the total acreage available for policy implementation.

With 250,000 acres of AMLs statewide, these sites provide a potential opportunity for carbon sequestration. Restoring AMLs, however, can be challenging and very costly due to the need for site preparation because of uneven terrain and the legacy of their prior use. With the advent of drilling in the Marcellus Shale, the number of well pads and wells drilled per year has significantly increased. In the calculations an average well pad size of five acres is used. It is also assumed there will be four wells per pad and an average (2007 – 2011) of 977 wells drilled per year for a total available acreage of 1,221.

This initiative would combine projected acreage from the Tree Vitalize and CREP forest riparian establishment programs. It could build on successes of highly successful programs such as Tree Vitalize1 to target that establishment of 1,000 acres/year in riparian areas for years 2013 and 2014. It also targets the annual establishment of 3,500 acres from 2013 through 2020. Annual carbon sequestration is based on cumulative acreage planted under this scenario.

Durable Wood Products

This option seeks to enhance the use and lifetime of durable wood products. Durable products made from wood prolong the length of time forest carbon is stored and not emitted to the atmosphere. Wood products disposed of in landfills may store carbon for long periods under conditions that minimize decomposition, especially when methane gas is captured from landfills (carbon originally stored in wood products becomes methane during decomposition). Substituting building products made from wood for building products made from materials with higher embodied energy can reduce life-cycle GHG emissions. This can be achieved through improvements in production efficiency, product substitution, expanded product lifetimes and other practices. Increasing the efficiency of the manufacturing life cycle for wood products will enhance GHG benefits.

Forest Protection Initiative – Easements

This initiative would increase the carbon sequestration benefits of Pennsylvania's forestland by preserving the existing forest base and conserving additional forestland. The goal of this initiative would be to protect 2,000 acres of forestland each year from 2013 through 2020 and would augment the carbon-sequestering benefits of Pennsylvania’s forests by assisting local partners in acquiring open space, such as parks, greenways, river and stream corridors, trails and natural areas; and acquisition of voluntary conservation easements with private landowners.

Forest Protection Initiatives – Acquisition

This initiative considers three scenarios aimed at reducing the permanent loss of forest acreage through direct acquisition. The GHG benefits include avoided carbon emissions that might have otherwise taken place on converted acreage, as well as carbon storage on cumulative protected acreage. This initiative would protect private forestland conversion and reduce the likelihood of forestland conversion to developed use through direct acquisition.

By developing a set of criteria for evaluating proposed projects involving the protection of existing forestland to identify potentially significant carbon sequestration opportunities at low marginal costs and with associated environmental co-benefits, GHGs may be reduced.

Reforestation

This initiative focuses on enhancing carbon storage in existing forests that have been poorly managed. Reforestation efforts aimed at re-stocking/planting and restoration practices (soil preparation, erosion control, etc.) can increase carbon stocks above baseline levels and ensure conditions that support forest growth, particularly after intense disturbances.

This work plan was not voted on by the CCAC, although the concept is broadly supported. It will be revisited in future updates to the Climate Change Action Plan.

Urban Forestry

This option would increase carbon stored in urban forests, and thereby reduce residential, commercial and institutional energy use for heating and cooling. Carbon stocks in trees and soils in urban land uses—such as in parks, along roadways and in residential settings—can be enhanced in a number of ways, including planting additional trees, reducing the mortality and increasing the growth of existing trees, and avoiding tree removal. Forest canopy cover, properly designed, can also reduce energy demand by reducing building heating and cooling needs.

No-Till Farming

During farming, conventional-till is when 100 percent of the surface is mixed or inverted by plowing, power tilling, or multiple disking. "No-till" farming describes when a crop is planted directly into a seedbed that has been not tilled since the harvest of a previous crop, or the planting of a crop into sod, previous crop stubble, or a cover where only the intermediate seed zone is disturbed.

No-till cropping systems sequester soil carbon that would otherwise be released to the atmosphere through conventional cultivation practices. No-till farming also reduces the amount of nitrogen-based fertilizer being applied therefore, providing reductions in N_2O emissions. No-till also results in reduced time spent preparing the fields such that diesel fuel consumption is reduced and therefore, provides a third source of greenhouse gas reductions.

Over the last several years, no-till practices have been increasing in Pennsylvania agriculture. In 2007, no-till was practiced on 50.4 percent of the major crop acreage and conventional tillage was used on 29.2 percent of the major crop acreage in Pennsylvania. Other conservation tillage practices were used on the remaining 20.4 percent. In 2012, USDA reports that no-till was practiced on 59.8 percent of the major crop acreage, and other conservation tillage practices were used on the remaining 22.5 percent in Pennsylvania. With more crop growers realizing potential advantages to no-till and other conservation tillage practices including reduced labor costs and increased water filtration, it is anticipated that no-till practices will continue to increase through 2020.

Pennsylvania: Tillage Practices by Crop, 2007							
Crop	Total Acres Planted	No-Till [1]		Other Conservation		Conventional Till	
		Acres	% of Total	Acres	% of Total	Acres	% of Total
Corn	1,450,000	720,000	49.7	310,000	21.4	420,000	29.0
Soybeans	440,000	280,000	63.6	70,000	15.9	90,000	20.5
Barley	60,000	24,000	40.0	19,000	31.7	17,000	28.3
Winter Wheat [2]	170,000	75,000	44.1	40,000	23.5	55,000	32.4
Oats	120,000	30,000	25.0	18,000	15.0	72,000	60.0
Total [3]	**2,240,000**	**1,129,000**	**50.4**	**457,000**	**20.4**	**654,000**	**29.2**
Alfalfa Seedings[4/5]	-	-	21.4	-	21.4	-	57.1

[1] Sum of no-till, other conservation tillage and conventional till percents of total may not add to 100 percent due to rounding. [2] Wheat seeded the previous fall for all intended purposes including grain, cover, silage, hay or any other utilization. [3] Total excludes Alfalfa Seedings. [4] New alfalfa seeded or to be seeded during 2012. [5] Alfalfa seeded acres will be available in January 2013.

Pennsylvania: Tillage Practices by Crop, 2013							
Crop	Total Acres Planted	No-Till [1]		Other Conservation		Conventional Till	
		Acres	% of Total	Acres	% of Total	Acres	% of Total
Corn	1,500,000	900,000	60.0	325,000	21.7	275,000	18.3
Soybeans	560,000	410,000	73.2	110,000	19.6	40,000	7.1
Barley	75,000	50,000	66.7	17,000	22.7	8,000	10.7
Winter Wheat [2]	190,000	125,000	65.8	40,000	21.1	25,000	13.2
Oats	105,000	30,000	28.6	32,000	30.5	43,000	41.0
Total [3]	**2,430,000**	**1,515,000**	**62.3**	**524,000**	**21.6**	**391,000**	**16.1**
Alfalfa Seedings[4/5]	-	-	45.0	-	23.0	-	32.0

[1] Sum of no-till, other conservation tillage and conventional till percents of total may not add to 100 percent due to rounding. [2] Wheat seeded the previous fall for all intended purposes including grain, cover, silage, hay or any other utilization. [3] Total excludes Alfalfa Seedings. [4] New alfalfa seeded or to be seeded during 2012. [5] Alfalfa seeded acres will be available in January 2013.

Chapter 5. Macroeconomic Assessment of Action Plan

This analysis presents 31[35] simulations of the macro-economic impact of greenhouse gas (GHG) reduction strategies in Pennsylvania. There are immediate positive economic impacts from the group of work plans (climate mitigation policy actions) as a whole, creating more than 21,000 net jobs by 2015, and more than 18,000 net jobs on average over the analysis period. The most notable outcomes of the analysis are that the net costs of individual work plans do not necessarily result in negative macroeconomic consequences; in contrast, quite often they stimulate the economy and growth in jobs, income and or gross state product (GSP).

The differences in the economic impacts of those strategies are remarkable. While most strategies have relatively small impacts, two work plans sway results from the entire group from positive to negative. Analysis of the entire group without these two work plans yield strongly positive impacts to GSP, $3.97 billion over the forecast period, and four times as many net jobs by 2020. The choice of which work plans to pursue is an important question for policy makers given their impact on a variety of performance measures, including emissions reductions and economic and energy benefits, with particularly important implications for the economy.

This chapter discusses the impact of the 31 quantified work plans on Pennsylvania's economy by analyzing each work plan separately, and further by analyzing the totality of the impact of the work plans when implemented simultaneously (in aggregate) to reflect the benefit of interaction between the various cost elements of the work plans. This is particularly important where supply and demand actions are implemented at the same time, for instance. In certain cases, especially the forestry work plans, specific assumptions outlined in the work plans limit the positive macroeconomic benefits of the work plans but yield positive employment impacts even when impacts to GSP are negative. Further modifications in the policy design of specific work plans and their approach to analysis (including key assumptions) could significantly improve performance in some cases.

All of the cost estimates of the quantified work plans in the action plan are local economic impacts. It was beyond the scope of the subcommittees' analysis to evaluate broader regional and national macroeconomic impacts. The work plans do, however, include the effects of decreased or increased spending on carbon mitigation or sequestration and the interaction of demand and supply in various markets that can be further evaluated for macroeconomic impacts.

For example, reduction in consumer demand for electricity reduces the demand for generation by all sources, including both fossil energy and renewables. It therefore reduces the demand for fuel inputs such as coal and natural gas. Moreover, the investment in new equipment may partially or totally offset expenditures on ordinary plant operations and equipment depending in part on whether investment is attracted from outside the state. At the same time, businesses and households whose electricity bills have decreased have more money to spend on other goods and

[35] Chapter 5 was prepared by the Center for Climate Strategies using draft work plans. The data contained in the final work plans voted on by the Climate Change Advisory Committee may vary from the earlier draft work plans which may impact the final macroeconomic assessment conclusions.

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services. If the households purchase more food or clothing, this stimulates the production of these goods, at least in part, within the state. Food processing and clothing manufacturers in turn purchase more raw materials and hire more employees. Then more raw material suppliers in turn purchase more of the inputs they need, and the additional employees of all these firms in the supply chain purchase more goods and service from their wages and salaries.

The sum total of these "indirect" impacts is some multiple of the original direct on-site impact; hence this is often referred to as the multiplier effect, a key aspect of macroeconomic impacts. It applies to both increases and decreases in economic activity. It can be further stimulated by price decreases and muted by price increases.

The remainder of this chapter is divided into three sections. The first section discusses the input data, modeling assumptions, and how the input data and assumptions are linked to key structural and policy variables in the Regional Economic Models, Inc. (REMI) PI+[36] model. The second section presents the simulation results, including a sensitivity analysis and interpretation of results. The last section provides a summary and discusses some policy implications. See Appendix L for a discussion of the workings of the REMI Model and the steps involved in linking work plans to model variables.

Input Data

Since 2009, significant changes have been made to the estimated costs and/or savings for several of the work plans. The inputs for the macroeconomic analysis are based on the choices of methods, data sources, assumptions, and uncertainty about costs and savings developed by the subcommittees. Changes in assumptions for costs developed by the subcommittees have also driven significant changes in macroeconomic impacts, particularly where cost estimates were increased. Declining prices of natural gas is an example of another important factor in reducing the value of energy savings.

Table 5.1 shows a comparison of the macroeconomic impacts for the 2009 versus 2013 work plans where the macroeconomic impacts are significantly different. For example, relative to the 2009 analysis, inputs to the 2013 macroeconomic analysis of the re-light Pennsylvania work plan had $1.7 billion in reduced energy savings and $2.7 billion in increased costs. With other changes, there were $4.1 billion in negative changes to inputs to the macroeconomic model.

Another work plan, combined heat and power, is notable for its large negative impacts in 2009 and became an even more negative influence on the results of the 2013 analysis when cost estimates were increased. Combined heat and power had the most complicated analysis of all the work plans, having the most diverse set of economic impacts. Costs of the work plan are distributed to 164 commercial and industrial sectors across the state while separate analysis of biomass CHP added additional costs to industrial sectors. Energy savings to commercial and industrial sectors added economic stimulus to the heating and ventilation equipment and forestry sectors. Energy distribution sectors saw reduced demand. Very large increases in costs shown in the input data were not offset by increases in benefits.

[36] PI stands for "Policy Insight".

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Assumptions made by subcommittees in the forestry sectors included the removal of lands from productive use in the forest acquisition work plan and did not consider revenues that could potentially be derived from the sustained management of the acquired forest lands. The forestry work plans included options for greater scales of implementation, shown in Table 5.4.

Table 5.1. Comparison of Significant Differences in Macroeconomic Impact Results for Work Plans Included in 2009 and 2013 Climate Action Plan

Billions of Fixed 2012 Dollars					
	2013 Analysis		2009 Analysis		
Work Plan	GSP	Net Present Value (2013 - 2020)	GSP	Net Present Value (2009 - 2020)	Explanation (relative to 2009 analysis)
Combined Heat & Power (CHP)	-1.59	-4.68	-0.94	-3.24	Capital costs increased by about $2 billion
Industrial Electric Best Management Practices (BMPs)	0.12	0.18	1.06	2.47	Energy savings are much lower in 2013 work plan because natural gas programs were removed
Re-light PA	0.05	-0.72	0.95	1.98	Costs are $1.7 billion higher and savings are $2.4 billion lower in 2013 work plan
Re-roof PA	-1.34	-2.90	-0.31	-0.57	Costs are $2 billion higher and benefits are $70 million lower in 2013 work plan
Geothermal Heating and Cooling[37]	-0.01	0.08	0.18	0.54	An $800 million increase in energy bills offset $70 million decrease in capital cost in 2013 work plan
Demand-Side Management (DSM) Natural Gas	0.10	0.58	0.35	1.85	Capital costs are $500 million higher in 2013 work plan
DSM Oil	-0.01	-0.07	0.09	0.98	Biofuel heat is eliminated in 2013 work plan reducing income from production of biofuels

The extent of the many types of linkages in the economy and macroeconomic impacts is broad and cannot be traced by a simple set of calculations. It requires the use of a sophisticated model that reflects the major structural features of an economy, the workings of its markets, and all of the interactions between them. In this study, REMI PI+ modeling software was used to be discussed below (REMI, 2012). This is the most widely used state level economic modeling software package in the United States and has been heavily peer reviewed.

The REMI Model is used extensively to measure proposed legislative and other program and policy economic impacts across the private and public sectors by government agencies in nearly every state. In addition, it is often the tool of choice to measure these impacts by a number of university researchers and private research groups that evaluate economic impacts across a state

[37] This work plan was not voted on by the CCAC.

and nation. The Pennsylvania version of the REMI Model was applied to the estimation of the macroeconomic impacts of the major GHG mitigation work plans on output, income, employment and prices in the state for years 2013 through 2020 (i.e., eight years).

Modeling Assumptions

Each of the individual work plans was developed by DEP and the subcommittees. The scope of the work plans and their assumptions are the basis of the analysis and results. Key factors such as fuel price, capital cost and the degree to which energy efficient goods are purchased within the state, are very important. Sensitivity analysis of these key variables is included. Certain work plans are considered for the degree that they may be implemented. For example, with urban forests, three options are considered. In these cases, the same options have been chosen for macroeconomic analysis as were used for the 2009 analysis. When the alternatives are new to this analysis, the smallest alternative is chosen for analysis.

The major data sources of the analysis are the subcommittees' quantification results or their best estimation of the cost/savings of various recommended work plans. However, these were supplemented with additional data and assumptions in the REMI analysis in cases where these costs and some conditions relating to the implementation of the work plans are not specified by the subcommittees. Below is the list of major assumptions we adopted in the analysis:

1. Assumptions outlined in documents provided for each work plan by the CCAC have been implemented in every case. For example, increased forest harvest activities do not include increased downstream activities, such as milling, and assume that acquired forestlands are not used in productive processes.
2. It is assumed that increases in household spending on energy-efficient appliances will reduce household spending in other commodity categories by the same dollar amount. Similarly, energy bill savings will enable households to increase spending on other products and services by the same dollar amount.
3. For some work plans, energy consumers' costs related to energy efficiency programs are computed for the residential, commercial, and/or industrial sectors by the subcommittees. For the commercial and industrial sectors, the subcommittees' analyses provide total costs for the entire commercial sector and industrial sectors. The total costs for the commercial and industrial sectors were distributed among 169 individual sectors based on the input-output data provided in the REMI model for Pennsylvania.
4. For urban forestry, many non-market goods (public goods) such as improved air quality and storm water management, benefits are simulated as non-pecuniary impacts. It is assumed that one-quarter of program funding comes from the state government budget, one half from households and one quarter from sources such as donated labor, private foundations and federal grants.
5. For combined heat and power, costs and benefits are distributed to both the industrial and commercial sectors. Costs and benefits from biomass projects are added to these, although stimulative impacts specific to biomass production are input separately.
6. None of the work plans were assumed to be large enough to displace investment that otherwise would occur elsewhere in Pennsylvania due to crowding out of capital or by causing constraints in the labor market.

The analysis below is based on the best estimation of the cost of various mitigation work plans. However, these costs, and some conditions relating to the implementation of these work plans, are not known with certainty. Examples include the net cost or cost savings of the work plans themselves, which are highly dependent on assumptions regarding fuel prices and other factors.

Accordingly, sensitivity analyses were performed to investigate these alternative conditions. The action plan attempts to identify the least costly mitigation work plans, and in fact, has identified several that result in net cost savings. For example, many electricity demand-side management practices translate into less electricity needed to produce a given outcome, such as running an assembly line or cooling a home. When this is accomplished at a net cost savings on an electricity bill, this is referred to as an energy efficiency improvement.[38] In other cases, as when new equipment must be purchased, the additional expense may exceed cost savings.

It was beyond the scope of the subcommittees' direct impact analysis to evaluate broader regional and national macroeconomic impacts. The subcommittees computed estimated GHG reductions and direct costs of implementation within the assumptions outlined for each work plan. These results have been analyzed here to estimate macroeconomic impacts and consider numerous secondary impacts. For instance, reductions in energy demand are common to each work plan and result in reduced demand for the products of utility and energy sectors and savings to energy consumers. Investments required to implement work plans are costs to specific sectors while also stimulus to those sectors and their suppliers. For example, businesses and households, whose electricity consumption has decreased, have therefore more money to spend on other goods and services. This increased spending stimulates the production and sales of goods, as it reduces production by the affected utilities.

The results indicate that the net macroeconomic impacts on the Pennsylvania economy are estimated to be positive for more than half of the work plans. A list of work plans with the greatest and least economic benefit is presented below. Combined impacts of all of the work plans simulated together are shown.

Linking the Pennsylvania Work Plans to the REMI Model Input

In total, the 31 quantified work plans that are analyzed in this chapter have the potential to generate billions in net cost savings and reduce millions of tons of carbon dioxide-equivalent (CO_2e) GHG emissions during the 2013 through 2020 period, analyzed by the subcommittees in separate analyses.

Analysis of costs and savings by the CCAC focused on the direct effects of implementing the work plans. The direct costs of an energy efficiency work plan include a ratepayer's expense for energy and both customers' and firms expenditures on energy efficiency equipment. Direct benefits include customer savings on energy bills. A more detailed discussion of the workings of the REMI model is also available in Appendix E.

[38] This definition is widely used by economists and employed here; however, the *Climate Action Plan* may also include some positive cost demand-side management measures within the meaning of "energy efficiency."

Results

A summary of results is presented in Tables 5.2 and 5.3. Table 5.2 shows impacts to GSP for each work plan. The net present value (NPV) for the period 2013 to 2020 is shown. Results are all in 2012 dollars. Table 5.3 presents results for employment statewide. Section E in Appendix E contains more detailed results. Individual sector results are presented in Section D of the Appendix. In these results, a positive number in the tables represents a positive stimulus to the economy, an increase in GSP or employment. A negative number means a negative impact to the state economy, a decrease in GSP or a decline in total employment.

The impact to GSP of all 32 work plans combined, when simulated together, are negative for all but the first year. This is due to strong negative effects from a small set of specific work plans shown in Table 5.1. Total employment impacts over the analysis period are positive, but are also negatively impacted by the same two work plans. The NPV of the GSP impacts for the period 2013 - 2020 is about -$3.7 billion. Results become strongly positive, $3.97 billion, when only two work plans are removed from the mix, a difference of $7.7 billion. The strength of only two work plans to affect results from all 31, when simulated together as a group, underlines the value of viewing proposed work plans individually, in context of one another, and of prioritizing them for their macro-economic impacts.

Most work plans had relatively small impacts. The majority had less than $10 million impact to GSP in any given year. Overall, the work plans show a wide range of impacts. The full range of impacts to GSP is listed in Table 5.2.

The last row of tables 5.2 and 5.3 present the simulation results of GSP and employment, in which we assume that all the work plans are implemented concurrently. Any combination of results might be simulated as a group. Table 5.3 shows results from a handful of alternate scenarios.

Table 5.2 highlights several important points:

- 21 of the 31 work plans are estimated to increase GSP.
- 18 work plans could have positive employment impacts.
- The urban forestry and lost and unaccounted for natural gas work plans yield the highest positive impacts on the economy--an NPV of $2.85 billion;
- The urban forestry work plan relies heavily on non-pecuniary values associated with planting urban trees, and assumes substantial non-market inputs. This is the only work plan based upon assumptions about non-pecuniary effects.
- The scale of forest work plans was modeled as the minimum scale of the three options developed for the work plans, except where the 2009 analysis used the middle option for the forest acquisition and urban forests.

Table 5.2. Gross State Product (GSP) Impacts of the Pennsylvania Climate Action Plan

Billions of Fixed 2013 Dollars					
Work Plan	**2015**	**2018**	**2019**	**2020**	**Net Present Value**
Sulfur Hexafluoride (SF6)	0.00	0.00	0.00	0.00	0.00
Combined Heat & Power (CHP)	-0.43	-1.10	-1.34	-1.59	-4.68
Nuclear	-0.01	-0.04	-0.04	-0.05	-0.13
Subtotal - Electricity	**-0.44**	**-1.13**	**-1.38**	**-1.63**	**-4.82**
Coal Mine Methane	0.03	0.03	0.03	0.02	0.19
Industrial Electric Best Management Practices (BMPs)	0.00	0.04	0.09	0.12	0.18
Lost Unaccounted (LU) Gas Production	0.35	0.15	0.09	0.08	1.51
LU Gas Distribution[39]	0.00	0.00	0.00	-0.01	0.00
Subtotal - Industrial	**0.38**	**0.22**	**0.20**	**0.22**	**1.89**
Building Commissioning	0.02	0.05	0.05	0.06	0.22
Re-light PA	-0.14	-0.08	-0.02	0.05	-0.72
Re-roof PA	-0.16	-0.68	-0.97	-1.34	-2.90
Appliance Standards[40]	0.02	0.12	0.14	0.16	0.41
Geothermal Heating and Cooling[41]	0.02	0.01	0.01	-0.01	0.08
Demand-Side Management (DSM) Natural Gas (NG)	0.09	0.10	0.11	0.10	0.58
DSM Oil	-0.01	-0.01	-0.01	-0.01	-0.07
DSM Water	0.09	0.10	0.11	0.10	0.58
Subtotal - Residential/Commercial	**-0.07**	**-0.38**	**-0.58**	**-0.88**	**-1.82**
Forest Easements	-0.01	-0.01	-0.01	-0.01	-0.04
Forest Acquisition 2	-0.02	-0.04	-0.05	-0.05	-0.18
Reforestation 1[42]	0.04	0.03	0.03	0.03	0.23
Afforestation 1	0.00	0.00	-0.01	-0.01	0.00
Urban Forest 2	0.16	0.27	0.32	0.37	1.35

[39] This work plan was not voted on by the CCAC. DEP decided not to include this work plan in the Action Plan due to the efforts already undertaken by the PUC for Utility DSIC.
[40] This work plan was not voted on by the CCAC. DEP decided not to include this work plan in the Action Plan due to the existing federal Department of Energy requirements.
[41] This work plan was not voted on by the CCAC. DEP decided not to include this work plan in the Action Plan. The concept will be revisited in the next Action Plan.
[42] The Reforestation work plan was not voted on by the CCAC and was not selected to be included as an option in this Action Plan, although the concept is supported. This analysis was conducted on a prior version of the work plan where the benefits were overstated. The current version of the work plan shows negative GHG benefits within the 2020 time period and much higher associated costs.

Billions of Fixed 2013 Dollars					
Work Plan	**2015**	**2018**	**2019**	**2020**	**Net Present Value**
Fuels for Schools[43]	0.01	0.01	0.02	0.02	0.06
Durable Wood Products 1	0.01	-0.02	-0.03	-0.03	0.00
Subtotal - Forestry	**0.19**	**0.25**	**0.28**	**0.31**	**1.42**
Manure Digester	0.00	0.00	0.00	0.00	0.00
No Till	0.00	-0.01	-0.01	-0.02	-0.04
Subtotal - Agriculture	**0.00**	**-0.01**	**-0.02**	**-0.02**	**-0.05**
Improved Wastewater Treatment	0.00	0.00	0.00	0.00	0.00
Waste-to-Energy (WtE) Digester	0.00	0.00	0.00	0.00	0.00
WtE Municipal Solid Waste (MSW)[44]	0.00	0.00	-0.01	-0.01	0.00
Increased Recycling	0.01	0.01	0.01	0.01	0.09
Subtotal - Waste	**0.02**	**0.01**	**0.01**	**0.00**	**0.09**
Alternative Fueled Vehicles (AFV) Taxis NG	0.00	-0.01	-0.02	-0.02	-0.05
Freight Efficiency	0.00	0.02	0.02	0.03	0.07
Subtotal – Transportation	**0.00**	**0.01**	**0.01**	**0.02**	**0.03**
Summation Total	**0.07**	**-1.04**	**-1.48**	**-1.98**	**-3.26**
Simultaneous Total	**-0.14**	**-1.00**	**-1.36**	**-1.84**	**-3.73**

Net present values shown in Table 4.2 compute values from 2013 - 2020, years shown do not sum to NPV.
Note: A positive number in this table means a potential positive stimulus to the state's economy; a negative number means a potential negative impact to the state's economy. Totals do not sum due to rounding.

Most of the work plans that may generate positive impacts do so because they result in cost-savings for energy customers. Some result in significant operational savings for producers, most especially reduced lost and unaccounted for natural gas among gas producers and industrial electric best management practices. Work plans with negative economic impacts invariably had implementation costs that outweighed potential benefits through the analysis period. Those with negative trends at the end of the analysis period tended to continue those trends into the period after the analysis period.

High implementation costs impact the economy first on the balance sheet of those most directly affected, but also in related sectors of the economy via higher prices for inputs to downstream processes. Costs in the energy sector, for example, affect every sector of the economy because

[43] This analysis was conducted before the CCAC discussed this work plan. After discussion, DEP agreed with the committee to not include this work plan as one of the cost-effective strategies, due to the negligible GHG benefits.
[44] This macroeconomic analysis was conducted on an earlier version of the work plan. The current version has more GHG benefits and lower costs.

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energy is an input to every economic process to one degree or another, including running a household.

Forest acquisition and forest easements are also distinct from the larger group. These work plans rely on preserving forestland. Costs are associated with identifying funding to acquire land. These are different from all the other work plans that involve improved economic processes through the diffusion of best practices and technology. The forest acquisition work plan assumes that lands are removed from productive use in the economy. Analysis of sustainable economic uses of the land in lieu of the development activities from which these lands are protected may be worthy of further analysis to determine if they may yield important positive economic benefits.

The source of funding is not the same for each work plan. Many rely on requirements that may be imposed on utilities by the state, others on investments the state may choose to make. Still others are largely voluntary programs driven by market forces.

Two programs, reforestation[45] and durable wood products, seek to re-establish a once-viable industry on neglected lands through market forces. The reforestation work plan is notable for the very large positive impacts of its alternative scenarios. Production associated with processing forest products is assumed by the subcommittees to take place out of state. These important potential benefits are removed from consideration by assumption.

No obvious relationship exists between the degree of benefit to the economy and the source of funding for each work plan. Within each of the major groups that bear costs for GHG reduction work plans, consumers, government, commercial, and industrial sectors, there are work plans with both positive and negative economic impacts.

The size of work plan costs is not necessarily related to net economic benefits. The relationship between benefits and costs, and the sector of the economy where these benefits and costs occur affect macroeconomic results, rather than the size of any individual factor.

Table 5.3. Employment Impacts of the Pennsylvania Climate Action Plan

Thousands of Net Jobs				
Work Plan	**2015**	**2018**	**2019**	**2020**
Sulfur Hexafluoride (SF6)	0.00	0.00	0.00	0.00
Combined Heat & Power (CHP)	-4.96	-12.03	-14.36	-16.71
Nuclear	0.40	0.73	0.73	0.92
Subtotal - Electricity	**-4.55**	**-11.30**	**-13.63**	**-15.79**

[45] The reforestation work plan was not voted on by the CCAC and was not selected to be included as an option in this Action Plan, although the concept is supported. This analysis was conducted on a prior version of the work plan where the benefits were overstated. The current version of the work plan shows negative GHG benefits within the 2020 time period and much higher associated costs.

Thousands of Net Jobs				
Work Plan	**2015**	**2018**	**2019**	**2020**
Coal Mine Methane	0.38	0.33	0.31	0.28
Industrial Electric Best Management Practices (BMPs)	0.03	0.84	0.90	1.03
Lost Unaccounted (LU) Gas Production	4.44	2.00	1.29	1.16
LU Gas Distribution[46]	-0.03	0.00	-0.03	-0.07
Subtotal - Industrial	**4.82**	**3.17**	**2.47**	**2.41**
Building Commissioning	1.45	2.06	2.05	2.04
Re-light PA	1.85	1.21	1.37	0.30
Re-roof PA	-1.36	-5.86	-8.32	-11.40
Appliance Standards[47]	1.75	2.54	2.63	2.68
Geothermal Heating and Cooling[48]	-0.40	-0.72	-0.84	-0.58
Demand-Side Management (DSM) Natural Gas (NG)	1.15	1.13	1.08	1.00
DSM Oil	-0.17	-0.11	-0.11	-0.10
DSM Water	0.52	0.69	0.74	0.79
Subtotal - Residential/Commercial	**4.78**	**0.95**	**-1.39**	**-5.28**
Forest Easements	-0.14	-0.14	-0.14	-0.14
Forest Acquisition 2	-0.37	-0.73	-0.84	-0.96
Reforestation 1[49]	1.40	1.42	1.40	1.38
Afforestation 1	2.33	2.31	2.35	2.36
Urban Forest 2	10.27	17.35	19.90	22.34
Fuels for Schools[50]	0.40	0.71	0.81	0.90
Durable Wood Products 1	1.09	0.35	0.22	0.13
Subtotal - Forestry	**14.96**	**21.28**	**23.69**	**26.02**
Manure Digester	0.01	0.02	0.02	0.02
No Till	-0.02	-0.07	-0.08	-0.10

[46] This work plan was not voted on by the CCAC. DEP decided not to include this work plan in the Action Plan due to the efforts already undertaken by the PUC for Utility DSIC.

[47] This work plan was not voted on by the CCAC. DEP decided not to include this work plan in the Action Plan due to the existing federal Department of Energy requirements.

[48] This work plan was not voted on by the CCAC. DEP decided not to include this work plan in the Action Plan. The concept will be revisited in the next Action Plan.

[49] The reforestation work plan was not voted on by the CCAC and was not selected to be included as an option in this Action Plan, although the concept is supported. This analysis was conducted on a prior version of the work plan where the benefits were overstated. The current version of the work plan shows negative GHG benefits within the 2020 time period and much higher associated costs.

[50] This macroeconomic analysis was conducted before the CCAC discussed this work plan. After discussion, the DEP agreed with the committee to not include this work plan as one of the cost-effective strategies, due to the negligible GHG benefits.

Thousands of Net Jobs				
Work Plan	**2015**	**2018**	**2019**	**2020**
Subtotal - Agriculture	**-0.01**	**-0.05**	**-0.06**	**-0.08**
Improved Wastewater Treatment	**0.00**	**0.01**	**0.01**	**0.01**
Waste-to-Energy (WtE) Digester	**0.01**	**0.02**	**0.02**	**0.02**
WtE Municipal Solid Waste (MSW)[51]	**0.10**	**0.01**	**-0.02**	**-0.05**
Increased Recycling	**0.14**	**0.12**	**0.12**	**0.11**
Subtotal - Waste	**0.25**	**0.16**	**0.13**	**0.09**
Alternative Fueled Vehicles (AFV) Taxis NG	-0.06	-0.22	-0.27	-0.33
Freight Efficiency	-0.03	-0.06	-0.07	-0.09
Subtotal – Transportation	**-0.08**	**-0.21**	**-0.26**	**-0.31**
Summation Total	**20.17**	**13.99**	**10.95**	**7.06**
Simultaneous Total	**21.18**	**16.42**	**13.34**	**8.34**

Note: A positive number in this table means job creation in Pennsylvania; a negative number in this table means a reduction in the total employment of Pennsylvania. Totals do not add due to rounding.

The employment impacts summarized in Table 5.3 are slightly different than the GSP impacts because investments in green technologies tend to be very labor intensive, resulting in high employment impacts, even when impacts to GSP are negative. Work plans which decrease utility bills also cause increases in consumer spending on goods and services. This re-allocates economic activity from the highly mechanized energy sector to labor intensive services and consumer goods sectors.

Impacts to inflation are projected to be very small, with an increase of 0.3 percent by 2020.

Differences between the simultaneous simulation and the sum of work plans simulated separately are due to synergies in economic actions captured by the REMI model in non-linear relationships. In other words, many relationships between economic actors are not constant. The higher positive impact from the simultaneous simulation is due to non-linearities and synergies in the model that reflect real world considerations. For example, changes that are larger in scale can cause shifts from labor to capital, affecting aggregate results. However, for the purpose of prioritizing projects and selecting work plans for further analysis, the results from simulating work plans individually can be expected to be of same order of magnitude and generally to have similar rank order.

Appendix E presents results for impacts to individual sectors. Sectors with the largest negative impacts are the electric utility, natural gas utility, and petroleum and coal products sectors.

Alternative Scenarios

[51] This analysis was conducted on a prior version of the work plan. The current work plan includes greater GHG benefits with lower costs, making it more cost effective.

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The subcommittees considered alternative implementation scenarios for six work plans. Five of these are forestry work plans, and one is an alternative between electric and natural gas taxis. Table 5.4 shows results from 2013 - 2020 for impacts to GSP. Except for the alternative fueled vehicle scenarios, the alternatives present varying degrees to which work plans are implemented, greater numbers of affected acres and greater numbers of trees, in increasing order from alternatives 1 to 3.

Table 5.4. Alternative Work Plan Scenarios

	Gross State Product- 2012 $million				**Net Present Value**
Work Plan	**2015**	**2018**	**2019**	**2020**	**2013 - 2020**
Afforestation 1	4.03	-4.33	-6.84	-9.16	-1.68
Afforestation 2	7.81	-8.85	-13.31	-17.64	-3.13
Afforestation 3	15.63	-16.78	-25.76	-34.91	-4.34
AFV Taxis HEV	-2.62	-9.22	-12.02	-14.40	-38.17
AFV Taxis NG	-3.42	-12.51	-16.11	-20.08	-50.98
Durable Wood Products 1	7.51	-23.56	-28.75	-31.86	3.04
Durable Wood Products 2	22.58	-13.12	-19.59	-23.13	93.76
Forest Acquisition 1	-16.30	-32.47	-37.78	-42.97	-148.50
Forest Acquisition 2	-19.59	-39.92	-46.57	-53.28	-181.16
Forest Acquisition 3	-39.06	-79.65	-92.90	-106.32	-361.26
Reforestation 1[52]	37.96	33.94	32.59	30.94	231.51
Reforestation 2[51]	350.22	314.09	299.80	286.56	2,131.06
Reforestation 3[51]	664.55	596.68	569.58	544.49	4,044.98
Urban Forest 1	61.52	105.77	123.60	141.05	525.10
Urban Forest 2	156.07	273.38	320.74	366.76	1,348.12
Urban Forest 3	411.50	683.65	791.14	897.09	3,441.55

Two of the work plans show very large potential economic benefits of increases in the scale at which they are implemented. Simulations that include all 31 work plans, called consolidated herein, show marked improvement when the forest alternatives at greater scale are included. In Table 5.4, alternatives, which were included in Table 5.2, are shown with grey shading, and are the same results shown in millions of dollars, rather than billions.

Sensitivity Analysis

[52] The reforestation work plan was not voted on by the CCAC and was not selected to be included as an option in this Action Plan, although the concept is supported. This analysis was conducted on a prior version of the work plan where the benefits were overstated. The current version of the work plan shows negative GHG benefits within the 2020 time period and much higher associated costs.

In the sensitivity analysis, The Center for Climate Strategies (CCS) simulated the macroeconomic impacts of changes to fuel price, capital cost, the percentage of goods that are produced within the state, and the discount rate. Sensitivities were performed on several different work plans. They are as follows:

- Nuclear
- Re-light PA
- Re-roof PA
- Building commissioning
- Combined heat and power
- Appliance standards

Sensitivity Tests

CCS performed sensitivity tests on appropriate parameters of the analysis for some of the work plans with large economic impacts. For example, for the nuclear work plan, parameters are capital costs and fuel costs. CCS performed sensitivity analyses with the following assumptions:

1. **Fuel Price:** The fuel prices are 50 percent lower or 50 percent higher than the levels used in the base case analysis. These would first affect the fuel cost savings to all the commercial and industrial sectors (which are the product of the physical amount of displaced fuel use and the price of fuels). Meanwhile, change of fuel prices will also affect the gross fuel costs for the CHP systems, which are part of the increased production cost to the commercial and industrial sectors. Moreover, these would also affect the "exogenous final demand" for the outputs of the Natural gas distribution sector and farm sector (in value terms). This sensitivity analysis has been performed for nuclear, building commissioning, re-light PA, re-roof PA, CHP, and appliance standards.

2. **Capital Cost:** Capital costs are 50 percent lower or 50 percent higher than the levels used in the current analysis. This was done for nuclear, CHP, re-roof PA, and appliance standards.

3. **Regional Purchase Coefficient:** The percentage of products that are produced inside the state is considered. The sensitivity increases the percentage, called the regional purchase coefficient (RPC), or decreasing it by 50 percent. This analysis is done for appliance standards and re-light PA.

4. **Discount Rate:** Calculation of net present value depends upon the level of interest rate used. The default interest rate included above has been 5 percent. For all of the work plans, alternate interest rates of 3 percent and 7 percent are use.

Conclusions

This chapter summarizes the analysis of the potential impacts of the *Pennsylvania Climate Action Plan* on the state's economy. CCS used a state of the art macroeconometric model to perform this analysis, based on data supplied from seven subcommittees who vetted them through an in-depth; consensus based technical assessment and stakeholder process. The results indicate that many of the GHG carbon mitigation and sequestration work plans could have positive impacts on the state's economy. The results from simulating all 31 work plans together are much different than results from 2009, the previous analysis, due to higher estimates of direct costs and lower benefits estimated by the subcommittees and provided as inputs for this analysis in 2013. On net, the combination of work plans together is estimated to create, on average, more than 21,000 jobs by 2015 and more than 17,000 jobs, on average, over the analysis period (2013 - 2020). On the other hand, GSP is estimated to decline by about $4.5 billion over the analysis period (2013 - 2020).

The wide range of impacts from work plans when simulated individually suggests that policy makers may benefit from consideration of certain subsets of the larger group. For example, a subset of the larger group that was simulated without CHP and re-roof PA improved the overall GSP impacts by $7.7 billion dollars over the 2013 - 2020 analysis period.

The analysis shows potential employment impacts at the same time as negative GSP impacts. This reflects in part the relatively labor intensive nature of green energy technologies, and that income that is redistributed to consumer goods from energy sector spending. The lost and unaccounted for natural gas and reforestation work plans contribute the highest GSP gains, 69 percent of the result from the group of 31, when simulated together. Urban forestry and re-light PA contribute the highest employment gains.

The macroeconomic gains stem primarily from the ability of work plans to lower the cost of production. This stems primarily from their ability to improve energy efficiency and thus lower production costs and increase consumer purchasing power. The results also stem from the stimulus of increased investment in plant and equipment and investment activities with higher than average multiplier effects on labor and GSP.

Several tests were performed to determine the sensitivity of the results to major changes in key variables such as capital costs, fuel prices and the degree that goods are produced within the state. The tests indicate the results are robust, i.e., the overall results do not change much even when these variables are changed by plus and minus 50 percent.

Note that the estimates of economic benefits to Pennsylvania represent a lower bound from a broader perspective. They do not include the avoidance of damage from the climate change that continued baseline GHG emissions would bring forth, the reduction in damage from the associated decrease in ordinary pollutants, the reduction in the use of natural resources, and the reduction in traffic congestion.

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Chapter 6. Recommendations of Legislative Change

Based on the research and analysis conducted by DEP, in consultation with the CCAC, and macroeconomic analysis completed by The Center for Climate Strategies, the following are recommendations for legislative action:

1: **Address long-term liability issues associated with carbon capture and sequestration.**

As discussed in section 4.4, one of the opportunities to reduce GHGs in the forestry sector relates to carbon capture and sequestration. In addition to restocking forests, Pennsylvania's geologic formations may be used to store carbon from stationary sources. One of the major concerns with geologic sequestration relates to the liability of leakage once CO_2 is injected into an underground formation.

2: Provide incentives for the capture and use of coal mine methane.

As discussed in section 4.1, the release of methane gas to the atmosphere is a major component of GHG emissions. Methane gas is a fossil fuel and energy source, commonly known as natural gas, which occurs in various geologic formations in Pennsylvania, including coal formations. When coal is mined and processed for use, substantial amounts of methane gas are released. Coal bed methane is contained within coal formations and may be extracted by gas exploration methods or released as part of coal mining operations.

3: Evaluate the effectiveness of Act 11 of 2012 (Utility DSIC) to ascertain the impact that accelerated natural gas distribution infrastructure replacement has on decreasing fugitive methane emissions.

As discussed in Section 4.1, when methane is emitted into the atmosphere, it is 21 times more potent a GHG than CO_2. Methane losses from natural gas extraction and delivery accounted for 32 percent of U.S. methane emissions. With EPA's NSPS requirements for green completions, methane emissions during extraction activities have been significantly reduced. Act 11 of 2012 required PUC to allow utilities to petition for the ability to recoup costs when repairs were made to utility lines. This has enabled natural gas distribution companies to make repairs or replace leaking distribution lines.

4: Enact legislation incentivizing and directing natural gas utilities to expand existing service territory to un-served customers in a cost-effective manner.

As discussed in Section 4.2, a major opportunity for Pennsylvania would be to expand natural gas distribution lines throughout the state. When natural gas is burned, it is significantly lower in not only CO_2, but also SO_2 and NOx. However, this cheaper and cleaner when burned fuel is not accessible to many consumers in Pennsylvania, both residentially and commercially. Expanding this fuel for heating and cooking consumption would not only reduce consumers' utility bills each month, it would also yield air quality benefits. SB 738 of the 2013/14 session creates the Natural Gas Consumer Access Act to require natural gas distribution system extension and expansion plans in Pennsylvania.

5: Provide additional incentives for the use of alternative fueled vehicles, such as electric vehicles and LNG/CNG fueled vehicles, particularly large fuel consumption fleet vehicles.

In Section 4.3 opportunities for alternative-fueled vehicles were discussed, including the Act 13 of 2012 funding for LNG/CNG retrofits for fleet vehicles over 14,000 lbs and AFIG. The monies provided by Act 13 of 2012 were only transferred to the Natural Gas Energy Development Fund for the first three years of the natural gas impact fee. As more infrastructure, such as CNG refueling stations and electric charging stations are built, more Pennsylvanians will be interested in purchasing vehicles that run on alternative fuels. Since 2011, DEP has invested $4.35 million toward electric vehicles. The benefits of alternative fuel vehicles are numerous, including significant benefits to air quality and savings at the pump for consumers. Programs such as these should be continued in the future with additional funding.

6: Consider legislation mandating or encouraging energy use profiling for commercial buildings, similar to the city of Philadelphia's ordinance.

The city of Philadelphia has set a goal in their 2009 Greenworks Philadelphia plan, to reduce 10 percent of energy consumption of residential and commercial buildings. This savings will be achieved by weatherizing existing homes and commercial buildings, developing new buildings that are more energy efficient and encouraging people to replace their light bulbs and upgrade to more energy-efficient appliances. By reducing the amount of energy consumed in Pennsylvania, there will be a significant impact on reducing GHGs and improving air quality.

7: Expand competitive electricity markets to foster and encourage renewable and alternative energy suppliers to enter Pennsylvania's market.

Renewable and alternative energy suppliers that enter Pennsylvania's energy market would be able to offer customers preferred generation options for their source of electricity, such as wind, solar and other renewable products. By giving consumers the choice on how their own electricity is generated, markets for renewables will be able to expand based on the marketplace.

8: Continue to support the implementation of AEPS.

As discussed in Section 4.1, the AEPS is helping to lower GHG emissions in Pennsylvania. Through 2020, AEPS will require annual increased use of alternative and renewable electricity. Through this increased use of alternative and renewables as discussed throughout this action plan, GHGs will continue to be reduced.

9: Amend AEPS to permit the inclusion of additional waste-to-energy facilities.

As discussed in Section 4.1, additional waste-to-energy facilities are opportunities for Pennsylvania to reduce GHGs with the disposal of municipal solid waste. There are also new technologies available that should be considered for the future deployment and processing of municipal solid waste. AEPS recognizes electricity generated by the state's six WTE facilities is recognized as a Tier II resource. The combustion of MSW by WTE facilities produces significant amounts of clean, baseload electricity with significantly lower GHG emissions than traditional fossil-fueled generation because approximately 50 percent of the GHG emissions from WTE facilities are biogenic in origin.[53]

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[53] http://www.epa.gov/cleanenergy/energy-and-you/affect/municipal-sw.html