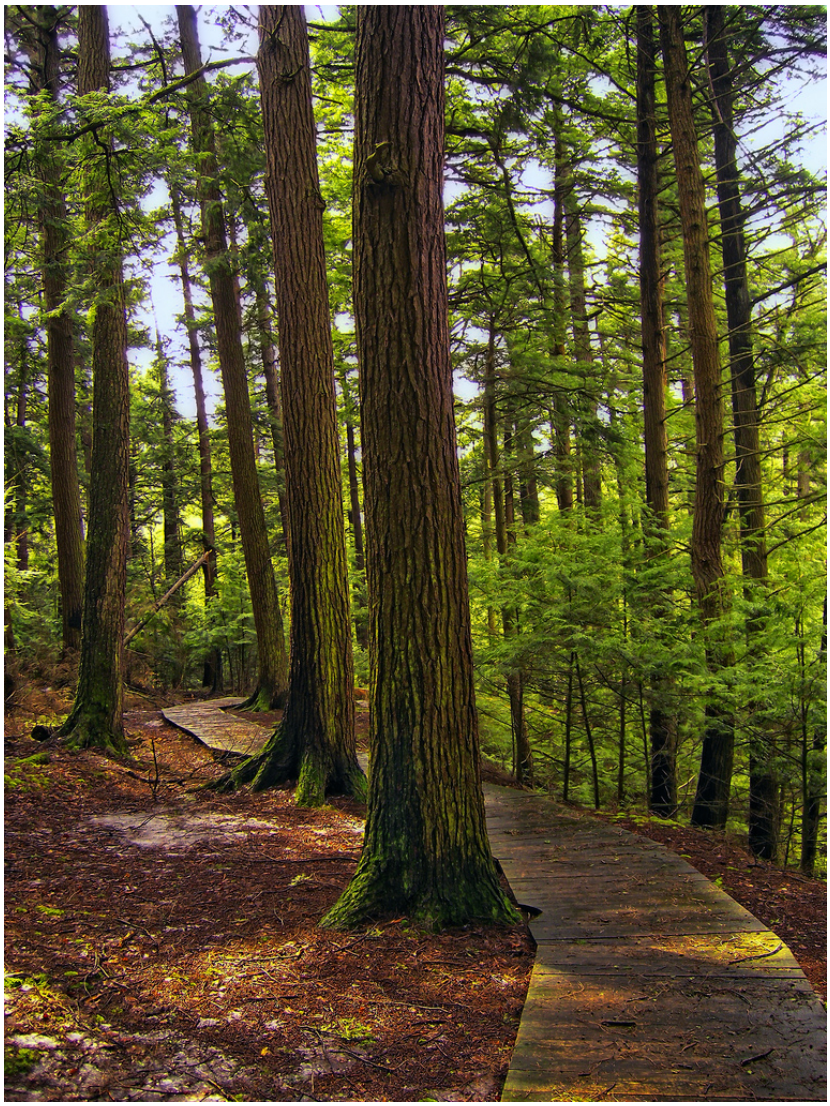
PENNSYLVANIA CLIMATE CHANGE ROADMAP



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Pennsylvania Climate Change Roadmap

This report is available on the Pennsylvania Environmental Council website: ***http://www.pecpa.org/roadmap***

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Executive Summary

Now is the time for action on climate change. The rising concentration of greenhouse gases (GHG) poses a multitude of risks to Pennsylvania and to our planet as a whole. Reducing those risks requires that, in the coming decades, we make significant cuts in emissions of greenhouse gases on a global scale. No state (and indeed no nation) can solve this problem on its own, but Pennsylvania can play an important role in addressing climate change, the most challenging environmental issue of our time. Addressing this issue is also essential to the long-term economic and geopolitical stability of the nation.

Currently, Pennsylvania is responsible for about one percent of the worldwide emissions of GHG. This level of emissions ranks third among U.S. states, and puts Pennsylvania in the league of the top 25 emitting nations in the world.

Challenges often bring opportunities, and the challenge of reducing GHG emissions brings opportunities related to which states will benefit the most from the growth of the clean technology industries that will solve the climate change problem. According to a May 2006 Cleantech Capital Group Report, venture capitalists invested $1.6 billion in North American clean technology companies in 2005, an increase of 43% from 2004. The same Report forecasts that between 2006 and 2009, $6.2 billion to $8.8 billion in venture capital is likely to be invested in clean technology start up companies in North America. The Cleantech Report also found that 79% of clean technology venture capitalists surveyed said that current public policies are a prominent factor in their investment decisions. The authors of the Report concluded:

> *No state or region has a dominant position in any cleantech segment yet. And the global pool of cleantech venture capital is not a zero-sum game – promising companies will always attract new capital. But the seeds are being laid now to determine which state's companies will get the lion's share of investment, and which states will call the leaders of the cleantech industry their own. The states that can best woo entrepreneurs and investors now will have a chance to create self-perpetuating cleantech clusters that drive dynamic economic growth while also improving the environment...*[1]

By recognizing that a carbon-constrained world presents an economic opportunity, Pennsylvania can position itself to attract new investment dollars and new companies, allowing innovative existing companies, such as GE Transportation in Erie, PA, to grow, and attracting new companies, such as occurred recently with Gamesa and ConEnergy.

Pennsylvania is already a recognized leader in many of the technologies, policies, and practices needed to reduce GHG emissions. Pennsylvania can be proud of its accomplishments in many areas: "green" buildings, windpower, recovery of landfill methane, sustainable management of

[1] P. Burtis et al., *Creating Cleantech Clusters: 2006 Update*, E2/Cleantech Venture Network, http://www.e2.org/ext/doc/2006%20National%20Cleantech%20FORMATTED%20FINAL.pdf.

forests, and commitments to cleaner vehicles and fuels, to name a few. Furthermore, Governor Rendell joined sixteen other governors in endorsing the '25x'25" vision:[2]

> *By 2025, America's farms, forests and ranches will provide 25 percent of the total energy consumed in the United States, while continuing to produce safe, abundant, and affordable food, feed and fiber.*

The Governor has also proposed an Energy Independence Strategy and announced his intention to unveil a climate change strategy in the summer of 2007. Building on its accomplishments to date, Pennsylvania can adopt a climate change strategy that puts it at the forefront of state leadership and spurs economic development in the clean technology area. Pennsylvania's strategy, and the policies and actions that flow from it, in turn, can help shape those of the United States, and those of other nations. This report can inform that strategy.

Recognizing the important role the Commonwealth can play in addressing climate change, the Pennsylvania Environmental Council (PEC) launched the Pennsylvania Climate Roadmap project (hereafter, the *Roadmap*). The aim of the project was to produce:

- An inventory and forecast of the Commonwealth's GHG emissions.
- Policy recommendations for reducing Pennsylvania's those emissions.
- Appropriate emission goals or targets for Pennsylvania, and a near-term strategy for pursuing them.

PEC gathered a stakeholder group to advise the project, and convened that group five times in meetings and conference calls. The Council also reached out to individuals in business, environmental groups, academia, and government to gather data and recommendations. The *Roadmap* is also informed by a second related project that PEC began after the launch of the *Roadmap*: the Carbon Management Advisory Group (CMAG), a collaboration with the Pennsylvania Department of Conservation and Natural Resources.[3] Chapter 1 provides a more detailed treatment of the motivation for, and implementation of, the *Roadmap* project.

In brief, the *Roadmap* presents a "base case" scenario reflecting current policies, Pennsylvania's GHG emissions are projected to grow in the coming years at roughly 10% per decade. However, Pennsylvania could lower and ultimately reverse this growth if it joins other states in setting goals for reducing GHG emissions, and adopting the necessary supporting policies. The policies should address every sector of the economy: industry, buildings, transportation, agriculture, forestry, etc. The policies should also be designed to achieve multiple goals: lower GHG emissions, energy independence, cleaner air and water for Pennsylvania, economic development and job creation. Table ES-1 below lists the policies recommended in the *Roadmap*, all of which are expanded on below in this Executive Summary and in the chapters that follow.

Estimates of the GHG impacts of these policies indicate that they could support a goal of reducing Pennsylvania's emissions to 25 percent below 2000 levels by the year 2025 (See Table ES-3 and accompanying discussion at the end of the Executive Summary). Within the

[2] See: www.25x25.org/storage/25x25/documents/Pennsylvania.pdf and, generally, www.25x25.org.
[3] See: http://www.dcnr.state.pa.us/info/carbon/.

recommended economy-wide approach to reducing GHG emissions, five outcomes would be critical to meeting this goal:

- Holding electricity demand in 2025 equal to current levels by applying an aggressive portfolio of energy efficiency policies.
- Strengthening Pennsylvania's Alternative Energy Portfolio Standard (AEPS) with a target of 25% alternative sources and a requirement that non-renewable AEPS sources be carbon-neutral by 2025, in keeping with spirit of the 25x'25 vision.
- Increasing renewable transportation fuels to supply 25 percent of the Commonwealth's needs, consistent with the 25x'25 vision.
- Implementation of a national cap-and-trade system that would achieve significant reductions from some of Pennsylvania's existing power plants and industrial plants that burn fossil fuels.
- Achieving the full commercialization of geological sequestration of GHG emissions by no later than 2025.

All five outcomes would require: visionary action by the Governor and the General Assembly; a mobilization of players in the private, public, and non-profit sectors; as well as federal action. All five represent a challenging call to the energy and transportation sectors in particular to begin the process of "de-carbonizing" Pennsylvania's economy. This process must continue in the coming decades. The *Roadmap* recommends a long-term emissions reduction goal for the Commonwealth that is based on the level of global reductions leading climate scientists recommend in order to stabilize GHG concentrations. A 2050 goal of an 80% reduction from current levels would be appropriate and similar to the long-term goals of other leading states.

These 2025 and 2050 goals would be line with the goals set by other leading states, and also with the position taken by the U.S. Climate Action Partnership, a group of influential businesses and national environmental groups.

The sections below present, in summary form, the inventory and forecast, the policy recommendations, and the GHG goals and strategy.

Table ES-1. Pennsylvania Climate Roadmap: Policy Recommendations

Energy Supply
Expand the AEPS to 25% by 2025 and Require Tier 2 Non-Renewables to Be Carbon-Neutral
Add a Dedicated "Tier 3" Energy Efficiency Component to AEPS
Create a Public Benefit Fund for Electric Utilities
Implement a Portfolio of Energy Efficiency Policies to Complement AEPS Tier 3
Enact New and Updated Energy Efficiency Standards for Electrical Equipment and Appliances
Reduce CH_4 and other GHG from Coal/Oil/Gas Operations
Residential/Commercial/Industrial (RCI)
Create a Public Benefit Fund for Natural Gas Utilities
Enact New and Updated Efficiency Standards for Natural Gas Equipment
Create Incentives for Efficient Building Design
Encourage Upgrades/Retrofits of Existing Residential and Commercial Buildings
Expand Use of Biomass Energy
Use Biofuel In Heating Oil
Promote Power Generation Using Methane from Wastewater Facilities
Provide Better Energy Efficiency and GHG Information to Consumers
Transportation and Land Use
Establish Renewable Fuel Standard of 25% by 2025
Expand Alternative Fuels Incentive Grant Program
Adopt Fuel Efficiency Standards for Replacement Tires
Pilot a Program of Nitrogen-Inflated Tires on Fleet Vehicles
Implement Smart Growth and Smart Transportation Initiatives of the Pennsylvania Transportation Funding and Reform Commission
Promote Smart Growth Development of Communities
Expand Incentives for Alternatives to Single Occupancy Vehicles
Encourage "Pay-As-You-Drive" (PAYD) Insurance
Ban Idling by Heavy-Duty Vehicles
Increase Use of Intermodal Freight Transportation
Agriculture
Promote Carbon Sequestration in Soil
Promote Consumption of Locally Grown Agricultural Products
Promote Improved and Integrated Animal Waste Management Systems
Forestry
Protect, Restore, and Regenerate Existing Forests
Establish New Forests
Enhance Use and Lifetime of Durable Wood Products
Geological Sequestration
Develop Protocols for Siting and Sequestration
Develop Pilot Projects to Demonstrate Geologic Sequestration
Cross-Cutting Issues
Shape National, Economy-Wide Cap-and-Trade Legislation, Likely to Become Law
Actively Shape the National "Climate Registry" and Help Establish a National Reporting System for Emissions
Pursue the Integration of Federal, State, and Local Efforts on Climate Change
Conduct a Broad Awareness and Training Program on Climate Change

GHG Inventory and Forecast

In 2006, PEC asked the Center for Climate Strategies (CCS) to prepare a draft inventory and forecast of Pennsylvania's GHG emissions covering the period 1990 to 2025. After stakeholder input and updating, a final analysis was completed in early 2007. Chapter 2 presents details on assumptions and methodology. The inventory and forecast covers the six types of gases included in the US Greenhouse Gas Inventory: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). Emissions of these greenhouse gases are presented using a common metric, CO_2 equivalence (CO_2e), which indicates the relative contribution of each gas to global average radiative forcing on a Global Warming Potential (GWP) weighted basis.

Table ES-2 below summarizes the results. The table shows *net* emissions growing from 291 million metric tons of carbon dioxide equivalent ($MMTCO_2e$) in 1990 to 369 $MMTCO_2e$ in 2025, using a "production basis" perspective that includes emissions associated with electricity exports. As presented in the table, *net* emissions are calculated as: *gross* emissions (representing the total amount of emissions released by Pennsylvania sources into the atmosphere) minus those emissions that are absorbed (or sequestered) in Pennsylvania, specifically by forests and soils. The table also presents a "consumption basis" perspective that adjusts emissions from the electricity sector by subtracting emissions associated with electricity exports. This can be a useful perspective when one wants to focus on emissions associated with Pennsylvania's *consumption* of electricity. Finally, the bottom of Table ES-2 notes a key change from the 2006 draft to this final version. The updating of forecasts for 2010 and beyond reflects the recent increases in natural gas prices which affect the mix of forecasted coal- versus natural gas-based power generation. The final forecast contains relatively more coal power and, hence, more GHG emissions (e.g., the forecast for the electricity sector increased from 140 to 152 $MMTCO_2e$ for the year 2020). The final forecast also extended the projections to 2025.

The forecast is a "base case" forecast: it aims to give a plausible view of the trajectory of future emissions given policies already adopted or implemented as of 2007. However, PEC considered it useful to be able to gauge the impact of two significant policies adopted recently: the Advanced Energy Policy Standard and the Clean Vehicle Program. Therefore, the base case forecast does not include the effects of these two policies (see Table ES-2 below for an illustration of how they affect the forecast).

Table ES-2. Pennsylvania GHG Emissions – Inventory and Forecast, 1990-2025
(Million Metric Tons CO_2e)

Production Basis (includes electricity exports)

	1990	2000	2010	2020	2025	Notes
Electricity Production	**104**	**118**	**133**	**152**	**161**	From coal, natural gas, and oil
Residential/Commercial/ Industrial (RCI)	**96**	**85**	**79**	**74**	**70**	From combustion of coal, natural gas, & oil (excludes fossil fuel production)
Transportation and Land Use	**62**	**73**	**81**	**96**	**103**	From gasoline, diesel, natural gas, LPG, jet fuel, other
Fossil Fuel Industry	**19**	**19**	**19**	**19**	**19**	From oil and gas production, and coal mining (methane)
Industrial Processes	**5**	**9**	**13**	**18**	**21**	From HFCs, PFCs, SF_6, cement, and other industries
Waste Management	**12**	**6**	**4**	**3**	**3**	From solid waste and wastewater management
Agriculture	**7**	**7**	**6**	**6**	**6**	From manure management, enteric fermentation, & agricultural soils (N_2O)
Gross Emissions (Production)	**305**	**317**	**335**	**367**	**383**	
Forestry	**-14**	**-14**	**-14**	**-14**	**-14**	From terrestrial sequestration
Net Emissions (Production)	**291**	**302**	**320**	**353**	**369**	

Consumption Basis (excludes electricity exports)

	1990	2000	2010	2020	2025	Notes
Gross Emissions (Production)	**305**	**317**	**335**	**367**	**384**	
Adjustment for electricity exports	*-27*	*-32*	*-34*	*-38*	*-40*	To reflect "consumption" in PA
Gross Emissions (Consumption)	**278**	**285**	**301**	**329**	**344**	
Forestry	**-14**	**-14**	**-14**	**-14**	**-14**	
Net Emissions (Consumption)	**264**	**270**	**287**	**315**	**330**	

Key Elements of Previous Inventory and Forecast (prepared in 2006)

	1990	2000	2010	2020	Notes
Electricity Production	**104**	**118**	**128**	**140**	2010 & 2020 were lower due to lower natural gas price in 2006 forecast. 2025 forecast was N/A. 2020 estimate excluding exports was 101 $MMTCO_2e$.
Gross Emissions (Production)	**305**	**317**	**329**	**355**	
Forestry	**-14**	**-14**	**-14**	**-14**	
Net Emissions (Production)	**291**	**303**	**315**	**341**	

Policy Recommendations

In developing policy recommendations for reducing GHG emissions, PEC examined options that are feasible now as well options that are likely to be feasible in the 2025 timeframe. This allowed for consideration of options involving technologies or processes that may not be fully commercialized now but are promising and carry a strong probability of being available in that time horizon. Many options are likely to create a net savings to the Commonwealth's economy, but others are likely to impose costs. Each chapter contains discussions on what could be expected in terms of costs and other impacts associated with various options.

As noted earlier, PEC has incorporated all the options under consideration in the CMAG process. PEC has also incorporated many of the proposals put forth by Governor Rendell in his Energy Independence Strategy, announced in February 2007. Finally, the *Roadmap* recommendations aim to make a major contribution to the national 25x'25 vision by setting ambitious targets for renewable power, biofuels, and energy efficiency in Pennsylvania.

The sections below summarize the *Roadmap's* policy recommendations. Chapters 3 through 9 present greater detail on these policy recommendations for reducing Pennsylvania's greenhouse gas emissions from various sectors of the economy.

Energy Supply

Recommendations in this sector address electricity production and the fossil fuel industry. To gauge the impact of recent policy changes, PEC first estimated the impact of the Alternative Energy Portfolio Standard (AEPS). Tier 1 of AEPS requires of 8% renewable generation as a percentage of sales in Pennsylvania, and 10% generation by other alternative sources by roughly 2020. The existing AEPS is estimated to reduce emissions from the power sector by 7 MMTCO2e in 2025. *Roadmap* policy recommendations are as follows:

- **Strengthen the AEPS to 25% by 2025 and require both Tier 1 and Tier 2 energy sources to be "carbon-neutral."** Tier 1 of AEPS should increase to 15%, and non-renewable Tier 2 sources should become carbon-neutral by 2025 via geologic sequestration and/or offset purchases.
- **Add a dedicated "Tier 3" energy efficiency component to the AEPS.**
- **Create a Public Benefit Fund to finance energy efficiency investments.**
- **Implement a portfolio of energy efficiency policies that complement the AEPS Tier 3.** Apply a portfolio of energy efficiency measures with the aim of holding total electricity demand in 2025 equal to current levels. The portfolio would include many of the Governor's proposed energy efficiency policies in his Energy Independence Strategy, along with strengthened appliance efficiency standards, decoupling of utility profits from sales volumes, and others.
- **Enact new and updated energy efficiency standards for selected electrical equipment and appliances.**
- **Expand efforts to reduce methane and other GHG emissions from coal mining and oil and gas production.** Pennsylvania currently emits about 19 $MMTCO_2e$ in the mining of coal

and extraction of oil and gas. There is significant potential to reduce these emissions, but time and resource constraints did not allow the *Roadmap* project to develop and quantify options in this area.

Chapter 3 describes all these policy options in detail.

Residential, Commercial, and Industrial (RCI)

Recommendations in this sector address fuel use in the three customer classes above, along with GHG emissions from various industrial processes and waste management. The energy efficiency portfolio described above would have a substantial impact on the electricity demand from these three sectors and, therefore, this forecasted impact is captured in the Energy Supply sector. In addition, emissions in the RCI sector can be reduced by:

- **Create a Public Benefit Fund for natural gas utilities.** Such funds are used in some other states to fund efficiency improvements in the use of natural gas. Pennsylvania could institute them among its gas utilities.

- **Enact new and updated energy efficiency standards for selected natural gas equipment and appliances.**

- **Create incentives for more efficient, environmentally friendly building design.**

- **Encourage upgrades/retrofits of existing residential and commercial buildings.**

- **Expand use of biomass energy.** Pennsylvania has ample supplies of wood and other biomass that can used to make and heat and power. Expanded use in power generation is captured in the expand AEPS Tier 1 above. Pure heating applications could also reduce GHG emissions.

- **Use biofuel in heating oil.** Biomass-derived fuels can be used in transportation and can also supplement heating oil. Pennsylvania could achieve a 5 percent goal in substituting biofuel for conventional heating oil.

- **Promote use of small-scale power generation using methane from wastewater facilities.**

- **Make better information available to consumers regarding their GHG emissions and the availability of energy efficient products and services.**

Chapter 4 describes these and other policy options that could apply to various industrial processes and waste management.

Transportation and Land Use

Recommendations in this sector address vehicle technology, fuels, and demand for transportation, including land use policies that affect that demand. The impact of the Clean

Vehicle Program already adopted by the state in 2006 is estimated to reduce GHG emissions from new light-duty vehicles by 14 $MMTCO_2e$ in 2025. *Roadmap* policy recommendations for transportation are as follows:

- **Establish a renewable fuel standard for 2025 with a requirement of displacing 25% of conventional fuels with lower-carbon renewable fuels, consistent with the 25 x '25 vision.** Decrease the use corn and other food crops as feedstocks and spur the transition to cellulosic ethanol production and other production methods that put less pressure on food supplies and land.

- **Expand the Alternative Fuels Incentive Grant Program to further increase use of hybrids and alternative fuels.**

- **Adopt fuel efficiency standards for replacement tires.** New cars are already equipped with low rolling resistance new tires that achieve higher fuel efficiency than typical replacement tires. Appropriate tire standards can put a floor on the fuel efficiency characteristics of those tires.

- **Pilot a program of using nitrogen to inflate tires on fleet vehicles.** Existing research indicates that tires filled with pure nitrogen maintain tire pressure 2 to 3 times longer than air, resulting in fuel efficiency gains, better traction, and longer tire life.

- **Implement the Smart Growth and Smart Transportation Initiatives recommended by the Pennsylvania Transportation Funding and Reform Commission.** The Pennsylvania Transportation Funding and Reform Commission made a number of recommendations that, if implemented, could reduce vehicle miles traveled (VMT) and related GHG emissions. These should be implemented with some modifications designed to improve their efficacy in reducing GHG emissions.

- **Promote more strongly the "smart growth" development of communities across the Commonwealth.**

- **Expand incentives for transportation options other than single occupancy vehicles.**

- **Encourage "Pay-As-You-Drive" (PAYD) insurance**. Pennsylvania could pilot and promote PAYD, which changes part of vehicle insurance payments from fixed charges to per-mile charges while not changing payments.

- **Implement a statewide ordinance banning idling by heavy-duty vehicles.** Model ordinances aim to save fuel, reduce GHG emissions and other pollutants, while allowing for idling when absolutely needed. Pennsylvania should also continue expanding truck stop electrification stations at key truck stops and truck rest areas.

- **Increase use of intermodal freight**. Strategically working with freight lines and major customers, Pennsylvania can encourage greater use of intermodal freight and expand terminals that allow efficient delivery to multiple locations.

Chapter 5 describes these and other policy options that could substantially reduce emissions from the transportation sector.

Agriculture

Recommendations in this sector address farming practices. Pennsylvania's Chesapeake Bay Tributary Strategy includes a number of Best Management Practices (BMPs) that will reduce GHG emissions in this sector and increase carbon sequestration. The Commonwealth can promote these BMPs and more as described below.

- **Promote agricultural practices that increase carbon sequestration in soils.** Pennsylvania's Rodale Institute has been a pioneer in this area.

- **Promote consumption of locally grown agricultural products.** Expanding these markets will reduce fuel use.

- **Promote improved and integrated animal waste management systems** that capture the energy potential associated with the waste and reduce nutrient loadings to water bodies.

Chapter 6 describes these policy options in greater detail.

Forestry

Recommendations in this sector address forestry and land use policies that affect the levels of terrestrial sequestration on Pennsylvania's lands.

- **Protect the forestland base, and restore and regenerate existing forests.** Through land acquisition and other means, Pennsylvania can reduce loss of forestlands and their associated carbon stocks and sequestration potential as a result of development or other types of land use and land cover change. Encouraging regeneration of existing forests through stocking/planting and restoration practices (e.g., soil preparation, erosion control, etc.) can increase carbon stocks above baseline levels and ensure conditions that support forest growth, particularly after intense disturbances.

- **Establish new forests.** Establishing new forests can increase the amount of carbon in biomass and soils compared to pre-existing conditions. Afforestation of abandoned mine lands offers a prime opportunity.

- **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.

Chapter 7 describes these and other policy options, giving a full description of policies that are under consideration in DCNR's Carbon Management Advisory Group, which will make formal and final recommendations later in 2007.

Geologic Sequestration

Recommendations in this chapter address the goal of enabling the Commonwealth to sequester CO_2 emissions in underground reservoirs.

- **Develop protocols for siting and operating geologic sequestration projects in Pennsylvania**. Such protocols should rely on *inter alia*: improved databases on potential sites and pipeline infrastructure, careful geologic assessments and site evaluations, a sophisticated geographic information system (GIS) to aid decision-making, and a comprehensive risk assessment that informs the necessary legal and regulatory framework to govern sequestration activities.
- **Develop pilot projects to demonstrate geologic sequestration in Pennsylvania.** Western Pennsylvania provides a variety of attractive sites that could test multiple types of reservoirs with large CO_2 emission sources close by, and a pilot in conjunction with coalbed methane production in the northeastern Pennsylvania would also generate valuable experience.

Chapter 8 describes these policy options in more detail. They are also under consideration by DCNR's Carbon Management Advisory Group.

Cross-Cutting Issues

Recommendations in this sector address a series of issues that cut across all sectors of the economy. The key recommendation here would affect the future of Pennsylvania's existing coal-fired power plants. Even if all of the policy recommendations above are implemented, the absence of any policies constraining CO_2 emissions from existing fossil fuels plants would mean those plants (largely coal-fired) would probably continue to emit over 100 $MMTCO_2e$, as they do now. There are options now to reduce their emissions ranging from efficiency improvements to co-firing with biomass; and, when geologic sequestration is commercialized, large reductions in their emissions will be feasible.

The costs associated with large reductions from existing fossil fuel plants are likely to be substantial. Furthermore, the costs are also likely to be highly variable among plants, due to differences in plant size, age, and fuel source, along with differences such as availability of biomass (affecting the cost of a co-firing option) or the distance to a underground injection site (affecting the cost of geologic sequestration).[4] The costs are also likely to be of a magnitude that Pennsylvania would be wary of incurring unilaterally. If Pennsylvania chose to decrease GHG emissions from its power sector by substantially increasing the cost of a large portion of those power supplies, the net effect might be what is sometimes referred to as "leakage." GHG emissions might "leak" to other states either by the migration of economic activity and jobs (if

[4] There will be other options, of course, including rebuilding or replacing the plants as lower-GHG or no-GHG power plants.

power becomes too expensive in the Commonwealth) and/or by reductions in power generation here and increased power imports from other states. Concerns such as these have led states to proposed regional approaches to limiting power sector emissions or large point-source emissions in general.

Given the variation in GHG control costs among plants and the issue of "leakage" for a state acting alone, the most appropriate policy approach is a "cap-and-trade" policy at a regional or national level. This is indeed is what is contemplated under the Regional Greenhouse Gas Initiative (RGGI[5]) Northeast states and the recently announced Western Regional Climate Action Initiative.[6] Momentum for national cap-and-trade legislation is also building, and many observers consider enactment of some form of cap-and-trade inevitable within five years. For very good reasons, Pennsylvania has observed but not joined the RGGI program as currently designed. Given this backdrop, Pennsylvania should become a much more active player in shaping the debate in Congress over national legislation.

- **Pennsylvania should act early and aggressively to shape the national, economy-wide cap-and-trade legislation that has emerged as the main pillar of the likely federal response to climate change**

By 2025, a well-designed national cap-and-trade program should be able to reduce several tens of $MMTCO_2e$ from Pennsylvania's fossil fuel power plants at an acceptable cost. However, costs would be likely lower and the burden spread more broadly if that cap-and-trade system includes other large point sources of GHG emissions. Chapter 9 describes this and other cross-cutting policy options and issues.

- **Pennsylvania actively shape the new national Climate Registry.**

The Climate Registry merges several state and regional efforts to establish a truly national system aimed at developing and managing a common greenhouse gas emissions reporting system. It will be capable of supporting various greenhouse gas emission reporting and reduction policies for its member states and tribes and reporting entities. It will provide an accurate, complete, consistent, transparent and verified set of greenhouse gas emissions data from reporting entities, supported by a robust accounting and verification infrastructure.

- **Pennsylvania should pursue the integration of federal, state, and local efforts at reducing GHG emissions.**

The Commonwealth should help develop, promote, and enact a comprehensive federal climate policy framework that applies the principle of federalism and designates specific roles for state and local government. Pennsylvania should lead and demonstrate the principle of federalism by consulting with the Commonwealth's local governments and designating specific roles for them in climate mitigation.

[5] *See* www.rggi.org.
[6] *See* www.climatechange.ca.gov/documents/2007-02-26_WesternClimateAgreementFinal.pdf.

- **Establish a climate change program that provides general training and conducts an awareness campaign.**

- **Create a *Climate Council*.**

To build on the *Roadmap*, the Governor should appoint a *Climate Council*, or similar blue-ribbon panel, as he has on other critical issues. The panel should have the right members and the needed resources to advise the Govenor on setting official state goals on climate change on design and implementation of policies needed to meet those goals.

Chapter 9 describes these policy options in more detail.

Long-Term Goals

Chapter 10 presents recommendations on goals for GHG reductions that Pennsylvania should adopt, and a near-term roadmap of actions that Pennsylvania should take in the next several years. The *Roadmap's* goals are:

- Set a GHG emissions goal for Pennsylvania for the mid-term (2025) that is based on analysis of available policies, practices and technologies (that are commercial or are likely to be commercialized by that date), their impacts on GHG emissions, and other impacts. A 2025 goal of reducing emissions to 25% below 2000 levels appears feasible given the reductions analyzed in the *Roadmap*, and would be line with the goals set by other leading states.[7] One or more intermediate goals could be set between now and 2025.
- Set a GHG emission reduction goal for Pennsylvania for the long-term. The long-term goal should be based on the level of global reductions that leading climate scientists recommend in order to stabilize GHG concentrations. A 2050 goal of an 80% reduction from current levels would be appropriate and, again, similar to the long-term goals of other leading states.

These 2025 and 2050 goals would also be line with the position taken by the U.S. Climate Action Partnership, a group of businesses and national environmental groups.[8] The Partnership advocates emission reductions at the national level of 10 to 30 percent below current levels in a 15-year timeframe, and 60 to 80 percent reductions by 2050. The European Union has endorsed reductions of similar magnitude: a 20 percent reduction below 1990 levels by 2020 (along with a goal of 20 percent of the EU's electricity coming from renewable sources).[9]

Table ES-3 presents *Roadmap* policy recommendations that have been quantified in terms of their potential impact on Pennsylvania's forecasted emissions in 2025. The analysis presented here indicates that a 2025 goal of reducing emissions to 25% below 2000 levels is feasible. The quantified options across all sectors are estimated to be capable of reducing emissions by 105 $MMTCO_2e$. An additional 39 $MMTCO_2e$ could be achieved through a combination of a national cap-and-trade system and other options not specifically identified or quantified in the table. As

[7] See Chapter 10 for a table of mid-term and long-term goals set by other states.

[8] See www.us-cap.org. Membership includes including Alcoa, Duke Energy, DuPont, General Motors, Johnson & Johnson, and Siemens, Environment Defense, Natural Resources Defense Council, World Resources Institute and others.

[9] *EU Leaders Agree to Cut Greenhouse Gases*, Associated Press, March 9, 2007.

the table illustrates, this portfolio of policies, affecting nearly all sectors of the economy, could lead to 144 $MMTCO_2e$ in reductions from the 2025 base case forecast of 369 $MMTCO_2e$, bringing emissions down to a level of 227 $MMTCO_2e$ (25% below 2000 levels of 302 $MMTCO_2e$.)

Table ES-3. Pennsylvania Climate Roadmap:
Quantified Policy Recommendations and Estimated GHG Impacts in 2025
(Million Metric Tons CO_2e)

	2025 Base Case	GHG Impact	2025 Roadmap Case	Notes
Electricity Production	**161**	**-55***	**106**	
Current AEPS Tier 1		-7		Adopted in 2004
Strengthened AEPS		-18		
Energy Efficiency Portfolio – Electricity[#]		-32		
Residential/Commercial/Industrial (RCI)	**70**	**-4***	**66**	
Expanded Wood/Biomass Energy		-1		For process heat (not electricity)
B5 Bioheat Initiative		-0.4		
Energy Efficiency Portfolio – Gas[##]		-3		
Transportation and Land Use	**103**	**-31***	**73**	
Clean Vehicles Program		-14		Adopted in 2006
Fuel Efficient Tires		-1		
25% Biofuels		-12		
Mass Transit / Smart Growth[###]		-6		
Anti-Idling Program		-0.1		
Fossil Fuel Production	**19**		**19**	Climate Council should develop and
Industrial Processes	**21**		**21**	quantify policy options in all four
Waste Management	**3**		**3**	of these areas. Soil sequestration
Agriculture	**7**		**7**	is quantified below.
Gross Emissions	**385**		**295**	
Agriculture – Sequestration	****	**-11**	**-11**	
BMPs for Soil Sequestration		-11		
Forestry - Sequestration	**-14**	**-4**	**-18**	
AML Afforestation		-1		
Forest Protection Initiative		-3		
Total Increase in Sequestration			**-29**	
Net Emissions	**371**		**266**	
Cross-Cutting Policies				
Cap-and-Trade for Large Point Sources		-39	**-39**	From cap-and-trade or other measures
Net Emissions With Cap-and-Trade	**371**		**227**	Target of 25% reduction below 2000 net emissions of 302 MMT = 227 MMT

* Due to overlapping effects, the combined effect of various options is less than a simple summation of individual impacts.

** No estimate is available on "base case" soil sequestration.

[#] Consists of AEPS Tier 3 for energy efficiency, System Benefits Fund (SBF), appliance standards, and other energy efficiency policies described in Chapter 3.

[##] Consists of SBF for natural gas utilities, appliance standards, encouragement of upgrades/retrofits of existing residential and commercial buildings, and other energy efficiency policies described in Chapter 4.

[###] Consists of Smart Growth, transit support, and other demand-related policies in Chapter 5.

Near-Term Agenda

Some of the recommendations in the *Roadmap* will require years, indeed decades, of patient work and must become part of bi-partisan agenda that has staying power regardless of the ebb and flow of political power among parties. Some key near-term agenda items are outlined below.

- Create the *Climate Council* (blue-ribbon panel of stakeholders and experts) to help set official state goals on climate change and advise the Governor on design and implementation of policies needed to meet those goals. Draw from this *Roadmap* and the ideas of other stakeholders, and build a bi-partisan climate change strategy.
- Recognizing the current and future reliance on coal in Pennsylvania, work aggressively with all stakeholders to pursue the full commercialization of geological sequestration of GHG emissions by no later than 2025. In pursuit of this goal:
    - Build all necessary and appropriate legal and regulatory frameworks to govern geologic sequestration in Pennsylvania.
    - Form a public-private consortium to conduct pilot projects testing geologic sequestration and pursue all options for cost-sharing with the federal government and the private sector.
- Help develop, promote, and enact an efficient and equitable cap-and-trade program for large point sources at the national level. This will require outreach to, and collaboration with, other Governors, the Pennsylvania Congressional delegation, and others.
- Pursue the integration of federal, state, and local efforts at reducing GHG emissions.
    - Help develop, promote, and enact a comprehensive federal climate policy framework that applies the principle of federalism and designates specific roles for state and local government.
    - Demonstrate the principle of federalism in Pennsylvania by creating incentives for specific actions related to climate mitigation by the Commonwealth's local governments.

Conclusion

The *Roadmap* lays out an ambitious agenda for making Pennsylvania a leader in meeting the challenge of climate change. That agenda should also help the Commonwealth build on its recent successes in attracting new investment, industries, and jobs related to clean technology. The time to act is now.

Acknowledgments

The Pennsylvania Environmental Council gratefully acknowledges help of the Center for Climate Strategies and the following individuals who contributed significantly to the success of this project: Steve Anderson, John Dernbach, Robert McKinstry, Marianne Tyrrell, and Jamie Tyrrell.

PEC also recognizes and appreciates the many individuals who participated as stakeholders in the project.

Finally, PEC would like thank the donor organizations that provided the financial support to this project: the Energy Foundation, the Heinz Endowments, and the Emily Hall Tremaine Foundation.

Preface

Thirty-nine years ago the astronauts of Apollo 8 gave us a new perspective on the Earth and one of the most memorable photographs ever taken. Called "Earthrise," the photo shows the Earth as a bright blue and white ball against the stark, black void of space with the grey moon in the foreground. It vividly illustrates how dependent all life is on a healthy environment, because just beyond our atmosphere there is nothing that sustains life.

It was no coincidence that Americans celebrated the first Earth Day less than two years later. Today it's time for a new Earth Day to tackle a problem that is truly global in scale — climate change.

The debate is over, science has spoken. Climate change will affect the crops we raise, how much rain we get, the kinds of forests and wildlife we have, the amount of energy we use, and how we develop our land. Now, as the third largest emitting state in the nation, Pennsylvania must show leadership in solving this problem.

This report represents the views of the Pennsylvania Environment Council. PEC convened a diverse group of stakeholders representing business, agriculture, energy generation, and environmental interests to help create a Climate Change Roadmap for our state. Although all stakeholders do not necessarily agree with every statement or conclusion in this report, their views, input, and analysis helped us shape the final recommendations. We benefited enormously from their involvement.

The final product, the Roadmap, shows the way to solutions and opportunities to address climate change in ways that work for Pennsylvania.

Brian Hill
President
Pennsylvania Environmental Council
June 2007

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Chapter 1
Background and Introduction

Recognizing the profound implications that climate change could have on the Commonwealth's economy, environment, and quality of life, the Pennsylvania Environmental Council (PEC) launched the Climate Change Roadmap project (hereafter, the *Roadmap*). Reducing the risks of climate change requires that, in the coming decades, we make significant cuts in emissions of greenhouse gases (GHGs) on a global scale. No state (and indeed no nation) can solve this problem on its own, but Pennsylvania can play an important role in addressing climate change—the most challenging environmental issue of our time. Addressing this issue is also essential to the long-term economic and geopolitical stability of the nation.

The aim of the *Roadmap* is to produce:

- An inventory and forecast of the Commonwealth's GHG emissions.
- Policy recommendations for reducing those emissions.
- Appropriate emission goals or targets for Pennsylvania and a near-term strategy for pursuing them.

This report is the outcome of that effort, one that involved a distinguished group of stakeholders, the Center for Climate Strategies (CCS), and several state agencies. This chapter introduces the Roadmap and provides some background information.

Climate Change Science, Impacts, and Policy

The scientific consensus on the issue of climate change is embodied in reports issued by the Intergovernmental Panel on Climate Change (IPCC) and the National Academy of Sciences.[1] The IPCC was established jointly by the World Meteorological Organization and the United Nations Environment Programme (UNEP). More than 2,500 scientific experts from 130 countries—including the United States—participate in this effort to provide the world with a clear and objective view of the present scientific understanding of climate change.

Beginning in early 2007 and stretching into November, the IPCC is releasing a series of important reports on climate change that represent its latest work (the Fourth Assessment). The release in February was a report on the Physical Science Basis of climate change. In that report, the IPCC concluded, for the first time, that global warming is "unequivocal" and that human activity is the main driver.

The second report, released in April, was on Impacts, Adaptation, and Vulnerability. It was an assessment of the harmful effects of global warming on daily life—those that are presently discernable and those that are likely to arrive in coming decades. Climate models indicate that global average temperatures could increase by 3 to 10 degrees Fahrenheit by the end of this

[1] *See*: www.ipcc.ch and http://dels.nas.edu/globalchange/.

century. The IPCC predicts that such a warming will result in rising sea levels, increased rainfall rates and heavy precipitation events (especially over the higher latitudes), and higher evaporation rates that would accelerate the drying of soils following rain events. With higher sea levels, coastal regions could face increased wind and flood damage, and some models predict an increase in the intensity of tropical storms. The reports warn that North America "has already experienced substantial ecosystem, social and cultural disruption from recent climate extremes," such as hurricanes and wildfires. It also predicts that ozone-related deaths from climate, now a small health risk, will turn into a substantial one.

The most recent assessment of impacts on Pennsylvania is contained in *Climate Change in the U.S. Northeast* authored by the Union of Concerned Scientists (October 2006).[2] For Pennsylvania and its Northeast neighbors, the report predicts higher average temperatures, more extreme heat days, less snow, more droughts, and more extreme precipitation events. In May, the IPCC released its third report on Mitigation of Climate Change, and the final Synthesis Report is due in November. These reports are all adding to the growing support for action on climate change.

The time has come for Pennsylvania, and the nation as a whole, to act decisively and provide the leadership needed to meet the challenge of climate change. Leading climate scientists recommend dramatic reductions in global greenhouse gas (GHG) emissions by 2050, and many states have set targets ranging from 50 to 80%. Such reductions are necessary to stabilize the level of GHGs in our atmosphere at between 450-550 parts per million (ppm). That level, which represents roughly a doubling over pre-industrial levels, will allow us to more reasonably manage the climate impacts that are already becoming apparent.

There is bipartisan support in Congress for strong federal legislation on climate change. Many states and cities already are showing strong leadership and taking effective actions. Twenty states, representing 150 million Americans, have developed, or are developing, comprehensive policies on climate change—policies that deliver major GHG reductions, along with economic savings, job growth, and other benefits. Economic analyses of state policies indicate they will generate billions of dollars in savings and tens of thousands of new jobs. Typically, states develop a portfolio of policies addressing all sectors of their economies, tailoring them to the unique features of each state. In addition, hundreds of mayors representing tens of millions of citizens are working to reduce significantly their cities' GHG emissions, while saving money and enhancing the quality of urban life.

The Roadmap Process

PEC gathered a stakeholder group to advise the project, and convened five stakeholder meetings as well as a conference call. The Council also reached out to individuals in business, environmental groups, academia, and government to gather data and recommendations. The *Roadmap* is also informed by a second related project launched by PEC after the *Roadmap*: the Carbon Management Advisory Group (CMAG), a collaboration with the Pennsylvania Department of Conservation and Natural Resources (DCNR).[3]

[2] *See* http://www.ucsusa.org/news/press_release/global-warming-will-alter.html.
[3] *See* http://www.dcnr.state.pa.us/info/carbon/.

This report represents the views of the Pennsylvania Environment Council. The *Roadmap* is not the product of a formal consensus-building process, thus all stakeholders do not necessarily agree with every statement or conclusion in this report. However, their views, input, and analysis helped PEC shape the final recommendations, and the *Roadmap* benefitted enormously from their involvement.

PEC strove to formulate policies for every sector of the economy: industry, buildings, transportation, agriculture, forestry, etc., and sought designs that could achieve multiple goals (e.g., decreased GHG emissions, energy independence, cleaner air and water for Pennsylvania, economic development, job creation, etc.).

PEC engaged CCS to prepare the inventory and forecast of GHG emissions.[4] A draft version received comment from stakeholders, and the final version appears in Chapter 2. CCS also prepared some analysis of various recommendations, focusing on their estimated impact on Pennsylvania's GHG emissions in 2025. The time and resources available for this project did not allow a complete analysis of GHG impacts or of economic costs.

The *Roadmap* chapters contain some illustrative cost numbers for some policy options drawn largely from the work of CCS in other states. These costs are expressed in terms of "cost-effectiveness" of reducing GHG emissions (i.e., dollars per ton of carbon dioxide (CO_2) equivalent). A positive number represents the estimated cost to Pennsylvania's economy; a negative number indicates that the Commonwealth would actually save money by implementing the option.[5]

There was no attempt in the *Roadmap* to do a traditional "benefit-cost" analysis of the recommendations. That approach would be inappropriate. PEC recognizes that no state (and indeed no nation) can solve this problem on its own. Any attempt to monetize the benefit of a single state's reduction in GHG emissions would produce a tiny number. Furthermore, benefit-cost analysis calls for discounting future benefits and costs to arrive at the net present value for a set of actions. While this methodology may be appropriate for some public policy issues and under some time horizons, the long-term nature of the effects of climate change mean that benefit-cost analysis would ascribe an inappropriately low value to the benefits to future generations resulting from climate mitigation undertaken now.[6]

PEC hopes that Pennsylvanians will see this *Roadmap* has an important step down the road to formulating our response to climate change, while recognizing much work remains to be done. PEC hopes Governor Rendell will convene a blue-ribbon *Climate Council*, as called for here; build on the foundation established in the *Roadmap*; and develop a deeper and broader climate change strategy for the Commonwealth.

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[4] *See* www.climatestrategies.us.

[5] The methodology underlying the work of CCS in this area are set forth in, for example, *CCS, Methods for Quantification of Draft GHG Mitigation Options Benefits and Costs*, available at http://www.ncclimatechange.us/ewebeditpro/items/O120F8528.pdf.

[6] For contrasting views on discount rates and climate change, compare The Stern Review, *After the Stern Review: reflections and responses, at* http://www.hm-treasury.gov.uk/media/C06/00/Paper_B.pdf with William Nordhaus, *The Stern Review on the Economics of Climate Change, at* http://nordhaus.econ.yale.edu/SternReviewD2.pdf.

Chapter 2
Inventory and Forecast of GHG Emissions

Introduction

As part of the PA Roadmap project, the Pennsylvania Environmental Council (PEC) prepared an inventory of Pennsylvania's greenhouse gas (GHG) emissions and a forecast of future emissions. PEC asked the Center for Climate Strategies (CCS) to prepare a draft for this purpose, entitled *Pennsylvania Greenhouse Gas Emissions Inventory and Reference Case Projections* (hereafter, the *Inventory and Projections.*[1]

This chapter presents a summary of the full study, *Inventory and Projections*, and includes the emission estimates (historical and projected) along with key methodological issues and uncertainties. These estimates are intended to assist the State and stakeholders' understanding of past, current, and possible future GHG emissions in Pennsylvania, and thereby inform the policymaking process.

Historical GHG emissions estimates (1990 through 2003) were developed using a set of generally-accepted principles and guidelines for State GHG emissions, relying to the extent possible on Pennsylvania-specific data and inputs.[2] The reference case projections out to 2025 are based on a compilation of various existing Pennsylvania and regional projections of electricity generation, fuel use, and other GHG emitting activities, along with a set of assumptions described later in this chapter.[3]

Inventory and Projections covers the six types of gases included in the US Greenhouse Gas Inventory: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). Emissions of these greenhouse gases are presented using a common metric, CO_2 equivalence (CO_2e), which indicates the relative contribution of each gas to global average radiative forcing on a Global Warming Potential (GWP) weighted basis.

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[1] This work builds on the previous work in A. Rose et al, *Greenhouse Gas Emissions Inventory for Pennsylvania*, Penn State University, June 2003, http://www.epa.gov/climatechange/emissions/downloads/inventory.pdf.

[2] The study generally follows the same approach to emissions accounting used by the US EPA in its national GHG emissions inventory (US EPA, Feb 2005. *Draft Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2003.* http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUSEmissionsInventory2005.html), and EPA's guidelines for states (http://yosemite.epa.gov/oar/globalwarming.nsf/content/EmissionsStateInventoryGuidance.html). These inventory guidelines were developed based on the guidelines from the Intergovernmental Panel on Climate Change, the international organization responsible for developing coordinated methods for national greenhouse gas inventories (http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.htm). The inventory methods provide flexibility to account for local conditions.

[3] The draft *Inventory and Projections* prepared in 2006 looked ahead to 2020, but the period of analysis was extended to 2025 in this final version.

Inventory and Reference Case Projections

The estimates below refer to Pennsylvania's *gross* emissions and *net* emissions. Gross emissions represent the total amount of emissions released by Pennsylvania into the atmosphere; net emissions deduct from this gross total those emissions that are absorbed (or sequestered) in Pennsylvania, specifically by forests and soils.

The inventory shows total *gross* emissions growing from 305.4 million metric tons of carbon dioxide equivalent ($MMtCO_2e$) in 1990 to 316.9 $MMtCO_2e$ in 2000, using a "production-based approach" described at the end of this section. Emissions are projected to increase to 383.2 $MMtCO_2e$ by 2025 (see Figure 2-1 and Table 2-1), based upon the assumptions set forth in the far right column in Table 2-1 and Table 2-3. Pennsylvania's gross emissions during the 1990s grew significantly slower than those of the nation as a whole (4% vs. 14%), but that difference is likely to narrow in the years ahead. The forecast indicates growth of near 10% over the period 2000 to 2020 in Pennsylvania.

Figure 2-1 Gross GHG Emissions by Sector, 1990-2025: Historical and Projected

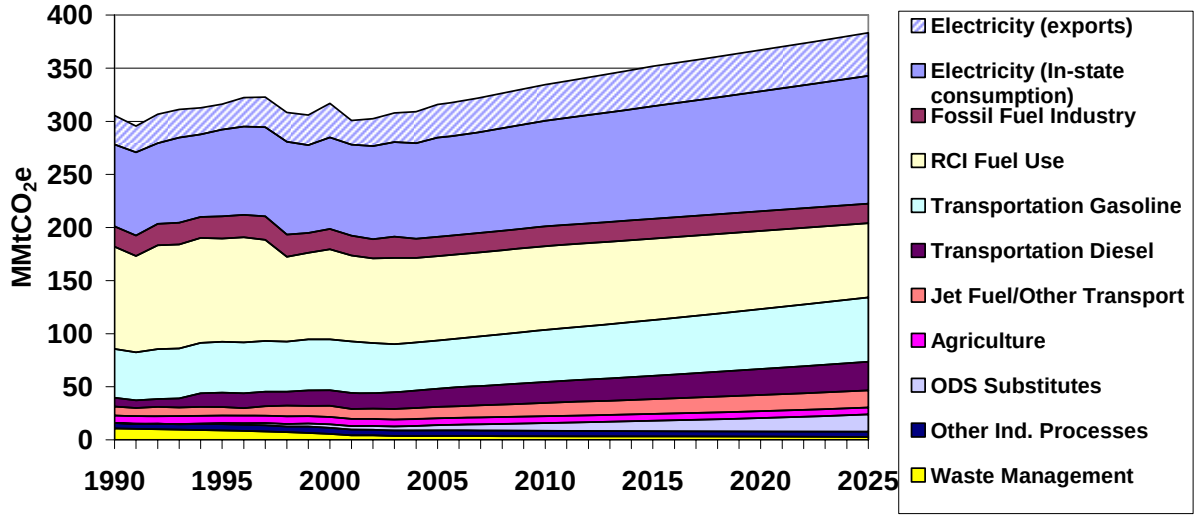


Table 2-1. GHG Emissions by Source: Historical and Projected, 1990-2025 ($MMtCO_2e$)
Production Basis (includes electricity exports)

Source	1990	2000	2010	2020	2025	Explanatory Notes
Electricity Production	**104.3**	**118.3**	**133.3**	**151.7**	**160.8**	
Coal	98.8	113.8	123.1	139.5	147.5	See electric sector assumptions in
Natural Gas	0.7	1.1	6.0	8.0	9.0	Table 2-4
Oil	4.8	3.4	4.2	4.2	4.2	
Res/Comm/Industrial (excl. fossil fuel industry)	**96.2**	**84.8**	**78.8**	**73.8**	**70.0**	
Coal	38.9	27.9	27.3	24.8	23.0	Based on US DOE regional projections
Natural Gas	33.0	34.9	31.8	31.1	30.5	Based on US DOE regional projections
Oil	24.2	21.8	19.5	17.6	16.3	Based on US DOE regional projections
Wood (CH_4 and N_2O)	0.2	0.2	0.2	0.2	0.1	Assumes no change after 2003
Transportation	**62.7**	**73.2**	**81.4**	**96.2**	**103.6**	
Gasoline	46.1	47.9	49.1	56.5	60.5	VMT from PennDOT, constant energy/VMT
Diesel	8.3	14.7	19.8	24.4	27.2	VMT from PennDOT, constant energy/VMT
Natural Gas, LPG, other	3.4	2.9	1.8	1.8	1.8	Based on US DOE regional projections
Jet Fuel & Aviation Gasoline	4.9	7.7	10.7	13.5	14.2	Based on US DOE regional projections
Fossil Fuel Industry	**19.1**	**19.0**	**18.7**	**18.5**	**18.5**	
Natural Gas Industry *	7.9	8.3	8.8	8.9	8.8	See footnote a
Oil Industry **	2.0	1.8	1.8	1.6	1.5	See footnote b
Coal Mining (CH_4)	9.2	9.0	8.1	8.1	8.1	Assumes no change after 2004
Industrial Processes	**5.1**	**9.0**	**12.5**	**17.5**	**21.1**	
ODS Substitutes	0.02	3.1	7.4	12.7	16.4	Based on national projections (State Dept.)
PFCs in Semi-conductor Industry	0.2	0.4	0.2	0.1	0.1	Based on national projections (US EPA)
SF_6 from Electric Utilities	1.2	0.6	0.5	0.3	0.2	Based on national projections (US EPA)
Cement & Other Industry	3.7	4.8	4.4	4.4	4.4	No changes projected
CO_2 Consumption						Not yet estimated
Waste Management	**10.8**	**5.6**	**3.5**	**3.1**	**2.9**	
Solid Waste Management	9.6	4.3	2.2	1.7	1.5	Based on national projections (State Dept.)
Wastewater Management	1.2	1.3	1.3	1.4	1.4	Increases with state population
Agriculture	**7.1**	**6.9**	**6.4**	**6.5**	**6.5**	
Manure Mgmt & Enteric Fermentation (CH_4)	3.7	3.4	3.4	3.4	3.5	Dairy emissions grow with population
Agricultural Soils (N_2O)	3.4	3.5	3.0	3.0	3.0	No changes projected after 2010
Total Gross Emissions	**305.4**	**316.9**	**334.6**	**367.2**	**383.2**	
Forestry and Land Use	**-14.4**	**-14.4**	**-14.4**	**-14.4**	**-14.4**	No changes projected
Total Net Emissions	**291.0**	**302.4**	**320.1**	**352.7**	**368.8**	

* 3% growth in production to 2010 then no change to 2020, T&D emissions increase with natural gas demand.

** 3% growth in production to 2010, then no change to 2020, energy consumption at refineries declines based on US DOE regional projections.

Pennsylvania GHG emissions mirror those of the nation in many ways. The Commonwealth's emissions are only slightly higher than the national figures measured on a per-capita basis and on a per-unit of-gross-domestic-product (GDP) basis (see Figure 2-2). Pennsylvania emitted a slightly higher level of emissions per capita (26 tCO_2e vs. 24 tCO_2e per capita), but has not experienced an equivalent decrease in emissions per unit gross product (20% vs. 33% per unit gross product reduction) in recent years.

Figure 2-2 Pennsylvania and US GHG Emissions, Per-Capita and Per-Unit-GDP (2000$)

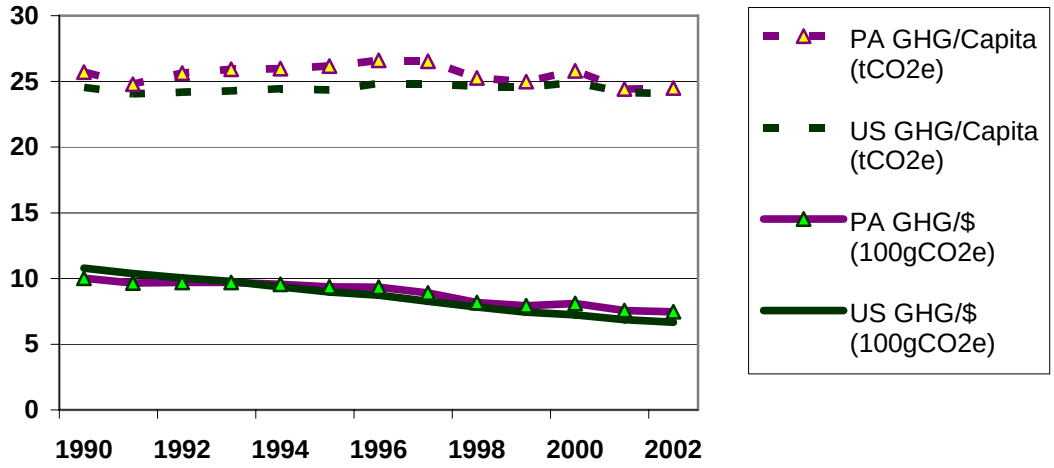
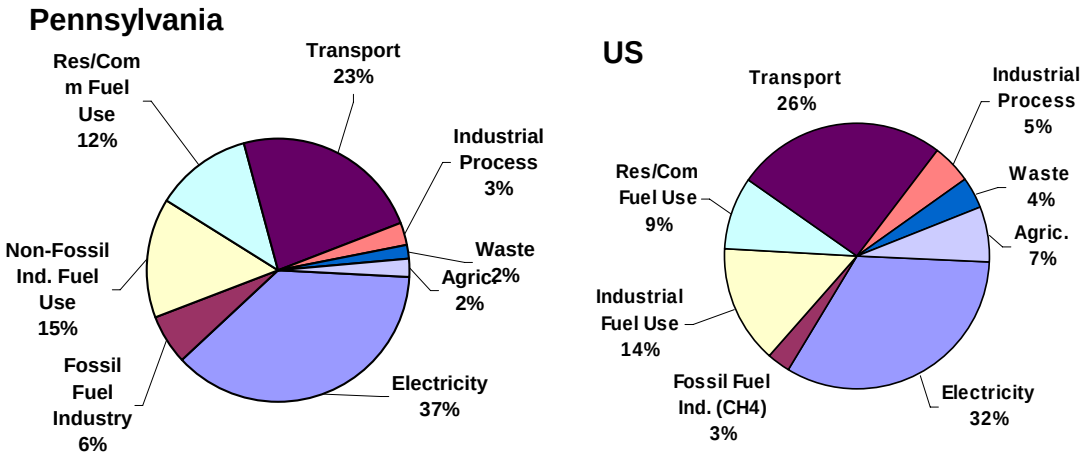


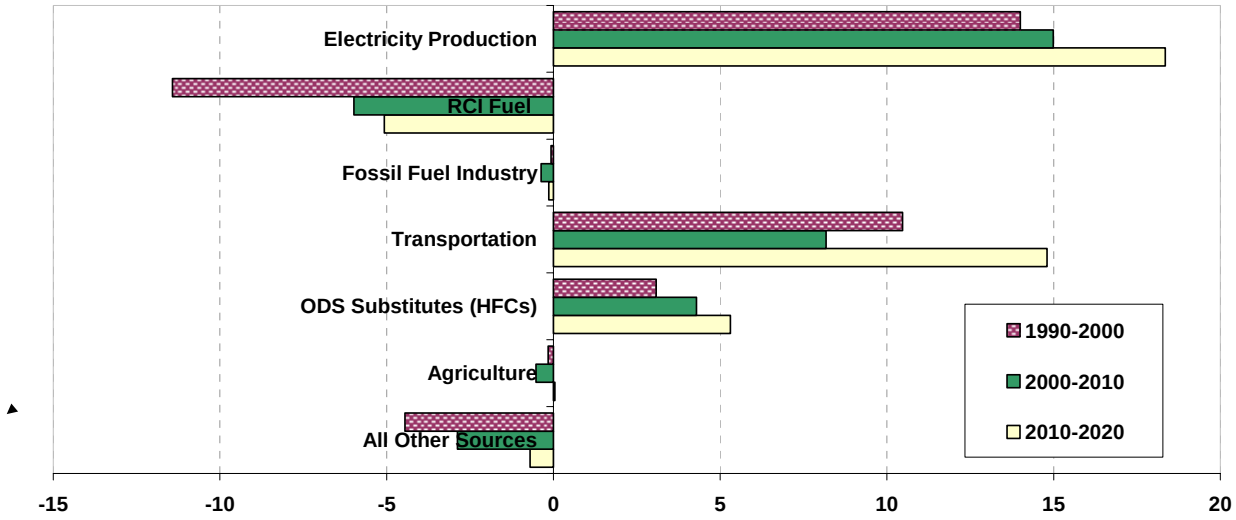
Figure 2-3 Gross GHG Emissions by Sector and Gas, 2000, Pennsylvania and US



In a sector-by-sector comparison, the national breakdown is quite similar to Pennsylvania's (see Figure 2-3 above). The most noteworthy differences come in the transportation and electricity sectors. Pennsylvania has a slightly lower fraction of emissions in the transportation sector (23% vs. 26%), due to the state's relatively dense population, and slightly higher emissions in the

electricity sector (37% vs. 32%) because Pennsylvania is a net exporter of electricity, producing more than is consumed in-state. As Figure 2-4 indicates, the electric and transportation sectors (already accounting for the largest portion of GHG emissions) are projected to be responsible for most of the growth from now through 2025. The forecasted decline in RCI emissions linked to fuel should be closely examined. Historically, there has been some decline, and the U.S. Department of Energy (US DOE) Energy Information Administration (EIA) regional forecast expects that decline to continue, but the underlying assumptions merit scrutiny.

Figure 2-4. Contributions to GHG Emissions Growth, 1990-2020: Reference Case Projections ($MMtCO_2e$)



This inventory aims to characterize Pennsylvania's emissions as comprehensively as possible by outlining both *production-based* emissions and *consumption-based* emissions. The distinction involves how emissions from the electricity sector are accounted in the inventory. Production-based inventories (the most common and easiest to monitor) include emissions from Pennsylvania's power plants, regardless of which state or country the electricity from those facilities actually services. Consumption-based inventories, on the other hand, include only those emissions associated with Pennsylvania's consumption of electricity, thus excluding any electricity exports from Pennsylvania while including any imports—an approach sometimes considered more useful when considering public policies. Table 2-2 below shows how a consumption-based perspective would lower Pennsylvania’s GHG profile, given that the Commonwealth is a net exporter of electricity.

Table 2-2. GHG Emissions by Source: Historical and Projected, 1990-2025 ($MMtCO_2e$)
Comparison of Production Basis and Consumption Basis (excludes electricity exports)

	1990	2000	2010	2020	2025	Explanatory Notes
Total Gross Emissions (Production Basis)	**305.4**	**316.9**	**334.6**	**367.2**	**383.2**	
Adjustment for electricity exports	**-27.3**	**-32.1**	**-33.5**	**-37.7**	**-39.0**	To reflect "consumption" in Pennsylvania
Total Gross Emissions (Consumption Basis)	**278.2**	**286.6**	**301.4**	**329.1**	**344.2**	
Forestry and Land Use	**-14.4**	**-14.4**	**-14.4**	**-14.4**	**-14.4**	
Net Emissions (Consumption Basis)	**263.8**	**272.2**	**287.0**	**314.7**	**329.8**	

Table 2-3 below provides some of the key assumptions underlying the projections.

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

	Historical 1990-2005	Projected 2005-2025	Sources/Uses
Population*	0.30%	0.15%	U.S. Census Bureau, Population Division, Interim State Population Projections, 2005.
Employment*	0.6%	0.6%	Historical Data and Projections from http://www.paworkstats.state.pa.us/ 2002-2012 projection used through 2025
Manufacturing	-1.5%	-0.9%	
Non-Manufacturing	1.1%	0.9%	
Electricity sales	1.6%	1.25%	EIA SEDS for historic, projections based on PJM projections.
Electricity production	1.5%	1.2%	EIA data for historic, projections based roughly on AEO2006 for the region; subject to uncertainties
Vehicle Miles Traveled*	1.5%	1.6%	PennDOT/PA DEP for projections (historical from HPMS Transportation Statistics, federal program administered by PennDOT)

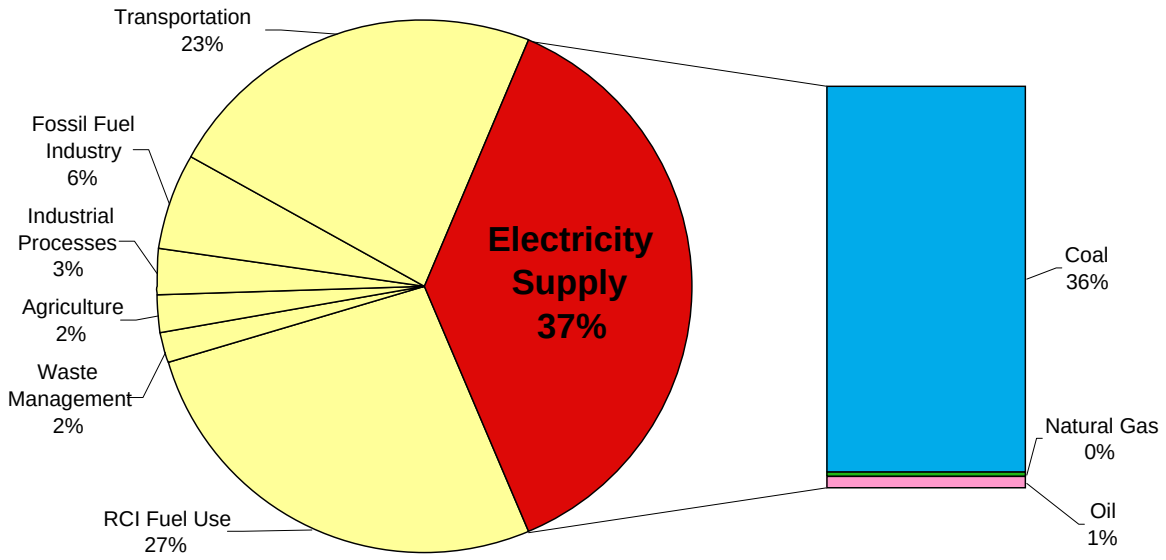
*Population, employment, and vehicle-miles traveled (VMT) projections for Pennsylvania were used together with US DOE's Annual Energy Outlook 2006 (AEO2006) projections of changes in fuel use on a per capita, per employee, and per VMT, as relevant for each sector. For instance, growth in Pennsylvania residential natural gas use is calculated as the Pennsylvania population growth times the change in per capita Pennsylvania natural gas use for the Mid-Atlantic region. Pennsylvania population growth is also used as the driver of growth in cement production, soda ash consumption, solid waste generation, and wastewater generation.

Chapter 3
Energy Supply

Overview of GHG Emissions

Electricity generation is the single largest source of greenhouse gas (GHG) emissions in Pennsylvania. Its carbon dioxide (CO_2) emissions are responsible for over one third of the Commonwealth's total emissions, or roughly 125 million metric tons of carbon dioxide equivalent ($MMtCO_2e$) annually (see Figure 3-1 below). Most of these emissions come from coal-fired generation in the Commonwealth, which produces about 55% of total generation. Nuclear generation is the second largest power source in Pennsylvania, accounting for about 37% of recent generation but no direct GHG emissions. Power generation and transportation are likely to be the two fastest growing sources of GHG emissions in the years ahead under a "business as usual" scenario.

Figure 3-1. Gross GHG Emissions in Electricity Supply, 2000, Pennsylvania



Production of fossil fuels also leads to GHG emissions. Currently, oil and gas extraction and coal mining are responsible for about 19 $MMtCO_2e$ annually, or 6% of total emissions, as illustrated in the upper left of Figure 3-1.

Recent Policy Developments

Pennsylvania has implemented several policies in recent years that are lowering GHG emissions.

- **Alternative Energy Portfolio Standard.** Pennsylvania enacted the Alternative Energy Portfolio Standard (AEPS) in November 2004. This law requires that 18% of electricity be

derived from "alternative sources" by roughly 2020. More specifically, the AEPS requires that, within 15 years of enactment, 8% of the total (Tier I) must be met through renewable energy resources or fugitive coal-mine methane (included a mandate for 0.5% solar photovoltaic power). Ten percent (Tier II) must be met through other sources such as energy efficiency, waste coal, integrated coal gasification combined cycle, incineration of municipal trash, and poultry farm wastes.

Promotion of renewable energy can generate benefits in the form of economic development. The AEPS was surely a factor in Pennsylvania attracting the second-largest wind energy company in the world to the Commonwealth. Gamesa will invest $84 million to base its US headquarters and East Coast development offices in Philadelphia, as well as construct four manufacturing facilities. One of the new plants, already built, employs over 230 workers in Cambria County while up to 300 workers will begin work at the new facilities in Bucks County.[1]

- **Net Metering Rules.** In 2006, Pennsylvania adopted a set of "net metering" regulations that will remove many of the traditional barriers to the development of clean distributed generation.[2] Key provisions include the following: utilities must reimburse customer-generators at the full retail rate for power produced; and the customer-generator can maintain ownership of any alternative energy credits produced, thus providing an additional potential revenue stream for the customer. Two provisions are especially "farmer-friendly": the regulations allow for both physical and virtual meter aggregation "regardless of rate class" on a property "owned and or leased" by a customer-generator, and the definition of virtual and physical meter aggregation allows for the combination of separate meters within 2 miles of the customer-generator's property. Both provisions recognize that farms can have both residential and commercial rate schedules, and sometimes have non-contiguous land holdings.

Key Challenges and Opportunities

Pennsylvania has 22,000 megawatts (MW) of coal-fired generation, most of which is 30 to 50 years old. These plants are mostly amortized, and their fuel costs are low. Reducing emissions from these plants would be quite expensive but may be necessary in the future. With natural gas prices likely to remain high, new coal plants are likely to be built in the absence of policies that constrain GHG emissions. In the mid-term, energy efficiency and renewables provide opportunities to make new coal plants unnecessary and hold emissions from the power sector relatively constant.

Policy Recommendations

Recommendations in this sector address electricity production and the fossil fuel industry. To gauge the impact of recent policy changes, the Pennsylvania Environmental Council (PEC) first estimated the impact of the current AEPS (specifically the Tier 1 target of 8% renewable generation as a percentage of sales in Pennsylvania). If this requirement is maintained, it will

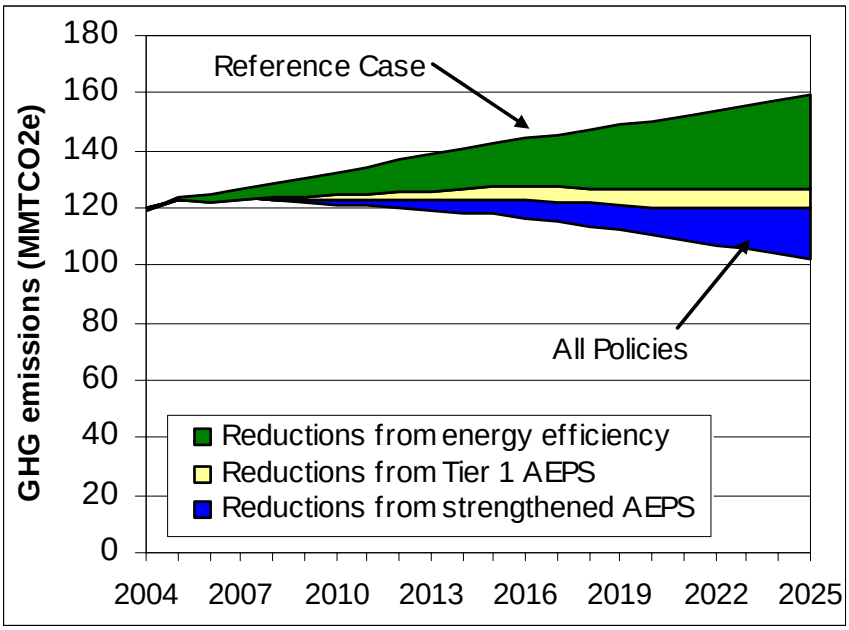
[1] See: www.ahs.dep.state.pa.us/newsreleases/default.asp?ID=3978&varQueryType=Detail.
[2] See: http://www.pennfuture.org/media_e3_detail.aspx?MediaID=655&TypeID=3.

reduce emissions from the power sector by 7 $MMtCO_2e$ in 2025 (see "Reductions from Tier 1" in Figure 3-2 below)..

Roadmap recommendations for electricity generation represent an ambitious plan to meet new demand through energy efficiency and alternative power sources, with an expansion of the AEPS from 18% to 25%. In 2025, coal would still be supplying most of Pennsylvania's power, but coal-fired electricity would not grow from current levels. This would preserve an important place for coal in the energy mix, while helping achieve substantial reductions in the Commonwealth's GHG emissions. The 25% goal is consistent with the spirit of the 25x'25 goal endorsed by Governor Rendell, 16 other governors, and many national groups.[3] The potential for decreasing emissions from coal plants via geologic sequestration is addressed in Chapter 9.

Figure 3-2 below summarizes the estimated impact on Pennsylvania's power sector emissions of adopting: 1) aggressive energy efficiency policies, and 2) a strengthened AEPS with a target of 25% and a requirement that non-renewable AEPS sources be carbon-neutral by 2025. The Commonwealth already taps into a variety of sources of renewable power including wind, solar, biomass, anaerobic digesters, and landfill gas, and has the potential to do much more.

Figure 3-2. Projected GHG Emissions from Pennsylvania Electricity Generation Reference Case and Policy Cases (Production Basis)



Because there are tight linkages between energy efficiency efforts targeted at electricity customers and new supply in the power sector, this chapter addresses both. Chapter 4 focuses on energy efficiency efforts outside of the power sector. Roadmap policy recommendations are presented below.

[3] See www.25x25.org.

- **Expand the AEPS to 25% by 2025 and require Tier 2 alternative energy sources to be "carbon-neutral."**

  This recommendation is in the spirit of the 25x'25 vision endorsed by the Governor, but it recognizes that achieving 25% renewable generation from *in-state* resources would be very difficult in the 2025 timeframe (though studies indicate it is feasible at the national level).

  Tier 1 sources in the current AEPS must be renewable and thus are inherently carbon-neutral.[4] Tier 2 sources are a mixture of alternatives that include sources with GHG emissions (e.g., waste coal and IGCC). Pennsylvania should increase the combined Tier 1 and 2 requirement to 25% by 2025, and require that Tier 2 sources be carbon-neutral via geologic sequestration and/or offset purchases. To achieve the 25% goal, Tier 1 should increase to 15% while Tier 2 should be held at 10%. The *Climate Council* could recommend a higher Tier 1 goal with the benefit of an updated technical and economic feasibility assessment. (Establishment of a Governor's *Climate Council* is a recommendation in Chapter 10.)

  The most comprehensive assessment of Pennsylvania's potential for generating renewable electricity was conducted in 2004 by Black & Veatch: *Economic Impact of Renewable Energy in Pennsylvania* (hereafter, the *B&V Report*).[5] That report found a technical potential of 224,000 GWh, accounting for all renewable sources, and a technical potential of 86,000 GWh if one excludes solar photovoltaic (projected to be much more expensive than other renewables and conventional generation).[6] The *B&V Report* also assessed "near-term potential," defined as feasible "market development potential" with a 10-15 year time horizon. This part of the assessment brought in economic factors, and resulted in a supply curve that met 10% of Pennsylvania's projected electricity consumption in 2015 with renewable sources ranging in cost from $30/MWh to slightly more than $100/MWh.

  The *B&V Report* should be updated to help guide expansion of the AEPS in the year 2025, and inform the Governor's overall climate change strategy. Oil and natural gas prices have risen sharply since 2004. The original assessment assumed a natural gas price of $4.50/Mbtu delivered to electricity generators, but this price averaged over $6/Mbtu during 2004 and is projected to average over $7/Mbtu in 2007.[7] Oil prices have also increased dramatically, rising from $43/barrel in 2004 to over $60/barrel in 2007. Coal prices increased about 20% between 2004 and 2007.[8] More importantly, with respect to coal, the likelihood of an implicit or explicit price on the carbon content of coal (and other fossil fuels) in 2025 is much higher now than it was three years ago. The *B&V Report* attached no cost associated with CO2 emissions to gas- or coal-fired generation. An updated assessment of Pennsylvania's renewable potential should account for current, higher projections of fuel prices along with plausible ranges for the added cost likely to be borne by fossil fuel generation in the 2025 timeframe.

[4] Tier 1 also includes generation from coal mine methane which has a net *negative* effect on GHG emissions, with reduction of methane emissions outweighing the CO2 emissions from methane combustion.
[5] See http://www.bv.com/news_3_publications/reports_3_studies/report_13.aspx.
[6] Non-solar sources assessed by Black & Veatch were: biogas, biomass co-firing, biomass direct, hydro, and wind.
[7] See EIA, *Annual Energy Outlook 2007*, http://www.eia.doe.gov/oiaf/aeo/excel/figure65_data.xls.
[8] See EIA, *Annual Energy Outlook 2007*, http://www.eia.doe.gov/oiaf/aeo/excel/aeotab_15.xls.

Table 3-1 below presents a plausible scenario for how Pennsylvania might increase Tier 1 of AEPS to 15% in 2025. The second and third columns present the technical potential and near-term potential and for various renewable sources as they appear in the *B&V Report* (shown in annual GWh of generation). The fourth column holds the near-term potential constant for all sources except wind, which increases to 13,000 GWh (equivalent to 5,000 MW of capacity). Windpower experts consulted for this report generally agree that this level of production is technically and economically feasible, while noting that aesthetic concerns appear to be a significant obstacle to this level of expansion.

Table 3-1. Renewable Power Potential from Black & Veatch Report and An Expanded Tier 1 Scenario for 2025 (GWh)

Renewable Power Source	Technical Potential	Near-Term Potential	Expanded Tier 1 Scenario
	(per *B&V Report*)		
Biogas	1,563	624	624
Biomass Co-firing	24,305	5,900	5,900
Biomass Direct	7,512	0	0
Hydro	9,194	2,408	2,408
Solar	137,812	5	5
Wind	43,651	8,696	13,000
Total Renewable Potential	224,037	17,633	21,937

Assuming that the energy efficiency goals in the Roadmap are met, the approximately 22,000 GWh in the Expanded Tier 1 Scenario above would represent 15% of roughly 150,000 GWh in electricity consumption in the Commonwealth in 2025.

Expanding Tier 1 to 15% and keeping Tier 2 at 10% would result in an AEPS of 25%. A Tier 1 requirement larger than 15% may be feasible, and should be determined in part by the updated assessment called for above.

By 2025, a full 100% of GHG emissions from Tier 2 sources should be offset or geologically sequestered, however, this new requirement should be phased in slowly. Offset purchases are available now, but geologic sequestration will not be commercialized for many years. Therefore, the fraction of required "carbon neutrality" should start out very low and escalate gradually to reflect the cost and availability of offsets and sequestration options. The precise

schedule requires additional study. In addition, responsibility for meeting this requirement should rest with the electric utility.[9]

Modeling of this expanded AEPS indicates that it could reduce GHG emissions by 18 $MMtCO_2e$ by 2025.

- **Add a dedicated Tier 3 energy efficiency component to the AEPS.**

  An AEPS Tier 3 devoted to the purchase of "negawatts" (sometimes called a energy efficiency portfolio standard or EEPS) would require electric utilities to reduce their expected growth in demand by certain increments, through investments and programs devoted to energy efficiency. States that have adopted an EEPS have set goals that range from 10 to 50% reductions in projected electrical demand (Texas and California, respectively). Pennsylvania has made a start in this direction by including energy efficiency as one option for meeting the AEPS Tier 2 standard of 10%. Tier 2 sources include waste coal, distributed generation systems, demand-side management, large-scale hydropower, and municipal solid waste. However, electricity from waste coal and municipal solid waste are likely to fill the Tier 2 requirement, negating the incentive for energy efficiency.

  "Negawatts" are widely considered the most cost-effective way to reduce GHG emissions. From an economic perspective, an EEPS generates net savings to ratepayers and typically generates more local employment than conventional electricity production. For example, to date, Texas reports net savings of at least $76 million. Typically, utilities choose from among the most cost-effective options available. They can also acquire needed equipment and technology at higher volumes, and hence lower prices, than individual residential, commercial, and perhaps even industrial customers.

  To date, no state has set an overall energy efficiency goal as ambitious as the one proposed here (i.e., holding total electricity demand at current levels in some future year). However, state experience thus far indicates the importance of long-term goals, and the recommendation here would allow for some interim growth as long as demand returned to current levels by 2025. Interim goals prior to 2025 for both efficiency and renewables should be a topic for the Climate Commission. Pennsylvania should also adopt a key policy pioneered by California: decouple utility profits from sales levels, so successful efficiency programs do not damage profitability.

- **Create a Systems Benefit Fund to finance energy efficiency investments.**

  To create a fund to finance efficiency investments, fifteen states currently apply a small charge to all electricity sales, generally known as a Systems Benefit Fund (SBF). In keeping with this concept, Governor Rendell has proposed creating an Energy Independence Fund that would invest in a variety of energy efficiency and clean energy projects. However, his

[9] In order to achieve this goal at lowest cost, an electric utility should not be required to sequester GHG emissions at the specific Tier 2 source, but should have the option of sequestering an equivalent quantity of GHG emissions at a non-AEPS source. For purchased power, the utility would need to ensure that the seller met the carbon-neutral requirement, or create an equivalent reduction through offsets or sequestration.

proposed charge is the third lowest among the fifteen states that employ a SBF. Pennsylvania should embrace an SBF commensurate with a goal of holding demand in 2025 to current levels (and a similar fund should be created for gas utilities as described in Chapter 4).

In his Energy Independence Strategy announced on February 1, 2007, the Governor proposed a system benefit charge of $0.0005 per kilowatt-hour (kWh) of electricity used (five-hundredths-of-a-cent or 0.5 mills). The fee would not exceed $10,000 per year for large industrial energy users. Money received by the charge would be placed in an $850 million Energy Independence Fund that would be used to help fund home appliance rebates and PA sunshine grants, grants and loans for venture capital for expansion of energy companies, and clean energy economic development projects. The proposal would considerably expand the money received by Pennsylvania Sustainable Energy Funds for similar purposes (funded as part of negotiated rate settlement with the Public Utility Commission).

As the Governor acknowledged, this would be among the lowest charges of any state in the country that has a system benefit charge. The charge in other states ranges between 0.03 to 3 mills per kWh; one mill equals one-tenth of one cent. In addition, there is considerable variation among states in funding for energy efficiency. The highest public benefit surcharge in a customer's electric bill (Connecticut, 3.0 mills per kWh) is 100 times greater than the lowest surcharge (Illinois, 0.03 mills). Other examples include California and New Jersey (1.3 mills) and Ohio (0.13 mills).

Systems Benefit Funds work; in those states with system benefit charges, annual energy savings range from 0.1 to 0.8% of total electricity sales, with an average savings of 0.4%. The capacity savings are also considerable; the eight states that report savings in MWs or system demand report an overall savings of 1,059 MW, or the equivalent of one large base load power plant.

- **Implement a portfolio of energy efficiency policies that complement the AEPS Tier 3.**

  A portfolio of energy efficiency measures to assist in holding total electricity demand in 2025 equal to current levels should be applied. The portfolio would include all the elements of Governor Rendell's proposed energy efficiency policies in his Energy Independence Strategy, as well as the following additional policies:

  - ***Provide rebates for consumers replacing old, inefficient air conditioners and refrigerators.*** Qualifying replacements would have to use at least 15% less energy.

  - ***Provide incentives for residential solar installations.*** Help consumers with up to half the cost of these technologies.

  - ***Encourage Smart Metering.*** Give consumers the right to have innovative electric meters installed in their home, which provide a new tool to reduce energy spending.

  - ***Promote microgrids that allow large energy consumers to generate their own power.***

- **Enact New and Updated Energy Efficiency Standards for Selected Electrical Equipment and Appliances.**

  States have authority to set energy efficiency standards where no federal standard exists and can petition to set a standard stronger than the federal one. Pennsylvania should apply this authority to electrical equipment and appliances after careful review of its options. Appliance efficiency legislation, covering eight common products that are not covered by federal standards, was introduced in both the House and the Senate in the spring of 2005. Overall, the benefits of the standards were estimated to outweigh the costs by more than 9 to 1. The Appliance Standards Awareness Project has prepared a thoughtful review of candidate standards and how states should approach this issue. [10] That review would be a good starting point for consideration by the Climate Commission of appropriate actions in this area.

- **Expand efforts to reduce Methane (CH_4) and other GHG emissions from coal mining and oil and gas production.**

  The reference case forecast suggests that emissions from the fossil fuel industry will hold relatively constant at about 19 $MMtCO_2e$ from now until 2025. However, Pennsylvania Department of Environmental Protection (PA DEP) analysis indicates that emissions from natural gas production may increase substantially as higher prices spark more drilling and extraction. The Roadmap process was unable to probe deeply into this sector, but there are likely to be significant mitigation possibilities that merit close attention. Further exploration of this sector may also be necessary to improve the reference case forecast to reflect market developments.

GHG Reductions and Costs

Modeling indicates that if the entire portfolio of energy efficiency recommendations presented in this Chapter is adopted, GHG emissions could be reduced by 32 $MMtCO_2e$ by 2025. (See Table 3-2 below.) If the recommendations are combined with the existing AEPS (7 $MMtCO_2e$) and the expanded Tier 1 AEPS described above, emissions could be reduced by 55 $MMtCO_2e$ by 2025. (Due to overlapping effects, the combined effect of various options is less than what a simple summation of individual impacts would suggest.)

Table 3-2. Energy Supply Sector Quantified Policy Recommendations and Estimated GHG Impacts in 2025 ($MMtCO_2e$)

	2025 Base Case	GHG Impact	2025 Roadmap Case	Notes
Electricity Production	**161**	**-55**	**106**	
Current AEPS Tier 1		-7		Adopted in 2004
Strengthened AEPS (Tiers 1 and 2)		-18		
Energy Efficiency Portfolio – Electricity*		-32		

* Consists of AEPS Tier 3 for energy efficiency, Systems Benefit Fund, appliance standards, and other energy efficiency policies described in this Chapter.

[10] American Council for an Energy Efficient Economy and the Appliance Standards Awareness Project, *Leading the Way: Continued Opportunities for New State Appliance and Equipment Efficiency Standards*, January 2005.

Time and resources did not allow a comprehensive analysis of the cost of implementing these recommendations. However, recent work by the Center for Climate Strategies (CCS) can provide some insight on the likely range of costs.[11] Recent estimates provided to North Carolina show the following costs for new generation in the year 2020:

Type of Generation	**Levelized Cost** ($/MWh, 2005 dollars)
Natural Gas Combined Cycle	52
Pulverized Coal	51
Integrated Gasification Combined Cycle	53
Integrated Gasification Combined Cycle with Carbon Capture and Storage	89
Wind	55
Biomass	66
Biogas – livestock	28 – 54
Biogas – municipal solid waste	34
Solar Photovoltaic (PV)	189

These estimates suggest that renewables (with the except of PV) are already competitive or close to competitive with conventional coal and natural gas options, and become competitive with Integrated Gasification Combined Cycle (IGCC) when the cost of CO_2 emissions is "internalized" by requiring carbon capture and sequestration. This suggests that an aggressive renewable energy portfolio standard would carry a relatively small cost, or even move the Commonwealth onto to a lower cost path, given the likelihood of federal CO_2 limits in the future.

CCS analysis for Arizona and New Mexico found that aggressive renewable energy portfolios proposed there (25 to 30% requirements) would reduce GHG emissions at $6 to $8 per tCO_2e, providing further indications that costs would be fairly low.

CCS also analyzed proposed aggressive energy efficiency portfolios for Arizona, New Mexico, and North Carolina and found net savings to those states.[12] The effective cost for reducing a ton of CO_2e emitted to the atmosphere was *negative*, ranging from -18 to -36 dollars per ton. Although no state has set a goal as aggressive as proposed here in the *Roadmap* (i.e., holding demand flat), studies to date by CCS and other bodies confirm the huge potential for cost-effective energy efficiency measures.

The Climate Council recommended here should examine GHG impacts and costs in depth.

[11] See *Updated Analytical Results* at http://www.ncclimatechange.us/Energy_Supply.cfm. This analysis is likely to be incorporated into a final report for the North Carolina Department of Environment and Natural Resources later in 2007. Fuel price forecasts incorporated into these estimates are from the Annual Energy Outlook 2007, which foresees only modest increases in the price of natural gas in the decade ahead. Escalating gas prices, of course, would drive the cost gas-fired electricity beyond the level in the table.

[12] See final reports at www.azclimatechange.gov and www.nmclimatechange.us, and analysis in progress at http://www.ncclimatechange.us/capag.cfm.

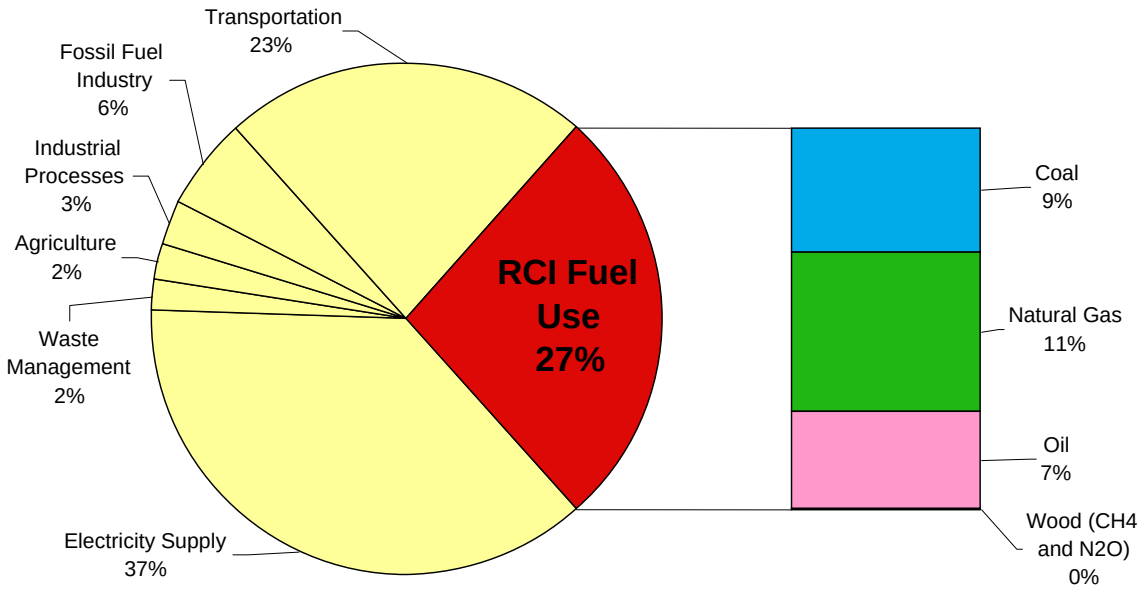
Chapter 4
Residential, Commercial, and Industrial Sectors

Overview of GHG Emissions

The residential, commercial, and industrial (RCI) sectors emit 27% of the Commonwealth's greenhouse gas (GHG) emissions directly through fuel use on-site (see Figure 4-1) and create the overwhelming share of demand for electricity (accounting for 37% of GHG emissions). Buildings of all types both generate large demand for electricity, natural gas, and other fuels, and are responsible for 43% of total GHG emissions in the US, when all energy use is accounted for.[1] Buildings present tremendous potential for reducing emissions through better design and energy efficiency measures.

Chapter 3 addressed the options for the RCI sectors to reduce their electricity demand, thus reducing emissions "off-site" (at the electricity generation site). This chapter focuses on direct fuel use.

Figure 4-1. Gross GHG Emissions in RCI Fuel Use, 2000, Pennsylvania

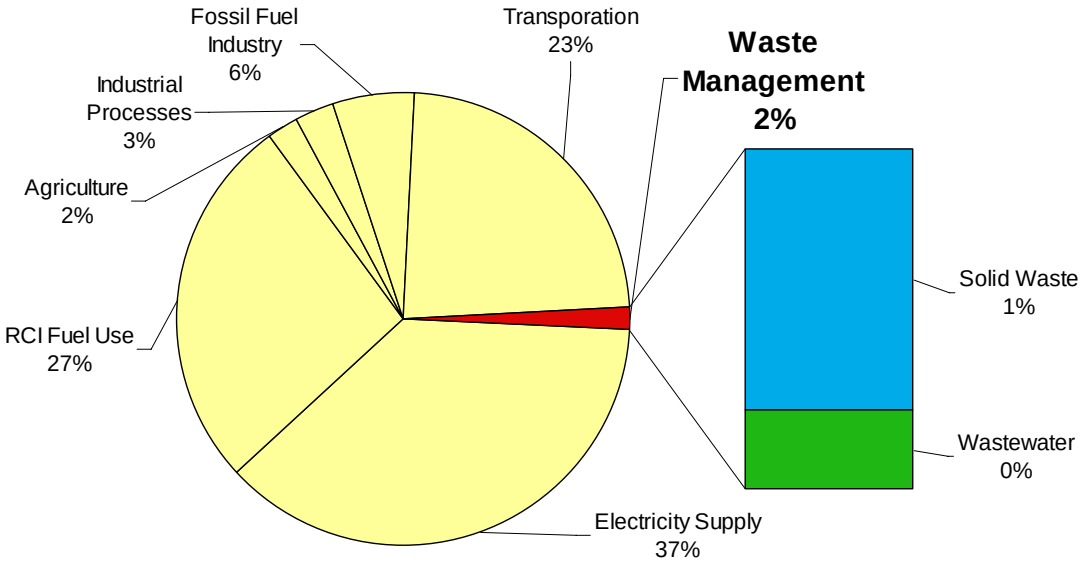


Emissions associated with waste management are properly considered to be an industrial activity and, therefore, are also addressed in this chapter. The emissions associated with waste

[1] Pew Center on Climate Change, *Building Solutions to Climate Change*, November 2006, http://www.pewclimate.org/policy_center/policy_reports_and_analysis/buildings/index.cfm. The Architecture 2030 project adds the impact of the embodied energy in construction materials and reports the carbon emissions of buildings as 48% of the national total. *See* http://www.architecture2030.org/.

management in Pennsylvania amount to about 2% of the total GHG emissions in the Commonwealth, as shown in Figure 4-2 below. Emissions from waste management have the benefit of containing methane (CH_4) (over 50%), which can often be captured and used as a fuel.

Figure 4-2. Gross GHG Emissions in Waste Management, 2000, Pennsylvania



Numerous other possibilities exist for emission reductions in waste management. Beyond capturing CH_4 emissions, there are opportunities for increased energy efficiency of waste management equipment, reduced energy use by switching to recycled products instead of raw products, and potential production of alternative fuels such as biodiesel.

Finally there are various industrial processes that generate GHG emissions other than CO_2. These represent about 3% of total emissions as shown the figure above, and include: perfluorocarbons (PFCs), SF_6, and hydrofluorocarbons (HFCs) (replacements for chlorofluorocarbons (CFCs) which deplete the ozone layer).

Recent Policy Developments

- **LEED Buildings.** Pennsylvania, once a leader in introducing green buildings to the marketplace, as recognized by the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) program, is now falling behind other states in the nation that have adopted policies requiring LEED certification for state owned and publicly funded buildings.

- **Small Business Advantage Grant Program**. This program helps small businesses improve energy efficiency and decrease pollution with a 50% match of funds up to $7,500. The program has helped nearly 490 businesses since July 2004 with more than $2.2 million in grants.

- **Keystone Home Energy Loan Program.** This $20 million fund, sponsored by the PA Treasury Department, offers low-interest loans to Pennsylvania residents for home energy-efficiency improvements.

- **Landfill Methane Recovery.** With Pennsylvania Department of Environmental Protection (PA DEP) leadership, Pennsylvania continues to be a leader in reducing emissions from landfills.

Key Challenges and Opportunities

Looking at total energy consumption as indicative, Pennsylvanians used 321 million BTUs of energy per capita in 2003, which is slightly less than the national average of 339 million BTUs per capita. Per capita energy consumption in three of the other most populous states is lower: New York, California, and Florida. New York and California have expended considerable effort and financial resources over a significant period of time to lower their energy consumption. With greater policy and financial commitments, Pennsylvania can reduce its energy use, save money, and generate jobs in the energy efficiency field.

Policy Recommendations

- **Create a Public Benefit Fund for Natural Gas Utilities.**
  Chapter 3 recommended a large-scale Public Benefit Fund for Pennsylvania's electric utilities. A similar fund should be created for natural gas utilities to invest in programs that help customers use gas more efficiently. Although Pennsylvania's gas utilities engage in some efforts in this area, the Commonwealth as a whole lags behind leading states such as Minnesota, New Jersey, and California. For instance, Minnesota gas utilities are required to spend 0.5% of their revenues on efficiency. The best natural gas efficiency programs combine technical assistance with financial incentives. They address residential, commercial, and industrial end-users, and sometimes have targeted efforts aimed at low-income residential customers (e.g., Massachusetts).[2]

  Residential programs typically focus on improving efficiency in space and water heating. Commercial and industrial programs address these areas as well as process energy use. The scale and design of a Systems Benefit Fund (SBF) for gas utilities should be a topic for the *Climate Council*. Research by the American Council for an Energy Efficient Economy (ACEEE) has identified 29 outstanding natural gas efficiency programs that can jumpstart that process.[3] Pennsylvania could also strengthen its partnership with the federal Energy Star programs that can reduce both gas and electric demand.[4]

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[2] All of the big PA gas utilities have low-income programs (known as LIURP—Low-Income Usage Reduction Program) that focus on building improvements for low-income customers (http://www.sustainable.doe.gov/profiles/Penn.htm). However, the SBF proposed here would be broader in scope.

[3] American Council for an Energy Efficient Economy, *Responding to the Natural Gas Crisis: America's Best Natural Gas Energy Efficiency Programs*, Report U035, Washington DC, December 2003.

[4] The Energy Star portfolio of residential programs is a suite of initiatives aimed at specific market segments and technologies. At the same time, each strategy compliments the effectiveness of the other by leveraging common branding and messaging, and by providing solutions for each of the primary elements of residential energy use. Various programs in each category have been operating in many regions of the country, including neighboring

- **Enact new and updated energy efficiency standards for selected natural gas equipment and appliances.**

  As noted in Chapter 3, states have authority to set energy efficiency standards where no federal standard exists and can petition to set a standard stronger than the federal one. Pennsylvania should apply this authority to natural gas-burning equipment and appliances after careful review of its options. The Appliance Standards Awareness Project has prepared a thoughtful review of candidate standards and how states should approach this issue.[5] That review would be a good starting point for consideration by the *Climate Council* of appropriate actions in this area.

- **Create incentives for more efficient, environmentally friendly building design and operations.**

  Developed by the U.S. Green Building Council (USGBC), the voluntary LEED Standards have helped building users achieve average reductions in energy use of 33%, saving the typical building a quarter of its heating, cooling, and/or electricity bills. Acknowledging the importance of climate change and the potential for LEED to address it more aggressively, USGBC is currently revamping LEED so that every LEED certified building will reduce its carbon emissions by 50% from conventional practice. Additionally, where LEED standards have been introduced in schools, student productivity has increased; in retail stores, sales have increased; and in offices, worker productivity has jumped.[6]

  LEED rating systems have been developed for new commercial and institutional construction, new residential construction, fit-up of interiors, commercial building core and shell, neighborhood developments, and, perhaps most importantly, the operations and maintenance of existing buildings. Through grass roots efforts, Pennsylvania was an early leader in introducing LEED standards to the marketplace shortly after its introduction in 2000. However, Pennsylvania has lost its leadership position in this area to other states that have adopted the use of LEED as public policy[7]

  The upfront costs for constructing a new LEED-certified building average 2 percent above conventional construction costs. Simple payback is generally less than 3 years, and the cost savings over the lifetime of the building are substantial. As an illustrative example, the National Renewable Energy Laboratory (NREL) recently completed a study of the

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states, for as many as eight to ten years or more. Pennsylvania stands to gain from the extensive experience of these programs and the evolution that has occurred in the underlying US EPA and US DOE standards. Perhaps most critical among the lessons learned is the need to move beyond merely the promotion of higher efficiency rated equipment, to delivering measurably improved energy and building performance, sustainable demand and consumption savings, and permanent market transformation effects. *See* http://www.puc.state.pa.us/electric/pdf/DSR/DSRWG_RDOC_PACDR.pdf.

[5] "Leading the Way: Continued Opportunities for New State Appliance and Equipment Efficiency Standards," January 2005, American Council for an Energy Efficient Economy and the Appliance Standards Awareness Project.

[6] USGBC presentation.

[7] USGBC presentation.

Pennsylvania Department of Environmental Protection's (PA DEP) building in Cambria.[8] Compared to the same building built according to the normal ASHRAE 90.1-2001 energy standards, the LEED-certified Cambria building reduced energy consumption by 40%. With construction costs "within the same cost range as building a conventionally constructed office building," the Cambria building will save 78 cents per square foot per year in energy costs. At this rate and with 34,500 square feet of office space, the Cambria building will save the Commonwealth over $25,000 per year. Also, a recently released report sponsored by the American Federation of Teachers, American Institute of Architects (AIA), USGBC, American Lung Association, and the Federation of American Scientists, showed that a typical LEED certified school costs about $3 per square foot more to build but has a net present value return of more than a $70 per square foot.

Along with initiating general education efforts to raise awareness about the benefits of LEED buildings, Pennsylvania should adopt LEED as a mandatory standard for its existing buildings and for all new buildings and renovations constructed with state funds. Additionally, the Commonwealth should provide incentives to the private sector for conforming to LEED standards. This would encourage more sustainable and more efficient buildings in Pennsylvania, realizing a host of ancillary benefits beyond the GHG reductions associated with energy conservation. Incentives could range from sales tax credits, to property tax exemptions, to cost-sharing grants.

- **Encourage Upgrades/Retrofits of Existing Residential and Commercial Buildings.**

  Pennsylvania's commercial and residential building codes include the 2006 standards adopted under the International Energy Conservation Code. As a practical matter, however, these codes tend to apply to new residential and commercial structures, not existing ones. For example, 60% of existing residences are not well-insulated and 70% or more of commercial buildings lack roof or wall insulation. Thus, considerable energy efficiency opportunities are available in retrofitting and upgrading existing structures and their heating, ventilation, and air conditioning systems.

  A variety of institutional barriers and market imperfections prevent the economic savings available from retrofits and upgrades from being realized. To some degree, there is not enough information available in an easily accessible form to builders, contractors, homeowners, lessors, businesses, and others who own or occupy such dwellings. To accomplish an upgrade or retrofit that has a significant energy savings component, moreover, all of the relevant participants—the building owner, the contractor, subcontractors, and suppliers—need to have the same understanding about what is available and what can be accomplished. The initial financial cost can also be an obstacle, despite the available cost savings. For energy users, in principle, reducing energy use and improving efficiency are opportunities to save money. But it is not always clear to energy users how to save money. Many replacements of existing furnaces, air conditioners, and other appliances and equipment occur when they break down, often suddenly and without notice and at

[8] All information in this paragraph taken from *Technical Report: Analysis of the Design and Energy Performance of the Pennsylvania Department of Environmental Protection Cambria Office Building*, prepared by the National Renewable Energy Laboratory.

inconvenient times. For the purchaser, energy use is often (and understandably) subordinate to simply getting the appliance or equipment replaced. More generally, hundreds of thousands of builders, contractors, architects, and purchasers make decisions about whether to seek, design, build, or operate more energy efficient appliances, equipment, buildings, and motor vehicles. A great many factors are involved in such decisions, and it is abundantly clear that energy efficiency and energy consumption are not the only important factors, or even among the important factors. Still, a variety of energy efficiency options or opportunities are not readily available that would, if they were convenient and accessible, likely be used to a considerable degree.

Particularly for the residential market, a major problem is the lack of trained and certified contractors who can accurately diagnose and install the optimal energy improvements. Too often, consumers who want to save energy are at the mercy of contractors recommending window replacements (with a twenty-plus year payback), when what consumers need are accurate diagnoses of air leakage paths and properly installed insulation and heating systems (with paybacks of eight years or less). A training, certification, and quality assurance program, such as Home Performance with Energy Star, would help consumers differentiate among contractors, obtain accurate building diagnostics, and ensure proper installation.

In the Energy Policy Act of 2005, Congress provided that homeowners who make certain efficiency improvements at their residence before the end of 2007 can receive a credit of up to $500.[9] In addition, energy-efficient commercial building expenditures that are put in service before the end of 2007 may qualify for a deduction of $1.80 per square foot.[10]

Pennsylvania should create several incentives to increase retrofits and upgrades in existing residential and commercial buildings.

- ***Encourage and support businesses supplying energy efficiency services to residential and commercial buildings.*** Many of these options and opportunities could be provided by the private sector with the help of appropriate governmental assistance. A key example is energy efficiency upgrades of existing residential and commercial buildings. Such upgrades could have considerable impact on energy efficiency while reducing energy costs for businesses and individuals, including people living in poverty. While energy service companies do this kind of work for large institutional and commercial clients, much less of this work is done for smaller businesses, smaller institutions, and residential buildings. If improved energy efficiency in one's home or business were as easily available as having a roof replaced or a driveway paved, a great many more individuals would use those services. The standard explanation for the relative unavailability of such services is that economies of scale are too small to make this kind of work economically attractive to energy service companies, and the void is filled by manufacturers and installers, each promoting their own product. To realize optimal energy efficiency in the residential and small commercial sectors, Pennsylvania needs to transform the way the current marketplace works, through targeted incentives for building diagnostics, training, certification, and outreach. Such energy efficiency services

[9] Energy Policy Act of 2005 §1333 (codified at 16 U.S.C. §25C).
[10] Energy Policy Act of 2005 §1331 (codified at 16 U.S.C. §179D).

would help to develop Pennsylvania's indigenous "efficiency resource" and create jobs within the Commonwealth.

Pennsylvania has a standard set of economic development tools that are used to solve exactly this kind of problem. These include grants, loans, subsidies, tax incentives, locational assistance, and expedited permits and other approvals. These tools are also employed or assisted by specialized economic development agencies with considerable experience in this field. Pennsylvania could create partnerships with manufacturers, contractors, architects, builders, vocational and technical schools, community colleges, and others to create and stimulate markets for energy efficiency technologies and know-how as well as energy efficiency services. The building trades, including roofers, electricians, plumbers, and their respective labor unions, could be natural allies in this effort because their work so directly involves the use of energy. As part of this energy efficiency partnership, the government could provide support services for the development or expansion of new energy efficiency businesses, and could help businesses identify those markets where efficiency improvements would be the greatest. Vocational and technical schools and community colleges, in partnership with manufacturers and others, could provide training concerning new technologies and developments. Career development officials in these institutions, as well as high schools, could help identify individuals who might be interested in pursuing a trade that has a significant energy efficiency component. In these and other ways, energy efficiency could also provide significant job creation opportunities

- ***Provide appropriate tax incentives.*** Oregon, which appears to have the oldest and most well established state energy efficiency tax credit, provides a useful model.[11] A residential tax credit is available for certain new highly efficient appliances. Between 1998 and 2001, 66,000 taxpayers claimed the credit for appliances. Overwhelming majorities of those surveyed said the program influenced their buying decision and that they would use it again.[12] Business tax credits are available, among other things, for retrofit projects that will result in a 10% energy efficiency improvement and lighting retrofit projects that are 25% more efficient.[13] Between 1981 and 2001, 3,655 energy related projects took advantage of the business tax credit program.[14] The Oregon program has reduced demand for electricity by 530 million kilowatt hours (kWh) and demand for natural gas by 580 billion BTUs.[15]

  Such incentives are already available to Pennsylvania residents in at least two ways. First, the Energy Policy Act of 2005 provides a range of tax credits and deductions for energy

[11] Or. Rev. Stat. §469.185-.225; William Prindle et al., *Energy Efficiency's Next Generation: Innovation at the State Level* 13 (2003), *available at* http://www.aceee.org/pubs/e031full.pdf [hereinafter Prindle], at 32.
[12] Prindle, *supra* n.9, at 34.
[13] Oregon Department of Energy, *Business Energy Tax Credits* (2006), http://www.oregon.gov/ENERGY/CONS/BUS/BETC.shtml (last visited July 21, 2006). The credit applies to 35% of eligible project costs. *Id.*
[14] Prindle, *supra* n.9, at 34.
[15] Prindle, *supra* n.9. at 32. Based on Oregon's experience, a state with average population size and a comparable program could expect to reduce demand for electricity by 863 million kWhs and demand for natural gas by 945 million BTUs. *Id.*

efficiency. Second, Pennsylvania provides rebates, including rebates to purchasers of new fuel-efficient cars such as the Toyota Prius.

Pennsylvania could expand this by providing tax credits to persons who upgrade or retrofit existing residential and commercial structures to Energy Star levels of energy efficiency.[16] The U.S. Environmental Protection Agency's (US EPA) Energy Star program has standards for energy efficiency in existing buildings. This tax credit should apply, among others, to landlords of apartments now occupied predominantly by persons who are eligible for low-income weatherization assistance. In addition, homes or businesses that use a combination of renewable energy and energy efficiency to become zero energy homes or businesses, or homes and businesses that provide renewable energy to the grid, should also be given a tax credit. Finally, manufacturers and businesses could be given a 15% investment tax credit for investments that lead to reduced energy intensity (reduced energy consumption per unit of output). This tax credit would help stimulate both energy efficiency improvement and economic development. It also could be applied to projects that replace existing coal burning facilities with facilities that are more energy efficient, that produce both recoverable heat as well as electricity, or both.

- ***Expand Low-Income Weatherization Program.*** Weatherization programs for low-income persons are another means of providing incentives for energy efficiency upgrades and retrofits. While the U.S. Department of Energy's (US DOE) weatherization program began with a focus on insulation and caulking, it now includes a range of energy efficiency services, including improved heating and cooling systems and more efficient appliances.[17] For each dollar spent on this program, the economic and non-economic benefits are estimated at $3.71.[18]

  In Pennsylvania, the Low Income Home Energy Assistance Program (LIHEAP) provides benefits to more than four hundred thousand residents each winter. The majority of the funding, however, has historically subsidized consumption (i.e., helping to pay bills, as opposed to reducing energy usage through building improvements). During the past fiscal year, the Rendell Administration allocated an additional $10 million of a supplemental federal appropriation of $33 million for low-income weatherization, bringing the total allocated for low-income weatherization in Pennsylvania to $43 million.

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[16] Home Performance with Energy Star is an US EPA sponsored market transformation program aimed at saving energy in existing homes while improving its durability and the health and safety of the residents. Home Performance with Energy Star (HPwES) may be seen as the existing homes counterpart to ENERGY STAR Homes for new construction. HPwES programs provide training and certification to participating contractors, offer zero or low interest rate financing or other incentives for homeowners who undertake Home Performance projects with participating contractors, and market the availability of this service to homeowners, supporting the marketing efforts of participating contractors. Typical HPwES jobs involve taking a "whole house" approach to building upgrades. For example, a homeowner might ask a contractor to replace the heating system; a HPwES contractor would make sure the replacement was a properly sized high-efficiency unit with sealed ductwork, and suggest improvements to the building envelope as well.

[17] US DOE, *Weatherization Assistance Program: Steady Advances in Weatherization Technologies*, *at* http://www.eere.energy.gov/weatherization/wx_technologies.html (last visited July 21, 2006).

[18] US DOE, *Weatherization Assistance Program: Non-Energy Benefits of Weatherization* (2003), *at* http://www.eere.energy.gov/weatherization/ne_benefits.html (last visited July 24, 2006).

The Commonwealth could take advantage of significant energy efficiency opportunities in this program by directing a much greater share of funding to actual energy efficiency improvements and by significantly increasing funding for low-income weatherization. At least half of the overall annual spending for the program should be for activities that actually reduce energy costs—the installation of programmable thermostats, insulation, double-pane windows, and more efficient appliances, for instance. A percentage of the increased electric and gas utility SBF should be allocated for that purpose. An additional $26 million per year would be sufficient to weatherize 10,000 more homes annually. Weatherization programs for low-income persons are another means of providing incentives for energy efficiency upgrades and retrofits. While the US DOE's weatherization program began with a focus on insulation and caulking, it now includes a range of energy efficiency services, including improved heating and cooling systems and more efficient appliances.[19]

- ***Begin Low-Income "Neighborhood Blitz" Program for Energy Efficiency.*** Many states and utilities are now employing a targeted "neighborhood blitz" approach to energy efficiency in low-income neighborhoods.[20] These programs provide residents in low-income neighborhoods with kits containing such items as low-flow showerheads and setback thermostats. These kits, which cost between $17 and $180 each, are distributed free of charge. The economic and energy saving benefits are considerable; for some programs, the savings to a household in the first year alone exceed the cost of the kit.[21]

  The Administration, in partnership with the Commonwealth's gas and electric utilities, should run this program in targeted neighborhoods totaling at least 100,000 homes each year. This program should be run in conjunction with the expanded and modified LIHEAP program. Initial funding for the program should be provided by a small percentage of the added system benefit charge, as described above.

- **Expand use of biomass energy.**

  Pennsylvania has ample supplies of wood and other biomass that can used to make heat and power. Expanded use in power generation is captured in the expanded Alternative Energy Portfolio Standard (AEPS) Tier 1 above. Pure heating applications could also reduce GHG emissions.

- **Use biofuel in heating oil.**

  Biomass-derived fuels can be used in transportation, but can also supplement heating oil. Pennsylvania could achieve a 5% goal in substituting biodiesel for conventional heating oil.

- **Promote use of small-scale power generation using methane from wastewater facilities.**

[19] US DOE, *Weatherization Assistance Program: Steady Advances in Weatherization Technologies, at* http://www.eere.energy.gov/weatherization/wx_technologies.html (last visited July 21, 2006).
[20] Southwest Energy Efficiency Project, *Low Cost/No Cost Energy Efficiency Measures: Neighborhood Blitz, Direct Install and Conservation Kit Programs, available at* http://www.epa.gov/cleanrgy/pdf/ee_lowcost.pdf.
[21] *Id.* at 4.

This technology has emerged as a cost-effective way to reduce methane emissions and convert it into a useful energy source.

- **Make better information available to consumers regarding their GHG emissions and the availability of energy efficient products and services.**

  Experience suggests that people will respond positively to information on ways to protect the environment and/or use less energy. To be effective, the information should: (1) show that others have done, or will do, the same thing, and that everyone's effort is necessary to a good outcome; (2) be accompanied by explanations of the convenience of pro-environmental behavior; and (3) focus on smaller groups, like neighborhoods or workplaces. These are the lessons from Pennsylvania's experience with Act 101 of 1988 on recycling. The law requires municipalities of a certain size to establish curbside recycling programs. Curbside programs are convenient because people can simply put their recyclables at the curb on the same day as their trash is picked up. The public availability of information about time and place of pickup, and what individual municipalities have achieved, also helped make the program work.

  Pennsylvania's experience with meeting Act 101's 25% recycling goal, and the 35% recycling goal that was subsequently adopted, indicates the willingness and ability of Pennsylvanians to do their share to meet statewide goals. This same can-do spirit can be harnessed in service of the goal of holding electricity demand down and reducing natural gas use.

  Various state agencies or designated local organizations should make available to individuals and consumers, in a variety of media and contexts, information about energy savings opportunities. These would include, for example, information on where and how to purchase compact fluorescent lamps and information on the relationship between maintaining adequate tire pressure and improved gas mileage. These agencies should also be directed to provide public information about economic, social, and environmental effects of making (and not making) appropriate choices. This information could also include information enabling and encouraging individuals to be "carbon neutral," including information on credible offset providers, and particularly offset providers in Pennsylvania. Finally, these agencies should be charged with the responsibility for continually finding ways to engage individuals, informing them of available choices. [22]

  Pennsylvania should also require owners of existing residential and commercial buildings who put their properties on the market, to provide information on the monthly energy costs

[22] Energy-efficiency actions by Pennsylvania citizens can have a substantial impact on the state's energy profile. For example, if every Pennsylvania household installed five compact fluorescent lights, each household would reduce their electricity usage by 500 kWh/year, or $50/year, and reduce their carbon emissions by 550 pounds/year. This simple action would lead to statewide electricity savings of 2.4 billion kWh/year, or $243 million/year, and prevent 2.6 billion pounds of CO_2 from entering the atmosphere—equivalent to removing 230,000 automobiles from the road. If Pennsylvanians could be motivated to reduce their residential energy use by only 5%—easily achievable through simple low-cost changes such as programmable thermostats—such simple actions would save $470 million/year from Pennsylvania's $9.4 billion residential energy bill. Translating similar actions to the Commonwealth's schools and workplaces would yield even greater savings. (Kathy Greely, PEC, personal communication)

for those buildings via their real estate agents. Such information would provide an additional incentive to upgrade and renovate such structures for energy efficiency purposes and would provide useful information to interested buyers.

GHG Reductions and Costs

Modeling was conducted for some options, which resulted in the following estimated impacts. An aggressive portfolio of efficiency measures targeting natural gas customers should be able to decrease natural gas consumption by at least 10% from project 2025 levels, which would reduce GHG emissions by 3 million metric tons of carbon dioxide equivalent ($MMtCO_2e$) by 2025. Some substitution of biomass for fossil fuels in the RCI sector should be able to reduce emissions by an additional 1 $MMtCO_2e$, and the B5 heating requirement should be able to reduce a few more hundreds of thousands of tons, according to the PA DEP. Taken together, RCI emissions could decrease about 4.4 $MMtCO_2e$ by 2025 (rounded to 4 in Table 4-1 below). However, one should keep in mind the huge savings in power generation emissions that would actually be implemented and assisted by the actions of RCI customers (see Chapter 3).

Table 4-1. Residential, Commercial, and Industrial Sectors Quantified Policy Recommendations and Estimated GHG Impacts in 2025 (Million Metric Tons CO_2e)

	2025 Base Case	GHG Impact	2025 Roadmap Case	Notes
Residential/Commercial/Industrial (RCI)	**70**	**-4**	**66**	
Expanded Wood/Biomass Energy		-1		For process heat (not electricity)
B5 Bioheat Initiative		-0.4		
Energy Efficiency Portfolio – Gas*		-3		

* Consists of SBF for natural gas utilities, appliance standards, encouragement of upgrades/retrofits of existing residential and commercial Buildings, and other energy efficiency policies described in this Chapter.

Time and resources did not allow a comprehensive analysis of the cost of implementing these recommendations. However, recent work by the Center for Climate Strategies (CCS) can provide some insight on the likely range of costs. [23]

CCS analyses for Arizona, New Mexico, and North Carolina found that state appliance efficiency standards would reduce GHG emissions at a *negative* cost, ranging from -46 to -66 dollars per ton, thus benefiting the state's economy. Similarly, analyses in these three states examined strengthened building codes and design incentives and found they would reduce GHG emissions at a *negative* cost, ranging from -12 to -18 dollars per ton. CCS examined an efficiency portfolio for New Mexico's natural gas utilities and estimated reduced GHG emissions at a *negative* cost of -55 dollars per ton.

The *Climate Council* should examine GHG impacts and costs in depth in the RCI sector.

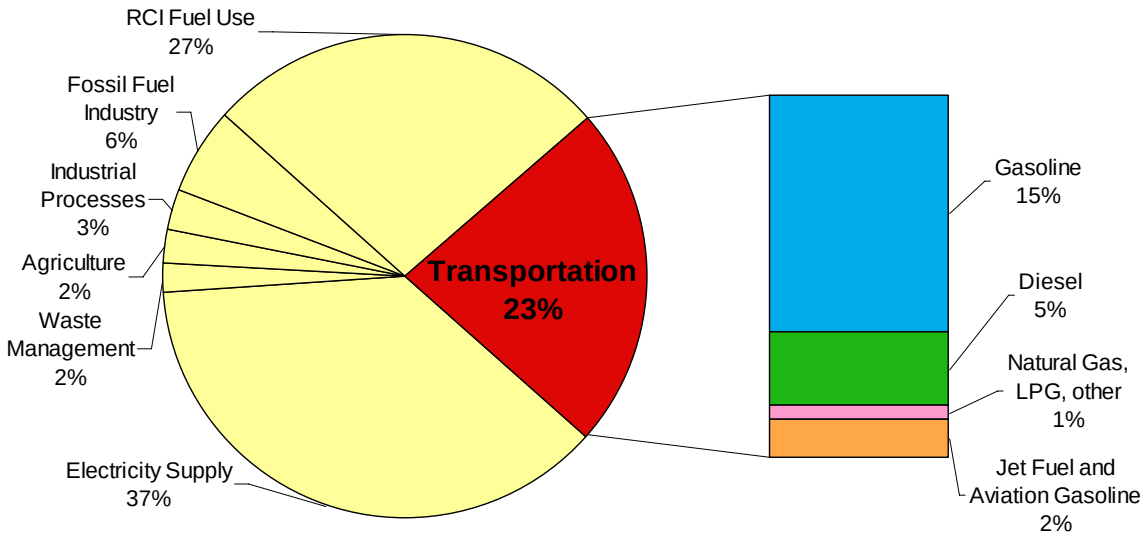
[23] See final reports at www.azclimatechange.gov and www.nmclimatechange.us, and analysis in progress at http://www.ncclimatechange.us/capag.cfm.

Chapter 5
Transportation and Land Use

Overview of GHG Emissions

The transportation sector is responsible for nearly one-fourth of Pennsylvania's total greenhouse gas (GHG) emissions, currently accounting for about 75 million metric tons of carbon dioxide equivalent ($MMtCO_2e$) (see Figure 5-1 below). Motor vehicles are the fastest growing source of those emissions, and currently account for about 15% of total emissions. Vehicle miles traveled (VMT) continue to grow and the fuel efficiency of vehicles is generally stagnant, though recent spikes in the cost of gasoline have increased interest in hybrids and vehicles with high fuel economy. Patterns of VMT are critically related to patterns of land use. The increasing trend in VMT is directly related to "sprawl" type development. Compact patterns of mixed-use development are necessary to support transit-oriented development and to allow use of low-intensity GHG methods (such as public transportation, or walking and biking to work, shopping, and entertainment). Sprawl patterns of development will also lead to GHG emissions from loss of "carbon sinks" caused by permanent conversion from forest or farmland. This group of policy options is aimed at: increasing fuel economy via technology, using cleaner fuels with lower GHG emissions, and reducing VMT. The measures to prevent forest and farmland conversion will also be discussed in the Chapters of this Roadmap dealing with Forestry and Agriculture.

Figure 5-1. Gross GHG Emissions in Transportation, 2000, Pennsylvania



Recent Policy Developments

In the 2004-2006 period, Pennsylvania adopted several policies that will reduce GHG emissions from the transportation sector in the years ahead. Several worth highlighting appear below:

- **Clean Vehicles Program.** In 2006, Pennsylvania adopted the Clean Vehicles Program (also known as the "Pavley" standards or California GHG Emission Standards), which will reduce GHG emissions from new light-duty vehicles (passenger cars and light-duty trucks) sold in Pennsylvania. When fully implemented, the program will reduce GHG emissions by about 30% compared to current new vehicles. Modeling results indicate that this program will lower GHG emissions by about 14 $MMtCO_2e$ in 2025 compared to a scenario without the program.

- **Alternative Fuels Incentive Grant Program (AFIG).** In 2004, Governor Rendell signed into law Act 178, expanding the AFIG (first created in 1992) and offering user-friendly rebates instead of grants to residents who purchase hybrid or alternative fuel vehicles.

- **Keystone Principles & Criteria for Growth, Investment & Resource Conservation.** These principles were developed by the Interagency Land Use Team and were adopted by the Economic Development Sub-Cabinet on May 31, 2005. They will help foster growth that is less carbon-intensive.[1]

- **Rail Freight Assistance program.** This program provides assistance to support the rehabilitation of rail freight lines owned by private and public utilities.[2] In February 2006, the Governor's budget recommended a $2 million increase to expand this program to preserve essential rail freight service and to stimulate economic development through the creation of new or expanded rail freight service.

- **Government Lead-By-Example.** The Governor launched a major effort in 2005 to replace conventional Commonwealth vehicles with hybrid vehicles. There are currently 30 hybrid vehicles within the Commonwealth's fleet and Governor Rendell is committed to build upon this commitment so that by 2011, 25% of the fleet will consist of hybrid vehicles.[3]

- **Growing Greener II and the Home Town Streets and Safe Routes to Schools programs.** On May 17, 2005, the voters of Pennsylvania approved the "Growing Greener II" program, authorizing $625 million in bond proceeds to support: (1) investments in alternative energy sources including wind farms, solar cells, and alternative fuels; (2) protection and preservation of farmland, natural areas, and open space; and (3) restoration of communities, expansion of affordable housing, and improvement of community parks. The latter two goals will assist in promoting smart growth and more compact patterns of development. In his 2004 budget address to the legislature, Governor Rendell committed $200 million over four years to the Home Town Streets and Safe Routes to Schools program as part of the Growing Greener II program. These initiatives link with the Commonwealth's existing Main Street and Elm Street programs, and will improve downtowns, neighborhoods, and walking routes. The Home Town Streets program includes a variety of streetscape improvements that will help to revitalize downtown and commercial centers. Projects may include sidewalk improvements, street lighting, pedestrian crossings, transit bus shelters, traffic calming,

[1] *See* http://www.newpa.com/newsDetail.aspx?id=303 and www.phmc.state.pa.us/bhp/pkp.pdf.
[2] *See* http://www.budget.state.pa.us/budget/cwp/view.asp?a=3&q=206356.
[3] *See* http://www.state.pa.us/papower/cwp/view.asp?Q=458594&A=11.

bicycle amenities, kiosks, signage, and other visual amenities. The Safe Routes to Schools program is designed to make physical improvements to promote safe walking and biking passages to schools. It will save on school busing costs and promote a healthy lifestyle for children.[4] This program represents one of the best examples of interagency cooperation in state government.

- **Pennsylvania State Planning Board.** In 2004, Governor Rendell reactivated the Pennsylvania State Planning Board (the "Board") under Act 42 of 1989, amending the Administrative Code, 2 Pa.Stat.Ann. § 451, as an advisory board within the Governor's office. The Board conducts research and collects, compiles, and analyzes data bearing on the present and future welfare of the Commonwealth; identifies issues of interest and concern to the Commonwealth; develops strategic plans, programs, and recommendations; and solicits information and input from state government and private sources as part of the strategy development process.

- **Pennsylvania Brownfields Program**. Pennsylvania operates one of the most advanced Brownfields program in the nation. The Pennsylvania Brownfields Program encourages redevelopment of former contaminated sites to encourage development in existing urban centers rather than new "greenfield" sites that encourage sprawl type development that fosters increases in VMT.

Key Challenges and Opportunities

Development in Pennsylvania consumes a surprising amount of land given relatively modest population growth. In 1997, Pennsylvania ranked fifth in the rate of land converted to development, but forty-eighth in population growth. Developed land covered about 15.3% of all the land in Pennsylvania in 2003, as compared to 10.1% in 1982—an increase of more than 50%. Much of the development in Pennsylvania is low-density sprawl that occurs far outside traditional urban centers, resulting in the loss of prime farmland and forestland. It also results in inefficient transportation systems with: commuters traveling longer distances to work; less investment in urban renewal; increased non-point source pollution; and increased emissions of GHGs and traditional air pollutants, such as ozone (O_3), carbon monoxide (CO), and nitrogen oxides (NO_x). Reduction in GHG emissions through reduction in VMT can have a variety of incidental benefits, such as reductions in incidental air pollution, increased health through increased walking and bicycling, protection of farmland and forest land for future generations, and general improvements in the quality of life.

Pennsylvania contains many city and traditional town centers with concentrated patterns of mixed-use development that allow low-GHG-intensity transportation options such as walking, biking, and public transportation. While the loss of population in these areas has created sprawl-type development, the existing areas and infrastructure present the opportunity of redirecting growth to existing urban centers and reversing this trend. Pennsylvania has recently been experiencing a movement of baby-boomers back to urban centers. Accordingly, the rate of land conversion to development has slowed somewhat in recent years. Pennsylvania is experiencing

[4] *See* http://www.dvrpc.org/transportation/capital/hts_srs.htm.

land development rates last seen in the 1980's, after a peak in 1992-1997. Nevertheless, about 56,000 acres of land per year were converted to development between 1997 and 2003.

Reversing these patterns of development is made more difficult by a fragmented system of land use regulation, which includes 2,562 local government units, located in 67 counties. Moreover, annexation and consolidation of local government units is nearly impossible to achieve as a practical matter. Although the 2000 Amendments to the Municipalities Planning Code (MPC) included many measures to encourage regional cooperation and integration and traditional neighborhood development, the fragmentation of local government units makes effective regional land use controls very difficult to achieve, at best, and often impossible, in practice.

Pennsylvania has an existing infrastructure of rail and public transportation that provides a sound capital base upon which to build a system of effective public transportation. The existing SEPTA system in the heavily-settled southeastern portion of the Commonwealth, and the AMTRAK east-west and north-south intercity service provide significant opportunities. However, ridership has continued to fall as a percentage of VMT, and public transportation systems have faced a spiral in which limited funds have led to service cutbacks that have caused ridership to decline and revenues to fall. In addition, the shutdown of some routes throughout the Commonwealth, sprawl, and changes in development patterns have limited the accessibility of many shopping and work areas to public transportation routes.

Pennsylvania is the Keystone State for freight traffic, with major interstate east-west and north-south trucking and freight routes and major ports. However, much of the traffic increase has occurred in the trucking sector, which tends to be more GHG-intensive. Facilitation of rail and water use presents the opportunity to reduce GHG emissions, energy use, and wear and tear on highways.

Policy Recommendations

In addition to the existing initiatives, the following are recommended as measures to reduce GHG emissions:

- **Establish a renewable fuel standard for 2025 with a requirement of displacing 25% of conventional fuels with lower-carbon renewable fuels, consistent with the "25 x '25" goal.**

  Lower GHG emissions can result from use of renewable fuels such as ethanol, biodiesel, electricity (made from renewable sources), and other fuels that are promising but not fully commercialized yet. In many cases, their impact on GHG emissions depends on how the fuels are made (e.g., the source of the electricity, and starch-based versus cellulosic ethanol). Pennsylvania should set a goal of displacing 25% of conventional gasoline and diesel, consistent with the 25x'25 vision endorsed by Governor Rendell and 16 other governors.[5] This recommendation can build on, and go beyond, the PennSecurity Fuels Initiative. This

[5] *See* www.25x25.org/storage/25x25/documents/Pennsylvania.pdf. The overall vision of 25x'25 is: "By 2025, America's farms, forests and ranches will provide 25 percent of the total energy consumed in the United States, while continuing to produce safe, abundant, and affordable food, feed and fiber."

2006 initiative of the Governor consists of several actions designed to increase the sustainability and decrease the climate impact of Pennsylvania's transportation fuel use.[6] The initiative aims to: displace 900 million gallons of conventional fuel with alternative fuels, mandate that a portion of transportation fuels be derived from alternative sources, support the development of the refueling and production infrastructure for these alternative fuels, encourage new renewable fuel markets for the Commonwealth's farmers, and develop a credit trading system to bolster a variety of compliance options.

Many states have adopted renewable fuel standards (RFS) for both gasoline and diesel, notably Iowa (25% by 2020) and Connecticut (20% by 2020).[7] Minnesota has set a target of displacing 20% of gasoline with ethanol by 2013. At the national level, the 2005 Energy Policy Act set an RFS of about 6% for 2012, a level already surpassed in 2007. The Department of Energy's Biofuels Initiative has a goal of replacing 30 percent of current levels of gasoline consumption with biofuels by 2030.[8] Pennsylvania should also explore adoption of elements of California's recent initiative to specifically encourage low-carbon fuels, measured on a lifecycle basis (a program design also getting attention at the national level).[9]

Modeling of a 25% renewable fuels standard indicates that it could reduce GHG emissions by 12 $MMtCO_2e$ by 2025.[10] However, a careful assessment must be made to ensure that state (or national) biofuel targets do not put harmful pressure on land or food prices. Hopeful signs are emerging that cellulosic ethanol production methods are nearing commercialization, a development that would shift demand away from corn, the most common current feedstock for ethanol production. Although Pennsylvania has a good supply of biomass for production of biofuels (and electricity), it is unlikely to be capable of providing for all in-state demand. Thus a 25% renewable fuels standard would require out-of-state sources as well.

- **Expand the AFIG Program to further increase use of hybrids and alternative fuels.**

  As noted earlier, Pennsylvania encourages alternative fuels and hybrid vehicles via the AFIG Program. In 2003, only grants were offered (even for individual purchases of hybrid vehicles), meaning that consumers had to apply and be accepted by the program before they could purchase the vehicle. A lack of awareness about the program and the difficulty of applying for the grant before purchasing a vehicle resulted in a low impact. For instance, in 2003, only 133 grants were claimed in the entire Commonwealth for hybrid or alternative fuel vehicles.[11] Beginning in March 2005, however, the program started offering rebates, which can be claimed after a purchase, instead of just grants. Currently the rebate is only $500. With funding recently doubled to $3 million, up to 6,000 rebates could be distributed.

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[6] *See* www.ahs.dep.state.pa.us/newsreleases/default.asp?ID=3940.

[7] *See* http://www.eere.energy.gov/afdc/laws/incen_laws.html for a database of state RFS programs.

[8] *See* http://www1.eere.energy.gov/biomass/biofuels_initiative.html.

[9] *See* http://gov.ca.gov/index.php?/fact-sheet/5155.

[10] Although the GHG reductions occur upstream from the point of combustion in vehicles, conventional practice is for states to take credit for biofuel-related GHG reductions.

[11] *See* www.dep.state.pa.us/newsletter/default.asp?NewsletterArticleID=2814&SubjectID=.

The program could be expanded with higher levels of funding and an advertising campaign. Special emphasis could be placed on changing over private fleet vehicles to alternative fuels. Universities, hospitals, municipalities, school districts, businesses, and other fleet operators would be ideal recipients of such funding. The program could also be expanded, or a new program created, to include personal transportation efficiency initiatives such as carpooling and alternative transportation development, such as bike routes. Current price premiums for hybrid vehicles are around $2500—much greater than the $500 rebate. Yearly fuel savings range from just over $100 to over $350.[12] For hybrids to be cost competitive with conventional cars, the monthly fuel savings should balance out the increased monthly payments (from the price premium) on a typical five-year loan.

- **Adopt a fuel efficiency standard for replacement tires.**

  New cars are already equipped with low rolling resistance new tires that achieve higher fuel efficiency than typical replacement tires. An appropriate tire standard can put a floor on the fuel efficiency characteristics of those tires. Modeling indicates that this recommendation could reduce GHG emissions by 1 $MMtCO_2e$ by 2025.

- **Pilot a program of using nitrogen to inflate tires on fleet vehicles.**

  Existing research indicates that tires filled with pure nitrogen maintain tire pressure 2 to 3 times longer than air. Maintenance of proper inflation can result in fuel efficiency gains of over 3%, along with better traction and longer tire life. Pennsylvania should conduct a well-designed pilot program with a research partner and industry to investigate the potential benefits of nitrogen inflation of tires. The pilot could involve public and/or private fleet vehicles.

- **Implement the Smart Growth and Smart Transportation Initiatives Recommended by the Pennsylvania Transportation Funding and Reform Commission.**

  The Pennsylvania Transportation Funding and Reform Commission made a number of recommendations, which, if implemented, could reduce VMT and related GHG emissions. These should be implemented with some modifications designed to improve their efficacy in reducing GHG emissions. These include the following:

  - ***Link land use and transportation and encourage transit-oriented development*** around and near existing transit stations will encourage use of public transportation over use of single occupancy vehicles.[13]

  - ***Develop an incentive-based funding program*** to link land use and multimodal community investments through collaboration with partners including municipalities, Metropolitan Planning Organizations, Rural Planning Organizations, and other interested parties. This program should encourage investment in existing and emerging town centers and regionally significant corridors. Consideration of pedestrian and bicycle use should

[12] All fuel use and emissions data taken from www.fueleconomy.gov.
[13] *See* www.transitorienteddevelopment.org.

be included for transportation investments that promote sustainable development and decrease GHG emissions. Capital improvements funded through this program would be predicated upon local implementation of necessary land use policy/ordinance changes to support GHG emissions reduction goals.

- ***Establish a new, dedicated Transit Trust Fund*** that includes all current state transit funding sources to ensure stable transit funding is provided annually (similar to the Motor License Fund for highways and bridges). Existing subsidies should be replaced with a dedicated tax that grows with inflation and increases state and local funding for transit in order to: (1) put the existing public transportation systems on sound financial footing and provide for targeted expansion, (2) stabilize and expand service for Programs of Statewide Significance and create a Service Stabilization program for community transportation services, and (3) create a new Fixed Guideway initiative.

- ***Implement the Governor's proposal for public transportation funding.*** To implement the funding recommendations of the Commission, Governor Rendell has proposed a 6.17% tax on oil company profits in Pennsylvania, to generate an estimated $760 million a year for highway construction and mass transit systems. In addition, his companion plan, leasing the turnpike, is expected to raise at least $900 million a year for the Pennsylvania Department of Transportation and $65 million a year for municipal governments to use for local streets and bridges. Implementing these recommendations would both create disincentives for driving and create funding to improve the efficiency of transportation. As an alternative, a comprehensive GHG tax and vehicle registration fee based on GHG emissions would better accomplish the dual objectives.

- **Promote more strongly the "smart growth" development of communities across the Commonwealth.**

  As noted earlier, Pennsylvania is making efforts to promote "smart growth" that will reduce and potentially reverse the growth of VMT, but progress is slow. Smart growth aims to revitalize towns and cities by: improving the sense of community; creating mixed use development that places shopping, working, and living spaces in close proximity; creating walkable and bikable communities; encouraging redevelopment of existing urbanized brownfields areas; and conserving surrounding "green" areas. Pennsylvania should continue its existing efforts, but needs to implement additional measures to increase effectiveness. These should include the following:

  - ***Increase incentives for redevelopment.*** Although the existing brownfields programs remove the disincentives to redevelopment arising from contamination or concerns about contamination, redevelopment often involves private costs involved in removing or renovating existing buildings and these costs often exceed the cost of "greenfield" development. Creating grants for redevelopment of existing abandoned or underutilized sites, and funding the grants by an increased real estate transfer tax on first sales of formerly undeveloped property, could change the relative costs of developing new properties.

- ***Promote "location-efficient" mortgages***. Pennsylvania should encourage lending institutions to adopt location-efficient mortgage principles, such as recognizing transportation cost savings when calculating a household's borrowing ability. Recognizing these savings for mortgages for properties in existing urbanized areas or those with walkable or bikable access to transit centers will encourage redevelopment and denser patterns of development.

- ***Create additional incentives for mixed use and traditional neighborhood development.*** Despite the changes implemented in the 2000 Amendments to the MPC, many municipalities retain single-use zoning that discourages smart growth, and implementation of the traditional neighborhood development option presents practical difficulties that discourage developers. The Commonwealth should develop sample ordinances and encourage mixed-use development.

- ***Require county comprehensive plans and make consistency mandatory.*** The MPC should be amended to provide that comprehensive plans should be prepared at the county or regional level and make preparation of these plans mandatory. Moreover, inconsistency with a county plan should be made grounds for reversing a land use decision.

- ***Create an effective greenbelt program based on existing greenspace plans***. The creation of greenbelts in England and some United States jurisdictions has created an effective method for preventing sprawl-type development and redirecting it into existing cities and towns. The creation of a greenbelt for London effectively prevented sprawl and led to the revitalization and reuse of many former brownfield sites already served by infrastructure. Investment-backed expectations and property rights can be protected through mechanisms such as transfer development rights that will allocate rights to greenbelt areas that can only be used to increase density in existing urbanized areas and that can be sold to developers operating within existing urbanized areas. A greenbelt mechanism could be effectively applied to existing urbanized areas experiencing substantial amounts of sprawl-type development, such as Philadelphia and its suburbs, the City of Harrisburg, and the State College/Centre County area. Moreover, greenspace plans developed for the Philadelphia area, the Pittsburgh area, and others could serve as the framework for such a program.[14] However, such plans would require regional implementation that, in turn,

[14] ***The GreenSpace Alliance*** (the "GSA") was founded in 1992 by the City of Philadelphia to develop a comprehensive "GreenPlan" to support Philadelphia's Metropolitan Planning Organization's Open Space Plan—an existing, but less comprehensive open space plan. The GreenPlan's primary goal is to preserve urban Philadelphia's open space by establishing and expanding upon existing open space systems incorporating parks, natural habitats, stream corridors, forested areas, wetlands, and historic sites. The GSA also develops strategies to implement development that does not compromise the integrity of environmentally sensitive areas and combats urban sprawl. One example of GSA's work is demonstrated by its pioneering application of "jointures." Jointures, which are currently in use in the North Chester County Federation Project, are alternative zoning structures that allow municipalities to coordinate land use requirements between their territories. In addition to seeking to build strong regional citizen support from the five counties that make up the Philadelphia region (i.e., Bucks, Chester, Delaware, Montgomery, and Philadelphia), the GSA has brought land conservancies, county and municipal officials, state and federal agencies, environmental groups, business leaders, and planners together in pursuit of its goals.
Greenways for Pittsburgh program was designed under the administration of Pittsburgh mayor Richard Caligiuri in the 1980s. The Greenways program is designed to offer a strategy to cope with the largely undeveloped land on the
(continued...)

would require either an unparalleled level of regional cooperation, or a state statutory mandate. The MPC should therefore be amended to provide for a state greenbelt plan and "transferable development rights"[15] to implement the plan.

- ***Adopt recommendations of the State Planning Board to improve intergovernmental cooperation***. These changes would enable municipal authorities to be brought into cooperative agreements with local governments and help resolve conflicts among the governing codes of cooperating municipalities so as to clarify what provisions apply to new intergovernmental ventures.

- ***Reform Pennsylvania's System of Land Use Regulation.*** Pennsylvania is unlikely to be able to prevent sprawl or manage local transit with its current, fragmented system of local government control over land use. Redirecting land use control and taxing authority to support transportation initiatives to a larger regional entity, such as the county, is an essential first step to make this possible. In many cases, even existing counties are of insufficient size to manage regional patterns of growth or transportation. In some cases, such as Philadelphia and Pittsburgh, the metropolitan region consists of several counties. In more rural areas, counties' populations are too small to provide services cost-effectively. Major progress on smart growth would be accelerated by: (1) amendment of the MPC to increase the responsibility of county governments and regional planning organizations, (2) amendment of the MPC to require that land use and transportation be consistent, or (3) a constitutional convention to reconsider and revise Pennsylvania's system of local government.

- **Expand incentives for transportation options other than single occupancy vehicles.**

  The Commonwealth should provide additional incentives for alternative transportation options beyond those recommended by the Transportation Funding and Reform Commission. These include alternatives to single-occupancy vehicles. These include methods to: improve coordination of modes of transportation, which are often absent in urban areas; strategically fund and link transit/rideshare/bike-ped and park and ride facilities; expand individual workplace participation in Rideshare carpool and vanpool programs; promote high-occupancy vehicle lanes; and improve bike and pedestrian infrastructure both as feeders and stand-alone modes, particularly in urban areas.

(...continued)
surrounding hillsides. The program seeks to consolidate the many small tax-delinquent public parcels, paper streets, and scattered private parcels that, for a variety of practical reasons, are not appropriate for development. Under the program, these consolidated lands will be managed under a single agency. These lands will ultimately be joined with existing parklands, new riverfront areas, cemeteries, and institutionally managed open space to create a coherent and well-maintained open space system to surround and reinforce Pittsburgh's neighborhoods. The implementation of this program led to the creation of a "Green Map" which identifies five officially designated greenways in the city. The Green Map was adopted by Pittsburgh's City Council in 1989. In 1995, the County Planning Department for the County Board of Commissioners published the Allegheny County Greenways handbook that both delineates the benefits of successful greenways systems and identifies specific activities to be accomplished by county and municipal entities, as well as by the citizenry, to ensure that greenways and the goals they intend to accomplish are effectuated.

[15] *See* http://www.ndol.org/ndol_ci.cfm?kaid=139&subid=274&contentid=250739.

- **Encourage "Pay-As-You-Drive" (PAYD) insurance**.

  Pennsylvania could promote PAYD insurance, which changes part of vehicle insurance payments from fixed charges to per-mile charges while not changing payments. This approach has been piloted in Texas and elsewhere, and gives drivers an opportunity to save money by driving less. It is currently allowed under Pennsylvania insurance rules, but companies have shown little interest in offering it. A pilot program co-funded by the Commonwealth would generate useful information and test the market.

- **Implement a statewide ordinance banning idling by heavy-duty vehicles.**

  Adoption of an anti-idling ordinance could: (1) save fuel, (2) reduce GHG emissions and other pollutants, and (3) allow idling only when absolutely needed. Pennsylvania should also continue expanding truck stop electrification stations at key truck stops and truck rest areas. Modeling indicates that this recommendation could reduce GHG emissions by 0.1 $MMtCO_2e$ by 2025.[16]

- **Increased intermodal freight transportation**.

  Pennsylvania is truly the Keystone State with respect to freight transportation, with major east-west and north-south Interstate highways and other limited access highways, rail freight lines that carry significant amounts of interstate freight, and port cities with the ability to handle water-based freight transportation. One of the major challenges of encouraging greater use of intermodal freight is the location of terminals that allow efficient delivery to multiple locations. Strategically working with freight lines and major users of the system would allow the Commonwealth to identify locations where intermodal terminals would increase use of rail freight and to assist in the development of terminals. This could reduce freight-related emissions, reduce wear and tear on highways, decrease the demand for new roads, and spur economic development at those locations.

GHG Reductions and Costs

Estimates of the GHG reductions in 2025 were available for several options in the transportation and land use sector, as noted above: Clean Vehicles program (14 $MMtCO_2e$), 25% Renewable Fuel Standard (12 $MMtCO_2e$), and Fuel Efficient Tires (1 $MMtCO_2e$). Modeling indicates that the transit- and smart growth-related recommendations presented here could reduce GHG emissions by about 6 $MMtCO_2e$ by 2025.

This, in combination with other transportation measures, could reduce GHG emissions by 31 $MMtCO_2e$ total by 2025, as shown in Table 4-1. (Due to overlapping effects, the combined effect of various options is less than what a simple summation of individual impacts would suggest.)

Table 4-1. Transportation and Land Use Sector Quantified Policy Recommendations and Estimated GHG Impacts in 2025 ($MMtCO_2e$)

[16] For a summary of existing state ordinances, *see* http://www.epa.gov/otaq/smartway/documents/statelaws.pdf.

	2025 Base Case	GHG Impact	2025 Roadmap Case	Notes
Transportation	**104**	**-31**	**73**	
Clean Vehicles Program		-14		Adopted in 2006
Fuel Efficient Tires		-1		
25% Biofuels		-12		
Mass Transit / Smart Growth[###]		-6		
Anti-Idling Program		-0.1		

[###] Consists of Smart Growth, transit support, PAYD, etc.

On the cost side, though already adopted, the Clean Vehicles Program is widely estimated to reduce GHG emissions at a *negative* cost of about -100 dollars per ton. Contrary estimates of financial burden to drivers are hard to justify.[17] Fuel efficient tires have a similar cost savings effect. The Center for Climate Strategies (CCS) examined a tire standard for New Mexico and estimated reduced GHG emissions at a *negative* cost of -92 dollars per ton. CCS has examined anti-idling regulations in Arizona and North Carolina and estimated a *negative* cost of -22 dollars per ton.

Cost estimates for policy options related to biofuels are extremely difficult. First of all, the oil market is extremely volatile so it is very hard to predict the value of gasoline and diesel displaced by biofuels next year, much less in 2025. Second, a generous and complex set of federal subsidies reduces the apparent cost of biofuels (especially ethanol), thus the cost of biofuels varies tremendously depending on whether one examines it from the perspective of the national economy vs. the state economy. Finally, large private and public investments are underway to commercialize several promising technologies that could substantially reduce the cost of biofuels (e.g., cellulosic ethanol production). Given this landscape, the impacts of biofuels merit close attention from the *Climate Council*.

Turning to policies that affect the demand for travel, a wide variety of literature finds that integrated transportation and land use planning produces savings on infrastructure and transportation costs. Although building costs (including land) may be higher, the preponderance of literature suggests net savings overall. A Transportation Research Board review found substantial regional and state-level infrastructure cost savings from more compact development.[18]

Pennsylvania-specific studies reach the same conclusion. For example, one study from 2000 found that compact, planned-growth scenarios can reduce construction costs for roads, utilities, and schools by as much as 25%, which would have saved local governments in the range $120

[17] CCS examined an industry-sponsored study in the context of North Carolina work. The result appears in CCS, *Briefing – AB1493 (Pavley) Cost*, April 2007, http://www.ncclimatechange.us/ewebeditpro/items/O120F11585.pdf.
[18] See, e.g.: US EPA, *Our Built and Natural Environments: A Technical Review of the Interactions Between Land Use, Transportation, and Environmental Quality*, 2001 and Robert Burchell, *et al*., *The Costs of Sprawl—Revisited (TCRP Report 39)*, Transportation Research Board/National Research Council/National Academy Press, Washington, D.C. 1998.

million. [19] The study found that compact growth would have reduced private housing costs by 2% to 8% and reduced annual automobile-related expenses by $1500 for suburban households and by $4600 for rural families.

A 2003 report by the Brookings Institute estimates that, over the next twenty-five years, the existing pattern of decentralized development will cost Pennsylvania taxpayers and the government an additional $1 billion for road, sewer, and water infrastructure expenses alone. [20] Furthermore, the report states that sprawl causes urban decline, which decreases tax revenues—one of the heaviest costs of sprawl. The report also identifies other unquantifiable costs of sprawl such as Pennsylvania's: static economy, poor demographic trends, "brain drain," and declining competitiveness.

The *Climate Council* should examine in depth, the options, GHG impacts, and costs in the transportation and land use sector.

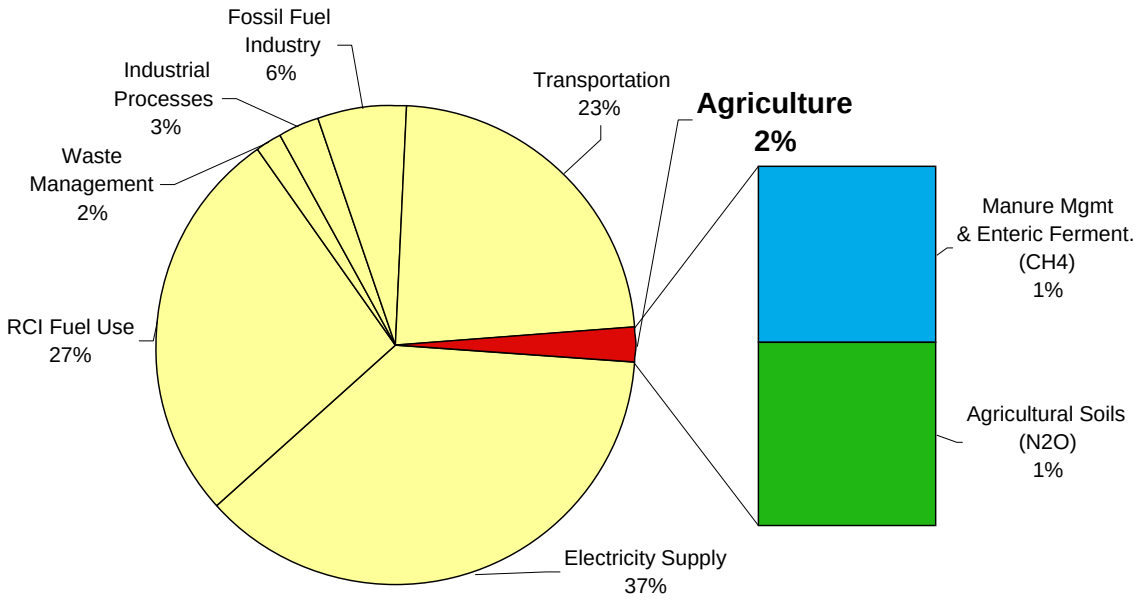
[19] Clarion Associates, Inc., *The Costs of Sprawl in Pennsylvania*, 2000, *at* http://www.sustainablepittsburgh.org/pdf/Costs_of_Sprawl_in_Pennsylvania.pdf.
[20] Brookings Institute, *Back to Prosperity: A Competitive Agenda for Renewing Pennsylvania*, 2003, *at* http://www.brookings.edu/Pennsylvania.

Chapter 6
Agriculture

Overview of GHG Emissions

Agriculture in Pennsylvania released about 2% of the state's greenhouse gas (GHG) emissions in 2000 (see Figure 6-1 below), from animal waste and the interaction of agricultural soils with the atmosphere. As noted below, certain farming practices can also greatly increase the amount of carbon sequestered in soil. In addition, agriculture provides feedstocks for crop-based renewable fuels (discussed in Chapter 5) and can contribute biomass electricity to power supplies, along with sites for wind power (as noted in Chapter 3).

Figure 6-1 Gross GHG Emissions in Agriculture, 2000, Pennsylvania



Recent Policy Developments

- **Pennsylvania's Chesapeake Bay Tributary Strategy**. Published in 2004, the Tributary Strategy includes both mandatory and voluntary programs that can reduce Pennsylvania's contribution of nitrogen, phosphorous and sediment to the Chesapeake Bay by 2010, in accordance with Chesapeake Bay Program goals. Several of the measures, including land conservation programs, agricultural nutrient management regulations and recommended best management practices, and wastewater treatment facility improvement programs, can lead to significant reductions in GHG emissions of methane (CH_4) and nitrous oxides (NO_x).

- **Advancing Soil Sequestration.** The Pennsylvania Department of Agriculture (PDA) and Pennsylvania Department of Environmental Protection (PA DEP) signed a collaborative agreement to explore agricultural carbon sequestration, energy savings, and other opportunities. The Commonwealth's vision is now expanding to foresee a system of carbon credits to farmers who can demonstrate quantitatively that they positively contribute by their agricultural practices toward increased soil carbon and/or reduced fossil fuel use. Government agencies are supporting this effort through competitive grants to answer basic questions on the technological platform needed to make this vision a reality.

- **Pennsylvania Preferred.** The Pennsylvania Preferred™ program assists Pennsylvania farmers by encouraging consumers to purchase Pennsylvania products, while assuring consumers with important quality standards.[1] More local purchasing can lead to lower transportation costs, and lower GHG emissions, while keeping the local economy strong.

Key Challenges and Opportunities

Although the direct GHG emissions to the atmosphere attributable to the agriculture sector are relatively small as indicated above, Pennsylvania's farmers can still play an important role in decreasing the Commonwealth's net emissions. Pennsylvania's farms can help reduce GHG emissions through a broad array of activities including: reductions in nitrogen emissions from fertilizer use and manure management, reduced CH_4 emissions from animal waste, and reduced transportation emissions resulting from food imports. Such activities often carry significant co-benefits in terms of better air and water quality and rural economic development.

Policy Recommendations

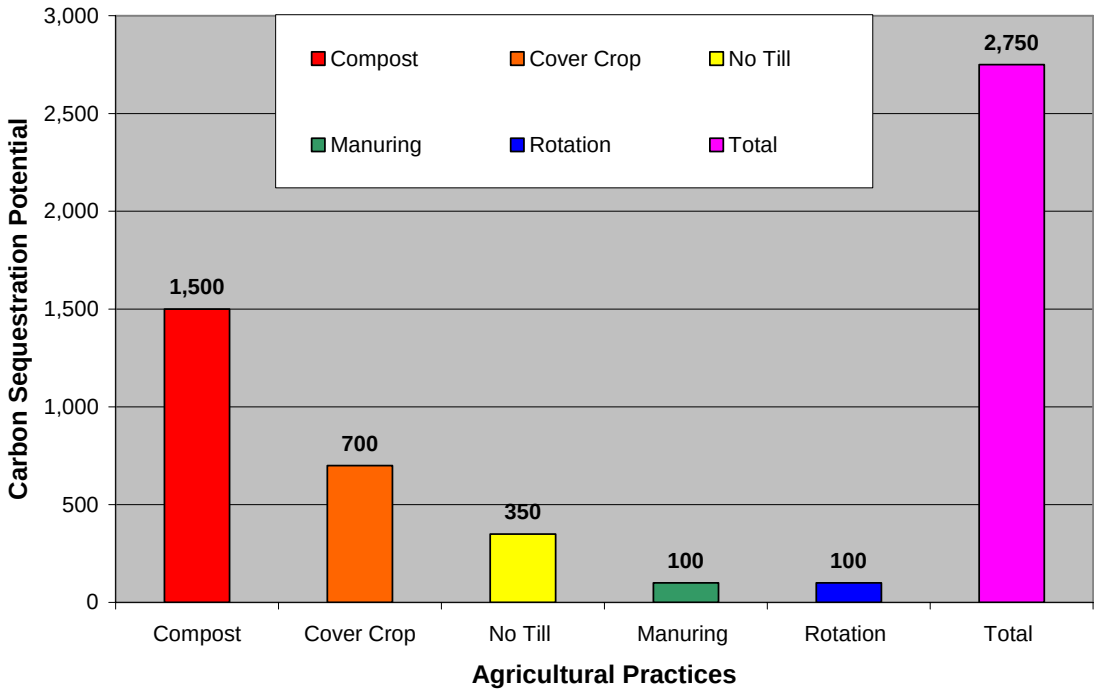
- **Promote agricultural practices that increase carbon sequestration in soils.**

  Practices such as using compost, cover crops, no till agriculture, rotation, and manure (or a combination of these practices) can have a significant impact on the amount of carbon sequestration in soil. Figure 6-2 below presents estimates by the Rodale Institute of the maximum potential sequestration on agricultural lands.[2]

[1] *See* http://www.agriculture.state.pa.us/papreferred/site/default.asp

[2] Hepperly, P.R., Douds, D.D., and Seidel, R., *The Rodale Institute Farming Systems Trial 1981 to 2005: Long Term Analysis of Organic and Conventional Maize and Soybean Cropping Systems*, December 2006, http://www.ars.usda.gov/research/publications/Publications.htm?seq_no_115=207137. See also: Raupp, Joachim, Carola Pekrun, Meike Oltmanns, Ulrich Köpke (Eds.) *Long Term Field Experiments in Organic Farming*. ISOFAR Scientific Series No 1. Verlag Dr. Köster, Berlin, Germany, 2006. http://www.isofar.org/publications/scientific-01.html

Figure 6-2
Carbon Sequestration Potential of Selected Agricultural Practices
(pounds of carbon per acre per year)



Currently about 3.9 million acres are used in Pennsylvania agriculture. "No till" is used on approximately 30% of those acres, but the other practices are used on less than 2% of total agricultural acreage. Therefore the potential for increased soil sequestration is large. If all practices were used on 100% of Pennsylvania's farmlands, the Rodale Institute estimates a maximum sequestration potential of 20 million metric tons of carbon dioxide equivalent ($MMtCO_2e$) per year. Recognizing that 100% adoption rates are unlikely, the practical, achievable level of sequestration will be less. Modeling suggests that a plausible estimate for achievable agricultural sequestration by the year 2025 is approximately 11 $MMtCO_2e$, reflecting an assumption of adoption of these agricultural practices on about two-thirds of Pennsylvania's farmlands. However, better estimations of this range merit more study. The Pennsylvania Environmental Council (PEC) is collaborating with the Capital Regional Resource Conservation District on an evaluation of the carbon sequestration potential in no-till agriculture.

The Rodale Institute also found that after a few years yields from organic farms very nearly caught up to conventional farms.[3] The study confirmed that the income from an organic farm is greater than that from a conventional farm with only minimal price premiums for organic

[3] See D. Pimental et al, *Environmental, Energetic and Economic Comparisons of Organic and Conventional Farming Systems*, Bioscience 55(7):573-582. (a study by The Rodale Institute, Cornell University, University of Maryland, and the Eastern Region Research Center of the USDA-ARS.
See also: http://www.rodaleinstitute.org/science/.

products (10% or less).[4] When the environmental benefits of organic farming are included in the analysis, organic farming appears quite attractive. In terms of energy use, a one third reduction of fossil fuel use in organic agriculture is related to the use of legume cover crops rather than ammoniated nitrogen in conventional agriculture. In terms of conventional industrialized animal production, large masses of manures are sources of GHG. If these are stabilized, for instance through composting, and returned to the production system, the fossil fuel requirement for fertilization is not only cut but the carbon can improve the soil and be a GHG credit.

Recent increases in the price of its natural gas feedstock have made chemical nitrogen fertilizers a major cost issue with farmers, and have increased interest in these farming practices that enhance soil carbon accumulation. Pennsylvania should promote these agricultural practices to help protect farmers from increasing fertilizer prices, and produce a variety of environmental dividends.

- **Promote consumption of locally grown agricultural products**

  Consumption of more local food has potential to reduce significant amounts of transportation- and manufacturing-related emissions. Broadly speaking, the food system in the United States accounts for approximately 15% of the total energy consumed. Imported food, and even domestically produced foods, can travel thousands of miles before reaching a grocery store. The PA Preferred program is a good start, but should be expanded and marketed more heavily.

- **Promote improved and integrated animal waste management systems.**

  Despite regulations and promotion of best management practices, animal waste is still a large source of degradation in the Chesapeake Bay and other water bodies. Over 4 million tons per year of animal waste are produced in Lancaster County alone. Improved and integrated systems could improve water quality and reduce GHG emissions. Pennsylvania should promote operations that anaerobically digest or burn manure (reducing volume by 20 to 90%) and then compost the remains. This will produce two marketable products: energy and compost. The energy can displace fossil fuels and the compost can help build soil carbon. With support from the Pennsylvania Department of Agriculture, PEC, Penn State, and other partners are demonstrating the use of composted chicken manure to reclaim abandoned mine lands. Carbon credits for such activities may be possible in future markets.

GHG Reductions and Costs

Modeling was conducted only for the soil sequestration option, which resulted in an estimate of 11 $MMtCO_2e$ by 2025. Research by the Rodale Institute indicates that this can be accomplished with no cost or net savings to farmers, and that practices described can bring a wealth of co-benefits in terms of reduced fertilizer and pesticide use. The *Climate Council* should examine GHG impacts and costs in depth for all options in the agriculture sector.

[4] The current premium for grains, vegetables, and fruits that are organically certified is 80% above that of the conventional counterpart.

Chapter 7
Forestry

Recommendations in this chapter relate to forestry and land use policies that affect the levels of terrestrial carbon sequestration in Pennsylvania's forests. These recommendations are drawn from those in draft form under consideration in the Carbon Management Advisory Group (CMAG) process noted in Chapter 1.[1]

Overview of GHG Emissions

Forest growth sequestered the equivalent of around 5% of Pennsylvania's total greenhouse gas (GHG) emissions, or about 14 million metric tons of carbon dioxide equivalence ($MMtCO_2e$). Beyond this, biomass harvested from Pennsylvania's forests can be used to displace conventional fossil fuels, resulting in a carbon-neutral energy source. Trees can also be planted strategically near buildings to reduce heating and cooling needs. Further potential comes from energy displacement through substitution of low-energy wood building materials for conventional materials. These actions can provide positive net GHG benefits if harvested forest biomass is replaced through regeneration, land protection, and other sustainable forest practices. Other co-benefits in terms of habitat preservation and water resources are associated with healthy forestlands.

Recent Policy Developments

- **Growing Greener II and Natural Resource Conservation.** The Pennsylvania Department of Conservation and Natural Resources (DCNR) plans to acquire 20,000 acres per year (at current funding levels) in its program of "Conserving Special Places" under Growing Greener II.[2] The Department plans to direct future land investments in a more strategic way to complement regional landscape conservation initiatives or better leverage natural resource conservation and economic development programs across multiple communities or counties.

- **Fuels for Schools and Beyond.** DCNR is partnering with other agencies in a program promoting the utilization of biomass for school heating and aiming for considerable cost savings and carbon offset potentials. For example, the Mt. View School District in Susquehanna County has offset the use of an estimated 90,000 gallons of fuel oil annually with cost savings ranging from $200,000-$300,000. This program is building huge interest and momentum statewide. Similar programs have been successful in Vermont and a number of western states.

- **TreeVitalize.** In 2005, DCNR launched this public-private partnership and regional collaboration effort to address the loss of tree cover in the five-county Southeastern Pennsylvania region.[3] The program is the largest in place planting street trees and stream

[1] *See* http://www.dcnr.state.pa.us/info/carbon/.
[2] *See* http://www.dcnr.state.pa.us/info/conservingspecialplaces.doc.
[3] *See* http://www.treevitalize.net/.

buffers. As of February 2007 11,526 trees have been planted and 179 acres of forested riparian buffers restored.

- **Conservation Reserve Enhancement Program (CREP).** Using United States Department of Agriculture (USDA) funding, DCNR and federal, state, and local agencies administer an incentive to farmers to keep highly erodable acres planted with warm season grass. These acres could be a significant source of bio-fuel in switchgrass, providing terrestrial sequestration benefits as well as carbon neutral biomass feed stocks. Pennsylvania uses Growing Greener funds to enhance federal cost-share payments for installation of conservation practices. In addition to warm season grasses, the CREP program subsidizes riparian forest buffer practices.

Key Challenges and Opportunities

Pennsylvania's landscape is dominated by forests. They are an integral part of the Commonwealth's identity and provide a suite of services from soil protection to water quality to tourism and recreation to forest products. There are emerging opportunities to sustainably utilize the forests for a number of carbon neutral benefits, which can interact directly with global warming policy initiatives. At the forefront of these issues are the concepts of renewable energy, terrestrial carbon sequestration, and sustainable forest management.

Of the 17 million acres of forestland within Pennsylvania, 26% are publicly owned. DCNR's Bureau of Forestry 2.1 million acre land base is third-party certified as being sustainably managed,[4] and DCNR's record is considered by many constituents and stakeholders to be an example of how to "do things right." Nevertheless, there are real challenges to expanding sustainable management practices to the remaining 74% of the forestland base. A key challenge facing the commonwealth is how to translate the benefits of conservation-based forest management to the public at large in order to ensure the most productive working forest, which then can provide the ancillary opportunities of renewable energy and carbon offsets.

The use of woody biomass as an energy source has the opportunity to offset hundreds of thousands of gallons of petroleum based energy annually. There are two distinct areas of opportunity on this issue and key differences in the approaches of these two alternatives—large-scale, utility-sized biomass facilities or small-scale, local biomass systems. There are a number of examples of states that have participated in either federally or state supported initiatives, which have succeeded in providing rural school districts with environmentally friendly heat at considerable cost savings, while providing local sustainable economic development opportunities. This is one of the main benefits of a locally-driven biomass utilization program. Such a program provides opportunities for local communities to participate in the procurement of the energy supply while providing forest management opportunities, which will benefit the long-term health and vitality of the local forests. For instance, a local school may utilize between 500 and 2000 tons of woody biomass annually depending on the annual average temperature in the region.

The second potential woody biomass opportunity lies in the use of the emerging cellulosic ethanol technologies. Such operations hold promise to lower carbon dioxide (CO_2) emissions

[4] Certification is performed under the guidelines of the Forestry Stewardship Council.

while offsetting fossil energies. Nevertheless, these operations demand tremendous volumes of biomass and, if expressed in wood fiber, surpass the demand of many of the traditional wood pulp facilities. Supply curves and market analyses are necessary to determine the long-term sustainability of such enterprises.

Some key challenges to either or both approaches include several key aspects: the availability of woody biomass, the cost of transportation, and the potential ecological impacts. Access to the material is paramount to sound policy development. Many data sources report that there are millions of tons of woody, biomass material available annually within the commonwealth. These estimates reflect actual trends but do not consider the commercial availability of the product. Understanding what proportion of the land base is accessible, based on physical or economic constraints, is critical to determining what expectations can be placed on the need for materials to fuel an alternative energy market. Furthermore, soft markets in the woody biomass sector are classically caused by the impact of fluctuations in fossil-based energy prices on the cost of transporting this relatively heavy raw material to processing facilities. There is a need to fully understand how transportation or hauling costs could be adjusted to maintain productivity through fossil-based energy market fluctuations and at what price points such activities maintain their economic viability. Finally, concurrent with an evaluation of the economic considerations, Pennsylvania, through DCNR, will need to evaluate the impact of extracting woody biomass on the overall health of the Commonwealth's forest ecosystems.

Policy Recommendations

Recommendations in this sector relate to forestry and land use policies that affect the levels of terrestrial sequestration on Pennsylvania's lands.

- **Protect the forestland base.**

  Pennsylvania should reduce loss of forestlands—and their associated carbon stocks and sequestration potential—as a result of development or other types of land use and land cover change. When forests are converted to other land uses and land cover, forest biomass is cleared and the carbon stored in biomass is emitted through decay, combustion, and/or transferred into wood products. Cleared areas generally contain much lower amounts of biomass and its associated carbon, and sequester less carbon on a per-area basis than forests.

- **Establish new forests.**

  Increase carbon stored in forests through expanding the forestland base. Establishing new forests ("afforestation") increases the amount of carbon in biomass and soils compared to pre-existing conditions. Goals should include:

  - Aggressive program of establishing forests on abandoned mined lands (AML).

  - Establish forest riparian buffers along the Chesapeake Bay drainage.

  - Establish forested riparian buffers along the Ohio and Chesapeake Bay drainages through CREP. Expand CREP to the Delaware and Lake Erie basins.

- **Restore and regenerate existing forests with best management practices.**

  Pennsylvania should increase forest carbon stocks through changes in management practices on existing forestland—for example, through practices that increase tree density, enhance forest growth rates, alter rotation times, or decrease the chances of biomass loss from fires, pests, and disease. In addition, increasing the transfer of biomass to long-term storage in wood products can increase net carbon sequestration, provided a proper balance is maintained, in which enough biomass remains on site as residues to serve as nutrient inputs to the forest. Practices may include management of rotation length, density and ecosystem health, and sustainable use of wood products.

- **Promote the use of wood and biomass energy.**

  Pennsylvania should expand the use of forest biomass energy sources. Biomass can be used to generate renewable energy in the form of liquid fuels (such as cellulosic ethanol) or, through direct combustion, to generate electricity, heat, or steam (through biomass combustion). Carbon in forest biomass is considered biogenic under sustainable systems; CO_2 emissions from biomass energy combustion are replaced by future carbon sequestration. Expanded use of biomass energy, in place of fossil fuels, results in net emissions reductions by shifting from high to low carbon fuels (when sustainably managed). For this to be true, the full lifecycle of energy requirements for producing fuels must not exceed the energy content of the renewable resource. Expanded use of biomass energy can be promoted by increasing the amount of biomass produced and used for renewable energy, and by providing incentives for the production and use of renewable energy supplies.

- **Enhance the use and lifetime of durable wood products.**

  Pennsylvania should enhance the use and lifetime of durable wood products. Durable products made from wood prolong the length of time forest carbon is stored rather than emitted into the atmosphere. Wood products disposed of in landfills may store carbon for long periods under conditions that minimize decomposition, which delays the release of methane gas from landfills. (Carbon originally stored in wood products becomes methane during decomposition.) Increasing carbon stored in the wood products pool increases carbon sequestration from forests. This can be achieved through improvements in production efficiency, product substitution, expanded product lifetimes, and other practices. In addition, increasing the efficiency of the manufacturing lifecycle for wood products enhances GHG benefits.

- **Enhance urban and suburban tree stocks.**

  Pennsylvania should 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 (e.g., in parks, along roadways, and in residential settings), can be enhanced in a number of ways, including planting additional trees, reducing mortality and increasing growth of existing trees, and avoiding tree removal (or deforestation). Properly designed forest canopy and cover can reduce heating and cooling needs of buildings. Furthermore, the TreeVitalize program should be expanded across the Commonwealth.

GHG Reductions and Costs

Preliminary modeling done as part of the CMAG process was available for two options, which resulted in the following estimated impacts. Afforestation on AML should be able to sequester at least 1 $MMtCO_2e$ by 2025, and when other lands are added the quantity of sequestered carbon would increase. A forest protection initiative could lead to sequestration of an additional 3 $MMTCO_2e$ by 2025. Taken together, by 2025 forest sequestration could increase by about 4 $MMtCO_2e$ over a base of 14 $MMtCO_2e$, as shown in Table 7-1 below.

Table 7-1. Forestry Sector Quantified Policy Recommendations and Estimated GHG Impacts in 2025 ($MMtCO_2e$)

	2025 Base Case	GHG Impact	2025 Roadmap Case	Notes
Forestry and Land Use - Sequestration	**-14**	**-4**	**-18**	
AML Afforestation		-1		
Forest Protection Initiative		-3		

Time and resources did not allow a comprehensive analysis of the cost of implementing these recommendations. However, the CMAG process will conclude later in 2007, and should provide good cost estimates, along with quantification of all GHG impacts of various forestry options.

Chapter 8
Geologic Sequestration

Recommendations in this chapter address the goal of enabling the Commonwealth to capture carbon dioxide (CO_2) emissions from large emitting sources and sequester them in underground geologic reservoirs. These recommendations are drawn from those in draft form under consideration in the Carbon Management Advisory Group (CMAG) process noted earlier.[1] Studies to date show that Pennsylvania has substantial geologic sequestration opportunities where future emissions from centralized sources could be safely stored for at least a millennium at a reasonable cost.

Technology and Economics

The long-term storage of CO_2 in underground reservoirs (such as saline aquifers or depleted gas fields) provides great potential for the continued use of fossil fuel resources with dramatically lessened impacts on climate change. An exhaustive collaborative study has shown that the geologic region including Pennsylvania could have ample underground storage capacity for centuries at current emission levels, with Pennsylvania itself having over 88 gigatonnes (GT) of potential CO_2 reservoirs.[2] This storage process, called geologic sequestration, requires a concentrated flow of CO_2, such as that from electricity generation; iron, steel, cement, and ammonia production; and refineries.[3] These concentrated sources are distinct from distributed emissions (such as those from automobiles), which cannot be captured and sequestered. Pairing geologic sequestration with carbon capture at an advanced coal electricity plant, for instance, offers an avenue by which future coal plants can reduce their carbon emissions 90% below conventional coal plants.[4]

The technology to capture CO_2 emissions is coming to commercial fruition and has been studied in detail by an international panel of experts and is briefly summarized here.[5] At coal plants, CO_2 can be captured chemically or physically from the gaseous mixture produced after coal is combusted (post-combustion capture). However, the nature of this mixture makes capturing and concentrating the CO_2 an energy intensive process, although technological improvements continue to increase its efficiency. One emerging technology called oxyfuel combustion improves the process by combusting the fuelstock with oxygen instead of typical air (which is

[1] *See* http://www.dcnr.state.pa.us/info/carbon/.
[2] Midwest Regional Carbon Sequestration Partnership, *MRCSP Phase I Final Report* (Columbus: Battelle, December 2005), 49 and 86, http://198.87.0.58/PhaseIReport.aspx. The Partnership noted that its conclusions may be optimistic and that the storage capacity is not distributed evenly (97-98).
[3] *See* Chapter 3 of International Panel on Climate Change, *IPCC Special Report on Carbon Dioxide Capture and Storage*, prepared by Working Group III of the IPCC, Bert Metz et al., eds., (New York: Cambridge UP, 2005), http://www.ipcc.ch/activity/srccs/SRCCS.pdf.
[4] *See* Table 3.7 and Table 3.10 in International Panel on Climate Change, *IPCC Special Report on Carbon Dioxide Capture and Storage*, 151 and 156.
[5] For more detailed information on capture technology, refer to Chapter 3 of International Panel on Climate Change, *IPCC Special Report on Carbon Dioxide Capture and Storage*. Also refer to Chapter 4 of Midwest Regional Carbon Sequestration Partnership, *MRCSP Phase I Final Report*.

mostly nitrogen), although producing the required oxygen itself requires energy. Yet instead of capturing CO_2 after combustion of the coal, the coal can also be gasified—a widely demonstrated technology—and the CO_2 extracted after gasification but before the resource is combusted, which tends to make carbon capture more efficient (chemically *and* economically) vis-à-vis conventional methods. Called pre-combustion capture, this method is particularly well-suited to coal-fired Integrated Gasification Combined Cycle (IGCC) electricity generation.

After CO_2 has been captured by the emission source and pressurized, the gas can then be transported via pipeline (or even truck or ship) to a location where it can be geologically sequestered. At the sequestration site, the CO_2 is pumped through a wellhead down into whatever geologic formation has been identified and approved for its long-term storage. Likely formations in Pennsylvania include deep saline aquifers (far below sources of groundwater) or depleted natural gas or coalbed methane (CBM) fields. In fact, sequestration of CO_2 can be used to increase the output of these depleted fields. Of course, concerns for leakage and the permanence of the storage necessitate appropriate site selection and monitoring measures, even though experts consider it "likely that 99% or more of the injected CO_2 will be retained for 1000 years."[6]

The requisite technology has been widely demonstrated, though not at a commercial scale, in the variety of contexts conceivable in Pennsylvania. One notable project has taken the CO_2 through all of the steps (capture, transport, and sequestration). Since 1999, the Great Plains Synfuels Plant in North Dakota has captured CO_2 for transport over 200 miles to Canada's Weyburn oilfield, enabling the production of over 130 million barrels of petroleum (a doubling of its rate of oil recovery) while so far sequestering over five million tons of CO_2.[7] Numerous facilities around the globe will also complete each step: SaskPower in Canada, ZeroGen in Australia, RWE Power in Germany, E.ON in the United Kingdom, and FutureGen and American Electric Power in the United States (among others).[8] At least three commercial projects have

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[6] International Panel on Climate Change, *IPCC Special Report on Carbon Dioxide Capture and Storage*, 197.

[7] US Department of Energy, "Practical Experience Gained During the First Twenty Years of Operation of the Great Plains Gasification Plant and Implications for Future Projects," April 2006, v, 45, and 47, http://www.fossil.energy.gov/programs/powersystems/publications/Brochures/dg_knowledge_gained.pdf.

[8] *See*: SaskPower, "Clean Coal Project," http://www.saskpower.com/pdfs/cleancoalfactsheetRVSD.pdf ; ZeroGen, "Project Overview," http://www.zerogen.com.au/files/FactSheetReviewOctober2006ProjectOverview.pdf ; RWE Power, "RWE Plans to Build a CO_2-Free Coal-Fired Power Plant Including CO_2 Storage – a Global First," press release on March 30, 2006, http://www.rwe.com/generator.aspx/presse/language=en/id=76864?pmid=4001048 ; E.ON UK, "E.ON UK Considers World-Leading Clean Coal Technology for New Pilot Power Station in Lincolnshire, Calls for Government Support," press release on May 24, 2006, http://www.eon-uk.com/pressRelease.aspx?id=937&month=5&year=2006&p=1 ; Department of Energy, "FutureGen: A Sequestration and Hydrogen Research Initiative," Project Update: December 2006, http://www.fossil.energy.gov/programs/powersystems/futuregen/Futuregen_ProjectUpdate_December2006.pdf ; and American Electric Power, "AEP to Install Carbon Capture on Two Existing Power Plants; Company Will Be First to Move Technology to Commercial Scale," press release on March 15, 2005, http://www.aep.com/newsroom/newsreleases/default.asp?dbcommand=DisplayRelease&ID=1351 ; and Michael G. Morris, "Morgan Stanley Global Electricity & Energy Conference: American Electric Power," presentation on March 15, 2007 in New York, NY, http://www.aep.com/investors/present/documents/MorganStanley_Mar-15-2007.pdf.

demonstrated the feasibility of sequestering CO_2 emissions.[9] The Weyburn oilfield in Canada, Sleipner in the North Sea, and In Salah in Algeria have all been sequestering carbon (for different reasons) at similar rates of at least 3,000 tons of CO_2 per day for a combined total of over 20 years.[10] The challenge in Pennsylvania is to synthesize the elements of commercialization from projects like these around the world.

The cost of capturing CO_2 combined with the cost of transport and geologic sequestration composes the total cost of carbon capture and sequestration. More abstractly, it represents the effective cost of shifting CO_2 emissions from being vented into the atmosphere and instead sending them to a stable, safe, and long-term underground reservoir. Because the technology is rapidly developing, published cost estimates may soon (or already) be outdated, especially in forecasting what options might be available in three, five, ten, or twenty years. Although highly dependent on localized factors, the estimated cost of capture per avoided ton of CO_2 ranges from \$13-\$74.[11] The cost of transport adds only slightly to this, likely on the order of a few dollars or less;[12] and the same can be said for geologic storage.[13]

The Midwest Regional Carbon Sequestration Partnership (MRCSP) estimated a supply curve for sequestration, reproduced below as Figure 9-1 and adjusted such that the red sections represent the geologic opportunities and blue sections represent the terrestrial sequestration opportunities. While some opportunities are available below \$30 per ton, most of the geologic opportunities are available from \$30 per ton and upwards. This cost curve is likely to shift downward with technological improvements over the coming years. Figure 9-2 provides the MRCSP's cost estimates of carbon capture by emission source.

Many experts conclude that widespread deployment of carbon capture and sequestration will come at costs on the order of \$25 to \$35 per ton of CO_2.[14]

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[9] A wealth of information and an international, searchable project database are available online with continual updates from the International Energy Agency Greenhouse Gas R&D Programme, "CO_2 Capture & Storage," http://www.co2captureandstorage.info/.

[10] International Panel on Climate Change, *IPCC Special Report on Carbon Dioxide Capture and Storage*, 200-204; Statoil, "Sleipner CO_2 Project," http://www.statoil.com/statoilcom/svg00990.nsf/web/sleipneren?opendocument; and British Petroleum, "Carbon Capture and Storage," http://www.bp.com/sectiongenericarticle.do?categoryId=9007626&contentId=7014493.

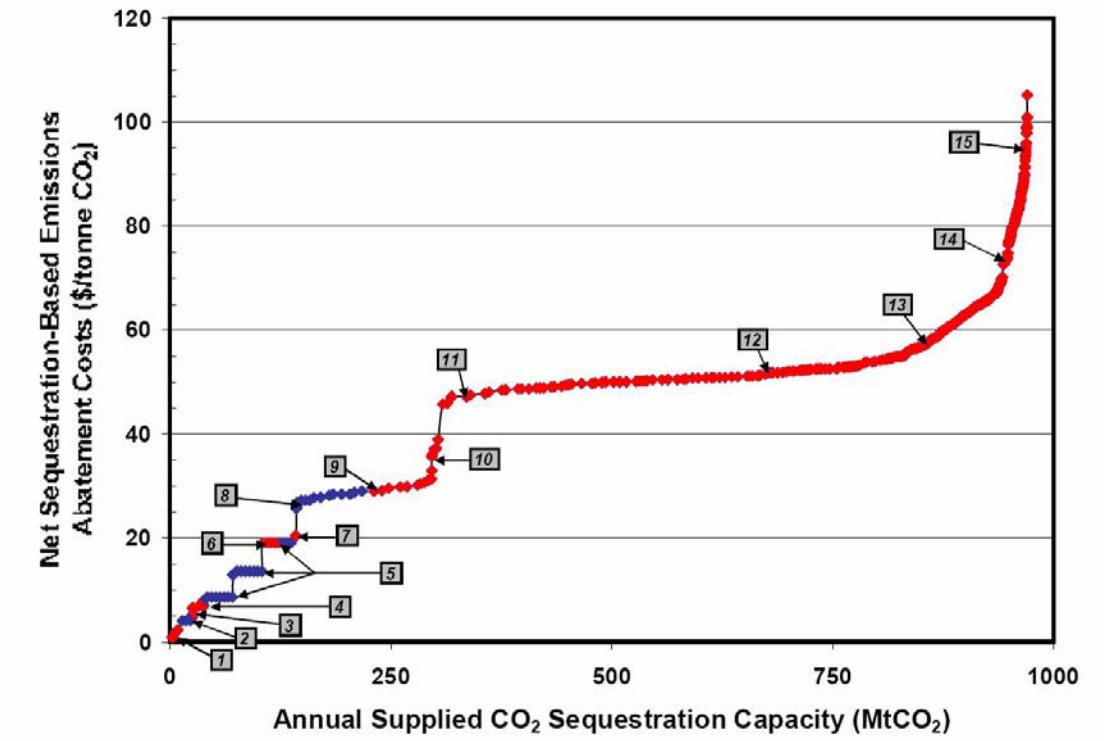
[11] International Panel on Climate Change, *IPCC Special Report on Carbon Dioxide Capture and Storage*, 107.

[12] The cost of transport depends largely upon the diameter of the pipeline (and, correspondingly, the rate of CO_2 flow) and the total distance covered, although terrain and population density also influence the cost; *see* International Panel on Climate Change, *IPCC Special Report on Carbon Dioxide Capture and Storage*, 190-192.

[13] Based on a review of the literature and Table 5.9 of International Panel on Climate Change, *IPCC Special Report on Carbon Dioxide Capture and Storage*, 260, noting that Pennsylvania's prevailing opportunities are saline formations.

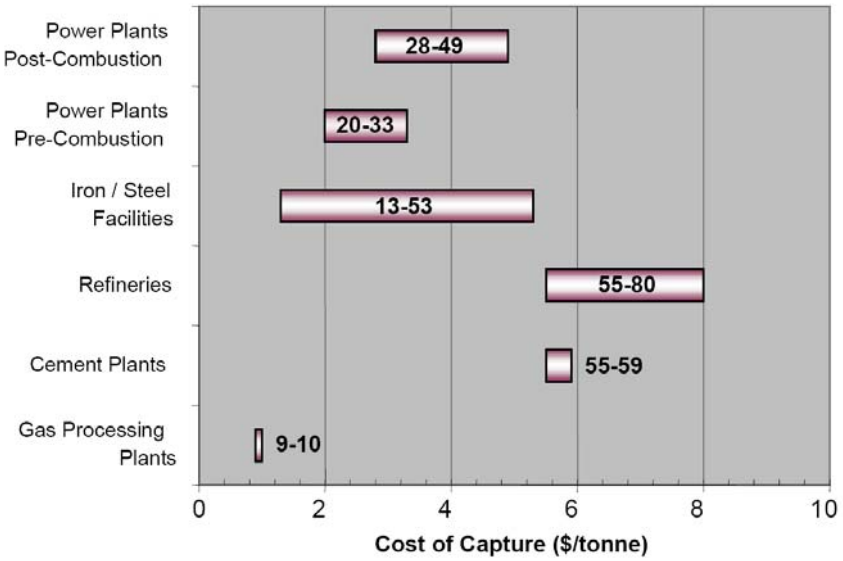
[14] A \$30/tCO_2 estimate is given in *The Future of Coal: Options for a Carbon-Constrained World*, Massachusetts Institute of Technology, 2007, Massachusetts Institute of Technology Coal Energy Study Participants, xi, http://web.mit.edu/coal/The_Future_of_Coal.pdf. A \$25-\$35/tCO_2 range is cited in Robert H. Williams and David G. Hawkins, "Coal Low-Carbon Generation Obligation for US Electricity," draft, provided by Williams via e-mail on October 13, 2006, 1. A \$100-\$200 per ton of carbon range (\$27-\$55/tCO_2) is offered by Robert H. Socolow and Stephen W. Pacala, "A Plan to Keep Carbon in Check," *Scientific American*, September 2006, http://search.epnet.com/; and \$100 per ton of carbon (\$27/tCO_2) is offered by Howard Herzog, quoted in "Can Carbon Sequestration Solve Global Warming? Researchers Examine Limits, Promise of New Science," press release

Figure 8-1 Cost of Sequestration for the Midwest Region including Pennsylvania



Source: Midwest Regional Carbon Sequestration Partnership, *MRCSP Phase I Final Report*, 232.

Figure 8-2 Cost of Capturing CO_2 by Emission Source



Source: Midwest Regional Carbon Sequestration Partnership, *MRCSP Phase I Final Report*, 29.

by American Association for the Advancement of Science, February 17, 2003, http://www.aaas.org/news/releases/2003/0217carbon.shtml.

The MRCSP also notes that few current laws and regulations are directly relevant to CO_2, though the Underground Injection Control program under the federal Safe Drinking Water Act could be relevant.

Legal and Regulatory Issues

Carbon capture and geologic sequestration present some new legal and regulatory issues, primarily for the transportation pipelines, injection and long-term storage, and liability. These issues will need resolution before this technology can help reduce greenhouse gas (GHG) emissions to the atmosphere.

The US Department of Transportation's Pipeline & Hazardous Materials Safety Administration currently oversees the nation's pipeline network via the Office of Pipeline Safety (OPS).[15] This national office partners with state agencies in most states in order to collaboratively uphold national pipeline safety regulations. The bylaws that cover CO_2 mandate "provisions for safety in the design, construction, inspection, operation, and monitoring of pipelines."[16] While Pennsylvania collaborates with OPS for some substances, the state does not participate in the program that covers CO_2 transport.[17] Therefore, in lieu of delegating authority to Pennsylvania, OPS currently retains oversight of CO_2 pipelines in the state.

An area of greater regulatory uncertainty for carbon capture and sequestration projects is the injection and storage of CO_2 underground. Currently, the Safe Drinking Water Act covers underground injection of CO_2 through the United States Environmental Protection Agency (US EPA)'s Underground Injection Control (UIC) program.[18] The fossil fuel industry has used authorized Class II wells under the UIC program to inject CO_2 for enhanced oil and gas recovery, and pilot projects sequestering CO_2 for long-term storage have recently been designated as experimental Class V wells, but larger commercial scale wells for long-term storage will likely be classified in yet another category, yet to be determined.[19]

A third large issue for geologic sequestration is legal liability. Although large-scale leakage of CO_2 is considered unlikely, if such an event were to occur, it remains unclear who, if anyone, would be responsible for any harm to human health or environmental quality, let alone at what level of proof or compensation. Texas presents an interesting case study of what can be done, if deemed necessary, to provide protection from liability under the circumstances. In 2006, Texas passed a bill that transferred ownership of and responsibility for captured CO_2 to a state

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[15] For more information, please refer to the Office of Pipeline Safety's web site, "OPS Programs," http://ops.dot.gov/init/partner/partnership.htm.

[16] Partha S. Chaudhuri, Michael Murphy and Robert E. Burns, *Commissioner Primer: Carbon Dioxide Capture and Storage* (Columbus, OH: National Regulatory Research Institute, 2006), 15, http://www.nrri.ohio-state.edu/dspace/bitstream/2068/976/1/06-02+CO2+Primer.pdf.

[17] Office of Pipeline Safety's web site.

[18] For the most recent information, please see the US EPA's web site on the subject, http://www.epa.gov/safewater/uic/wells_sequestration.html.

[19] US EPA, "Using the Class V Experimental Technology Well Classification for Pilot Geologic Sequestration Projects – UIC Program Guidance (UICPG #83)," March 2007, http://www.epa.gov/safewater/uic/pdfs/guide_uic_carbonsequestration_final-03-07.pdf.

authority, effectively shielding the source from liability while the state may itself become protected under the legal doctrine of sovereign immunity.[20]

Other issues, currently unaddressed include: potential conflicts over subsurface property rights involved with geologic sequestration, and whether CO_2 should be treated as a commodity or as waste and as hazardous or non-hazardous.[21]

Policy Recommendations

- **Develop protocols for siting and operating geologic sequestration projects in Pennsylvania**.

  Such protocols should rely on *inter alia*: improved databases on potential sites and pipeline infrastructure, careful geologic assessments and site evaluations, a sophisticated geographic information system (GIS) to aid decision-making, and a comprehensive risk assessment that informs the necessary legal and regulatory framework to govern sequestration activities.

- **Develop a pilot project to demonstrate geologic sequestration in western Pennsylvania.**

  Funding could come from some combination of: private companies, state government, MRCSP, and/or other federal programs. A successful demonstration would provide valuable information and experience to guide future sequestration projects. Western Pennsylvania provides a variety of attractive sites that could test multiple types of reservoirs with large CO_2 emission sources close by.

- **Develop a pilot project to demonstrate geologic sequestration in conjunction with CBM production in the northeastern Pennsylvania.**

  Funding could come from sources noted above, and a pilot would yield similar valuable information and data. Northeastern Pennsylvania offers many potential sites.

[20] Jay B. Stewart, "The Texas Experience," Congressional Testimony before the Energy and Air Quality Subcommittee of the House Committee on Energy and Commerce, March 2, 2007, http://energycommerce.house.gov/cmte_mtgs/110-eaq.030607.carbon_capture.shtml.

[21] Chaudhuri, *Commissioner Primer*, 19-22. For additional discussion of legal issues, see Kate Robertson, Jette Findsen and Steve Messner, *International Carbon Capture and Storage Projects Overcoming Legal Barriers* (Department of Energy and National Energy Technology Laboratory, 2006), http://www.netl.doe.gov/energy-analyses/pubs/CCSregulatorypaperFinalReport.pdf; also see Kevin Bliss, *Carbon Capture and Storage: A Regulatory Framework for States* (Oklahoma City: Interstate Oil and Gas Compact Commission, 2005), prepared for Department of Energy, http://www.iogcc.state.ok.us/PDFS/CarbonCaptureandStorageReportandSummary.pdf.

Chapter 9
Cross-Cutting Policies

Overview of Cross-Cutting Policies

Some issues and options relating to climate policy cut across multiple or all sectors. These issues include: economy-wide cap-and-trade policies, greenhouse gas (GHG) registry and reporting systems (for possible future credit and/or recognition), a variety of public education and outreach activities regarding climate change, and other options that simply do not fit neatly in a sectoral category.

Cap-and-trade is a powerful policy tool used successfully to control sulfur dioxide (SO_2) emissions at the national level under the Clean Air Act Amendments of 1990. Several climate bills under consideration in the current Congress use cap-and-trade as the centerpiece of provisions to reduce GHG emissions. Many of the other cross-cutting policies discussed here are "enabling" policies with emission impacts that are difficult to quantify.

Recent Policy Developments

Pennsylvania has adopted many policies of a cross-cutting nature that result (indirectly) in lower GHG emissions.

- **Sustainable Energy Funds.** As part of the restructuring of the electric industry in the 1990s, the Commonwealth created four "sustainable energy funds" (SEFs). They all engage in "cross-cutting" activities. The Pennsylvania SEFs have been instrumental in development of several wind energy projects, photovoltaic (PV) systems, green buildings, and energy efficiency programs. However, the SEFs' success has been limited due in part to: uncertainty about continuing funding beyond current levels and time frame, and a low level of funding in comparison to other states' funds. The System Benefit Fund called for in Chapter 3 could improve both the amount and certainty of funding, and thus improve SEF performance. Pennsylvania should also strengthen the role of its Sustainable Energy Board (SEB) in coordinating and integrating the programs among the various SEFs.

- **Keystone Green Investment Fund.** [1] After a year-long series of stakeholder discussions and consultations with experts on sustainable investments, in September 2006, the State Treasurer announced that a portion of its investment portfolio would be targeted towards businesses promoting renewable energy. Under this program, the Keystone Green Investment Fund, $90 million of the state's dollars will be invested in this growing sector, reducing the state's climate impact and hedging the state against the risk of conventional energy sources.

- **Pennsylvania Energy Development Authority (PEDA).** Governor Rendell reestablished the PEDA in 2005, an independent public financing authority providing grants, loans, and loan guarantees for renewable or alternative fuels. The PEDA has already provided $21

[1] *See* http://www.patreasury.org/KeystoneGreen.htm.

million for 57 clean energy projects, leveraging $240 million in private investment and creating 975 permanent and construction jobs. According to the Pennsylvania Department of Environmental Protection (PA DEP), "energy output from all the projects will generate an estimated 15,710-megawatt hours (MWh) of electricity, enough to power about 1,600 Pennsylvania homes, and produce the equivalent of enough natural gas to supply almost 2,500 homes for a year. Another 208,000 million British thermal units (BTU) will be conserved. The projects also have the potential to produce 115-million gallons of biofuel."[2]

- **Pennsylvania Energy Harvest Grant Program.** The state has fostered the development of renewable energy through the Pennsylvania Energy Harvest Grant Program, which began in May 2003. The program has provided $21 million and leveraged another $51.9 million from private sources for projects with demonstrable reductions in pollutants. The funds encourage energy sources such as solar, wind, biomass, geothermal, biodigestion, and landfill methane gas, in addition to promoting energy efficiency and green building. These programs have also spurred the nation's first fully integrated biofuels production and distribution facilities with local soybeans as the raw material.

- **Growing Greener II.** The original Growing Greener program, and the Growing Greener II program (approved by Pennsylvania voters in the spring of 2005) provide significant funding for environmental initiatives. Several of the program's objectives impact greenhouse gas emissions, including the preservation and restoration of natural areas, incentives for smart growth planning, and support for renewable and other advanced energy systems. Depending on the extent to which the funding from this program is channeled towards these goals, substantial GHG emissions could be avoided or sequestered.

- **Pennsylvania Hydrogen and Fuel Cell Consortium.** Governor Rendell convened this consortium in 2003. Led by the PA DEP, various organizations, agencies, and private companies meet to generate support and form partnerships to further the foundation for a hydrogen economy in the state. Pennsylvania houses many advanced manufacturers and research facilities that provide an excellent base for continued research, development, and demonstration.

- **Government Lead-By-Example.** In 1998, Governor Tom Ridge created the Governor's Green Government Council. The Council helps the state government to "embed environmental sustainability" in everything it does. Initially, the state government committed to purchasing 5% of its energy needs from "green sources." Governor Ed Rendell doubled that commitment to 10% in October 2004, and has since redoubled the commitment to 20%. In addition, Governor Rendell issued an executive order in December 2004 requiring state facilities to implement best management practices for energy management and conservation. The practices range from performing life-cycle cost analyses, to using motion-sensing lights, to setting computers to sleep mode after five minutes of inactivity. The state government also committed itself to making hybrid vehicles be 25% of new vehicle acquisitions for the state fleet by 2011, with the aim of eventually expanding the hybrid share to 100%.

[2] *See* http://www.ahs.dep.state.pa.us/newsreleases/default.asp?ID=4261&varQueryType=Detail.

- **Academia Lead-By-Example.** Pennsylvania's colleges and universities lead the nation in purchases of green energy. Thirty-four members of the Pennsylvania Consortium for Interdisciplinary Environmental Policy (PCIEP), a group of institutions of higher education, now purchase 92,200 MWh of wind energy each year. Most purchase at least enough wind energy to cover 10% of the institution's needs. These 34 institutions represent "nearly half of all colleges and universities purchasing renewable energy in the nation" and constitute "the largest non-governmental aggregated commitment to wind power in the U.S."[3]

Policy Recommendations

- **Pennsylvania should act early and aggressively to shape the national, economy-wide cap-and-trade legislation that has emerged as the main pillar of the likely federal response to climate change.**

  The past year has seen a surge of commitment to addressing climate change among politicians of both parties and at all levels of government. In addition, a growing number of large corporations are joining environmental groups in calling for controls on GHG emissions at the national level.[4] The preferred approach appears to be a cap-and-trade system covering most or all of the economy, and the bills introduced in Congress on this topic are receiving serious debate. With this growing momentum, many observers consider enactment of some form of cap-and-trade inevitable within five years.

  Such a national policy could have a huge impact on Pennsylvania's existing coal-fired power plants. Even if all of the policy recommendations in the previous chapters are implemented, the absence of any other policies constraining carbon dioxide (CO_2) emissions from existing fossil fuels plants would mean that those plants (largely coal-fired) would probably continue to emit over 100 million metric tons of carbon dioxide equivalence ($MMtCO_2e$) as they do now. There are options now to reduce their emissions, ranging from efficiency improvements to co-firing with biomass, and when geologic sequestration is commercialized, large reductions in their emissions will be feasible.

  The costs associated with large reductions from existing fossil fuel plants are likely to be substantial. Furthermore, the costs are also likely to be highly variable among plants, due to differences in plant size, age, and fuel source, along with differences such as availability of biomass (affecting the cost of a co-firing option) or distance to a underground injection site (affecting the cost of geologic sequestration).[5] The costs are also likely to be of a magnitude that Pennsylvania would be wary of incurring them unilaterally. If Pennsylvania chose to decrease GHG emissions from its power sector by substantially increasing the cost of a large portion of those power supplies, the net effect might be what is sometimes referred to as "leakage." GHG emissions might "leak" to other states either by the migration of economic

[3] Pennsylvania Colleges & Universities Increase Wind Energy Commitment, press release, April 12, 2005. *See*, www.communityenergy.biz/pr/cei_pr_college-univ_commitment.html.
[4] See www.us-cap.org. Membership includes including Alcoa, Duke Energy, DuPont, General Motors, Johnson & Johnson, and Siemens, Environment Defense, Natural Resources Defense Council, World Resources Institute and others.
[5] There will be other options, of course, including rebuilding or replacing the plants as lower-GHG or no-GHG power plants.

activity and jobs (if power becomes too expensive in the Commonwealth) and/or by reductions in power generation here and increased power imports from other states. Concerns such as these have led states to proposed regional approaches to limiting power sector emissions or large point-source emissions in general.

Given the variation in GHG control costs among plants and the issue of "leakage" for a state acting alone, the most appropriate policy approach is a "cap-and-trade" policy at a regional or national level. This is indeed what is contemplated under the northeast states' Regional Greenhouse Gas Initiative (RGGI[6]) and the recently announced Western Regional Climate Action Initiative.[7]

Given this backdrop, Pennsylvania should act aggressively and assertively to shape the coming national cap-and-trade plan. For very good reasons, Pennsylvania has observed but not joined the RGGI program as currently designed. Pennsylvania should become a much more active player in shaping the debate in Congress over national legislation.

By 2025, a well-designed national cap-and-trade program should be able to reduce several tens of $MMTCO_2e$ from Pennsylvania's fossil fuel power plants at an acceptable cost. Those costs will be lowest and the burden spread broadly if that cap-and-trade system is, indeed, national in scope and includes other large point sources of GHG emissions.

- **Pennsylvania should actively shape the new national Climate Registry.**

  Given that it may take several years to enact national cap-and-trade legislation, there are preparatory steps that Pennsylvania can take. A first and necessary step in implementing climate change policies would be to have accurate, up-to-date, and complete information about the state's emissions of greenhouse gases. Mandatory monitoring of GHG emissions from large point sources could be done by the PA DEP, building on its existing programs for monitoring air emissions. An aggregation of GHG emissions from large point sources could become a major component of an annual inventory of the state's emissions. Having such information available on a yearly basis will improve decision-making for climate change policies. Implementing such a mandate would also provide the backbone of any future emissions trading scheme, which would use the emissions data for each facility as its actual yearly emissions and would create a GHG registry as the technical foundation for the trading platform. Registries are under study and consideration in the Pennsylvania Department of Conservation and Natural Resources (DCNR)'s Carbon Management Advisory Group (CMAG) process.

  Earlier this year, The Climate Registry merged several state and regional efforts to establish a truly national system aimed at developing and managing a common GHG emissions reporting system.[8] It will be capable of supporting various GHG emissions reporting and reduction policies for its member states and tribes and reporting entities. It will provide an accurate, complete, consistent, transparent, and verified set of GHG emissions data from reporting entities, supported by a robust accounting and verification infrastructure. Near the

[6] *See* www.rggi.org.
[7] *See* www.climatechange.ca.gov/documents/2007-02-26_WesternClimateAgreementFinal.pdf.
[8] *See* http://theclimateregistry.org.

conclusion of the Roadmap process, Pennsylvania joined this effort and should actively help shape it.

- **Pennsylvania should pursue the integration of federal, state, and local efforts at reducing GHG emissions.**

  The Commonwealth should help develop, promote, and enact a comprehensive federal climate policy framework that applies the principle of federalism, and designates specific roles for state and local governments. Pennsylvania should lead and demonstrate the principle of federalism by consulting with the Commonwealth's local governments and designating specific roles for them in climate mitigation. This area is ripe for leadership.

- **Establish a climate change program that provides general training and conducts an awareness campaign.**

  Substantial reductions in GHG emissions could be realized through general public awareness of the problem and the available consumer choices. By choosing to purchase products that are less energy-intensive and have a longer lifetime, for instance, energy needs and waste production can both be decreased. Professionals, whether architects or contractors, can be educated on green building techniques, so they can expose their clients to energy-saving, cost-saving, environmentally-friendly designs. Conservation and efficiency training can have a large impact on energy use in government buildings, schools, hospitals, office buildings, and colleges. Township building inspectors need to understand and enforce the most up-to-date building requirements, not only to know what they are but also to understand why they are important. Schools can undertake demonstration projects that both realize productive change and incorporate hands-on learning into curricula. This general training and awareness campaign can, over many years, have significant and widespread, albeit indirect, impacts on GHG emissions.

Chapter 10
Long-Term Goals and A Near-Term Agenda

Twenty states representing 150 million Americans have developed, or are developing, comprehensive policies on climate change that are tailored to each state's particular set of characteristics. Projections of the impact of these policies indicate that they can deliver large greenhouse gas (GHG) reductions, generate billions of dollars in economic savings, create tens of thousands of new jobs, and provide other significant benefits.[1] Many states have set goals for reducing GHG emissions as shown in Table 10-1 below.

Table 10-1. State Climate Change Goals

STATE	GHG EMISSIONS TARGET
Arizona	2020: return to 2000 levels 2040: 50% below by 2040
California	2020: 1990 levels 2050: 80% below 1990 levels
Connecticut, Maine, Massachusetts, Rhode Island	2010: 1990 levels 2020: 10% below 1990 levels Long-term: 75-85% below current levels
New Jersey	2020: 1990 levels 2050: 80% below 2006 levels
New Mexico	2012: 2000 levels 2020: 10% below 2000 levels 2050: 75% below 2000 levels
New York	2010: 5% below 1990 levels 2020: 10% below 1990 levels
Oregon	2010: 1990 levels 2020: 10% below 1990 levels 2100: 75% below 1990 levels
Puget Sound, Washington	2010: 1990 levels 2020: 10% below 1990 levels 2100: 75% below 1990 levels

As the table demonstrates, various states are setting goals as near-term as 2010 or 2012 and as long-term as 2050 or 2100. Typically, these goals do not have the force of law, but they guide policymaking.

[1] The home page of the Center for Climate Strategies (CCS) provides a good portal to information on state climate policies: www.climatestrategies.us.

It is time for Pennsylvania to join these states. As the third largest emitting state in the country with the highest emissions of any in the world, the Commonwealth should demonstrate leadership. Pennsylvania should set a GHG emissions goal for Pennsylvania for the mid-term (15-20 years out) that is based on: analysis of available policies, practices, and technologies (that are commercial or are likely to be commercialized in the projected timeframe); their impacts on GHG emissions; and other impacts.

In this spirit, the *Roadmap* recommends a GHG emissions goal for Pennsylvania for 2025. Looking across all sectors in this report, Table 10-2 presents *Roadmap* policy recommendations that have been quantified in terms of their potential impact on Pennsylvania's forecasted emissions in 2025. The analysis presented here indicates that a 2025 goal of reducing emissions to 25% below 2000 levels is feasible. The quantified options across all sectors are estimated to be capable of reducing emissions by 105 million metric tons of carbon dioxide equivalent ($MMtCO_2e$) by 2025. An additional 39 $MMtCO_2e$ could be achieved through a combination of a national cap-and-trade system and other options not specifically identified or quantified in the *Roadmap* (see discussion below).

As the table illustrates, this portfolio of policies, affecting nearly all sectors of the economy, could lead to 144 $MMtCO_2e$ in reductions from the 2025 base case forecast of 371 $MMtCO_2e$, bringing emissions down to a level of 227 $MMtCO_2e$ (25% below 2000 levels of 302 $MMTCO_2e$). This goal would be line with the goals set by other leading states as shown in Table 10-1. One or more intermediate goals could be set between now and 2025.

Pennsylvania should also set a GHG emission reduction goal for Pennsylvania for the long-term. The long-term goal should be based on the level of global reductions that leading climate scientists recommend in order to stabilize GHG concentrations. A 2050 goal of an 80% reduction from current levels would be appropriate and, again, similar to the long-term goals of other leading states. This goal should inform long-term policy and planning, research and development, infrastructure decisions, etc.

Table 10-2. Pennsylvania Climate Roadmap:
Quantified Policy Recommendations and Estimated GHG Impacts in 2025
($MMtCO_2e$)

	2025 Base Case	GHG Impact	2025 Roadmap Case	Notes
Electricity Production	**161**	**-55***	**106**	
Current AEPS Tier 1		-7		Adopted in 2004
Strengthened AEPS		-18		
Energy Efficiency Portfolio – Electricity[#]		-32		
Residential/Commercial/Industrial (RCI)	**70**	**-4***	**66**	
Expanded Wood/Biomass Energy		-1		For process heat (not electricity)
B5 Bioheat Initiative		-0.4		
Energy Efficiency Portfolio – Gas[##]		-3		
Transportation and Land Use	**103**	**-31***	**73**	
Clean Vehicles Program		-14		Adopted in 2006
Fuel Efficient Tires		-1		
25% Biofuels		-12		
Mass Transit / Smart Growth[###]		-6		
Anti-Idling Program		-0.1		
Fossil Fuel Production	**19**		**19**	Climate Council should develop and
Industrial Processes	**21**		**21**	quantify policy options in all four
Waste Management	**3**		**3**	of these areas. Soil sequestration
Agriculture	**7**		**7**	is quantified below.
Gross Emissions	**385**		**295**	
Agriculture – Sequestration	****	**-11**	**-11**	
BMPs for Soil Sequestration		-11		
Forestry - Sequestration	**-14**	**-4**	**-18**	
AML Afforestation		-1		
Forest Protection Initiative		-3		
Total Increase in Sequestration			**-29**	
Net Emissions	**371**		**266**	
Cross-Cutting Policies				
Cap-and-Trade for Large Point Sources		-39	**-39**	From cap-and-trade or other measures
Net Emissions With Cap-and-Trade	**371**		**227**	Target of 25% reduction below 2000 net emissions of 302 MMt = 227 MMt

* Due to overlapping effects, the combined effect of various options is less than a simple summation of individual impacts.

** No estimate is available on "base case" soil sequestration.

[#] Consists of Alternative Energy Portfolio Standard (AEPS) Tier 3 for energy efficiency, System Benefits Fund (SBF), appliance standards, and other energy efficiency policies described in Chapter 3.

[##] Consists of SBF for natural gas utilities, appliance standards, encouragement of upgrades/retrofits of existing residential and commercial buildings, and other energy efficiency policies described in Chapter 4.

[###] Consists of Smart Growth, transit support, and other demand-related policies in Chapter 5.

Near-Term Agenda

Some of the recommendations in the *Roadmap* will require years, indeed decades, of patient work and must become part of bi-partisan agenda that has staying power regardless of the ebb and flow of political power among parties. Some key near-term agenda items are outlined below.

- Create the *Climate Council* (blue-ribbon panel of stakeholders and experts) to help set official state goals on climate change and advise the Governor on design and implementation of policies needed to meet those goals. The *Climate Council* should draw from this *Roadmap* and the ideas of other stakeholders, and build a bi-partisan climate change strategy. It should pay particular attention to the areas where the *Roadmap* has not been able to quantify options (e.g., fossil fuel production, industrial processes, waste management, and agriculture).[2] There are also numerous details of policy design related to the *Roadmap's* recommendations on which the Climate Council should engage.

- Recognizing the current and future reliance on coal in Pennsylvania, work aggressively with all stakeholders to pursue the full commercialization of geological sequestration of GHG emissions by no later than 2025. In pursuit of this goal:

    - Build all necessary and appropriate legal and regulatory frameworks to govern geologic sequestration in Pennsylvania.

    - Form a public-private consortium to conduct pilot projects testing geologic sequestration and pursue all options for cost-sharing with the federal government and the private sector.

- Help develop, promote, and enact an efficient and equitable cap-and-trade program for large point sources at the national level. This will require outreach to, and collaboration with, other Governors, the Pennsylvania Congressional delegation, and others.

- Pursue the integration of federal, state, and local efforts at reducing GHG emissions. Pennsylvania should help develop, promote, and enact a comprehensive federal climate policy framework that applies the principle of federalism and designates specific roles for state and local governments.

On this last point, hundreds of mayors across the US, representing tens of millions of citizens, are working to substantially reduce their cities' GHG emissions while saving money and enhancing the quality of urban life (e.g., through the International Council for Local Environmental Initiatives (ICLEI)'s Cities for Climate Protection program).[3] These include cities such as Philadelphia, Pittsburgh, West Chester, and others. Pennsylvania has the opportunity to create synergies among state and local government and demonstrate the principle of federalism by creating incentives for specific actions related to climate mitigation by the Commonwealth's local governments.

[2] In the agricultural sector, the *Roadmap* was able to quantify a soil sequestration option, but other options, including those affecting direct emissions from this sector, should be explored.
[3] *See* http://www.iclei.org/index.php?id=1118.

Conclusion

The *Roadmap* lays out an ambitious agenda for making Pennsylvania a leader in meeting the challenge of climate change. That agenda should also help the Commonwealth build on its recent successes in attracting new investment, industries, and jobs related to clean technology. The time to act is now.

Glossary of Abbreviations

ACEEE – American Council for an Energy Efficient Economy
AEO2006 – EIA's Annual Energy Outlook 2006
AEPS – Alternative Energy Portfolio Standard
AFIG – Alternative Fuels Incentive Grant Program
AIA – American Institute of Architects
BTU – British thermal unit
C – Carbon
CBM– Coal Bed Methane
CCS – Center for Climate Strategies
CFCs – chlorofluorocarbons
CH_4 – Methane
CMAG – Carbon Management Advisory Group
CO_2 – Carbon Dioxide
CO_2e – Carbon Dioxide equivalent
CRP – Federal Conservation Reserve Program
EEPS – Energy Efficiency Portfolio Standard
EIA– US DOE Energy Information Administration
GHG– Greenhouse Gases
GIS – Geographic Information System
GSA – GreenSpace Alliance
GT – gigaton (1 billion metric tons)
GWh – Gigawatt-hour
GWP – Global Warming Potential
HFCs – Hydrofluorocarbons
HPMS – Highway Performance Monitoring System
HPwES – Home Performance with ENERGY STAR
IGCC – Integrated Gasification Combined Cycle
IPCC – Intergovernmental Panel on Climate Change
kWh – kilowatt-hour
LEED – Leadership in Energy and Environmental Design
LFGTE – Landfill Gas Collection System and Landfill-Gas-to-Energy
LIHEAP – Low Income Home Energy Assistance Program
LIURP – Low-Income Usage Reduction Program
LPG – Liquefied Petroleum Gas
Mt – Metric ton (equivalent to 1.102 short tons)
MMt – Million Metric tons
MPC – Municipalities Planning Code
MRCSP – Midwest Regional Carbon Sequestration Partnership

MSW – municipal solid waste
MW – Megawatt
MWh – Megawatt-hour
NREL – National Renewable Energy Laboratory
O_3 – Ozone
ODS – Ozone-Depleting Substances
OPS Office of Pipeline Safety
PA DEP – Pennsylvania Department of Environmental Protection
PAYD – Pay-As-You-Drive
PEC – Pennsylvania Environmental Council
PennDOT – Pennsylvania Department of Transportation
PFCs – Perfluorocarbons
PJM – Pennsylvania, New Jersey, Maryland
PV – Photovoltaic
RCI – Residential, Commercial, and Industrial
RPA – Resources Planning Act Assessment
SBF – Systems Benefit Fund
SED – State Energy Data
SEPTA – Southeastern Pennsylvania Transportation Authority
SF_6 – Sulfur Hexafluoride
tCO2 – metric ton of carbon dioxide
UIC – US EPA's Underground injection Control
UNEP – United Nations Environment Programme
UNFCCC – United Nations Framework Convention on Climate Change
US EPA – United States Environmental Protection Agency
US DOE – United States Department of Energy
USDA – United States Department of Agriculture
USFS – United States Forest Service
USGBC – United States Green Building Council
USGS – United States Geological Survey
VMT – Vehicle-Miles Traveled
WMO – World Meteorological Organization