Chapter 4
Electricity Generation, Transmission, and Distribution

Sector Overview

Overview of GHG Emissions
The electricity generation, transmission, and distribution (EGTD) sector includes greenhouse gas (GHG) emissions from all generation, transmission, and distribution of electricity. Pennsylvania is a net exporter of electricity. Pennsylvania power plants are expected to continue to produce significantly more electricity than is consumed in the state\(^1\) for residential, commercial, and industrial uses while also providing electricity to meet the demands of other Mid-Atlantic States.

This sector is the largest source of GHG emissions in the state. In 2000, on an electricity production basis, the sector contributed about 116.2 million metric tons of carbon dioxide equivalent (MMtCO\(_2\)e) emissions (about 37%) to Pennsylvania’s total statewide gross GHG emission. On a consumption basis, in 2000 the sector contributed about 83.7 MMtCO\(_2\)e of emissions (about 30%) to Pennsylvania’s total gross GHG emissions.

Figure 4-1 shows historical and projected GHG emissions from sources in this sector. Overall, emissions for the sector are expected to increase by 40% on a consumption basis between 1990 and 2020. Specifically, the production-based GHG emissions associated with Pennsylvania’s electricity sector increased by 11.5 MMtCO\(_2\)e between 1990 and 2000. This accounted for 11.5% of the state’s total growth in gross GHG emissions during this period. On a consumption basis, GHG emissions associated with Pennsylvania’s electricity sector increased by 8.3 MMtCO\(_2\)e between 1990 and 2000, accounting for 11% of the state’s growth in gross GHG emissions during this period. By 2020, consumption-based emissions are expected to increase from 2000 levels by approximately 26%, from roughly 83.7 MMtCO\(_2\)e in 2000, to about 105.4 MMtCO\(_2\)e in 2020. In other words, GHG emissions from electricity consumption will increase as a share of the state’s total.

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\(^1\) Estimating GHG emissions associated with electricity production and use (consumption) requires an understanding of the electricity sources used by utilities to meet consumer demand (both in-state and out-of-state). The production-based approach accounts for emissions associated with all electricity generated by facilities located in Pennsylvania. Much of this is consumed by Pennsylvanians but about 30% is exported. The consumption-based approach accounts for emissions associated with electricity generated by facilities located in Pennsylvania and consumed by end-users that reside in Pennsylvania. Estimating emissions based on these two accounting methods can be helpful for understanding approaches to mitigate GHG emissions from the electricity sector. Note, however, that for other sectors, data are not typically available to support development of emission estimates for the production-based method. Therefore, the emission estimates discussed elsewhere in this report (including the inventory and forecast in Chapter 3) reflect the GHG emissions associated with the electricity sources used to meet Pennsylvania’s demands, corresponding to a consumption-based approach. The consumption-based approach better reflects the emissions that can be affected by the behavior of Pennsylvania’s consumers and is consistent with the methodology used in other state action plan reports.
Almost all GHG emissions from electricity production in Pennsylvania are from coal-fired generation. Figure 4-2 shows the breakdown of in-state gross electricity generation and in-state GHG emissions by fuel type for 2000. Nuclear accounts for over a third of total generation, with coal comprising most of the balance. There are almost no GHG emissions associated with nuclear generation and a relatively small volume of emissions from most other sources. As a result, coal-fired generation contributes nearly all of the states GHG emissions from electricity generation.

**Key Challenges and Opportunities**

There are significant opportunities to reduce GHG emissions growth associated with energy production and supply in Pennsylvania. These include promoting distributed, renewable generation; investing in technology research and development; and diminishing the carbon intensity of electrical generation through greater use of nuclear power and natural gas. As noted in Figure 4-3, the portfolio of generating capacity is changing in Pennsylvania. Further, the PJM has confirmed that the level of coal-fired generation has declined and natural gas-fired generation has increased since June 2008. The department believes that several factors will likely serve to keep this trend in place.

Clearly, the biggest GHG reduction challenge facing Pennsylvania is electricity production. GHG emissions from the combustion of coal for the generation of electricity represent 93% of all electricity emissions. So, within the electricity sector, the largest single contribution is from
coal-fired generation. Also, continued growth in electricity demand and the age of the state’s coal generation fleet are issues of concern. Finally, Pennsylvania is the second largest exporter of electricity in the nation, supplying electricity to the regional energy market area, known as PJM. This means that approaches to reducing Pennsylvania’s GHG emissions will need to take into consideration demand patterns and electric reliability considerations in a market area with about 51 million people.

Figure 4-2. Breakdown of Pennsylvania In-state Generation and CO₂ Emissions—2000 Base Year

<table>
<thead>
<tr>
<th>Gross Generation</th>
<th>Emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>(201,688 gigawatt-hours)</td>
<td>(116.23 MMtCO₂e)</td>
</tr>
<tr>
<td>Nuclear (37%)</td>
<td>Natural Gas (4%)</td>
</tr>
<tr>
<td>Coal (58%)</td>
<td>Renewable 0%</td>
</tr>
<tr>
<td>Petroleum (2%)</td>
<td>Other (1%)</td>
</tr>
<tr>
<td>Natural Gas (1%)</td>
<td>Coal 93%</td>
</tr>
</tbody>
</table>

Figure 4-3 Pennsylvania Generation Capacity 2000 vs. 2009

<table>
<thead>
<tr>
<th>2000 (MW, %)</th>
<th>2009 PA Generation Capacity (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuclear (9557, 24%)</td>
<td>Coal (21776, 55%)</td>
</tr>
<tr>
<td>Landfill Gas (128, 0%)</td>
<td>Natural Gas (10915, 22%)</td>
</tr>
<tr>
<td>MSW (256, 1%)</td>
<td>Petroleum (Diesel &amp; Resid); 3982; 8%</td>
</tr>
<tr>
<td>Wind (10, 0%)</td>
<td>Solar; 9; 0%</td>
</tr>
<tr>
<td>Hydro (1,992, 5%)</td>
<td>Digester Gas; 16; 0%</td>
</tr>
<tr>
<td>Natural Gas (953, 2%)</td>
<td>Other; 218; 0%</td>
</tr>
<tr>
<td>Petroleum (4669, 12%)</td>
<td>Water; 2040, 4%</td>
</tr>
<tr>
<td>Wood (30.5, 0%)</td>
<td>2009 (MW, %)</td>
</tr>
<tr>
<td>Solar (0, 0%)</td>
<td>Nuclear; 10915; 22%</td>
</tr>
<tr>
<td>Digester Gas (11, 0%)</td>
<td>MSW; 248; 1%</td>
</tr>
<tr>
<td>Other (241, 1%)</td>
<td>Wind; 817, 2%</td>
</tr>
</tbody>
</table>
Increasing electricity demand in Pennsylvania is projected at 1.25% per year during the forecast period (2009–2020) even after the demand side management effects of Act 129. There are significant opportunities to reduce GHG emissions through the work plan recommendations addressing electricity consumption. In addition, conservation generally results in significant energy cost savings. The department and the Climate Change Advisory Committee (CCAC) are recommending two work plans that address improvements for demand-side energy efficiency, while several other opportunities to promote and develop energy efficiency and conservation measures are identified in the residential, commercial, and industrial (RCI) sector, discussed in Chapter 7.

While the age of Pennsylvania’s coal-burning power generation fleet is a challenge, it is also an opportunity. Older coal plants are typically less efficient than new plants and many will be candidates for retrofit or replacement within the forecast period. The opportunities to move to lower carbon intensity-based fuels and highly efficient, advanced coal combustion technologies are substantial. In addition, Pennsylvania is endowed with significant, potential renewable energy sources principally from wind and biomass. The region also contains geologic formations that offer significant potential for in-ground CO₂ storage as carbon capture and sequestration technologies become commercially competitive.

**Co-firing Coal with Biomass**

Co-firing with biomass can play a useful role in reducing plants’ net greenhouse gas emissions. Even if carbon capture and storage were to become viable, co-firing could still play a role since the CO₂ captured from combustion of biomass would in effect amount to a net withdrawal from the atmosphere.

In recent years there has been increasing interest in the use of biomass for power generation. This has been due to several reasons, the principal one being that the co-utilization of biomass with coal represents a least-cost option for reducing CO₂ emissions.

A number of studies have acknowledged the benefits of sustainably produced biomass in future energy scenarios. A recent study projected that, if only 3% of the current coal-fired power generating capacity in Pennsylvania were co-fired, it would amount to 540 MWe of biomass power and offset CO₂ emissions by almost 3.3 Mt per year. Similarly, a National Renewable Energy Laboratory (NREL) study estimated an 18% reduction in CO₂ emissions for 15% biomass energy co-firing in existing pulverized-coal plants.

Data suggests that if all Pennsylvania coal plants were to co-fire biomass at a 10% rate (thermal basis), it would double the current total demand for Pennsylvania woody biomass. This level of demand may impact woody biomass availability, existing wood industries, and potential wood energy projects with higher efficiency of conversion, such as district/industrial CHP projects. However, co-firing of these facilities would potentially produce positive benefits to these alternative biomass markets, and forest management opportunities, if constrained to a more moderate level, in the range of 2-4% by thermal input.²

² Personal communication, Dr. Charles Ray, Pennsylvania State University
Co-firing Coal with Natural Gas

Co-firing with natural gas can provide a useful means of reducing not only CO₂ but also SO₂ and NOₓ emissions, providing a flexible response to emissions requirements and seasonal fuel prices. Reburning with 20% natural gas can reduce CO₂ emissions by up to 10%, equaling 9.5 MMt per year in Pennsylvania.

Ability to Meet Pennsylvania’s Electricity Demand

In 2007 Pennsylvania produced 74,515 million kilowatt hours of electricity in excess of what we consume. That is the equivalent demand of 6.2 million homes, more than the 4.8 million occupied homes reported in the 2000 census of Pennsylvania. The generation potential from nuclear uprates can provide an additional 8,738 million kilowatt hours per year. Because of the recommendations of this plan to require additional cost-effective energy efficiency and conservation measures, the growth in renewable and natural gas-fueled electricity generation coupled with similar trends in neighboring states the department is confident that there is abundant opportunity to continue to meet the energy demands of Pennsylvania residents and businesses.

Description of Recent State Actions

Existing policies influence in-state electricity consumption. These include mandates for reduced electricity consumption under Act 129, renewable energy investments under the Alternative Energy Investment Act, and the Alternative Energy Portfolio Standard requiring the procurement of low- to zero-emissions generation resources. Also, renewable energy and energy efficiency projects will be supported through Pennsylvania programs established under the American Recovery and Reinvestment Act.

Electricity 1. Act 129 of 2008 (HB 2200)

The state has an energy efficiency standard in place to secure cost-effective reductions in electricity consumption. The standard, set as part of Act 129 of 2008, was signed into law on October 15, 2008. The Act requires that each major electric distribution company in Pennsylvania achieve specific levels of energy savings and demand reduction:

- A reduction in electricity consumption, by May 31, 2011, of 1% below consumption levels for the period June 1, 2009, through May 31, 2010.
- A reduction in electricity consumption, by May 31, 2013, of 3% below consumption levels for the period June 1, 2009, through May 31, 2010 (additional reduction of 2% from the June 2009 through May 2010 baseline for a net total reduction of 3%).
- A reduction in peak demand, by May 31, 2013, of 4.5% of the highest 100 hours of historical demand for the period June 1, 2007, through May 31, 2008.

The Pennsylvania Public Utility Commission (PUC) must approve cost-effective energy efficiency and conservation programs for each electric distribution company (EDC) by October
Act 129 does not apply to the very modest consumption and demand of the numbers of municipalities that are authorized to distribute electricity to its residents, the thirteen rural electric cooperatives, and four small regulated electric utilities. It is anticipated that these programs will be in operation at the very end of 2009 or the beginning of 2010.


The Alternative Energy Portfolio Standard (AEPS) was signed into law on November 24, 2004. It requires that all electricity sold in Pennsylvania at retail by regulated electric utilities include prescribed levels of renewable and sustainable energy. The required levels of AEPS resources by 2021, and all future years, are at least 0.5% solar photovoltaic (PV) technology, 7.5% from other renewable (Tier I) sources, and 10% from other alternative energy (Tier II) sources. Successive amendments to the AEPS have made clear that electric utilities must make a good faith effort to procure renewable and sustainable energy sources and have added additional resources to the list of those eligible under Tier I.

This analysis of the AEPS requirement includes an understanding of the impact of “price suppression effects” of renewables deployment. The deployment of new renewables drives down the wholesale price of electricity. Known as price effects, or price suppression, any new energy source in the wholesale market at either a low or zero prices will tend to reduce locational marginal prices. This pricing strategy is generally used by resources that must run for various reasons. Renewable resources, including hydroelectric power generally fall into this category. For renewable resources, the intermittent nature of the “fuels” makes it necessary that they operate whenever the sun is shining or the wind is blowing or, for run-of-river hydro, when there is adequate water flow. In other words, they cannot choose to operate according to a set operating schedule or strategy that is determined by fuel prices. For nuclear generation, the operating characteristics make it impossible to cycle these units on and off in response to prices. As a result, they operate as much as 93% of the time knowing that, on average, they will make money.

In wholesale electricity markets, prices are set according to marginal offers from generation sources. The market operator (PJM) directs entities to turn generation on to meet load. It does this by taking offers from least expensive to most expensive. In practice, this generally means that the most expensive generating source needed to supply electricity demand sets the price. When a very low or zero offer is added to the mix of available units, as is the case with renewables, a more expensive generating unit need not be brought on line and the market price – the price paid by all purchasers in the wholesale market – is lower than it would otherwise have been.

New electric generation resources, including renewables, generally cost less to operate than most existing resources because of improvements in efficiency and lower operating/production costs. Renewables have the lowest operating costs of all power plants. Nuclear power plants have lower operating costs than coal and natural gas-fired power plants. Conversely, renewables have typically had higher capital costs than fossil energy power plants. Capital costs for wind energy are above that of natural gas power plants but are on par with that of coal and less expensive as compared to the estimated costs of a coal-fired power plant equipped with carbon capture and sequestration. Generally, high capital cost generators are low production cost generators and low
capital cost generators are high production cost generators. From a consumer's perspective, the effect on the wholesale energy market will be felt in relationship to production costs, not as to their capital cost. For renewables, the price will be lower due to the operating necessities noted above. Their high costs will be recovered from other sources including other PJM markets, monetized tax credits, and renewable energy credits. Thus, the addition of renewables is expected to reduce wholesale electricity market prices in this region (see Appendix E for assumptions).

The price suppression analysis here of the AEPS in Pennsylvania draws upon a PJM study examining such effects for the region. In their study, the PJM estimates savings of $4-4.5 billion from the 43,000 gigawatt hours (GWh) of wind generation in 2013. This equates to approximately $100 per megawatt hour (MWh) of wind generation ($4.25 billion / 43,000 GWh) in the study. The PJM study base case indicates a gas price assumption of $6.44/MMBtu, along with a comparable 2008 coal price, that drives a $100/MWh price suppression effect. If fossil fuel prices increase, the price suppression effect will correspondingly increase. Since fossil fuel prices have since fallen below the levels used in the PJM study (Jan 2009), a lower price of $50/MWh for each MWh of renewable generation added to the system is used for this analysis. This analysis also examines a scenario of no price suppression associated with renewables deployment—that is, $0/MWh price suppression effect for each MWh of renewables. The two price suppression scenarios lead to a range of potential costs of the AEPS, ranging from a low of -$615 million to $1.56 billion from 2009 to 2020.

Overview of Work Plan Recommendations and Estimated Impacts

The Electricity Generation, Transmission and Distribution Subcommittee membership includes Wayne Williams (former Chair), David Cannon (Chair), Richard Allan, Robert Barkanic, George Ellis, Sarah Hetznecker, Jan Jarrett, John Quigley, Nathan Willcox and Ed Yankovich. The department and the CCAC recommend a set of nine work plans for the EGTD sector. Taken together, these offer the potential for significant GHG emission reductions. Of the nine work plans, seven were analyzed for their potential emission reduction and cost impacts and two are recommended as non-quantified work plans. In addition, the CCAC analyzed two recent state actions (documented in the work plan format) to estimate their potential emission reduction and cost impacts. Table 4-1 presents the analytical results for the seven quantified work plans and two recent actions discussed above. Impacts are presented on an annual basis for 2020 and on a cumulative basis for the 2009 to 2020 period. The last column of Table 4-1 summarizes the number of CCAC members that voted to approve, disapprove, or abstained from recommending that DEP include the work plans in the Pennsylvania Climate Action Plan.

In addition to the GHG emissions reductions the work plan recommendations provide other co-benefits. Several of the work plans will provide decreases in emissions of sulfur dioxide (SO₂), nitrogen oxides (NOₓ), mercury, other hazardous air pollutants and fine particulate matter. Reductions in NOₓ emissions foster a decrease in the formation of ground-level ozone that

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contributes to a variety of respiratory ailments, particularly among children and the elderly. Implementation of recommendations that result in reductions of criteria air pollutants, such as \( \text{SO}_2 \) and \( \text{NO}_x \) can also make it easier and more cost-effective for power generators to comply with federal clean air standards. Self-generating electrical and thermal energy through the operation of combined heat and power (CHP) systems maximizes the efficient use of energy reducing overall energy expenditures. CHP systems also provide increased power reliability and can help decrease congestion mitigation concerns.

The analysis of the two recent actions show that Pennsylvania is already making significant progress in mitigating GHG emissions associated with the EGTD sector. As shown at the bottom of Table 4-1, the two recent actions together are estimated to reduce annual emissions in 2020 by 15 MMtCO\(_2\)e, and cumulative emissions by 116 MMtCO\(_2\)e over the 2009-2020 period. Act 129 (Electricity-1) is expected to result in a net cost savings while the effects of the AEPS (Electricity-4) could result in a net cost or cost savings depending on the previously discussed impact of “price effects” of renewable energy deployment.

1 The CCAC voted to refer the Nuclear Capacity work plan back to the department for further consideration and analysis. The department’s recommendation is to keep only the nuclear uprates in the analysis.

### Table 4-1. Summary Results for Electricity Generation, Transmission, and Distribution Work Plan Recommendations and Recent Actions (noted at bottom of table)

<table>
<thead>
<tr>
<th>Work Plan No.</th>
<th>Work Plan Name</th>
<th>Annual Results (2020)</th>
<th>Cumulative Results (2009-2020)</th>
<th>CCAC Voting Results (Yes / No / Abstained)(^1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Reduced Load Growth</td>
<td>$7 -$432 -$64</td>
<td>23 -$849 -$36</td>
<td>13 / 8 / 0</td>
</tr>
<tr>
<td>3</td>
<td>Stabilized Load Growth</td>
<td>$9 -$593 -$64</td>
<td>27 -$990 -$36</td>
<td>13 / 8 / 0</td>
</tr>
<tr>
<td>5</td>
<td>Carbon Capture and Sequestration in 2014</td>
<td>$5 $291 $58</td>
<td>13 $391 $31</td>
<td>20 / 1 / 0</td>
</tr>
<tr>
<td>6</td>
<td>Improve Coal-Fired Power Plant Efficiency by 5%</td>
<td>$5 $8 $1.5</td>
<td>55 $101.9 $1.8</td>
<td>13 / 8 / 0</td>
</tr>
<tr>
<td>7</td>
<td>Sulfur Hexafluoride (SF(_6)) Emission Reductions from the Electric Power Industry</td>
<td>0.1 $0.1 $0.6</td>
<td>0.7 $0.3</td>
<td>20 / 1 / 0</td>
</tr>
<tr>
<td>8</td>
<td>Analysis to Evaluate Potential Impacts Associated with Joining RGGI</td>
<td>See Appendix D</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Promote Combined Heat and Power (CHP)</td>
<td>4 $53 $12</td>
<td>23 $209 $9</td>
<td>21 / 0 / 0</td>
</tr>
<tr>
<td>10</td>
<td>Nuclear Capacity*</td>
<td>4 $74 $20</td>
<td>20 $233 $12</td>
<td>20 / 1 / 0</td>
</tr>
<tr>
<td>11</td>
<td>Greenhouse Gas Performance Standard for New Power Plants</td>
<td>Qualitative Work Plan--Not Quantified</td>
<td>21 / 0 / 0</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Transmission and Distribution Losses</td>
<td>Qualitative Work Plan--Not Quantified</td>
<td>21 / 0 / 0</td>
<td></td>
</tr>
<tr>
<td><strong>Sector Total After Adjusting for Overlaps</strong></td>
<td><strong>21</strong></td>
<td><strong>$248</strong></td>
<td><strong>$12</strong></td>
<td><strong>120</strong></td>
</tr>
<tr>
<td><strong>Recent State Actions(^2)</strong></td>
<td><strong>15</strong></td>
<td><strong>-$1,001 to $285</strong></td>
<td><strong>-$91 to 26</strong></td>
<td><strong>116</strong></td>
</tr>
<tr>
<td>1</td>
<td>Act 129 of 2008 (HB 2200) (Already in Electricity Baseline Forecast)</td>
<td>4 $-258 $-65</td>
<td>40 $-1,409 $-35</td>
<td>NA</td>
</tr>
</tbody>
</table>

4 - 8


Sector Total Plus Recent Actions

| 47 | See Ranges above | See Ranges above | 236 | See Ranges above | See Ranges above |

1 NA in this column means “not applicable.” Electricity 1 and 4 are recent Commonwealth of Pennsylvania actions. For Electricity 8, the CCAC analyzed the potential impacts associated with joining the RGGI initiative only and, therefore, was not considered as a work plan recommendation.

2 Totals are shown as a range reflecting the estimated GHG emission reductions and cost savings associated with Act 129 and the GHG emission reductions and range of costs / savings associated with the three Alternative Energy Portfolio Standard scenarios (i.e., without price suppression effects and with a moderate and high price suppression effects scenario)

* For Electricity 10 the CCAC voted to refer the work plan back to the DEP for further analysis.

GHG = greenhouse gas; MMtCO2e = million metric tons of carbon dioxide equivalent; $/tCO2e = dollars per metric ton of carbon dioxide equivalent; NPV = net present value; RGGI = Regional Greenhouse Gas Initiative.

Negative values in the Cost and the Cost-Effectiveness columns represent net cost savings.

The numbering used to denote the above work plans is for reference purposes only; it does not reflect prioritization among these important work plans.

The potential impacts associated with the seven quantified work plans were estimated and are incremental to the two recent actions. The results indicate that, if all seven work plans are fully implemented, they have the potential to reduce annual emissions in 2020 by 21 MMtCO2e at a cost over the next 11 years of about $250 million on a net present value basis (NPV).5

- The weighted-average cost-effectiveness of the work plans combined is estimated to be a net cost of about $33 per ton of CO2e reduced ($/tCO2e) in 2020.
- From 2009 through 2020, the work plans (if fully implemented) are estimated to reduce cumulative GHG emissions by 120 MMtCO2e with a potential net cost of about $638 million on a NPV basis.
- The weighted-average cost-effectiveness of the work plans combined is estimated to be a net savings of about $14/tCO2e for the 2009 through 2020 period.

Although not quantified, implementation of Electricity-11 and Electricity-12 have the potential to cost-effectively reduce emissions further if these recommendations are carefully, designed and implemented.

- Electricity Work Plan Nos. 2 and 3 (Electricity-2 and Electricity-3) include recommendations to increase demand-side energy efficiency in the state.
- Electricity-5 and Electricity-6 would affect coal-fired generation through higher efficiencies and carbon capture.
- Electricity-7 and Electricity-12 primarily affect transmission and distribution infrastructure.

5 The net costs or cost savings, shown in constant 2007 dollars, are based on fuel expenditures, operations, maintenance, and administrative costs, and amortized, incremental equipment costs. All NPV analyses here use a 5% real discount rate.
Electricity-9 incentivizes more combined heat-and-power.

Electricity-10 would result in higher nuclear capacity in the state through uprates (increase in electrical power generation) at existing nuclear power plants.

Electricity-11 includes recommendations for DEP to conduct detailed technical and economic assessments potentially leading to a standard for new fossil-fuel generation units that would provide an equitable working environment for all sectors of Pennsylvania's economy.

RGGI is a power plant generation standard. Electricity-8 is included for the purpose of evaluating the potential impacts associated with Pennsylvania joining the Regional Greenhouse Gas Initiative (RGGI); however, the CCAC performed this analysis for informational/comparative purposes only and did not include this work plan among the CCAC’s set of work plan recommendations.

The quantification results reported in Table 4-1 take into account overlaps in the expected emissions reduction and costs. Specific overlaps dealt with include work plan recommendations within the ETGD sector, as well as between work plan recommendations in the EGTD, RCI, and agricultural, forestry, and waste management sectors. Care was taken in the determination of emission reductions and costs (or cost savings) from each of the sectors to ensure that the combined calculated impact of the work plans would not “double count” impacts. Thus, overlapping impacts have been eliminated from the analysis in this chapter. Primary areas of overlaps are:

- Several interactions are possible within work plans in the ETGD sector. First, Electricity-3, Stabilized Load Growth, includes a requirement that some of the electricity demand in the state be met with energy efficiency measures and would overlap with the energy efficiency goals of Electricity-2, Reduced Load Growth. The reductions under Electricity-2 were eliminated as a result.

- In addition, a number of the RC work plans (RC-3, RC-4, RC-5, RC-6, RC-7 and RC-8) decrease overall electricity demand through specific measures. As Electricity-3 sets a goal for overall demand-side energy efficiency, the resulting saved energy associated with the overlaps with the RC work plans listed above were eliminated to avoid double-counting.

- An overlap between Electricity-3 and Industry Work Plan No. 2 (Industry-2) for industrial energy efficiency was addressed by reduced the combined estimated reductions from Electricity-3 to ensure consistency with 2025 of industrial efficiency potential from a report by the American Council for an Energy-Efficient Economy.

- See Appendix E, Electric Generation, Transmission and Distribution Work Plans, for additional description of overlaps among sectors and of analyses of the cumulative GHG reductions from the combined effects of the CCAC work plans that were quantified.
Description of Work Plan Recommendations

The EGTD sector has several opportunities for mitigating GHG emissions from electricity generation. These include all identifiable activities associated with the generation, transmission, and distribution of electricity. Taken into consideration is the combustion of fossil fuels, renewable energy sources in a centralized power station supplying the grid, and distributed generation facilities. The CCAC work plan recommendations are described briefly here and in more detail in Appendix E of this report.

After adjusting for overlaps, the work plans discussed below produce a cumulative (2009-2020) reduction of 120 MMtCO₂e. Figure 4-4 depicts the quantity of GHG reduction identified for each of the seven quantified work plans and reductions associated with the two recent state actions (after adjusting for overlaps) contributes to the total reductions associated with the seven quantified work plans and recent state actions combined. Note that the Electricity Work Plan Nos. 11 and 12 were not quantified, (and Electricity 8 was not considered for recommendation as a work plan to DEP) so there are no GHG emissions reductions associated with these work plans.

**Figure 4-4. Contribution by Each Work Plan and Each Recent State Action to Total Emission Reductions Associated with the Work Plans and Recent State Actions Combined for the Electricity Generation, Transmission, and Distribution Sector**

The percent contribution by each work plan or recent action is calculated by dividing the cumulative reduction (2009-2020) for the work plan or recent state action by total cumulative reductions for all work plans and recent state actions combined (i.e., 236 MMtCO₂e). See Table 4-1 for numeric values used to calculate the percentages shown in this figure. The recent state actions include Act 129 (Electricity #1) and AEPS (Electricity #4).
Electricity 2. Reduced Load Growth

This work plan builds upon the electricity consumption requirements of Act 129 by requiring additional biennial reductions in electricity consumption equal to 1.5% per biennial period (0.75%/year), beginning in 2015 and carrying through 2020. The energy efficiency investments under this work plan reach 8.25% of load by the end of 2025 (11 years at 0.75%/year). These reductions are calculated from the previous year's estimated consumption. Note that this analysis does not include the very modest consumption and associated system losses from municipal electric utilities or for rural electric cooperatives.

Thirteen of the CCAC members approved and 8 members disapproved of recommending this work plan to DEP for including it in Pennsylvania’s Climate Action Plan. One concern raised was an objection to any expansion of Act 129-style requirements until Act 129 was fully implemented and the state could gauge the effectiveness and cost to ratepayers of expanding the Act’s requirements.

Electricity 3. Stabilized Load Growth

This work plan builds upon the electricity consumption requirements of Act 129 through additional reductions of 0.75%/year in the period 2015 through the end of 2017. This is followed by an assumption that consumption is static from 2018 through 2025. Historical annual load growth in Pennsylvania has been approximately 1.5%/year, which is what would be reduced in the 2018–2025 period. Therefore, the energy efficiency investments under this work plan affect 14.4% of load by the end of 2025 (2015–2017 at 0.75%/year, 2018 at 0.85%/year, and 2019–2025 at 1.6%/year). The annual reductions in 2018–2025 would be based on the previous year’s consumption figures and would allow a subsequent one-year “true-up” for electricity distribution companies to achieve stabilized consumption levels. Note that this analysis does not include the very modest consumption and associated system losses from municipal electric utilities or for rural electric cooperatives.

Thirteen of the CCAC members approved and 8 members disapproved of recommending this work plan to DEP for including it in Pennsylvania’s Climate Action Plan. One CCAC member objected to any expansion of Act 129-style requirements until Act 129 was fully implemented and the state could gauge the effectiveness and cost to ratepayers of expanding the Act’s requirements.

Electricity 5. Carbon Capture and Sequestration in 2014

The work plan entails carbon capture retrofit to existing supercritical pulverized coal plants starting in 2015 through 2019. In addition, the work plan calls for installation of an integrated coal gasification combined-cycle (IGCC) plant in the state in 2020. Retrofits of existing supercritical pulverized coal plants entail amine scrubbing with a CO₂ capture rate of 90% and an increase in heat rate (a decrease in efficiency). The reduction in efficiency results because the amine-scrubbing system diverts steam for power generation or consumes additional power for CO₂ compression. IGCC power plants use coal to produce electricity. The technology is based around a gasifier that produces a mixture of hydrogen and carbon monoxide called syngas. This syngas is burned in a gas turbine that is used to drive a generator. IGCC technologies with CO₂
capture are equipped with three more processes than the conventional IGCC technology without capture. The first is a process of reacting syngas with steam to produce CO₂ and hydrogen through shift reactors. The second process separates the CO₂ from the remaining gas. The final process compresses and dries the CO₂. Adding CO₂ capture technology to IGCC plants significantly reduces overall plant efficiency.

Twenty of the 21 CCAC members approved and 1 member disapproved of recommending this work plan to DEP for including it in Pennsylvania’s Climate Action Plan.

**Electricity 6. Improve Coal-Fired Power Plant Efficiency by 5%**

This work plan would entail a 5% increase in energy efficiency at coal-fired power plants by 2025. Each facility would have the flexibility to meet this efficiency requirement at the least-cost method available. This measure is assumed to be implemented linearly in 2015 following scheduled outage in PJM queue. Work plan implementation methods would need to be designed so as not to trigger the “Major Modification” clause in the U.S. Environmental Protection Agency’s (EPA) New Source Review (NSR) program for major stationary sources in attainment areas for the National Ambient Air Quality Standards. NSR requires plant owners to undergo review for environmental controls in case of major modifications beyond routine maintenance, repair, and replacements. Determination of what measures trigger NSR is made on a case-by-case basis, with numerous efforts by EPA to create broader guidelines to inform plant owners what measures trigger NSR.

Thirteen of the 21 CCAC members approved and 8 members disapproved of recommending this work plan to DEP for including it in Pennsylvania’s Climate Action Plan. Several of the CCAC members disapproving of recommending this work plan noted that plant efficiency measures that trigger NSR could dramatically alter the “cost effectiveness” and economics of the work plan. Other CCAC members believe that such an efficiency requirement would not work for subcritical generation, which could not bear the capital costs. They also believe that such improvements would have already been made for supercritical facilities to the extent that they would not trigger New Source Review.

**Electricity 7. Sulfur Hexafluoride (SF₆) Emission Reductions from the Electric Power Industry**

This work plan uses a pollution prevention approach, including a best management practice (BMP) manual and recordkeeping and reporting requirements, to ensure that all SF₆ emission reductions are quantified and permanent. SF₆ is identified as the most potent non-CO₂ GHG, with the ability to trap heat in the atmosphere 23,900 times more effectively than CO₂. Approximately 80% of SF₆ gas produced is used by the electric power industry in high-voltage electrical equipment as an insulator or arc-quenching medium. Sulfur hexafluoride is emitted to the atmosphere during various stages of the equipment’s life cycle. Leaks increase as equipment ages. The gas can also be accidentally released at the time of equipment installation and during servicing.

Twenty of the 21 CCAC members approved and 1 member disapproved of recommending this work plan to DEP for including it in Pennsylvania’s Climate Action Plan.
**Electricity 8. Analysis to Evaluate Potential Impacts Associated with Joining RGGI**

In response to comments during the CCAC’s process for identifying work plans to analyze, the CCAC asked the EGTD Subcommittee to evaluate potential impacts associated with Pennsylvania joining the Regional Greenhouse Gas Initiative (RGGI). However, the CCAC agreed to not include this work plan with the set of work plans the CCAC considered recommending to DEP for inclusion in the state’s Climate Action Plan. This work plan was not included with the set of work plan recommendations for several reasons, including the length of time required for the state to determine whether to join RGGI and the functional overlap between RGGI and the CCAC process. The CCAC, however, did recommend that the EGTD Subcommittee’s evaluation of potential impacts associated with Pennsylvania joining RGGI be included as appendix or attachment in Appendix F of this report so as not to lose the data and analysis. Consequently, the CCAC did not vote on this work plan.


This work plan encourages distributed CHP systems to reduce fossil fuel use and GHG emissions. Reductions are achieved through the improved efficiency of CHP systems, relative to separate heat and power technologies, and by avoiding the T&D losses associated with moving power from central generation stations to distant locations where electricity is used. CHP is a term used to describe scenarios in which waste heat from energy production is recovered for productive use. The theory of CHP is to maximize the energy use from fuel consumed and to avoid additional GHG’s by the use of reclaimed thermal energy. The reclaimed thermal energy can be used by other nearby entities (e.g., within an industrial park or district steam loop) for productive purposes. Generating stations in urban areas may have existing opportunities or may require the co-location of new industry.

All 21 members of the CCAC approved of recommending this work plan to DEP.

**Electricity 10. Nuclear Capacity**

This work plan examined the potential impact of capacity uprates at existing nuclear plants in the state, as well as a new plant build. This work plan incorporated both existing facility uprates, some of which are already in progress, as well as new nuclear capacity. To increase the power output of a reactor, typically a more highly enriched uranium fuel is added. This enables the reactor to produce more thermal energy and therefore more steam, driving a turbine generator to produce electricity. To accomplish this, such components as pipes, valves, pumps, heat exchangers, electrical transformers, and generators must be able to accommodate the conditions that would exist at the higher power level. In some instances, facilities will modify and/or replace components to accommodate a higher power level. Depending on the desired increase in power level and original equipment design, this can involve major and costly modifications to the plant, such as the replacement of main turbines. All of these factors must be analyzed by the facility as part of a request for a power uprate, which is accomplished by amending the plant's operating license. The analyses must demonstrate that the proposed new configuration remains safe and that measures continue to be in place to protect the health and safety of the public. Before a request for a power uprate is approved, the Nuclear Regulatory Commission must review these analyses.
Largely due to uncertainties associated with constructing and operating a new nuclear power plant, the CCAC voted to recommend that the department give further consideration to the development of this work plan. The Rendell Administration is supportive of new nuclear technology and was urged by PPL to include the possibility of a new nuclear power plant into the work plan for analysis. Governor Rendell provided a letter of support to the Nuclear Regulatory Commission on behalf of PPL’s proposed Bell Bend nuclear power plant. However, in consideration of the CCAC’s recommendation, the department’s recommendation is to keep only the nuclear uprate portion of the work plan as we have determined that 1,050 MW of generating capacity does exist via system upgrades and removes from consideration the potential for the proposed PPL Bell Bend nuclear power plant to come online in 2020.


This work plan provides recommendations to ensure that newly added fossil fuel-fired electric generating capacity would be consistent with the efforts of the Commonwealth to establish and maintain a climate change action plan. It would involve detailed technical and economic assessments potentially leading to a standard that would provide an equitable working environment for all sectors of Pennsylvania's economy, and that would balance the goal of reducing GHG emissions with the capability of meeting future energy demand within the Commonwealth. Such a performance standard could conceivably set standards unachievable by existing or proposed coal-fired generation and only possible through carbon capture and sequestration. Carbon capture and sequestration is not currently commercially available at the scale required nor are there other technologies on the immediate horizon that could significantly reduce CO₂ emissions. Generators could possibly meet the overall GHG reduction standards through the purchase of an equivalent volume of Certified Emissions Reductions, but this would also involve a detailed analysis of the available market and how it could be structurally related to a performance standard.

All 21 members of the CCAC approved of recommending this work plan to DEP.

Electricity 12. Transmission and Distribution Losses

This work plan examines potential increases in efficiency associated with new and existing transmission and distribution lines. It recommends that DEP look at potential increases in efficiency which reduces transmission and distribution losses. Because of the complexity, technical uncertainties and relation to national and state energy policy in this work plan, the CCAC elected to include it as a non-quantified work plan recommendation for further review by DEP.

All 21 members of the CCAC approved of recommending this work plan to DEP.

Conclusion

The electricity generation, transmission, and distribution (EGTD) sector is the largest source of GHG emissions in the state. The proportion of the state’s GHG emissions from EGTD is expected to increase through 2020. Coal-fired power generation accounts for nearly all of the state’s GHG emissions from the EGTD sector. Significant opportunities to reduce GHG
emissions from EGTD include: promotion and use of renewable energy sources to assist in fossil fuel combustion reduction; promotion and use of lower carbon fuels for electricity generation; retrofitting/replacement of less efficient coal-fired power plants; increase capacity at existing nuclear power plants; and investing in technology research and development including, but not limited to, carbon capture and sequestration technologies.

Next Steps – Pathways to Implementation

The Reduced Load Growth and Stabilized Load Growth work plans can be implemented by the PUC (Commission) under existing authority provided via Act 129, Sections 2806.1 (C)(3) and (D)(2). The Commission has contracted a statewide evaluator (SWE) that will conduct a market potential study to determine areas for additional incremental energy and load reductions and provide a report to the Commission by October 15, 2013. The contractor will also provide an Energy Efficiency and Conservation Program assessment report that will provide recommendations for improving the program as a whole. The report will also perform a cost-benefit analysis and recommend if additional reduction requirements should be imposed and what those reduction targets should be.

Implementation of the Carbon Capture and Sequestration (CCS) would be supported via passage of House Bill 80. DEP and DCNR are work in concert with a varied group of stakeholders and the Clinton Foundation to hasten the commercial deployment of CCS in PA. DCNR remains engaged in the assessment of potential storage sites with the possibility of facilitating/hosting a project on state forest land where the Commonwealth also owns the mineral rights as a means of jump-starting the first CCS project in PA. The DEP continues to examine and assess environmental and safety regulatory considerations and obligations associated with developing, operating and maintaining a CCS project. The DEP may also wish consider how it could facilitate expedited permitting for such projects. Together DEP and DCNR will pursue federal funding for CCS, estimated to be a combined $8 billion between EPACT ’05 and stimulus funding. The DCED’s Commonwealth Finance Authority could be used to provide loan guarantees for early-stage development of CCS infrastructure and thereby helping to reduce financing costs to bring these projects closer to government borrowing rates. Legislation that authorizes the Department of Revenue to provide for a tax credit program to offset the up-front capital costs should also be considered.

Implementation of the Improve Coal-Fired Power Plant Efficiency by 5% work plan would require legislative support. Conceptually the bill should require the DEP to establish a plan by which to assess and monitor the successful implementation of efficiency upgrades of subject power plants. The language of the bill should require that each power plant be surveyed for potential efficiency improvements, that the improvements be individually identified, that a uniform cost-effective metric be applied to individual improvements and to all improvements if done in concert. The bill should also require identification of total hours of system downtime to perform the upgrades. A schedule should be established by the power plant owner to make the minimum upgrades by no later than December 31, 2019. DEP should also be required to coordinate with the U.S. EPA to determine what efficiency improvements can be made at power plants without triggering New Source Review (NSR) requirements but that this determination
should not preclude power plant owners from complying with the five percent efficiency upgrade.

The Sulfur Hexafluoride (SF6) Emission Reductions work plan is a voluntary but market-driven work plan that does not require additional legislation or incentives.

Combined heat and power projects are considered to be cost effective because of the associated increases in energy efficiency and reduced need for fuel and/or electricity purchases. Analysis of the Combine Heat & Power (CHP) work plan however, indicates that these systems may not be cost effective unless the projects are run steady-state to provide baseload electric and thermal energy needs. The economics of these projects are largely dependent upon fuel prices, hours of operation and as compared to relatively low electricity rates. While no legislation is required to implement this program, new or amended legislation that provides tax credits towards the up-front capital costs of equipment would hasten deployment. Existing financing programs that can support CHP systems include PEDa, Green Energy Works and the CFA. It may be beneficial to specify minimum thermal efficiency standards to assist in evaluating projects that ultimately receive financial assistance.

The Nuclear Capacity work plan involves the implementation of uprates (efficiency upgrades) at existing nuclear power plants as well as considering the addition of constructing one new nuclear power plant. Similar to the effort to improve efficient generation at coal-fired power plants, it makes prudent sense to support the additional generation that can safely be done at existing nuclear power plants. The DEP believes that an additional 860 megawatts of generating capacity exists within our fleet of five nuclear power plants. These uprates are driven by economics. It is believed that all uprates will be implemented by 2020. A new nuclear power plant has several steps to clear before becoming reality. Among the economic details to be considered is whether or not a project developer can secure cost recovery for construction of a new plant.

To avoid under-mining the intent of a climate action plan considerations must be made for the possibility of new power generation within PA. The intent of the Greenhouse Gas Performance Standard for New Power Plants work plan is establish criteria under which new generation be facilitated but which will also not place unfair burden on existing generation sources. Legislation may be necessary and may be forthcoming from the federal government that could address this concern. Alternatively, the PA Air Pollution Control Act provides the authority under which the DEP could regulate greenhouse gas emissions from new sources. If the Department were to proceed with a regulatory process care should be given in establishing a minimum regulatory and permitting threshold. As a compliance option, standards could be drafted that would allow offsetting an equal and maximum allowable level of GHG emissions via one of the CCAC recommended GHG offset registry platforms: the Climate Action Reserve, the Gold Standard and the Voluntary Carbon Standard.