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# A Quantitative Analysis of the Pennsylvania Alternative Energy Portfolio Standard: And Options for the Future

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Presented to the Faculties of the University of Pennsylvania in Partial Fulfillment of the Requirements for the Degree of Master of Environmental Studies 2007.

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**Abstract**

This study evaluates Pennsylvania's Alternative Energy Portfolio Standard and its effect on promoting the development of new, utility-scale electricity generators fueled by alternative sources. The energy profile of Pennsylvania for 2005 and 2006 is determined from the Generation Attribute Tracking System, which tracks the creation of compliance credits according to the policy guidelines. The future energy profile is projected from the PJM Interconnection Queue, which lists the proposed future generating plants in the state. The forecast for electricity use in Pennsylvania is derived from the Energy Information Administration's 2007 Energy Outlook.

The study shows that the Tier II goals of the policy are currently met, with no need for further developments. The study predicts that Tier I and solar PV developments will fall short of the policy goals. Compatible Tier I technologies are profiled, and recommendations are made to meet future compliance.

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# A Quantitative Analysis of the Pennsylvania Alternative Energy Portfolio Standard And Options for the Future

Nicholas Tichich
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## Executive Summary

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# Introduction

In 2003, only 3% of electrical power in Pennsylvania was created from renewable sources, placing it 35th in renewable energy production in the United States.[1] In 2004, Pennsylvania enacted the Alternative Energy Portfolio Standard (AEPS), with a goal of increasing this percentage.

The efficacy of the AEPS relies on the strength of the policy, supporting policy, the tools it utilizes, as well as the technology it seeks to implement. This paper attempts to analyze the effect of the AEPS as a motivator for the development of new utility-scale alternative energy generators within Pennsylvania.

The AEPS has been widely reviewed by a number of different entities. In this paper I attempt to provide a review of the AEPS, a quantitative analysis of the existing and emerging electricity plants fueled by alternative energy sources in Pennsylvania, as well as options and recommendations for the future.

[1] Energy Information Administration, Form EIA-906, *Power Plant Report*, 2003.

# The Pennsylvania Alternative Energy Portfolio Standard

## *Summary of Policy*

To date, 20 states and the District of Columbia have established some version of a renewable energy portfolio standard (RPS).[2] While the specifications of each state's policy may differ, the general goal of these policies is to mandate a certain percentage of electricity in the state to be created from renewable fuel sources. These percentages are graduated along the lifetime of the policies, reaching a final percentage goal in the end year.

The effects of an energy portfolio standard on the energy market have been studied on a number of different levels. Portfolio standards have been shown to provide an even market, and in some cases an advantage, for the construction of new renewable energy power plants in a dominantly non-renewable energy field.[3] The use of renewable energy as an emission mitigating system has been studied for its economic viability, with case studies based on existing energy portfolio standards' progress and correlated emission reductions.[4] Energy portfolio standards are also seen as redefining the energy market economics, providing new incentives, motivation for new system development, and new ideas behind power purchase agreements.[5] Basic supply and demand effects have been studied for the numerous United States examples, and also for international energy portfolio standard implementation.[6]

The Pennsylvania AEPS differs from other state energy portfolio standards in many ways. The most obvious is in its title with the use of "alternative energy" instead

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[2] Database of State Incentives for Renewables & Efficiency, *www.dsireusa.org*, accessed October 28, 2006.

[3] Espey, S., "Renewables Portfolio Standard: A Means for Trade with Electricity from Renewable Energy Sources?", *Energy Policy*, Vol. 29, 2001.

[4] Apt, J., Dobesova, K., Lave, L. B., "Are Renewables Portfolio Standards CostEffective Emission Abatement Policy?", *Environmental Science & Technology*, Vol. 39, No. 22, 2005.

[5] Brasher, L. T., Kraske, P., "Renewable Energy Power Purchase Agreements", *Journal of Structured & Project Finance*, Vol. 9, Issue 1, Spring 2003.

[6] Nishio, K., Asano, H., "Supply Amount and Marginal Price of Renewable Electricity under the Renewables Portfolio Standard in Japan", *Energy Policy*, Vol. 34, 2006.

of the "renewable energy". Pennsylvania uses the term "alternative energy" to include non-renewable sources such as clean coal. The goal of the Pennsylvania AEPS is summarized by the following:

> *"providing for the sale of electric energy generated from renewable and environmentally beneficial sources, for the acquisition of electric energy generated from renewable and environmentally beneficial sources by electric distribution and supply companies and for the power and duties of the Pennsylvania Public Utility Commission".*[7]

The Pennsylvnia AEPS has two key mandates: one, greater reliance on alternative energy sources in serving Pennsylvania's retail electric customers; two, the opportunity for customer-generators to interconnect and net meter small alternative energy systems (or "distributed energy systems").[8]

Another quality which separates the Pennsylvania policy from that of other states is the separation of energy sources into two Tiers. While the term "alternative energy" does include non-renewable sources, the AEPS separates renewables from non-renewables (which are classified as "environmentally beneficial sources" according to the above summary) by using a two-tiered approach.

In the Pennsylvania AEPS, Tier I energy sources include solar photovoltaic (PV) energy, solar thermal power, wind power, low-impact hydropower, geothermal energy, biologically derived methane gas, fuel cells, biomass energy, and coal mine methane. Tier II alternative energy sources include waste coal, distributed generation systems, demand-side management, large-scale hydropower, municipal solid waste, wood pulping by-products, and integrated combined coal gasification technology. The Tier structure of the AEPS puts emphasis on the true renewable sources, but many of the Tier II sources have attracted criticism of the standard.[9]

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[7] The General Assembly of Pennsylvania, Senate Bill No. 1030, Session of 2004, p1.

[8] Pennsylvania Public Utility Commission, Implementation of the Alternative Energy Portfolio Standard of 2004, Proposed Rulemaking Order, Public Meeting of July 20, 2006 at Docket No. L-00060180

[9] PennEnvironment, Testimony Before Pennsylvania House of Representatives, April 13, 2004. http://www.pennenvironment.org/PE.asp?id2=17601, accessed Nov 15, 2006.

The AEPS dictates a compliance schedule for utilities based on the percentage of overall energy sold. The scheduled goals begin in June 2007, with 1.5% (Teir I) and 4.2% (Teir II), and increasing incrementally to the final goal in 2020 of 8.0% (Teir I) and 10% (Teir II).[10]

While there are two specific Tiers in the Pennsylvania AEPS, the policy also mandates specific goals for solar PV electricity production. Solar PV is included in the Tier I source list, however separate goals are mandated for solar PV electricity production.

In March 2005, the Pennsylvania Public Utilities Commission (PUC) developed an AEPS Implementation Order which detailed an implementation plan which would meet the AEPS requirements. This implementation plan is shown in Figure 1.

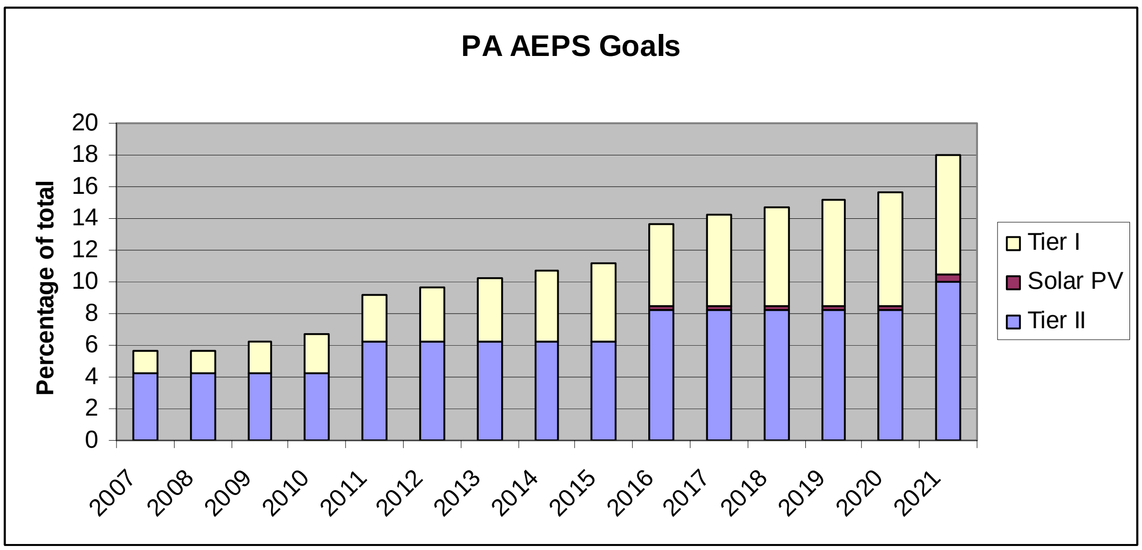


Figure 1[11]

[10] The General Assembly of Pennsylvania, Senate Bill No. 1030, Session of 2004.

[11] Source: Pennsylvania AEPS Implementation Order. The AEPS Implementation Order increases the goal percentages in May of each year. The graph above indicates the percentages required in May of the indicated years.

## *Tools for Policy Compliance*

In addition to the Tier definitions and compliance schedule, the AEPS establishes tools for progress tracking, reporting, and penalties. Under the AEPS, The Commonwealth of Pennsylvania agreed to enter into a collaborative group with the utilities, and the utilities agreed to report their progress at set dates. The AEPS also establishes the baseline rules for the alternative energy credit system, which is a method to quantify energy produced by alternative sources in a credit-based system. Under the credit system, an electrical generating company receives a unique credit for each mega-watt hour (MWh) it generates (referred to in other policies as Renewable Energy Credits, or RECs). The credits are associated with the fuel used for generation. By providing this fuel designation to the credits they become a record of the natural resources used by the generating company. Just as the AEPS is separated into Tiers, so are the credits which are created by the different Tier qualifying sources. Accordingly, credits are qualified as meeting Tier I, Tier II, or solar PV requirements.

For example, a company which generates 5,000 MWh in a month, half from a coal plant and half from a geothermal plant, will receive 2,500 "coal" credits and 2,500 "geothermal" credits. Under the AEPS regulations, the geothermal credits would be qualified as Tier-I credits, while the coal would not fall under any Tier. In this example, the generating company would have 50% of its generation coming from Tier I sources. If this were the case in 2007, where the AEPS only requires 1.5% of electricity to come from Tier I sources, this company would be beyond compliance and could sell or bank their excess credits.

Companies which cannot meet their goals through internal efforts can either buy credits from other producers at the market price, or pay an alternative compliance payment to the Commonwealth, which is capped at $45.[13,14] With help from PJM, the major energy grid operator for Pennsylvania which established PJM Environmental

[13] The General Assembly of Pennsylvania, Senate Bill No. 1030, Session of 2004.
[14] This $45 cap does not apply to the solar PV requirements. The compliance costs for lacking solar PV credits is set at 200% times the cost for a solar renewable energy credit

Information Services (PJM-EIS) in response to the creation of the AEPS, the Commonwealth established a generator attribute tracking system (GATS) as the alternative energy credits registry.[15] This system offers an online registry and approval of credit-generating systems, as well as a means for tracking the credits as they are created and traded.

The alternative energy credit system is similar to transferable discharge permits, or "cap and trade", used in some pollution control policies, such as the sulfur dioxide reduction policy for electric power producers, in that credits are associated with the attributes of electricity generation.[16] The alternative energy credits, while directly associated with MWh of generation, are entities in themselves which can be managed separately from the electricity. Thus, generating electricity by AEPS-qualified sources creates two products: the electricity itself and the energy credit. In some cases the electricity and the associated credits are managed together ("bundled"), but they can also be managed in separate markets ("unbundled").

The alternative energy credits can be banked by utilities or traded on the associated alternative energy credit market, which also sets the price for the credit. With this market-based approach, companies have the choice of implementing Tier-qualifying generation sources (and creating the associated credits), or of buying their required credits from other generating companies. In theory, the use of a credit system increases compliance flexibility and may reduce overall compliance costs, encouraging electricity suppliers to meet their purchase obligations in a least-cost fashion.[17]

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[15] Commonwealth of Pennsylvania, Pennsylvania Public Utility Commission, "Implementation of the Alternative Energy Portfolio Standards Act of 2004", Docket No. M-00051865, Dec 20, 2005.

[16] Field, Barry C., and Field, Martha K., *Environmental Economics*, 4th Ed., p 257, McGraw-Hill Irwin, New York, 2006.

[17] Chen, Cliff, Wiser, Ryan, and Bolinger, Mark, *Weighing the Costs and Benefits of State Renewable Portfolio Standards: A Comparative Analysis of State-Level Policy Impact Projections,* Ernest Orlando Lawrence Berkeley National Laboratory, March, 2007, p 1.

## State of Pennsylvania Energy Sources

Pennsylvania has a history as an energy-rich state. Titusville, Pennsylvania, was the home of the world's first commercial oil well in 1859.[18] In 2005, Pennsylvania produced 6.0% of the U.S. share of coal and had more oil refining capacity than any other state on the East Coast.[19]

Pennsylvania's main source of electricity generation is from coal and nuclear. Figure 2 shows the electric power generation by primary energy source in 2004.

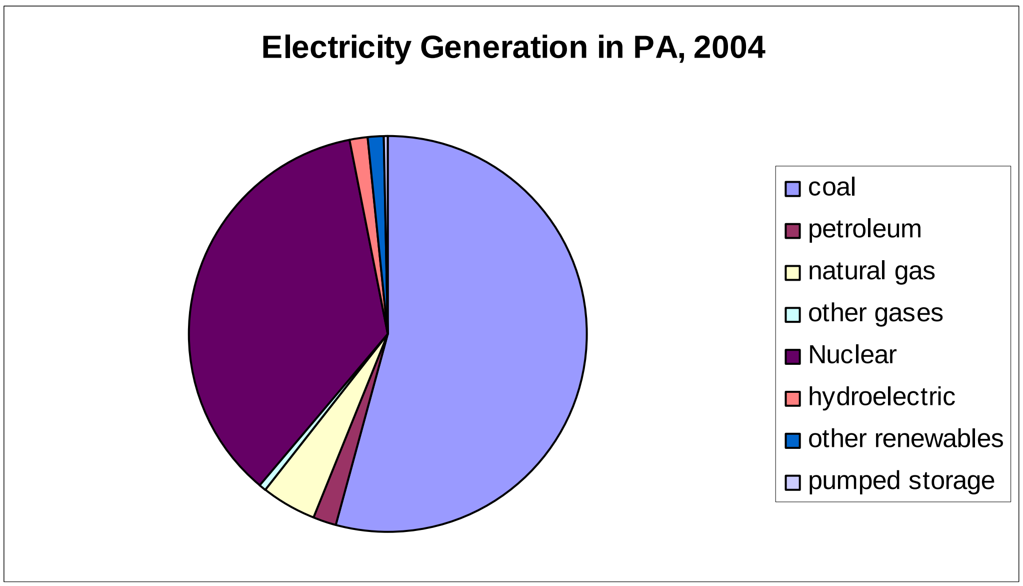


Figure 2[21]

While the current electricity consumption in Pennsylvania can be determined by existing data, there are many ways to forecast future consumption. For the sake of this study, a growth trend in US electricity consumption was measured from the EIA 2007 Energy Outlook, which gives current US electricity consumption and forecasts to the year

[18] Yergin, Daniel, *The Prize*, Touchstone, 1991.
[19] Energy Information Administration, State Electricity Profiles, http://tonto.eia.doe.gov/state/state_energy_profiles.cfm?sid=Pennsylvania, accessed Jan 15 2007.
[21] Energy Information Administration, State Electricity Profiles, p 185, 2004.

2030.[22] According to the EIA document, the average annual increase in US electricity consumption for the years 2008-2020 is predicted to be 1.55%. This increase was applied to Pennsylvania's current electricity generation capacity to create an electricity generation forecast for the state. These forecasted amounts were then compared to the Tier percentages according to the AEPS compliance schedule as shown in Figure 1, resulting in forecasted amounts of MWh required to meet the AEPS goals. The result is shown in Figure 3.

Another forecasting source is the PJM Load Forecast Report of 2006. This report was created by the PJM Capacity Adequacy Planning Department and forecasts the peak load growth rate for summer and winter operations for the 21 geographical zones in PJM up to the year 2016. According to this report, the average peak load growth rates are 1.54% (summer) and 1.44% (winter).[23] While the PJM Load Forecast Report provides detailed forecasting information, it only forecasts to the year 2016 and does not give state-specific information (the geographic zones are of various sizes and cross state boundaries).

The purpose of calculating this forecast is not to determine the exact amounts of electricity to be used in the future, but rather to show a trend in the growth of electricity generation based on available data. It is recognized that the forecast for Pennsylvania as derived from the EIA 2007 Energy Outlook has a margin of error, but it is selected for use in this study as it addresses the state specifically. The PJM forecast report produced similar increase percentages, and is included here to provide support to this study's forecasting methods.

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[22] EIA Annual Energy Outlook, 2007.
[23] PJM Capacity Adequacy Planning Department, *PJM Load Forecast Report*, February 2006.

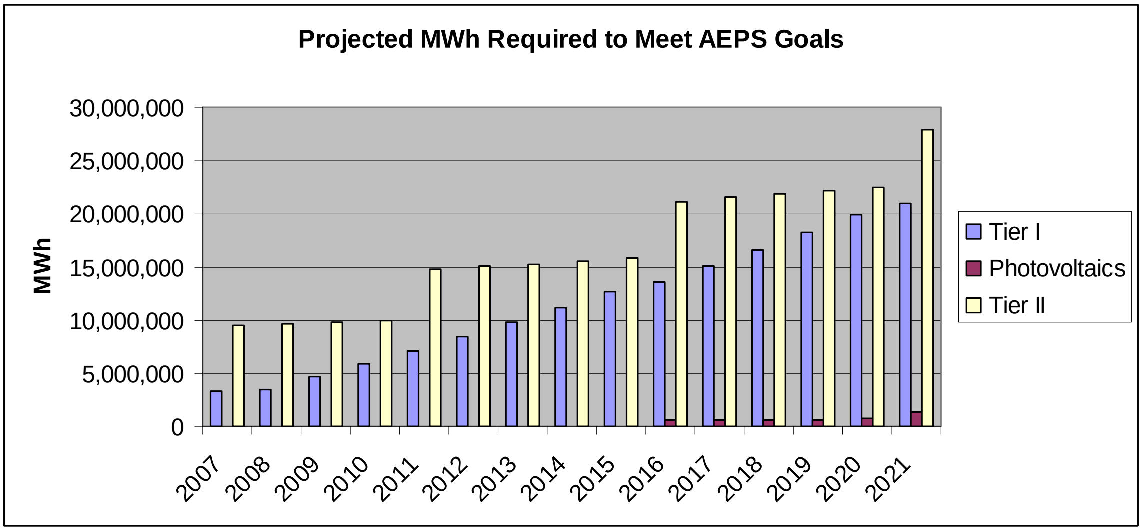


Figure 3

## Overview- Generation Attribute Tracking System (GATS)

The Pennsylvania AEPS, Section E, directs the commission to establish an alternative energy credit program as needed to implement the act, including the approval of an independent entity to serve as the credits program administrator.[24] In 2001, PJM-EIS began the establishment of the Generator Attribute Tracking System (GATS). This system was in response "to the need for state regulatory commissions, other state agencies and market participants for a single, regional, integrated system to implement state-imposed fuel mix and emissions disclosure requirements and renewable portfolio standards."[25]

GATS is a tracking mechanism for all electricity generation in the PJM territory. All generating units are registered in the system and provide reports to PJM on their operations. The system is designed to provide electricity generation data to comply with a wide range of policies and reporting requirements.

Once a generating unit is registered in GATS, a certificate with a unique serial number represents the attributes of the generation for each MWh produced by the

[24] The General Assembly of Pennsylvania, Senate Bill No. 1030, Session of 2004.
[25] PJM_EIS, *About GATS*, http://www.pjm-eis.com/gats/about-gats.html, accessed 15 Dec 2006.

generating unit.[26] These certificates are unbundled from the megawatt-hour of electricity, making them a separate entity which represents the attributes of the generation but not the generation itself.

Included in the generator registration data is the fuel source of the generating unit. For AEPS considerations, this fuel data is used to qualify certificates as meeting the fuel source requirements established in the AEPS. For example, a credit created by the MWh production from a wind power source will be given the attribute of meeting a Tier I requirement. On the other hand, a credit created by the MWh production of a non-alternative fuel source, such as coal, will be given a credit with the attributes of a non-alternative fuel source. In this way, GATS provides a system which generates certificates which represent the megawatt-hours produced by a certain fuel source. For fuel sources meeting the AEPS Tier requirements, these certificates become the currency in an electricity-generating company's attempt to meet the AEPS goals. GATS provides the tracking system as these certificates are generated, traded, banked, and retired.

## Overview- PJM Interconnection Queue

PJM is a major US regional transmission organization, responsible for coordinating the movement of electricity through all or parts of Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia, and the district of Columbia. This territory has a population of about 51 million and a peak demand of 144,644 megawatts.[27]

Prior to the addition of any new generation source to the electricity grid, a series of studies must be done to determine the effect such an addition would have on the overall integrity and operations of the grid. A new generating site begins these studies by entering into the PJM interconnection queue, and is given a specific queue number. Potential generating sites must disclose their operating capacity, source of fuel, point of interconnection to the grid, and technical specifications on the interconnection

[26] PJM-EIS, *GATS* Functionality, http://www.pjm-eis.com/gats/gats-functionality.html, accessed 12 Sep 2006.
[27] PJM, *Territory* Served, http://www.pjm.com/about/territory-served.html, accessed 23 Feb 2007.

components. PJM takes these inputs and models the new generation site on the existing grid at the desired point of interconnection. A series of studies are produced, each with a deeper level of system requirements and considerations for design and planning.

As these studies are produced, the potential generating company assesses the results of the studies and the associated costs of compliance. For example, a study may detail a list of electricity line upgrades required prior to interconnection, or may limit the output of the generating site. Associated costs are given for each requirement. The transmission availability and electricity expansion costs have become among the most important barriers to renewable energy in many states.[28] Generating companies consider these results, and have the choice of continuing with further studies (i.e. remaining "active" in the queue) or exiting the queue (i.e. "withdrawing").

## Statement of Data and Data Analysis Methods

### *GATS Data Source*

GATS historical data is available to the public through the GATS online interface (https://gats.pjm-eis.com). Complete data sets of all generation in the PJM service territory is available, including fuel source and number of certificates created (i.e. number of megawatt-hours from each fuel source). The GATS data for this report is based on database files received from the PJM-EIS public relations department, and is augmented by the online database system.

GATS data is used in this study to show the current generating capacity of Pennsylvania for power sources which meet the AEPS Tier requirements. This data shows the level of alternative energy generation for the years 2005 and 2006. As such, the data is taken as the existing capacity in Pennsylvania prior to the first round of AEPS requirements in 2007.

[28] Chen, Cliff, Wiser, Ryan, and Bolinger, Mark, *Weighing the Costs and Benefits of State Renewable Portfolio Standards: A Comparative Analysis of State-Level Policy Impact Projections*, Ernest Orlando Lawrence Berkeley National Laboratory, March, 2007, p v.

## Sources of Error and Limitations

The Pennsylvania AEPS addresses the fuel sources of electricity sold in Pennsylvania. Due to the intricacies of grid transmission operations, it is difficult to determine exactly which areas are being served by which plants. This is further confused when dealing with strictly public data. For the purposes of simplification, the GATS data were assumed to be related to electricity sold in Pennsylvania if they were related to electricity generated in Pennsylvania.

PJM covers the majority of Pennsylvania, but does not include a relatively small section of in the northwest section of the state. This section is covered by Midwest ISO, which is not integrated into the GATS database. Therefore, there is a small gap in the GATS data covering Pennsylvania.

The GATS historical data set received from PJM-EIS indicated fuel source but not Tier eligibility for the credits. A second dataset, downloaded from the online database, separates the credits by Tier eligibility and not by fuel source. Upon review, there were disparities in the amount of credits expected from the received dataset and the credits as recorded on the online database. In general, the dataset received from PJM-EIS showed more credits produced by Tier I eligible fuels than shown in the online historical database. The source of this disparity could be explained by assuming that some of the credits created by generating sites which use an apparent Tier-qualifying fuel source do not meet the GATS Tier eligibility for some other reason and were filtered from the database. The datasets cited here do not provide enough information to resolve this difference. For the purpose of this study, the disparities in the two data sets are indicated when the analysis is affected, and the source of all data is indicated throughout the study.

## GATS Data Statement

Figures 4 and 5 illustrate the number of Tier I, Tier II, and solar PV qualifying generators in Pennsylvania according to the GATS database. Figure 6 illustrates the energy credits produced in 2006, which correlates to the electricity output of these sources in MWh.

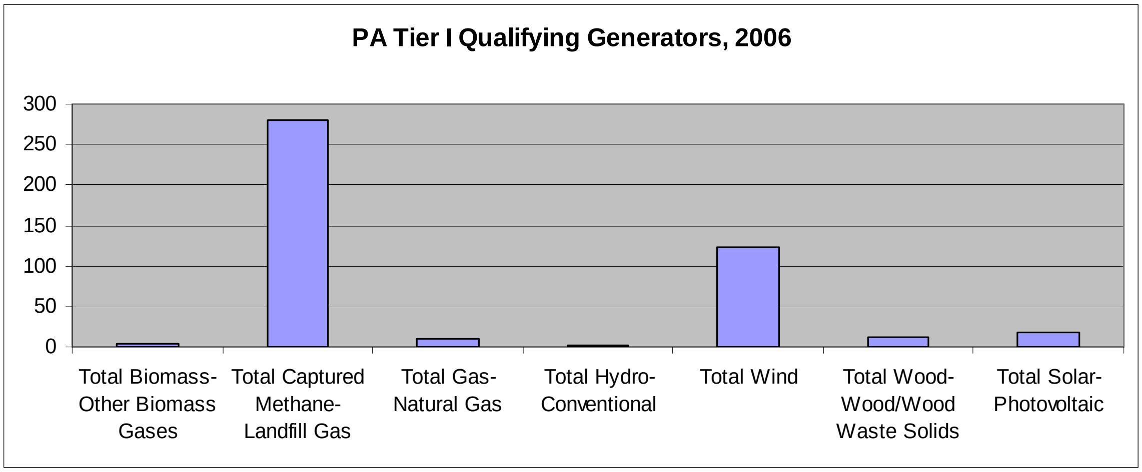


Figure 4[29]

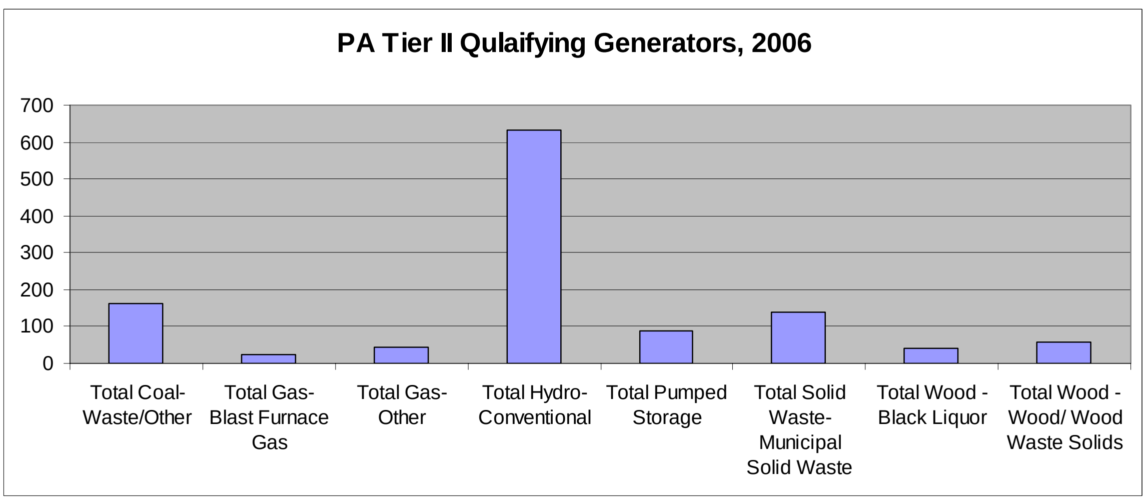


Figure 5[30]

[29] Source: GATS Database. This database includes natural gas as a Tier I source, although it is not listed as such under the AEPS

[30] Source: GATS Database.

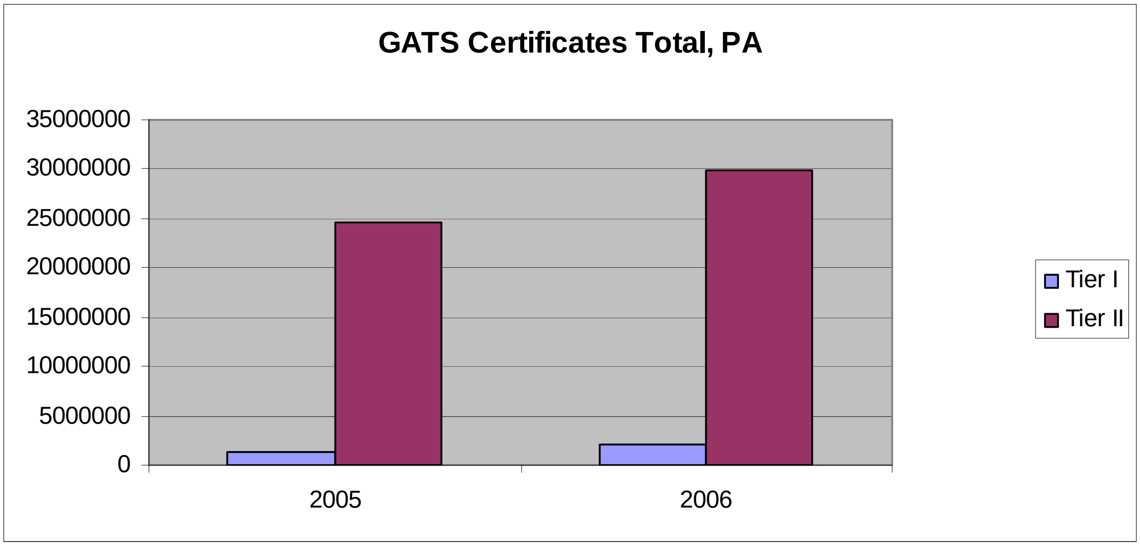


Figure 6[31]

The data for Figure 6 is summarized below, including the solar PV credit data.

| | **2005** | **2006** |
|---|---|---|
| **Solar PV** | 60 | 337 |
| **Tier I** | 1,359,566 | 2,128,131 |
| **Tier II** | 24,593,912 | 29,936,153 |

## *PJM Interconnection Queue Data Source*

The PJM interconnection queue is available to the public through the online interface (https://www.pjm.com/planning/project-queues/queue-gen-active.jsp). The online interface retains the generating company's name, but lists the queue number and date, interconnection substation, capacity, fuel source, and study status of the proposed generating unit. The data for this paper was received as a public report from the PJM-EIS Public Relations department.

As opposed to the GATS data, which is used to provide a baseline of electricity generating attributes currently in Pennsylvania, the PJM Interconnection Queue data is used to forecast the creation of new generating systems along with their fuel source.

[31] Source: GATS Online Database.

## Sources of Error and Limitations

The PJM interconnection queue does not specify the areas served by the proposed plants. For purposes of this study, the plants are assumed to serve Pennsylvania if they are located within the state.

The PJM Interconnection queue does not show the AEPS Tier eligibility of plants. While this does not create a source of error for fuel sources such as wind, which are all Tier I qualifiers, it does create a source of error for methane and hydropower projects, which could fall under Tier I or Tier II requirements depending on their actual source of fuel (e.g. landfill methane is Tier I, whereas coal mine methane is Tier II). For this study, all methane and hydropower projects listed in the PJM Interconnection Queue are assumed to fit Tier I requirements.

Only a fraction of the generating units in the PJM interconnection queue actually get constructed and reach the operational stage. While it is possible to do a more in-depth study to show which generation queues are further along in the study process, it is impossible to show which ones are going to actually be built prior to the end of the study cycle.

## PJM Interconnection Queue Data Statement

The data from the PJM Interconnection Queue data set are represented in Figures 7 and 8. These figures are shown here to give a snapshot of the trends in proposed new electricity generation plants since 1997. The data is analyzed in following sections.

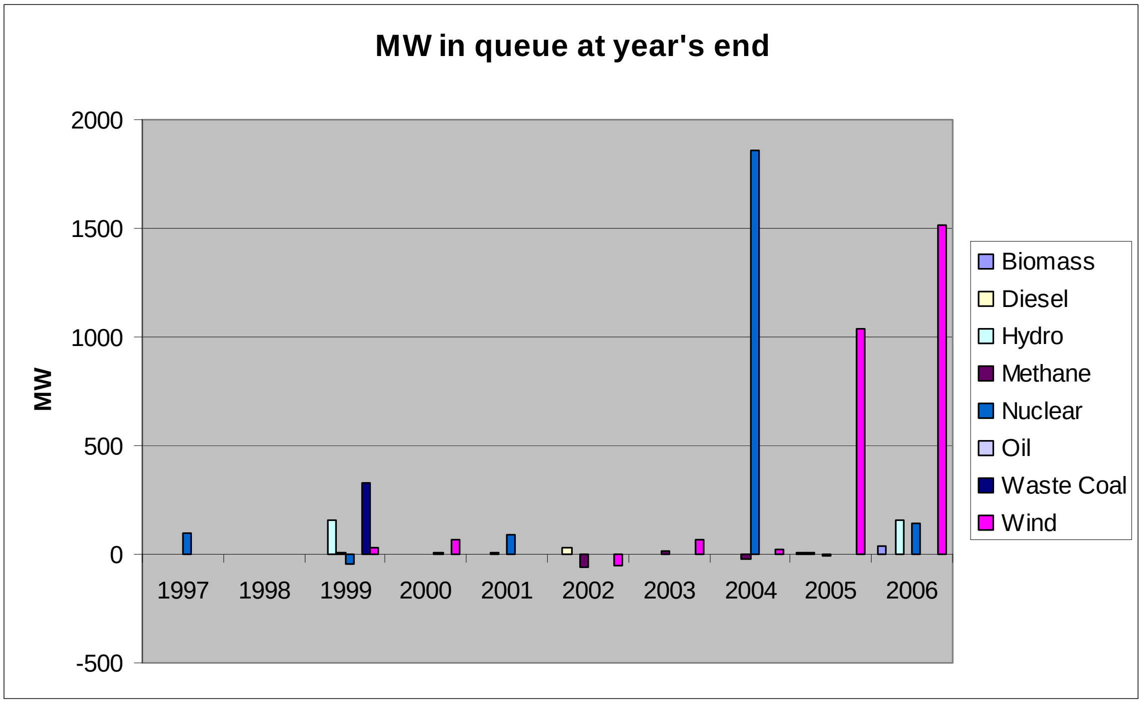


Figure 7[32]

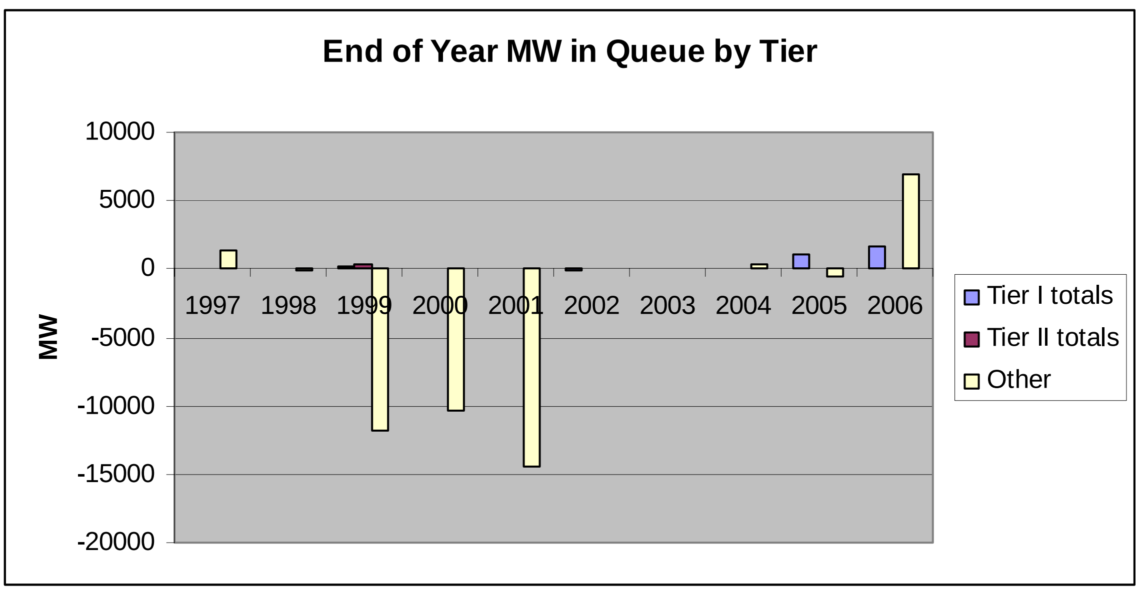


Figure 8[33]

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[32] Source: PJM-EIS Database. Negative values indicate that more MW worth of projects were withdrawn than initiated.

[33] Source: PM-EIS Database. For this graph, all methane and hydro projects are assumed to fit Tier I requirements. "Other" includes nuclear, natural gas, coal, oil, and diesel. Tier II is only waste coal. These

# Looking at Now- Meeting Goals in 2007

## *Tier I*

According to the GATS data, there were 2,128,131 certificates issued in 2006 for Tier I sources. The estimated value to meet 2007 compliance is 3,369,400 certificates, giving a deficit of over 1.2 million certificates.

Out of the existing Tier I generating plants, landfill methane plants are the most abundant. However, there are no significant new landfill methane plants in the generation queue. The emphasis on new development is on wind power, as shown in the PJM Interconnection Queue.

## *Tier II*

According to the GATS database, Pennsylvania recorded almost 30 million Tier II credits in 2006. This is over 20 million more credits than Pennsylvania is estimated to need in 2007, and is enough to meet the projected goals at the end of the compliance scheme in 2021.

## *Solar PV*

The solar PV situation is the most difficult to ascertain from the analysis tools. According to this data, there are 18 qualifying solar PV generators in Pennsylvania, but none planned in the interconnection queue. However, a look at the history of the interconnection queue shows that there have never been any solar PV generators planned.

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limitations are due to the lack of plant specifics in the database. The negative “other” is mainly due to natural gas withdrawals, and the positive “other” is mainly due to nuclear.

This leads to the conclusion that the qualifying PV electricity generators are of too small a capacity to be included in the PJM Interconnection Queue.[34]

According to the GATS qualifying generators data, there are 18 solar PV electricity generators in Pennsylvania which created 337 credits in 2006. According to the projections, the Pennsylvania AEPS will require over 2,900 credits to meet the 2007 requirements, leaving a projected deficit of over 2,500 solar PV credits in 2007.

## Looking Ahead- Meeting Requirements Beyond 2007

According to the trends in planned electricity generation sources, the Pennsylvania AEPS has encouraged the development of alternative energy systems. The formulation of the AEPS began in 2004, and the interconnection queue shows that this year marked the entrance of alternative electricity sources which had not been developed previously. This trend is most noticeable in the drastic increase in new wind projects since 2004. The question remains as to how Pennsylvania will continue to develop alternative electricity sources to meet the future requirements.

### *Meeting Requirements- Tier I*

There are a number of possible developments in the future of alternative energy technology. Spurred by the various benefits and incentives for alternative energy, there are many initiatives in the public and private sector exploring new energy technologies. From 1990 through 2004, venture capitalists invested an estimated $4.4 billion in the energy-technology sector, compared to just $380 million from 1993 to 1998.[35] The following sections detail the most promising technologies for Pennsylvania.

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[34] According to PJM informational resources (http://www.pm.com/planning/download/rtep-faqs.pdf) , "Generation resources that are smaller than 1 MW and will not participate in the PJM capacity and/or energy markets need only coordinate planning, construction, and/or interconnection operation with the host Transmission Owner."

[35] Carlton, J. and Buckman, R., *Alternative Fuel is Attracting Venture Capital*, The Wall Street Journal, April 14, 2007.

## Wind Power

Wind power has the capacity to account for a large part of the Tier I requirements in Pennsylvania using current technology. In general, wind is expected to be the dominant technology in meeting state energy portfolio requirements.[36] 2,555 MW of the 2,748 MW Tier I qualifying projects in the PJM Pennsylvania interconnection queue are wind energy projects.

Wind power is an intermittent resource, and wind power projects are given a "power factor" which correlates to the percentage of time that the plants produce electricity. The power factor is a function of the wind resource in the area of the project. For an estimation of the MWh which may be generated by these projects, an average power factor of 0.30 is used in this study. 2,555 MW of wind generating plants, operating at a power factor of 0.30, have the capacity to generate 21,829,920 MWh per year.[37] While only a percentage of the wind projects in the interconnection queue actually get built, 7% of the planned wind projects would meet the Tier I requirements for 2007. However, the construction timelines of these projects, which can be years from the time of entering the interconnection queue, may make these credits unavailable for the next few years.

It has been cited that Pennsylvania has the wind resources for 5,400 MW worth of developable wind capacity.[38] Using the same assumptions, this could provide 14,191,200 MWh per year. This value could meet the projected Tier I requirements (according to Figure 3) until 2017, but will still leave a deficit of 6.7 million certificates by the year 2021.

There are many initiatives underway to improve the technology of wind turbines and to make the technology more adaptable to different areas. For example, the Department of Energy, in conjunction with the National Renewable Energy Laboratory, is actively engaged in projects to develop wind technology viability (including low wind

[36] Chen, Cliff, Wiser, Ryan, and Bolinger, Mark, *Weighing the Costs and Benefits of State Renewable Portfolio Standards: A Comparative Analysis of State-Level Policy Impact Projections*, Ernest Orlando Lawrence Berkeley National Laboratory, March, 2007, p ii.
[37] The calculation is as follows: (8544 hrs/yr)*(MW)*(Power Factor)
[38] The Pennsylvania Energy Development Plan, April 2006 Draft, page 7.

speed technology and distributed wind technology) as well as technology use (including systems integration and technology acceptance).[39] These developments may expand the role in which wind power may play in Pennsylvania's energy market.

## Landfill Methane

Pennsylvania has 49 municipal waste landfills and 12 construction/demolition waste landfills.[40] According to the GATS data, there are currently 281 Tier I qualifying generators which use landfill methane. Landfill methane production is a relatively basic operation from a technology view, as it collects methane from landfills which would otherwise escape into the atmosphere and uses it as a combustible fuel for electricity generation. While there are no significant landfill methane projects in the PJM interconnection queue, there are policies which are addressing the expansion of this technology. For example, the US Environmental Protection Agency has established the Landfill Methane Outreach Program, which has assisted in developing 300 landfill methane utilization projects and has developed detailed profiles for over 1,300 candidate landfills.[41]

## Hydrogen

There have been many proposals for the development of hydrogen-based systems, such as fuel cells. Hydrogen is not in itself an energy source, but rather an energy transfer medium. Hydrogen must be extracted from natural sources, such as water, through a variety of energy-intensive methods. Once extracted, hydrogen can become a

[39] US Department of Energy, Office of Energy Efficiency and Renewable Energy, http://www1.eere.energy.gov/windandhydro/wind_research.html, accessed 12 Jan 2007.
[40] Commonwealth of Pennsylvania, Department of Environmental Protection, *List of Municipal Waste Landfills and Resource Recoevery Facilities,* http://www.depweb.state.pa.us/landrecwaste/cwp/view.asp?A=1238&Q=463564#CDWaste, accessed 14 April 2007.
[41] US Environmental Protection Agency, *Landfill Methane Outreach Program- Accomplishments,* http://www.epa.gov/lmop/accomplish.htm, accessed 14 April 2007.

fuel source for electricity generation as a combustion agent or through fuel cell technology.

The development of hydrogen to the AEPS goals can be on two levels. One, as a fuel for Tier I qualifying fuel cells. On a deeper level, however, the creation of a true hydrogen economy will require large infrastructure changes for hydrogen extraction, transportation, and use. As noted, hydrogen extraction requires an energy input. During the development of a hydrogen-based infrastructure, it could be possible to design large hydrogen extraction systems which are powered by alternative fuel sources, thus creating a new market for alternative energy development.

The creation of a hydrogen economy is still many years in development, and the technology behind viable fuel cells is still in development. The Federal Hydrogen Fuel Initiative has set a goal of achieving a technology readiness milestone by 2015, which will be used to guide hydrogen and fuel cell research and development activities.[42]

## Biomass

The use of agricultural sources as fuel is a burgeoning industry in the US. Much of the research for biomass is centered on producing fuels such as ethanol, mainly for transportation purposes. However, dedicated energy crops, such as fast-growing trees and grasses, are being developed which can grow sustainably on land which will not support intensive food crops.[43]

The technology behind biomass is being refined and new fuel crops are being developed. The economics behind biomass-fueled generators dictates 50 miles as the typical maximum distance feasible for fuel transportation from the fields to the generating site.[44] This offers a limit on the areas available for new biomass-fueled generator development. As the AEPS requires biomass for Tier I qualification to come

[42] US Department of Energy, Office of Energy Efficiency and Renewable Energy, *DOE Announces New Hydrogen Cost Goal*, Press Release, 14 July 2005.
[43] National Renewable Energy Laboratory, *Biomass Energy Basics*, http://www.nrel.gov/learning/re_biomass.html, accessed April 5 2007.
[44] US Department of Energy, Office of Energy Efficiency and Renewable Energy, *Wood Waste to Energy- An Old Technology with New Benefits for Federal Facilities*, Press Release, 11 November 2003.

from crops which are specifically grown for fuel (as opposed to waste from other industry, which qualifies under Tier II), collaborative planning between the agricultural and utility industry is required to establish these new Tier I biomass-fueled plants. This creates an opportunity for the agricultural industry in Pennsylvania to benefit from the AEPS by providing a market for fuel crops, adding a new market apart from the traditional food demand.

### *Meeting Requirements- Solar PV*

In 2006, 18 solar PV electricity generators in Pennsylvania created 337 credits, falling over 2,500 credits short of the 2007 requirements. Solar energy, like wind energy, is an intermittent resource and a capacity factor of 0.15 is assumed for Pennsylvania calculations. Using this assumption, it can be calculated that each of the 18 current solar PV electricity generators are rated at an average of 1.4 kW.[45] Accordingly, it can be estimated that 2.2 MW of installed solar PV electricity generating capacity will be required to meet the 2007 AEPS goal.

The estimated size of the current solar PV generators in Pennsylvania is on the scale of residential installations, such as solar PV cells situated on personal residences which are feed their extra electricity into the regional grid through a net metering process. As such, the development of new solar PV capacity falls under the second key mandate for the AEPS of creating an opportunity for customer-generators to interconnect and net meter small alternative energy systems. It is proposed that the information contained in this report could be used as a base for a second study on the effects of the AEPS on development of residential (non-utility) solar PV installations.

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[45] The calculation is as follows: (337 MWh)/(24 hrs)/(365 days)/(0.15)/(18 generators) = 1.4 kW/generator

## *Meeting Requirement - Supporting Policy*

While not all of the AEPS goals may be met in 2007, it is apparent that The AEPS creates a market for alternative energy in Pennsylvania. However, it alone does not provide the tools to overcome the entrance barriers of new energy technologies, specifically solar PV. Pennsylvania has addressed this idea through development of supporting policies such as the following:

### Pennsylvania Energy Development Plan

One of the largest changes in policy which is currently developing is an update of the Pennsylvania Energy Development Plan. This document, first established in 1984, is being revised to reinforce Pennsylvania's mission to expand the market for clean, indigenous energy resources, to enhance energy diversity and energy security, and to stimulate economic development and job creation in Pennsylvania, all in an environmentally beneficial manner.[46] The Energy Development Plan will aid in defining energy policy goals in conjunction with the AEPS and set out a plan for the allocation and distribution of financial and technical assistance.

### Pennsylvania Energy Independence Strategy

This strategy, revealed in February 2007, addresses Pennsylvania's intent to cut energy costs, move toward energy independence and stimulate the economy.[47] The strategy includes the establishment of the state Energy Independence Fund, which provides $106 million for venture capital, grants and loans for expansion of energy companies, and $500 million for clean energy projects and development or equipment costs for specific energy economic development projects. This fund will be created by

[46] Pennsylvania Energy Development Plan, April 2006 Draft.
[47] Office of the Governor, Commonwealth of Pennsylvania, *Governor Rendell Unveils Energy Independence Strategy to Save Consumers $10 Billion Over 10 Years, Reduce Reliance on Foreign Fuels*, Press Release, February 1, 2007.

charging consumers $0.0005 per kWh of electricity used, creating an average increase of $0.45 per month for consumers.[48]

### Model Wind Siting Ordinance

This policy creates a model for local townships to use when using their jurisdiction to dictate the placement of wind turbines in their areas. In effect, this policy takes the research done on the state level and makes it available to local governments for their use. This has the potential to streamline the permitting process in the state and to soften the siting and zoning barriers to new wind power development.

### Partnerships With Industry

A goal of the AEPS and the Pennsylvania energy policy is to expand the alternative energy industry in the state, creating jobs and adding to the state economic profile. Pennsylvania has supported the establishment of renewable energy companies in the state, such as Gamesa Energy USA (a wind power manufacturer and developer), which has established three manufacturing and assembly plants in the state in the past three years.

## *Meeting Requirements – In Action*

In March, 2007, PECO, an electric and natural gas utility serving southeastern Pennsylvania, took initial action to buy 450,000 alternative energy credits per year for the next five years. These credits would be purchased from alternative energy generators in the state, and would amount to about one-third of the total Tier I credits generated in Pennsylvania in 2006. PECO's strategy in this move is that, by purchasing the credits

[48] Ibid.

[50] PECO, *PECO Files Petition With Pennsylvania PUC ToTake Early Action To Meet Future Renewable Energy Requirements*, Press Release, March 19, 2007, Accessed on Yahoo!Finance.

now and banking them to meet future requirements, PECO can take advantage of the current low credit market prices.[50]

## Recommendations

The recommendations made here offer ways to make the AEPS more inclusive, more adaptable to the changing energy and environmental markets, and more effective in motivating the development of new utility-scale alternative energy systems.

### *Inclusion of Environmental and Health Benefits*

Many credit or attribute definitions in other states with renewable portfolio standards include emissions or environmental characteristics. However, the Pennsylvania AEPS makes no mention of environmental or emissions attributes in the definition of alternative energy credit, or any other section of the policy.[51]

The environmental and health affects of pollutants associated with non-renewable electricity generation have been addressed in the United States 1990 Clean Air Act Amendments. This act, which includes measures to control acid rain by reducing sulfur dioxide emissions from coal-burning power plants, proposed an approach that relies on marketable pollution allowances rather than "command and control" regulation. This policy is similar to the AEPS in that it uses a market-based approach to achieve emissions reductions more efficiently. [52]

However, there are other emissions from energy production which are more difficult to correlate to environmental and health degradation, most prominently greenhouse gases and their affect on climate change. The Intergovernmental Panel on Climate Change (IPCC), an international assembly of scientists, recently came to a 90% certainty level that the globally averaged net effect of human activities since 1750 has

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[51] Pennsylvania Public Utility Commission, *Implementation of the Alternative Energy Portfolio Standards Act of 2004*, Docket No. L-0060180, 20 July 2006, p 12.

[52] Vig, N., *Presidential Leadership and the Environment*, Environmental Policy, Ed. Kraft, M. and Vig, N., CQ Press, Washington, D, 2006, p 107.

been one of increasing the temperature of the climate, and that an increase in globally averaged temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations.[53] In addition, the report attributes climate events such heat waves and tropical cyclone activity as a result of this increase in temperature, and predicts that such events will very likely increase in intensity in the future.[54] While the IPCC report does not remove all scientific uncertainty, it does present a basis for adhering to the precautionary principle, which introduces greater caution into decisions in cases where there could be substantial future costs that are currently unknown.[55] The precautionary principle establishes a more explicit presumption on the side of environment and health protection in the absence of scientific certainty, and allows greater administrative discretion to regulate risks associated with the possible outcomes.[56]

While there are many greenhouse gases with varying attributes, carbon dioxide is commonly referenced as a main contributor to climate change. For electricity generators, future carbon regulations or carbon taxes may add significantly to the finances of a generating plant. Alternative energy credits can serve as a base for calculations on the amount of carbon dioxide created by a specific plant. For example, coal plants release about 2000 lbs of carbon dioxide per MWh of electricity, therefore one energy credit represents this amount of carbon dioxide released into the atmosphere.[57]

There are two ways in which this connection could be affected by future carbon dioxide restrictions. One is that the credits are traded on two markets: one to meet AEPS standards, and another to meet carbon dioxide standards. This approach adds complexity to the trading and banking schemes, and complexity to a company's approach to compliance. A second approach is that carbon dioxide emissions are integrated into the AEPS goals. In this approach, the goals set by the AEPS account for the carbon dioxide

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[53] Intergovernmental Panel on Climate Change, *Climate Change 2007: The Physical Science Basis-Summary For Policy Makers*, 5 February 2007, pp 5, 10

[54] Ibid, p 9.

[55] Field, M., and Field, B. Environmental Economics: an Introduction, 4th Ed., McGraw-Hill Irwin, New York, 2006, p 394.

[56] Andrews, R., *Risk-Based Decision Making: Policy, Science, and Politics*, Environmental Policy, Ed. Kraft, M. and Vig, N., CQ Press, Washington, D, 2006, p232.

[57] This value of carbon dioxide per MWh is estimated from the Department of Energy's *Carbon Dioxide Emissions from the Generation of Electric Power in the United States*, July 200. Petroleum plants create slightly less than this amount, and gas plants create about two-thirds of this amount.

emissions of the different Tiers, increasing the goals as necessary to meet carbon dioxide reduction demands. This approach has added complexity as well, as the carbon dioxide emissions of fuel sources is different for technologies in the same Tier (e.g. hydropower and waste coal technologies emit different amounts of carbon dioxide per MWh, although they are both Tier II sources).[58]

### *Tier Redefinition*

As shown, Pennsylvania does not need an increase in Tier II qualifying generation to meet the AEPS goals. The AEPS came under criticism for its inclusion of coal-based sources (such as waste coal)[59], but the data shows that no new Tier II sources are required to meet the goal. Therefore, the AEPS does not properly estimate the size of the current Tier II market and does not provide an incentive for new Tier II developments. This could be changed, however, if the Tier II goals are increased. A Tier II goal of 15% by 2021 would require that an estimated 1,360 MW of new Tier II qualifying generators be developed.[60] An alternate change would be to redefine the qualified Tier II generators, which would give Pennsylvania the opportunity to direct the policy at the most desirable developments.

### *Tier Limits*

As shown, the Tier structure is not currently scaled to correctly motivate the development of Tier II sources. Due to this, and to the predicted shortage in Tier I and solar PV credits, reverse percentages could be established for Tier II sources. The

[58] Carbon dioxide emissions are also inherent in varying levels for true renewable sources such as solar PV and wind energy. These emissions are associated with such things as the manufacturing processes and transportation.

[59] PennEnvironment, Testimony Before Pennsylvania House of Representatives, April 13, 2004. http://www.pennenvironment.org/PE.asp?id2=17601, accessed Nov 15, 2006.

[60] 15% would increase the annual estimated Tier II credits required to over 41.8 million, which is 11.9 million more Tier II credits than were generated in 2006. Assuming constant electricity generation, this translates into (11,900,000 MWh)/(365 days/yr)/(24 hrs/day) = 1,360 MW.

reverse percentages would set a maximum amount of electricity which could be generated by Tier II sources. Once this reverse percentage is met, then the policy would dictate that any new developments of electricity generators would have to qualify as Tier I or solar PV until the total generation brought the Tier II percentage below the maximum allowed. This would enhance the competitive market for Tier I and Solar PV.

### *Emerging Technology*

The technology behind alternative electricity sources is expected to mature throughout the life of the AEPS. The policy should remain flexible and adapt to new advances in technology. This could include revising the lists of qualifying sources under the Tier structure, as well as new external policies to promote the development of future technology as it becomes more attractive to the state's energy portfolio. If a new technology becomes a leader in alternative electricity generation (such as the development of a hydrogen economy), a new Tier could be established for that technology alone, as is currently done for solar PV.

### *Beyond 2021*

For beyond 2021, assuming that the goals are met, Pennsylvania should develop a policy which maintains the Tier percentages. It can be assumed that electricity demand will continue to grow in Pennsylvania, and that new electricity generators will be required. Mandating that alternative sources be included in these new developments will provide a maintainable baseline of alternative sources in the state energy portfolio. This is similar in theory to the popular "wedge principle" as proposed by Dr Socolow of Princeton University. Dr Socolow's principle addresses carbon emissions, and suggests that the emissions can be reduced by breaking the process into manageable wedges, each of which would take a step toward limiting carbon emissions to today's levels.[61] In this way, each year a new "wedge" accounts for the development of cleaner energy systems and, in time, the wedges add up to account for a sizeable amount of the total emissions from the total. In the case of the AEPS, the "wedges" would be the continual development of alternative electricity sources during the years after 2021. Using a forecast for increased electricity demand, Pennsylvania could create a "follow-on" AEPS which sets goals for future alternative energy electricity generating systems to maintain their respective percentages in the overall state energy portfolio.

## Recommendation for Future Study

### *Continuous Data Collection*

The data for GATS and the PJM Interconnection Queue was taken from publicly available sources, and is only available for limited years. It is assumed that these sources have a margin of error due to such things as reporting delays, proprietary information considerations, and inherent system inaccuracies. However, the overarching source of error for this study comes from the forecasting methods. Again, this was based on publicly available information and used in a way deemed appropriate for this level of study. The combining of the hard data (i.e. the GATS and PJM data) with the forecasted data makes it difficult to quantify the margin of error present in the results. This study is intended to show trends and the results, while quantitative, are intended to be interpreted with this margin of error in mind. For future studies, continuous data collection could be done to reduce these margins of error, increase the size of the data sets, and the resulting data could be studied using the same methods to produce more exact results.

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[61] Powell, A., *Step-by-step to a Cleaner Energy* Future, Harvard News Office, http://www.news.harvard.edu/gazette/2006/04.13/05-energy.html, 2007.

## *Case Studies of Previous Incentives*

The PJM Interconnection Queue shows that, between 1999 and 2001, there were extensive studies done for natural gas plants, but that almost all were removed from the queue before the year's end.  A study of the natural gas market, and any associated incentives, could provide an interesting case study for this energy market and the economics which drove the boom, and resulting bust, of the interest in natural gas plants in the state.  This study could provide a model for predicting the future effects of the AEPS on the alternative energy market.

## *Economic Analysis of Alternative Energy Credits*

The energy credit market as created under the AEPS is beginning to be established, but there is little historical data on the economic impacts of this market on developments of new generating plans.  As shown, the creation of credits can provide a secondary revenue stream for electricity plants.  An in-depth analysis of the credit market as it continues to emerge would provide electricity developers with a better understanding of how the credit system contributes to the overall costs of electricity.  This understanding would play a role in setting the prices for power purchase agreements (assuming that the credits remain bundled to the electricity output) which is directly connected to a company's prediction of the revenue stream from a new plant. Accordingly, companies would be able better to estimate their cost of AEPS compliance and decide on whether to create their own credits (the cost of which would change as technology progresses) or to purchase them from the credit market.

## Conclusions

The Pennsylvania AEPS is predicted to fall short of its goals in the first years of implementation. However, the policy has effectively created a market in Pennsylvania for the development of new electrical plants fueled by alternative sources. By establishing supporting policies and remaining flexible as new energy technologies emerge and become more viable, Pennsylvania will be able to meet the AEPS goals during the course of the policy implementation