ISSUE BRIEF

SENATE POLICY DEVELOPMENT AND RESEARCH OFFICE

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Potential of Pennsylvania's Alternative Energy Resources

Estimation of the potential of Pennsylvania's alternative energy resources to meet the Commonwealth's energy needs is fundamental in formulating sound state energy policy. Such evaluation requires knowledge and understanding of energy consumption and resource availability.

Energy Consumption in Pennsylvania

To put the potential impact of alternative and renewable energy resources into perspective, one needs to determine current energy consumption. According to the US Department of Energy's Energy Information Administration, Pennsylvania's *per capita* total energy consumption was 321 million Btu in 2003. In combination with the US Census Bureau's most recent population estimate of 12,440,621, an estimate of annual statewide energy consumption is nearly *4,000 trillion Btu*. (A Btu or British thermal unit is the quantity of heat required to raise the temperature of 1 lb of liquid water by 1° F at the temperature at which water has its greatest density [~39° F]).

Potential of Alternative Resources

Table 1 is a compendium of many of the alternative energy resources available in Pennsylvania.

Table 1. Alternative Energy Resources in Pennsylvania[1]

Resource	Estimated Amount Available (trillion Btu)[2]	% of 2003 Total Energy Consumption[3]
coalbed methane	39,436	985.9%
solar photovoltaics	18,435	460.9%
waste coal	2,301	57.5%
demand side management[4]	599	15.0%
municipal solid waste	217	5.4%
hydropower	142	3.6%
biomass	104	2.6%
wind	58	1.5%
waste tires[5]	7	0.2%
Total	61,299	1532.5%

[1] assumes deployment without economic, environmental, or technical constraints
[2] figures are annual for all resources except coalbed methane and waste coal; waste tires also have a non-renewable component
[3] 4,000 trillion Btu
[4] 15% of total energy consumption
[5] includes 2.8 trillion Btu from existing piles

Coalbed Methane

Coalbed methane occurs in coal seams throughout the Northern Appalachian coal basin, which includes parts of Pennsylvania, West Virginia, Ohio, Kentucky, and Maryland. In southwestern Pennsylvania and northwestern West Virginia, the total in-place coalbed methane estimate is 51 trillion cubic feet (Tcf) and the recoverable estimate is approximately 11.5 Tcf, according to research findings compiled by the Department of Conservation and Natural Resources. (The total-in-place resource will never be recoverable due to technical limits.) Given methane has an energy content of 1,031 Btu/cubic foot and assuming 75% of the in-place and recoverable resources are in Pennsylvania, the respective potential yields are 39,436 trillion Btu and 8,877 trillion Btu.

In 2005, coalbed methane production occurred in six counties: Indiana (988 million cubic feet), Greene (451), Washington (166), Westmoreland (147), Fayette (74), and Cambria (5), for a total of 1,831 million cubic feet or about 1.9 trillion Btu. The 2005 energy yield is only 0.021% of the total potential (8,877 trillion Btu) of this alternative energy resource.

Solar Photovoltaics

Pennsylvania's solar photovoltaic energy production potential is 5,402,905 million kilowatt-hours (kWh) per year, according to the US Department of Energy's National Renewable Energy Laboratory, or 18,435 trillion Btu in equivalent energy terms. However, current environmental, economic, and technical constraints will severely limit deployment of solar photovoltaic generation in the Commonwealth.

For perspective, California, the national leader in total net generation of solar energy with 536,713,000 kWh in 2005 according to the Energy Information Administration, meets only about 0.022% of statewide energy needs with solar power. Applied to Pennsylvania and in energy equivalent terms, 0.022% of statewide consumption amounts to about 1 trillion Btu annually.

Waste Coal

In the early 1980s, the Department of Environmental Protection completed an inventory of waste coal. The inventory includes waste coal sites identified prior to 1977 and likely represents the most comprehensive inventory available. This inventory comprises 819 sites in 35 counties and includes both bituminous coal and anthracite refuse. Collectively, these sites cover 8,529 acres and contain 233,703,549 tons of waste coal. In the mid-1980s, Neufeld found the energy content of samples of western Pennsylvania waste coal to average 4,923 Btu/lb, with a range of 2,328 Btu/lb to 7,178 Btu/lb. Thus, the magnitude of this alternative energy resource is 2,301 trillion Btu.

In 2006 and according to the Department of Environmental Protection, 7,400,467 tons of waste coal were processed, presumably for power generation purposes. This tonnage is 3.167% of the pre-1977 total. At 4,923 Btu/lb, the energy content of the 2006 tonnage was approximately 73 trillion Btu.

Demand Side Management

The Energy Information Administration defines Demand Side Management (also known as Demand Side Response) as "planning, implementation, and monitoring of utility activities designed to encourage consumers to modify patterns of electricity usage, including the timing and level of electricity demand … in response to utility-administered programs." Energy efficiency is critical to effective Demand Side Management. The Energy Information Administration defines energy efficiency as:

> **programs … aimed at reducing the energy used by specific end-use devices and systems, typically without affecting the services provided. These programs reduce overall electricity consumption … often without explicit consideration for the timing of program-induced savings. Such savings are generally achieved by substituting technologically more advanced equipment to produce the same level of end-use services (e.g. lighting, heating, motor drive) with less electricity. Examples include high-efficiency appliances, efficient lighting programs, high-efficiency heating, ventilating and air conditioning … systems or control modifications, efficient building design, advanced electric motor drives, and heat recovery systems.**

Demand Side Management targets can be established on several bases, for example, on overall consumption or *per capita*. For instance, the Maryland Public Service Commission recently ordered electricity usage reduction by 2015, predicated on a 15% cut in 2007 *per capita* usage for the utilities it regulates. According to the American Council for an Energy Efficient Economy, energy efficiency goals in other states include: Utah, 20% by 2015; New Jersey, 20% by 2020; Minnesota, 20% by 2020; and New York, 15% by 2015. *In Pennsylvania, a 15% reduction in total energy consumption would amount to 600 trillion Btu per year.*

Municipal Solid Waste

Based on Municipal Waste Disposal Information published by the Department of Environmental Protection, Pennsylvanians generated 14,981,967 tons of municipal solid waste and the Commonwealth received 9,163,188 tons (38.0%) of municipal solid waste from out-of state in 2006, for a total of 24,145,155 tons. Given the estimate by the Oregon Department of Energy that one pound of "raw" (undried) municipal solid waste has an energy content of 4,500 Btu/lb, Pennsylvania's annual municipal solid waste collection could yield 217 trillion Btu per year.

In 2006, 2,922,027 tons or 12% of the Commonwealth's municipal waste stream was managed at six resource recovery/waste to energy plants; this percentage is close to the national figure for 2005, 13.6%, reported by the US Environmental Protection Agency. Assuming this tonnage was combusted for energy production, the energy content was 26 trillion Btu.

Hydropower

In 2006, the US Department of Energy's Idaho National Laboratory published a Feasibility Assessment of the Water Energy Resources of the United States for New Low Power and Small Hydro Classes of Hydroelectric Plants. In the Assessment, low power was less than 1 MW (MW or megawatt equals 1,000 kilowatts or one million watts; enough electricity to supply roughly 900 Pennsylvania residential customers) and small hydro was 1 MW to 30 MW. Gross power potential was refined by applying criteria that considered site accessibility, load or transmission proximity, and land use or environmental sensitivities that would make development unlikely.

The Assessment quantified Pennsylvania's hydropower resource as follows: total, 4,764 MW or 142 trillion Btu annually and feasible projects, 954 MW or 29 trillion Btu annually. The feasible projects comprise 659 MW (69%) of small hydro and 295 MW (31%) of low power potential. The 954 MW of "new" feasible hydropower, combined with current hydropower output of 198 MW, leads to a total of 1,152 MW and an energy equivalency of 34 trillion Btu annually. (The preceding figures assume 100% capacity and 100% availability.)

Biomass

According to a 2005 report by the US Department of Energy's National Renewable Energy Laboratory, the Commonwealth's biomass resource comprises:

- agricultural residues:
  - crop residues, such as corn stover
  - methane emissions from manure management
- wood residues:
  - forest residues: logging slash and salvable dead wood
  - primary wood mill residues: bark and wood chunks and slabs
  - secondary wood mill residues: wood scraps and sawdust from woodworking industries
  - urban wood residues: yard waste, pallets, wood chips, and construction/demolition wood
- municipal discards:
  - methane emissions from landfills
  - methane emissions from domestic wastewater treatment
- dedicated energy crops, such as switchgrass, on:
  - Conservation Reserve Program lands
  - abandoned mine lands

Pennsylvania's total available biomass equals 6,569,000 tons per year. With an average energy content of 7,950 Btu/lb according to the US Department of Energy's Oak Ridge National Laboratory, this resource could yield 104 trillion Btu annually.

Wind

The US Department of Energy determined Pennsylvania's wind energy resource to be consistent with utility-scale production, with "good-to-excellent wind resource areas … concentrated on ridge crests in the southwestern part of Pennsylvania, located southwest of Altoona and southeast of Pittsburgh." The National Renewable Energy Laboratory conveys Pennsylvania's total onshore wind resource is 17,067 million kWh per year, which yields an

equivalent energy content of 58 trillion Btu. Upon application of land use and environmental exclusions, the resource decreases more than six-fold to 2,563 million kWh annually, for an equivalent energy content of 8.7 trillion Btu.

In 2005 and according to the Energy Information Administration, total net generation from wind equaled approximately 284 million kWh in Pennsylvania, for an equivalent energy content of roughly 1 trillion Btu. The 2005 figure is 1.665% of the unconstrained onshore resource and 11.090% of the constrained resource.

Waste Tires

In a recently released report, the Joint State Government Commission presents a summary of waste tire sites in the Commonwealth, as determined by the Department of Environmental Protection. The Department identified 202 sites with a combined total of 9,195,475 tires. Given the energy content of a tire is approximately 15,000 Btu/lb according to the Connecticut Department of Environmental Protection and the average weight of a tire is 20 pounds according to the referenced report, the potential yield of this alternative energy resource is nearly 2.8 trillion Btu.

In addition, the US Environmental Protection Agency claims waste tires are generated at the rate of one per person per year. Therefore, the renewable waste tire resource in the Commonwealth, if used exclusively for energy production, would be approximately 12,400,000 tires annually, with an energy yield of 3.7 trillion Btu.

Usage Scenario for Alternative Energy Resources

To estimate the impact of broadening Pennsylvania's energy mix to include expanded use of alternative energy sources, the identified resources were utilized in an attempt to comport with the goal of the Alternative Energy Portfolio Standards Act (AEPS, Act 213 of 2004), which is for the Commonwealth to obtain 18% of its electrical energy from alternative sources. In the present study, this percentage was applied holistically to total energy consumption, which includes electricity plus components such as transportation and heating.

Table 2. Usage Scenario for Alternative Energy Resources in PA[1]

Resource	Estimated Amount to Be Utilized Annually (trillion Btu)	% of 2003 Total Energy Consumption[2]
demand side management	244	6.100%
waste coal	219	5.468%
municipal solid waste	109	2.713%
biomass	104	2.610%
hydropower	34	0.850%
wind	9	0.225%
coalbed methane	6	0.143%
waste tires[3]	2	0.053%
solar photovoltaics	1	0.022%
Total	727	18.183%

[1]assumes deployment with economic, environmental, or technical constraints
[2]4,000 trillion Btu

Table 2 reveals the output from non-combustion-based energy generation sources, namely, 100% of hydropower, 100% of wind, and solar photovoltaics generating electricity in Pennsylvania at the same percentage of total energy consumption as California – which is currently technically impossible – would achieve only 1.097% of total energy consumption.

More positively, combustion-based energy generation sources, namely, waste coal and coalbed methane each at triple current production, municipal solid waste at 50% of the stream, 100% of biomass, and waste tires (50% of scrap tires from waste stream and 10% of tires from existing piles) could yield 10.986% of total energy consumption.

Most positively, Demand Side Management has the greatest potential to enable the Commonwealth to reach the AEPS goal of 18% of energy "production" from alternative sources. As reported in Table 2, cutting current total energy use by 6.1% (other states are attempting to cut use by as much as 20%), combined with the contributions detailed in the two preceding paragraphs, would permit Pennsylvania to reach its AEPS goal. Significantly, if a 20% reduction in total energy consumption could be attained via demand side management, and the other resources could be exploited at the specified levels, alternative energy sources could meet 30% of total energy consumption.

Regardless of the scheme for harnessing alternative and renewable energy resources in the Commonwealth, Demand Side Management will certainly play a central role and, as mentioned previously, energy efficiency is the foundation of Demand Side Management.

The National Action Plan for Energy Efficiency, published in July 2006, maintains well-designed energy efficiency programs:

- provide opportunities for customers to adopt measures that can improve their comfort and level of service, while reducing their energy bills;
- save energy at an average cost of about 50% of the cost of new power sources and about 33% of the cost of natural gas supply;
- deliver annual energy savings of about 1% of electricity and natural gas sales;
- offer environmental benefits, such as reduced air pollution and lower water use;
- develop the economy by redirecting energy savings, creating jobs, and improving infrastructure; and
- improve national security and supply system reliability by reducing *per capita* energy consumption.

To advance energy efficiency, the Action Plan offers the following recommendations:

- recognize energy efficiency as a high-priority energy resource;
- make a strong, long-term commitment to implement cost-effective energy efficiency as a resource;
- communicate widely the benefits of and opportunities for energy efficiency;
- promote sufficient, timely, and stable program funding to deliver energy efficiency where cost-effective;
- modify policies to align utility incentives with delivery of cost-effective energy efficiency; and
- modify ratemaking practices to promote energy efficiency investments.

In conclusion, prudent energy policy for Pennsylvania must focus on energy efficiency because:

- one percentage point of demand side reduction would amount to 40 trillion Btu, which would approach the output – 44 trillion Btu – of non-combustion alternative energy generation sources under very ambitious assumptions regarding availability and capacity;
- 10 points of demand side reduction (400 trillion Btu) plus one point of non-combustion alternative energy generation (44 trillion Btu)would eliminate the need for combustion-based alternative energy generation sources, which would corporately yield 439 trillion Btu; and
- 11 points of demand side reduction would eclipse the output of combustion-based alternative energy generation sources.