American Tradition Institute

The Cost and Economic Impact of Delaware's Renewable Portfolio Standard

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Executive Summary

In 2005, Delaware enacted Renewable Portfolio Standard (RPS) legislation that requires utilities to sell 10 percent of retail electricity sales from renewable sources by 2019-2020. In 2010, the Legislature amended the law to mandate that Delaware utilities use at least 5 percent renewable sources in the generation of electricity in 2010-2011. The mandate will grow steadily until reaching to 25 percent in 2025-2026. While the law includes a cost containment provision, it is unlikely that the Public Service Commission will implement the provisions.

The American Tradition Institute and the Cesar Rodney Institute commissioned the Beacon Hill Institute (BHI) to apply its STAMP® (State Tax Analysis Modeling Program) to estimate the economic effects of the Delaware RPS mandate. To account for the wide range of estimates for the renewable electricity costs and capacity factors, BHI uses a Monte Carlo analysis. The Monte Carlo analysis allows us to determine —with 90 percent confidence interval— the cost of the Delaware state RPS accounting for different cost and capacity factor estimates for electricity-generating technologies from the academic literature. Major cost findings include:

- Consumers will pay $310 million more for electricity in 2026, within a range of $239 million and $381 million.
- Over the period of 2017 to 2026, residents will pay an additional $2.34 billion, within a range of $1.859 billion and $2.822 billion.
- Electricity prices will increase by 18.1 percent in 2026, within a range of 13.9 percent and 22.2 percent.

These increased energy prices will hurt Delaware's households and businesses and will impair the state economy. According to the study by 2026:

- Delaware will lose an expected 2,159 jobs, within a range of 1,664 jobs and 2,653 jobs;
- Annual wages will fall by $944 per worker, within a range of $728 per worker and $1,160 per worker.
- Real disposable income will fall by $291 million, within a range of $224 million and $357 million.
- Net investment will fall by $49 million, within a range of $38 million and $60 million.
- Families will pay $269 per year and commercial businesses on average $2,108 per year in higher electricity costs in CY 2026.
- From 2017 to 2026, the average household ratepayer will pay $2,216 in higher electricity costs and the average commercial ratepayer will pay an extra $17,369.

Introduction

In 2005, with the passage of Senate Bill 74, Delaware enacted a Renewable Portfolio Standard (RPS) for the first time, which required that 10 percent of electricity sold in the state by 2020 derive from an Eligible Energy Resource (EER). [1] In 2007, state lawmakers passed Senate Bill 19, which increased the 2020 mandate to 20 percent and added a solar carve-out requiring solar generated electricity to provide 2.005 percent of all electricity sold in Delaware.[2] The RPS law charges the Public Service Commission (PSC) and the State Energy Coordinator (SEC) with implementing the RPS.

The PSC is charged with certifying all EERs and, once designated, an EER owner will be entitled to one renewable energy credit (REC) or solar renewable energy credit (SREC) for each megawatt hour of energy produced. Electricity suppliers must obtain a sufficient number of RECs and SRECs to comply with the RPS. If suppliers are unable obtain enough RECs or SRECs to comply with the RPS, they must pay Alternative Compliance Payments (ACP) or Solar Alternative compliance Payments (SACP) into the Delaware Green Energy Fund.

The ACP begins at $25 per MWh of shortfall and increases in subsequent years. For suppliers that paid the ACP in a previous year, the ACP increases to $50 per MWh, and the ACP increases to $80 per MWh in the third year in which it is used by a supplier. The SACP is $400 per MWh for the first use, $450 per MWh for the second use and $500 per MWh for any uses in subsequent years. The State Energy Coordinator has the authority to review and adjust the ACP and solar ACP given certain market conditions.[3]

The law allows electricity suppliers to recover "actual dollar for dollar costs incurred in complying with the State of Delaware's RPS" through a surcharge on the supply portion of the ratepayer's electricity bill. The total cost of compliance shall include the costs associated with

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[1] *An Act to Amend Title 26 of the Delaware Code Relating to Renewable Energy Portfolio Standards*. Senate Bill 74, 143rd General Assembly, http://depsc.delaware.gov/electric/rpsact.pdf (accessed April 15, 2011).

[2] *An Act to Amend the Delaware Code to Increase the Renewable Energy Portfolio Standard,* Senate Bill 19, 144th General Assembly, http://legis.delaware.gov/LIS/lis144.nsf/vwLegislation/SB+19/$file/legis.html?open (accessed April 15, 2011).

[3] Title 26, Public Utilities, Renewable Energy Portfolio Standards 75 Del. Laws, c. 205, § 1, (D, 1-4 and E,1-3) http://delcode.delaware.gov/title26/c001/sc03a/index.shtml#358 (accessed April 2011).

any ratepayer funded state renewable energy rebate program, REC and SREC purchases, and ACPs and SACPs.[4]

Enacted in July 2010, Senate Substitution 1 for Senate Bill 119 amended the Delaware RPS to require that 25 percent of all electricity sold in compliance year (CY) 2026 derive from renewable sources, including solar, wind, offshore wind, ocean energy, fuel cells, biomass, geothermal and hydroelectric.[5] Additionally, the bill increased the annual step-ups to meet this goal and expanded the solar mandate to 3.5 percent of energy production by CY 2026. The law contains several provisions that allow renewable projects located in Delaware to receive larger credits, up to 350 percent, toward satisfying the RPS mandate. [6]

Senate Substitution 1 established the Delaware Renewable Energy Task Force to recommend methods of establishing renewable energy trading mechanisms and other structures to support the growth of renewable energy in Delaware. To this end, the task force established a pilot program for trading SRECs using a structure with four tiers based on the output of the facility. Tiers 3 and 4 cover facilities with over 500 KWs of headline capacity, account for 68 percent of the total SRECs and trade at market prices. Tier 2 would cover facilities with a capacity between 50 kWs and 500 kWs and Tier 1 would cover facilities with a capacity of less than 50 kWs.[7] The Task Force "utilizes administratively set pricing" and twenty-year contracts for Tiers 1 and 2. The Task force assigns prices of $270 per MWh and $250 per MWh respectively for the first ten year period and $50 per MWh both Tier 1 and Tier 2 for the second ten-year period.[8]

The SREC administrative price of $50 for the second ten-year period is well below the likely market price for that period. Even if we assume that solar-power enjoys efficiency gains of

[4] Delaware Public Service Commission, "Rules and Procedures to implement The Renewable Energy Portfolio Standard," paragraph 4.1, (February 22, 2010) http://depsc.delaware.gov/electric/rpsrules_fin022211.pdf (accessed April, 2011), paragraph 4.1, 10.

[5] The compliance year runs from June to May, thus CY 2026 ends on May 31, 2026.

[6] *An Act to Amend Title 26 of the Delaware Code Relating to the Renewable Energy Portfolio Standards. 145th General Assembly*, Senate Substitute No. 1, http://www.legis.delaware.gov/LIS/lis145.nsf/vwLegislation/SS+1+for+SB+119/$file/legis.html?open. (accessed April, 2011).

[7] Synopsys of the Delaware 1 year SREC Pilot Procurement Program, http://www.dnrec.delaware.gov/energy/information/Pages/RenewableEnergyTaskForce.aspx (accessed April 2011). The document shows Tier 1 to be less than 500 kWs, but this must be a typo.

[8] Ibid.

3.5% per year, compounded over 20 years, the Tier 1 price of $270 would be $137 at the end of the period.[9] Therefore, in our analysis of the solar mandate, we assume that the administrative prices for tiers 1 and 2 will continue for the entire 20 year period.

The law applies to all utilities, including investor-owned, municipal and rural cooperatives. Initially municipal utilities and rural electric cooperatives were allowed to opt out of the RPS requirements if they established a voluntary green power program and created a green energy fund. However, the 2010 amendment replaced the exemption option by allowing municipal utilities and rural cooperatives to develop and implement a comparable RPS by 2013.[10] Therefore, we assume the municipal utilities and rural cooperatives must meet the same mandates as outlined in the RPS.

One utility, Delmarva Power, has responded to the RPS by agreeing to purchase offshore wind power from Bluewater Wind Delaware beginning in 2016. The 2010 Integrated Resource Plan for Delmarva Power shows that 288 GWh of offshore wind power will be purchased in 2016, increasing to 558 GWh in 2017 at a cost of $0.142 per kWh.[11] The production holds constant at 558 GWh over time, while the price will increase by 2.5 percent annually. We assume that this contract would not take place in the absence of the RPS and we use the contract to provide cost and generation for a portion of the RPS. This is explained in detail in the appendix.

The RPS specifically exempts industrial customers with a peak load of more than 1,500 kilowatts (kW). Industrial customers with multiple accounts totaling in excess of 1,500 kilowatts, the aggregate of their accounts with an NAICS Manufacturing Sector Code must have a Peak Demand of at least 751 kilowatts.[12] In light of this provision, we eliminate electricity sales to Delaware's industrial sector, about one-third of the total, from our analysis.

The law also includes cost containment provisions. In CY 2010 and thereafter, the PSC may review the status of RPS schedule and report to the legislature on the pace of the scheduled

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[9] Ryan Riser, Galen Barbose, Carla Peterman, "Tracking the Sun: The Installed Cost of Photovoltaics in the US from 1998 to 2007,"Lawrence Berkeley National Laboratory, (February 2009) http://eetd.lbl.gov/ea/ems/reports/lbnl-1516e.pdf, accessed (October 2010).

[10] Delaware Public Service Commission, "Rules and Procedures to implement The Renewable Energy Portfolio Standard," February 22, 2010, http://depsc.delaware.gov/electric/rpsrules_fin022211.pdf (accessed April, 2011), paragraph 2.4, 4.

[11] Delmarva Power & Light Company 2010 Integrated Resource Plan. December 1, 2010. http://www.delmarva.com/_res/documents/PUBLIC%20DE%20IRP%20FILING.pdf (accessed April, 2011).

[12] Ibid, 2.2.2, 4.

percentage increases toward the goal of 25%. If the Commission reports that "the schedule either needs to be accelerated or decelerated, it may make recommendations to the General Assembly for legislative changes to the RPS."[13]

Beginning in CY 2014, the PSC may slow the scheduled percentage increases towards meeting the RPs goal if certain conditions apply. First, if the PSC finds that if alternative compliance payments (ACP) or solar alternative compliance payments (SACP) comprise 30% or more of the total RPS compliance for three consecutive years. The PSC must also deem that "Retail Electricity Suppliers" have made adequate plans to comply with the RPS.[14]

The PSC may freeze the percentages from eligible energy resources and solar energy resources for regulated electric utilities if the Delaware Energy Office determines that the cost of complying with the RPS exceeds 1 percent and 3 percent of the total retail cost for solar energy resources and renewable energy resources respectively. Once frozen, the minimum cumulative requirements shall remain at the percentage for the compliance year in which the freeze was instituted.[15] The PSC may lift the freeze if the State Energy Coordinator finds that the total cost of compliance can reasonably be expected to be under the 1% or 3% threshold, as applicable.

The legislation does not provide for an automatic trigger to the cost containment provisions. Rather the law grants the PSC the discretion to decide if and when the cost containment provisions should be implemented. However, the law does mandate automatic percentage increases to the RPS schedule, which remains the central goal of the law. Moreover, the law allows electricity prices to rise by an aggregate of 34 percent, on an annual compound basis over the first ten years, against the baseline of no RPS mandate and 56 percent by CY 2026. Therefore, we believe that it is unlikely that the PSC will choose to implement the cost containment provisions, even if the cost thresholds are breached.

Most renewable electricity sources are more costly and unreliable than conventional energy sources such as coal and natural gas, so stand little chance of commercial success in a competitive market. This cost and reliability difference between conventional and renewable

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[13] Ibid, 3.2.14, 8.
[14] Ibid, 3.2.15, 8.
[15] Senate Substitute 1.

energy is likely to persist in the coming decades. In response, producers of renewable energy seek to guarantee a market through legislation similar to the Delaware RPS. But what the market offers in terms of renewable energy will always be limited. This "market" of joining a willing producer with a hesitant buyer does not overcome the limits inherent in renewable energy, namely its just-in-time reliability. In order to keep the electricity grid in equilibrium, intermittent resources such as wind and solar power need reliable back-up sources. If the wind dies down, or blows too hard (which trips a shutdown mechanism in commercial windmills), another power source must be ramped up instantly.

Not unlike taxes, artificially higher electricity prices produce negative effects on economic activity, since one is paying a higher price for electricity without an increase in the value of that electricity. Prosperity and economic growth are dependent upon access to reliable and competitively-priced energy. Consumers in Delaware will have limited opportunity to avoid these costs. For low income consumers, these higher electricity prices will force difficult choices between energy and other necessities such as food, clothing and shelter.

In this report, the American Tradition Institute and the Caesar Rodney Institute commissioned the Beacon Hill Institute (BHI) to estimate the costs of the RPS mandate and the economic impact of the legislation on the state economy. To that end, BHI applied its STAMP® models (State Tax Analysis Modeling Program) to estimate the economic effects of the state RPS mandate.

Results

A variety of cost estimates for renewable electricity sources are available. The U.S. Energy Information Administration (EIA), a division of the Department of Energy, provides estimates for the cost of conventional and renewable electricity generating technologies. A literature review shows that in most cases the EIA's projected costs can be found at the low end of the range of estimates, while the EIA's capacity factor for wind to be at the high end of the range.[16] The EIA appears to overlook the actual experience of existing renewable electricity power plants.

[16] The capacity factor measures the ratio of electrical energy produced by a generating unit over a period of time to the electrical energy that could have been produced at 100 percent operation during the same period.

In light of the wide divergence in the costs and capacity factor estimates available for electricity generation technologies, we utilize a Monte Carlo analysis to provide an estimated mean cost and a 90 percent confidence interval of the Delaware RPS mandate. We control for possible future variations in energy costs and technological improvements by allowing the cost per megawatt hour to vary within a normal distribution, based on the average of many cost estimates. Our estimates represent the change that will take place in the indicated variable against the assumption that the RPS mandate would not be implemented. The Appendix contains details of our methodology.

The RPS mandates that by Compliance Year (CY) 2010, 5 percent of energy sold in Delaware originate from renewable sources. The requirement increases to 7 percent in CY 2012, then by 1.5 percent each year until reaching 19 percent in CY 2020, and continues at a 1 percent increase each year until 25 percent of electricity is required to come from a renewable source in CY 2026. The solar carve-out starts at 0.018 percent in CY 2011, increasing to 0.2 percent in CY 2012, then an additional 0.2 percent each year until reaching 1 percent in CY 2016. The solar carve-out then increases by 0.25 percent each year, reaching 3.5 percent in CY 2026.[17]

As shown in Table 1, the RPS will impose costs of $310 million in CY 2026, within a 90 percent confidence interval of $239 million and $381 million. For the period of CY 2017 – 2026 the RPS mandate will cost $2.34 billion with a 90 percent confidence interval of $1.859 billion and $2.822 billion. As a result, the RPS mandate will increase electricity prices by 2.06 cents per kilowatt hour (kWh) or 18.1 percent, within a range of 1.59 cents per kWh, or 13.9 percent and 2.53 cents per kWh, or 22.2 percent.[18]

The RPS law will reduce economic output in Delaware. Delaware's ratepayers will face higher electricity prices which will increase the cost of living and doing business in the state. By CY 2026, Delaware will employ 2,160 fewer workers than without the RPS policy, within a 90 percent confidence interval of 1,660 and 2,650 workers.

[17] Senate Substitute No. 1. http://www.legis.delaware.gov/LIS/lis145.nsf/vwLegislation/SS+1+for+SB+119/$file/legis.html?open.

[18] We converted the aggregate cost of the RPS into a cost per-kWh by dividing the cost by the estimated total number of kWh sold for that year.

Table 1: The Cost of the RPS Mandate on Delaware (2010 $)

Costs Estimates	Expected	90% Confidence
Total Net Cost in 2026 ($ m)	310	239 - 381
Total Net Cost 2017-2026 ($ m)	2,340	1,859 - 2,822
Electricity Price Increase in 2026 (cents per kWh)	2.06	1.59 - 2.53
Percentage Increase	18.1%	13.9% - 22.2%
Economic Indicators		
Total Employment (jobs)	(2,160)	(1,660) - (2,650)
Gross Wage Rates ($ per Worker)	(944)	(728) - (1,160)
Investment ($ m)	(49)	(38) - (60)
Real Disposable Income ($ m)	(291)	(224) - (357)

The decrease in labor demand — as seen in the job losses — will cause gross wages to fall. In 2026, the Delaware RPS will reduce annual wages by $944 per worker, within a range of $728 and $1,160 per worker. The job losses and price increases will decrease real incomes as firms, households and governments are forced to allocate more resources to purchase electricity and less to purchase other items. In 2026, annual real disposable income will fall by $291 million, within a range of $224 million and $357 million.

Net investment will fall by $49 million, within a range of $38 million and $60 million. The relatively moderate investment losses will be offset by the investments required to build renewable power plants, transmission lines and reconfigurations to the electricity grid. However, these investments are not as productive as the ones based on conventional energy because the renewable mandate works its way through the production methods less efficiently. A good analogy would be applying a mandate to telecommunications.

The RPS is akin to requiring that 25 percent of all Internet Service Providers offer services that are comprised of dial-up service over plain telephone service lines. Business would certainly be good for dial-up modem manufacturers and telecommunications engineers whom Internet Service Providers would depend upon to retrofit their networks; but this investment would not increase productivity in the economy.

Table 2 displays how the RPS will affect the annual electricity bills of households and businesses in Delaware. In 2026, the RPS will cost families on average $269 per year and commercial businesses on average of $2,108 per year. Between 2017 and 2026, the average household ratepayer will pay $2,216 in higher electricity costs and the average commercial ratepayer will spend an extra $17,369.

Table 2: Effects of the RPS on Electricity Ratepayers (2010 $)

	Expected	90% Confidence
Cost in 2026		
Residential Ratepayer ($)	269	207 - 331
Commercial Ratepayer ($)	2,108	1,625 - 2,591
Total over period (2017-2026)		
Residential Ratepayer ($)	2,216	1,761 - 2,671
Commercial Ratepayer ($)	17,369	13,804 - 20,933

One could justify the higher electricity costs if the environmental benefits, in terms of reduced GHG emissions, outweighed the costs. But it is unclear that the use of renewable energy resources, especially wind and solar, significantly reduces GHG emissions. Due to their intermittency, wind and solar require significant backup power sources that are cycled up and down to accommodate the variability in their production. As a result, a recent study found that wind power could actually increases pollution and greenhouse gas emissions in areas that generate a significant portion of their electricity from coal.[19]

Moreover, the 2010 State of the Market Report for PJM, the regional grid operator for the mid Atlantic area including Delaware, coal comprised 68 percent of the marginal electricity generation. Thus the case for the heavy use of wind to generate "cleaner" electricity is undermined.

[19] See "How Less Became More: Wind, Power and Unintended Consequences in the Colorado Energy Market," Bentek Energy, LLC. (Evergreen Colorado: May, 2010).

Conclusion

The rush to renewable energy found in RPS mandates in states across the nation is flawed. The policy promotes certain forms of renewable energy — costly ones — at the expense of other, more affordable and dependable sources. The Delaware law is no different. On the surface, the cost containment provisions in the Delaware law appear to protect the state's electricity ratepayers. However, the provisions allow prices to rise significantly over the next 15 years and are only triggered at the discretion of the PSC. The RPS will result in higher utility prices, which will lead employment losses, diminished investment and lower incomes.

The solar carve out, requiring that solar photovoltaic generate more than 3 percent of electricity sold in Delaware, show the policy in its true light. If the RPS policy was truly about clean energy at the lowest cost, why does it require specific renewable energy sources? With the RPS policy in place, utilities would choose the most cost-efficient renewable energy sources, although more costly than conventional sources such as natural gas.

Senate Bill 74 cited several benefits of electricity from renewable energy sources, including "new economic development opportunities." Unfortunately, the policy fails to meet these expectations as the economic losses from higher electricity costs will outweigh any economic gains from the development of renewable energy in Delaware.

The Delaware RPS policy puts the state's competitiveness at risk. Higher electricity prices will result in slower economic growth for Delaware and a competitive disadvantage with respect to other states. Policymakers should pay careful attention to the real danger posed by higher electricity prices and repeal the mandate before costs begin to soar.

Appendix

Electricity Generation Costs

As noted above, governments enact RPS policies because most sources of renewable electricity generation are less efficient and less reliable and thus more costly than conventional sources of generation. The RPS policy forces utilities to buy electricity from renewable sources and thus guarantees a market for the renewable source. These higher costs get passed on to electricity consumers including residential, commercial and industrial customers.

The U.S. Department of Energy's Energy Information Administration (EIA) estimates the Levelized Energy Cost (LEC), or financial breakeven cost per MWh to produce new electricity in its *Annual Energy Outlook*.[20] The EIA provides LEC estimates for conventional and renewable electricity technologies (coal, nuclear geothermal, landfill gas, solar photovoltaic, wind and biomass) assuming the new sources enter service in 2016. The EIA also provides LEC estimates for conventional coal, combined cycle gas, advanced nuclear and onshore wind only, assuming the sources enter service in 2020 and 2035.

While the EIA does not provide LEC for hydroelectric, solar photovoltaic and biomass for 2020 and 2035, it does project overnight capital costs for 2015 and 2025. We can estimate the LEC for these technologies and years using the percent change in capital costs to inflate the 2016 LECs. In its *Annual Energy Outlook*, the EIA incorporates many assumptions about the future price of capital, materials, fossil fuels, maintenance and capacity factor into their forecast. Table 3 shows over time the EIA projects that the LEC for all four electricity sources (coal, gas, nuclear and wind) fall significantly from 2016 to 2025. The fall in capital costs drives the drop in total system LEC over the period.

The building of vast wind power plants will require large quantities of raw materials, particularly aluminum and other commodities. The rising demand for these commodities – from the construction of renewable energy plants and from fast growing emerging market economies – will certainly increase their prices and therefore costs for wind power plants.

[20] U.S. Department of Energy, Energy Information Administration, *2016 Levelized Cost of New Generation Resources from the Annual Energy Outlook 2010* (2009/$MWh) http://www.eia.doe.gov/oiaf/aeo/electricity_generation.html (accessed January 2011).

Aluminum prices have doubled over the past two years as the world economy emerges from the recession.[21] As a result, capital and other costs are more likely to rise than fall over the next two decades.

Table 3 : Levelized Cost of Electricity from Conventional and Renewable Sources (2009 $)

Plant Type	Capacity Factor	Levelized Capital Costs	Fixed O&M	Variable O&M (with fuel)	Transmission Investment	Total Levelized Cost
Advanced Coal - 2016	0.850	65.3	3.9	24.3	1.2	94.7
2020		68.6	4.1	25.5	1.3	99.5
2025		62.4	3.7	23.2	1.1	90.5
Gas - 2016	0.870	17.5	1.9	45.6	1.2	66.2
2020		16.9	1.8	44.1	1.2	64.0
2025		16.5	1.8	43.1	1.1	62.5
Nuclear -2016	0.900	90.1	11.1	11.7	1.0	113.9
2020		84.4	10.4	11.0	0.9	106.7
2025		70.6	8.7	9.2	0.8	89.2
Wind - 2016	0.344	83.9	9.6	0.0	3.5	97.0
2020		78.6	9.0	0.0	3.3	90.9
2025		73.3	8.4	0.0	3.1	84.8
Solar PV - 2016	0.217	194.6	21.1	0.0	4	219.7
2025						192.4
2025						165.1
Biomass -2016	0.830	55.3	13.7	42.3	1.3	112.6
2025						88.2
2025						63.7

Table 3 also displays capacity factors for each technology. The capacity factor measures the ratio of electrical energy produced by a generating unit over a period of time to the electrical energy that could have been produced at 100 percent operation during the same period. In this case, the capacity factor measures the potential productivity of the generating technology. Solar, wind and hydroelectricity have the lowest capacity factors due to the intermittent nature of their power sources. EIA projects a 34.4 percent capacity factor for wind power, which, as we will see below, appears to be at the high end of any range of estimates.

[21] MetalPrices.com, "LME Aluminum Price Charts," http://www.metalprices.com/FreeSite/metals/al/al.asp#MoreCharts (accessed April 15, 2011).

Estimating a capacity factor for wind power is particularly challenging. Wind is not only intermittent but its variation is unpredictable, making it impossible to dispatch to the grid with any certainty. This unique feature of wind power argues for a capacity factor rating of close to zero. Nevertheless, wind capacity factors have been estimated to be between 20 percent and 40 percent.[22] The other variables that affect the capacity factor of wind are the quality and consistency of the wind and the size and technology of the wind turbines deployed. As the U.S. and other countries add more wind power over time, presumably the wind turbine technology will improve, but the new locations for wind power plants will likely have diminishing or less productive wind resources.

The EIA estimates of LEC and capacity factors paint a particularly rosy view of the future cost of renewable electricity generation, particularly wind. Other forecasters and the experience of current renewable energy projects portray a less sanguine outlook.

Today wind and biomass are the largest renewable power sources and are the most likely to satisfy future RPS mandates. The most prominent issues that will affect the future availability and cost of renewable electricity resources are diminishing marginal returns and competition for scarce resources. These issues will affect wind and biomass in different ways as state RPS mandates ratchet up over the next decade.

Both wind and biomass resources face land use issues. Conventional energy plants can be built within a space of several acres and located close to large population centers with high electricity demand. However, a wind power plant with the same nameplate capacity (not actual capacity) would require many square miles of land. According to one study, wind power would require 7,579 miles of mountain ridgeline to satisfy current state RPS mandates and a 20 percent federal mandate by 2025.[23] Mountain ridgelines produce the most promising locations for electric wind production in the eastern and far western United States.

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[22] Renewable Energy Research Laboratory, University of Massachusetts at Amherst, "Wind Power, Capacity Factor and Intermittency: What Happens When the Wind Doesn't Blow?" Community Wind Power Fact Sheet #2a, http://www.ceere.org/rerl/about_wind/RERL_Fact_Sheet_2a_Capacity_Factor.pdf (accessed April 15, 2011).

[23] Tom Hewson and Dave Pressman, "Renewable Overload: Waxman-Markey RES Creates Land-use Dilemmas," *Public Utilities Fortnightly* 61 (August 1, 2009).

After taking into account capacity factors, a wind power plant would need a land mass of approximately 12 by 16 miles to produce the same energy as a nuclear power plant that can be situated on 600 square yards.[24]

The need for large areas of land for situating wind power plants will require the purchase of vast areas of land by private wind developers and/or allowing wind production on public lands. In either case, land acquisition/rent or public permitting processes will likely increase costs as wind power plants are built. Offshore wind is vastly more expensive than onshore wind power and suffers from the same type of permitting process faced by onshore wind power plants, as seen in the 10-year permitting process for the planned Cape Wind project off the coast of Massachusetts.

The swift expansion of wind power will also suffer from diminishing marginal returns as new wind capacity will be located in areas with lower and less consistent wind speeds. As a result, fewer megawatt hours of power will be produced from newly-built windmills. Moreover, the new wind capacity will be developed in increasing remote areas that will require larger investments in transmission and distribution, which will drive costs even higher.

The EIA estimates of the average capacity factor used for onshore wind power plants, at 34.4 percent, appears to be at the higher end of the estimates for current wind projects. This figure is inconsistent with estimates from other studies.[25] According to the EIA's own reporting from 137 current wind power plants in 2003, the average capacity factor was 26.9 percent.[26] In addition, a recent analysis of wind capacity factors around the world finds an actual average capacity factor of 21 percent.[27] Moreover, other estimates find capacity factors in the mid teens and as low as 13 percent.[28]

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[24] "Evidence to the House of Lords Economic Affairs Committee Inquiry into 'The Economics of Renewable Energy'," Memorandum by Dr. Phillip Bratby, May 15, 2008.

[25] Nicolas Boccard, "Capacity Factors for Wind Power: Realized Values vs. Estimates," *Energy Policy* 37, no. 7 (July 2009): 2680.

[26] Cited by Tom Hewson, Energy Venture Analysis, "Testimony for East Haven Windfarm," January 1, 2005, http://www.windaction.org/documents/720 (accessed December 2010).

[27] Boccard.

[28] See "The Capacity Factor of Wind, Lightbucket," http://lightbucket.wordpress.com/2008/03/13/the-capacity-factor-of-wind-power/, (accessed December 22, 2010) and National Wind Watch, FAQ, http://www.wind-watch.org/faq-output.php (accessed December 2010).

Biomass is a more promising renewable power source. Biomass combines low incremental costs relative to other renewable technologies and reliability. Biomass is not intermittent and therefore it can be dispatched with a capacity factor that is competitive with conventional energy sources. Moreover biomass plants can be located close to urban areas with high electricity demand. But biomass electricity suffers from land use issues even more so than wind.

The expansion of biomass power plants will require huge additional sources of fuel. Wood and wood waste comprise the largest source of biomass energy today. Other sources of biomass include food crops, grassy and woody plants, residues from agriculture or forestry, oil-rich algae, and the organic component of municipal and industrial wastes.[29] Biomass power plants will compete directly with other sectors (construction, paper, furniture) of the economy for wood and food products and arable land.

One study estimates that 66 million acres of land would be required to provide enough fuel to satisfy the current state RPS mandates and a 20 percent federal RPS in 2025.[30] When the clearing of new farm and forestlands are figured into the GHG production of biomass, it is likely that biomass increases GHG emissions.

The competition for farm and forestry resources would not only cause biomass fuel prices to skyrocket, but also cause the prices of domestically-produced food, lumber, furniture and other products to rise. The recent experience of ethanol and its role in surging corn prices can be casually linked to the recent food riots in Mexico and the surge in hunger in the Darfur region of Sudan. These two examples serve as reminders of the unintended consequences of government mandates for biofuels. The lesson is clear: biofuels compete with food production and distort the market.

Calculation of the Net Cost of New Renewable Electricity

To calculate the cost of renewable energy under the RPS, BHI used EIA data to determine the percent increase in utility costs that Delaware residents and businesses would experience.

[29] Biomass Energy Basics, National Renewable Energy Laboratory, Biomass Basics, http://www.nrel.gov/learning/re_biomass.html (accessed December, 2010).
[30] Hewson, 61.

This calculated percent change was then applied to calculated elasticities, as described in the STAMP modeling section.

We utilized the EIA "reference case Electric Power Projections for EMM Region, Reliability First Corporation / East" for retail electricity sales and prices by sector from 2008 to 2035.[31] To these totals, we applied the percentage of renewable sales prescribed by the Delaware RPS. By CY 2026, renewable energy sources must account for 25 percent of total electricity sales in Delaware.

Next we projected the growth in renewable sources that would have taken place absent the RPS. We used the EIA's projection of renewable energy sources by fuel for the Reliability First Corporation/East through 2035 as a proxy to grow renewable sources for Delaware. We used the growth rate of these projections to estimate Delaware's renewable generation through CY 2026 absent the RPS.[32]

Table 4: Projected Electricity Sales, Eligible Renewables and RPS Requirement

Year	Projected Electricity Sales MWhs (000s)	Eligible Renewable MWhs (000s)	RPS Requirement MWhs (000s)	Difference MWhs (000s)
2016	11,303	163	1,639	1,476
2017	11,668	163	1,867	1,704
2018	12,045	163	2,108	1,945
2019	12,435	163	2,363	2,200
2020	12,837	163	2,567	2,404
2021	13,253	163	2,783	2,620
2022	13,682	163	3,010	2,847
2023	14,125	163	3,249	3,086
2024	14,582	163	3,500	3,337
2025	15,055	163	3,764	3,601
Total	**130,985**	**1,630**	**26,849**	**25,219**

[31] U.S. Department of Energy, Energy Information Administration, *Annual Energy Outlook 2011*, "Table 81: Electric Power Projections for EMM Region/Reliability First Corp./ East, 2008 through 2035," http://www.eia.doe.gov/forecasts/aeo/tables_ref.cfm (accessed April 2011).
[32] U.S. Department of Energy, Energy Information Administration, *Annual Energy Outlook 2011*, "Table 92: Renewable Electricity Generation by Fuel," http://www.eia.gov/oiaf/aeo/tablebrowser/#release=AEO2011&subject=0-AEO2011&table=67-AEO2011&region=3-0&cases=ref2011-d120810c (accessed April 15, 2011).

Before making the projections about which renewable resources would be used to meet the Delaware RPS, we allocated part of the new renewable to be met with Delmarva Power's offshore wind purchases. According to the companies 2010 Integrated Resource Plan, Delmarva would purchase 288 GWh of electricity in 2016, increasing to 558 GWh for 2017 onward.[33] This energy would cost $0.142 per KWh, with an automatic annual increase of 2.5 percent per year. Since this is already contracted, we included it in the RPS mix, accounted for the solar carve out, then distributed the rest of the new renewable according to the regions projected renewable growth, per the EIA.

We subtracted our baseline projection of renewable sales from the RPS-mandated quantity of sales for each year from CY 2017 to CY 2026 to obtain our estimate of the annual increase in renewable sales induced by the RPS in megawatt hours (MWhs). The RPS mandate exceeds our projected renewable in all projected CY (2017 to 2026). This figure also represents the maximum number of MWhs of electricity from conventional sources that are avoided, or not generated, through the RPS mandate. We will revisit this shortly. Table 4 above contains the results.

The Delaware RPS, in addition to its renewable requirements, also has a specific solar carve-out, with a four tier system. Tier 3 and 4 represent the larger solar power sources, and the Solar Renewable Energy Certificate (SREC) that they generate would be priced though competitive bidding. Tier 1 and 2 are smaller scale and their SRECs would be administratively priced.[34] The PSC projects 68.4 percent of SRECs will come from Tire 3 and 4 producers, so we used our market cost estimates to price out this share of solar power coming online between 2017 and 2026. For the 13.4 percent of SRECs coming from Tier 1, we priced them at $270, the administrative price set by the pilot program. We priced the Tier 2 utilities at $250, which represent the final 18.2 percent of the carve-out.[35]

We used the 2016 LEC for the years 2010 through 2018 to calculate the cost of the new renewable electricity and avoided conventional electricity, assuming that before 2016 LEC underestimates the actual costs for those years and for 2017 and 2018, the 2016 LEC slightly

[33] Delmarva Power & Light Company 2010 Integrated Resource Plan. December 1, 2010. http://www.delmarva.com/_res/documents/PUBLIC%20DE%20IRP%20FILING.pdf (accessed April, 2011).
[34] Synopsis of the Delaware 1 Year SREC Pilot Procurement Program. April 7, 2011.
[35] Ibid.

overestimates the actual costs. We assumed that the differences will, on balance, offset each other. For 2019 and 2020 we used the 2020 LEC. The assumption is that LEC will decline over time due to technological improvements over time.

We use the EIA's reference case scenario for all technologies. Since capital costs represent the large component of the cost structure for most technologies, we used the percentage change in the capital costs from 2016 to 2025 to adjust the 2016 LECs to 2025. For the technologies that the EIA does not forecast LECs in 2020, we used the average of the 2016 and 2025 LEC calculations, assuming a linear change over the period.

We completed the calculations both the EIA cost estimates and cost estimates from a third party, and used the average. We adjusted the EIA costs down by 3 percent for nonrenewable power sources, to offset the EIA's 3 percent increase in the capital cost of these electricity sources due to presumed future national legislation on emissions.[36] We do not believe that national regulations are likely. Table 5 displays the average and standard deviation of the LEC and capacity factors for each generation technology.

For conventional electricity we assumed that the technologies are avoided based on their costs, with the highest cost combustion turbine avoided first. For coal and gas, we assumed they are avoided based on their estimated proportion of total electric sales for each year. Although hydroelectric and nuclear are not the cheapest technology, we assume no hydroelectric or nuclear sources are displaced since most were built decades ago and offer relatively cheap and clean electricity today.

We also adjusted the avoided cost of conventional energy to account for the lower capacity factor of wind relative to conventional energy sources. We multiplied the cost of each conventional energy source by the difference between its capacity factor and the capacity factor for the renewable source and then by the ratio of the new generation of the renewable source to the total new generation of renewable under the RPS. For example, for coal, we multiplied the avoided amount generation of electricity from coal (2.93 million MWhs in CY 2026) by the LEC of coal ($79.39 per MWh) and then by one minus the difference between the capacity factor of coal and the weighted average (using MWs as weights) capacity factor of wind (27 percent). This process is repeated for each conventional electricity resource.

[36] Levelized Cost of New Generation Resources in the Annual Energy Outlook 2011 http://www.eia.doe.gov/oiaf/aeo/electricity_generation.html (accessed May 2, 2011).

Table 5: LEC and Capacity Factors for Electricity Generation Technologies

	Capacity Factor (percent)	Total Production Cost ($/MWh) 2010	2020	2025
Coal				
Average	79.5	79.637	80.671	75.647
St. Dev.		7.430	9.635	7.369
Gas				
Average	86	70.039	67.649	66.953
St. Dev.		3.541	3.403	3.826
Nuclear				
Average	90	93.711	81.358	67.937
St. Dev.		10.196	13.472	11.311
Biomass				
Average	75.5	111.559	94.531	80.092
St. Dev.		1.421	5.477	11.108
Wind				
Average	26.9	190.881	178.847	166.814
St. Dev.		58.839	55.130	51.421
Solar				
Average	19	213.109	186.614	160.119
St. Dev.		21.311	18.661	16.012

To estimate the cost of producing the additional extra renewable energy under an RPS against the baseline, we used estimates of the LEC, or financial breakeven cost per MWh to produce the electricity.[37] However, as outlined in the "electricity generation cost" section above, the EIA numbers provide a rather optimistic picture of the cost and generating capacity of renewable electricity, particularly for wind power. A literature review provided alternative LEC estimates that were generally higher and capacity factors that were lower for renewable generation technologies than the EIA estimates.[38]

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[37] U.S. Department of Energy, Energy Information Administration, *2016 Levelized Cost of New Generation Resources from the Annual Energy Outlook 2011* (2009/$MWh), http://www.eia.gov/oiaf/aeo/tablebrowser/#release=AEO2011&subject=0-AEO2011&table=67-AEO2011&region=3-0&cases=ref2011-d120810c (accessed April 15, 2011).

[38] For coal, gas and nuclear generation we used the production cost estimates from the International Energy Agencies, Energy Technology Analysis Programs, "Technology Brief E01: Coal Fired Power, E02: Gas Fired Power, E03: Nuclear Power and E05: Biomass for Heat and Power," (April 2010), http://www.etsap.org/E-techDS/

To account for both of these projections we utilized computer software, Crystal Ball, to perform a Monte Carlo analysis.[39] We varied the cost of energy per MWh, one of the independent variables in our calculations, according to a normal distribution, where the mean was equal to the average between the EIA estimates, and the higher, cost estimates. The standard deviation was set equal to the difference between this average and the EIA price (or the higher price, as both calculations are equal, since it was the average of the two) times 1.645. This calculation resulted in 90 percent of the prices that Crystal Ball randomly generated in the modeling to be between the EIA cost estimate and the second, higher, cost estimate. We completed this analysis for each energy generation type and for each year.

With these distributions in place, we set the percent change in electricity price as our dependant variable or the variable that would be tracked across trials. At this point, we set Crystal Ball to run 10,000 random trials. Each trial selected a value for each independent variable, such that the aforementioned statistical rules were followed. These costs per MWh are applied to the amount of electricity supplied from renewable sources under the RPS, because this figure represents the amount of conventional electricity generation capacity that presumably will not be needed under the RPS. The difference between the cost of the new renewable sources and the costs of the conventional electricity generation Delaware represents the net cost of the RPS. This net cost increase divided by total retail sales equals the total cost increase per MWh due to the RPS. Crystal Ball divided this result by the EIA estimated price of electricity for the region in that year, and recorded the percent change in energy costs as final result.

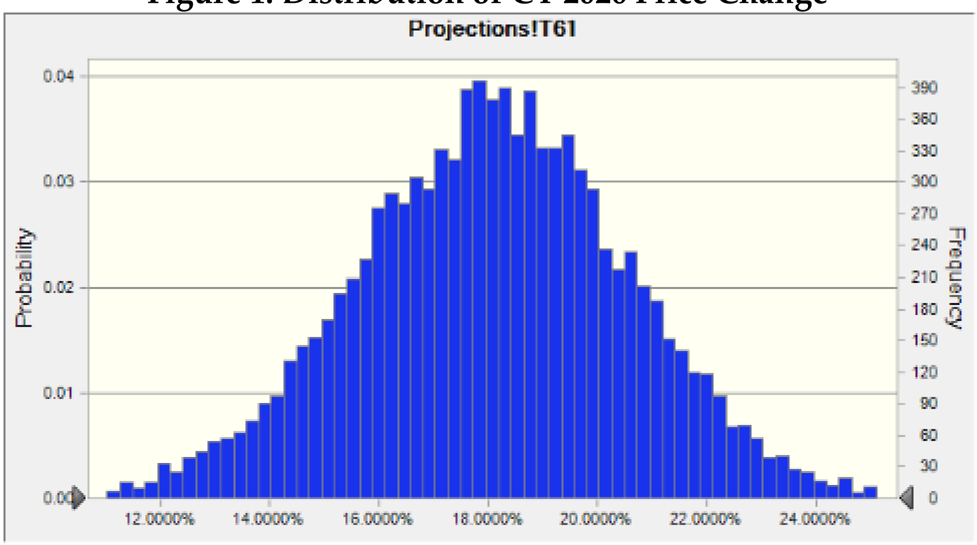
(accessed April 15, 2011). To the production costs we added transmission costs from the EIA using the ratio of transmissions costs to total LEC costs. For wind power we used the IEA estimate for levelized capital costs and variable and fixed O & M costs. For transmission cost we used the estimated costs from several research studies that ranged from a low of $7.88 per kWh to a high of $146.77 per kWh, with an average of $60.32 per MWh. The sources are as follows: Andrew Mills, Ryan Wiser, and Kevin Porter, "The Cost of Transmission for Wind Energy: A Review of Transmission Planning Studies," Ernest Orlando Lawrence Berkeley National Laboratory, http://eetd.lbl.gov/EA/EMP (accessed December 2010); Competitive Renewable Energy Zones (CREZ) Transmission Optimization Study, The Electric Reliability Council of Texas, April 2, 2008 http://www.ercot.com/news/presentations/2006/ATTCH_A_CREZ_Analysis_Report.pdf (accessed April 15, 2011); Sally Maki and Ryan Pletka, Black & Veatch, California's Transmission Future, August 25, 2010, http://www.renewableenergyworld.com/rea/news/article/2010/08/californias-transmission-future (accessed April 15, 2011).

[39] Oracle Crystal Ball. http://www.oracle.com/us/products/applications/crystalball.

An example of a trial run would begin with Crystal Ball selecting a random value, from a normal distribution, for each of the types of variables (i.e. Coal, Natural Gas, Nuclear, Biomass, Wind and Solar). The program applies the costs to the required quantity of renewables in order to meet the state RPS, to assess the cost, and to the foregone conventional energy, to assess the benefits. We subtract the benefits from the costs to calculate the net cost of the RPS. Dividing the next cost by the predicted retail sales that year results in the cost per kWh. This cost per kWh is then divided by the predicted electricity cost in Delaware resulting in our dependent variable. Crystal Ball repeated the calculation for the next trial, until 10,000 trials were completed. Figure 1 is a graphical representation of the 10,000 results for the percent change in electricity prices for year CY 2026.

The figure shows that the results are symmetrically grouped around the expected price increase for CY 2026, 15.2069 percent. The Standard Deviation was 3.0528 percent, while the median was 15.2087 percent. Skewness was 0.0394, meaning that the distribution is very symmetric.

Figure 1: Distribution of CY 2026 Price Change



With this data, we were able to calculate the mean price change, our expected change, as well as the upper and lower bound, such that there is only a 5 percent probability that the price increase would fall in either of the tails, or outside our the distribution range. This range forms our 90 percent confidence interval for electricity price changes.

The LECs are applied to the amount of electricity supplied from renewable sources under the RPS, because this figure represents the amount of conventional electricity generation capacity that presumably will not be needed under the RPS. The difference between the cost of the new renewable sources and the costs of the conventional electricity generation in Delaware represents the net cost of the RPS. Table 6 displays the results of our Expected Cost, as well as the upper and lower bound of the 90 percent confidence interval.

Table 6: Expected, Low and high Cost Cases of RPS Mandate

Year	Expected (2010 $000s)	Low (2010 $000s)	High (2010 $000s)
2017	133,607	102,090	165,124
2018	167,306	138,076	196,535
2019	189,520	154,349	224,690
2020	217,140	174,893	259,387
2021	222,994	178,176	267,813
2022	243,964	194,145	293,783
2023	264,670	209,868	319,473
2024	282,966	223,656	342,277
2025	308,440	244,971	371,909
2026	309,709	238,737	380,681
Total	**2,340,316**	**1,858,961**	**2,821,672**

Ratepayer Effects

To calculate the effect of the RPS on electricity ratepayers, we used EIA data on the average monthly electricity consumption by type of customer: residential, commercial and industrial.[40] The monthly figures were multiplied by 12 to compute an annual figure. We inflated the 2009 figures for each year using the average annual increase in electricity sales over the entire period.[41]

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[40] U.S. Department of Energy, Energy Information Administration, "Table 5. Residential Average Monthly Bill by Census Division, and State," (January 2010) http://www.eia.doe.gov/cneaf/electricity/esr/table5.html, We inflated the 2009 consumption figures using the increase in electricity demand from the EIA of 0.89 percent compound annual growth rate.

[41] U.S. Department of Energy, Energy Information Administration, Annual Energy Outlook 2011, "Table 8: Electricity Supply, Disposition, Prices, and Emissions," http://www.eia.gov/oiaf/aeo/tablebrowser/#release=AEO2011&subject=0-AEO2011&table=67-AEO2011&region=3-0&cases=ref2011-d120810c. (accessed April 15, 2011).

We calculated an annual per-kWh increase in electricity cost by dividing the total cost increase — calculated in the section above — by the total electricity sales for each year. We multiplied the per-kWh increase in electricity costs by the annual kWh consumption for each type of ratepayer for each year. For example, we expect the average residential ratepayer to consume 13,073 MWhs of electricity in CY 2026 and we expect the average cost scenario to raise electricity costs by 2.0572 cents per kWh in the same year in our expected cost case. Therefore, we expect residential ratepayers to pay an additional $269 in CY 2026.

Modeling the RPS using STAMP

We simulated these changes in the STAMP model as a percentage price increase on electricity to measure the dynamic effects on the state economy. The model provides estimates of the proposals' impact on employment, wages and income. Each estimate represents the change that would take place in the indicated variable against a "baseline" assumption of the value that variable for a specified year in the absence of the RPS policy.

Because the RPS requires Delaware households and firms to use more expensive "advance" power than they otherwise would have under a baseline scenario, the cost of goods and services will increase under the RPS. These costs would typically manifest through higher utility bills for all sectors of the economy. For this reason we selected the sales tax as the most fitting way to assess the impact of the RPS. Standard economic theory shows that a price increase of a good or service leads to a decrease in overall consumption, and consequently a decrease in the production of that good or service. As producer output falls, the decrease in production results in a lower demand for capital and labor.

BHI utilized its STAMP (State Tax Analysis Modeling Program) model to identify the economic effects and understand how they operate through a state's economy. STAMP is a five-year dynamic CGE (computable general equilibrium) model that has been programmed to simulate changes in taxes, costs (general and sector-specific) and other economic inputs. As such, it provides a mathematical description of the economic relationships among producers, households, governments and the rest of the world. It is general in the sense that it takes all the important markets, such as the capital and labor markets, and flows into account. It is an equilibrium model because it assumes that demand equals supply in every market (goods and services, labor and capital). This equilibrium is achieved by allowing prices to adjust within the model. It is computable because it can be used to generate numeric solutions to concrete policy and tax changes.[42]

In order to estimate the economic effects of the RPS we used a compilation of six STAMP models to garner the average effects across various state economies: New York, North Carolina, Washington, Kansas, Indiana and Pennsylvania. These models represent a wide variety in terms of geographic dispersion (northeast, southeast, midwest, the plains and west) economic structure (industrial, high-tech, service and agricultural) and electricity sector makeup.

Table 7: Average Elasticity of the Economic Variables

Economic Variable	Elasticity
Employment	-0.022
Gross wage rates	-0.063
Investment	-0.018
Disposable Income	-0.022

Using three different utility price increases – 1 percent, 4.5 percent and 5.25 percent – we simulated each of the six STAMP models to determine what outcome these utility price increases would have on each of the six state's economy. We then averaged the percent changes together to determine the effect of the three utility increases. Table 7 displays these elasticities, which were then applied to the calculated percent change in electricity costs for the state of Delaware discussed above.

We applied the elasticities to the percentage increase in electricity price and then applied the result to Delaware economic variables to determine the effect of the RPS. These variables were gathered from the Bureau of Economic Analysis Regional and National Economic Accounts as well as the Bureau of Labor Statistics, Current Employment Statistics.[43]

[42] For a clear introduction to CGE tax models, see John B. Shoven and John Whalley, "Applied General-Equilibrium Models of Taxation and International Trade: An Introduction and Survey," *Journal of Economic Literature* 22 (September, 1984): 1008. Shoven and Whalley have also written a useful book on the practice of CGE modeling entitled Applying General Equilibrium (Cambridge: Cambridge University Press, 1992).

[43] See the following: Bureau of Economic Analysis, "National Economic Accounts," http://www.bea.gov/national/; Regional Economic Accounts, http://www.bea.gov/regional/index.htm. See also Bureau of Labor Statistics, "Current Employment Statistics ," http://www.bls.gov/ces/.

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