The Beacon Hill Institute

The Economic Impact of Maryland's Renewable Energy Standard

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TABLE OF CONTENTS

TABLE OF TABLES

Executive Summary

The Beacon Hill Institute (BHI) has applied its STAMP® (State Tax Analysis Modeling Program) model to estimate the economic effects of the Maryland Renewable Energy Standard (RES). The Energy Information Administration (EIA), a division of the U.S. Department of Energy, estimates renewable electricity costs and capacity factors. This study bases our estimates on EIA projections and compliance reports from Public Utilities Commission of Maryland (PUC). The major findings show:

- The RES law will raise the cost of electricity by $474 million for the state's electricity consumers in 2022
- Maryland's electricity prices will rise by 5.83 percent by 2022.

These increased energy prices will likely hurt Maryland's residents and businesses, and consequently, inflict harm on the state economy. In 2022, the RES is expected to:

- Lower employment by an expected 3,395 jobs
- Reduce real disposable income by $518 million
- Decrease investment by $67 million
- Increase the average household electricity bill by $75 per year; commercial businesses by an expected $815 per year; and industrial businesses by an expected $4,185 per year.

Introduction

Maryland's Renewable Energy Portfolio Standard (RES) has been modified numerous times.[1] By enacting mandates for renewable energy production, the state of Maryland hoped to create in-state jobs. But when those jobs failed to materialize, lawmakers expanded the mandate to include offshore wind and solar carve-outs.

In 2006 the initial RES mandate required that renewable resources categorized as Tier I to comprise 1 percent of all retail electricity sales in Maryland.[2] Tier I renewable energy sources originally included solar, wind, biomass (excluding sawdust, methane, geothermal, ocean, and hydropower plans smaller than 30 megawatts which were already online at the introduction of the law).[3] The Tier I mandate increases gradually until reaching 20 percent of all electricity sales in 2022.

The Tier I category also carves out portions of the mandate for solar and offshore wind resources. Beginning in 2008, solar production must achieve 0.005 percent of total electricity sales, gradually increasing to 2 percent in 2022. In April 2013 another industrial carve-out was created, allowing up to a 2.5 percent mandate for offshore wind beginning in 2017 for facilities located between 10 and 30 miles offshore. Both carve-outs reduce the mandate for other Tier I resources.

Renewable resources categorized as Tier II are required to generate 2.5 percent of all retail electricity sales in Maryland through 2018, when that section of the law sunsets. Tier II resources include includes hydroelectric power (other than pump-to-storage generation) poultry litter, and waste-to-energy.[4]

Maryland does include a cost containment measure, but only for the solar carve-out. If the annual cost incurred for the purchase of solar energy exceeds one percent of the utilities' total annual electrical sales revenue, then the utility may request a one-year delay of the solar carve-out.[5] There is no language about a cost cap for the other 18 percent of the RES.

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[1] DSIRE, "Maryland Incentives/policies for Renewables," http://dsireusa.org/incentives/incentive.cfm?Incentive_Code=MD05R&re=0&ee=0.

[2] http://webapp.psc.state.md.us/intranet/ElectricInfo/home_new.cfm.

[3] Ibid.

[4] Maryland Public Service Commission, Maryland Renewable Energy Portfolio Standard Program , Frequently Asked Questions, Internet, http://webapp.psc.state.md.us/intranet/ElectricInfo/FAQ_new.cfm

[5] Maryland Law. Title 20: Public Service Commission. Subtitle 20.61.01.04. http://www.dsd.state.md.us/comar/getfile.aspx?file=20.61.01.04.htm.

The tracking of the RES will be done through the creation, and retirement of, Renewable Energy Credits (RECs) (or SRECS for the solar carve-out). Utilities obtain RECs for each megawatt-hour (MWh) of electricity generated by an approved renewable source. These RECs can then be either sold, banked or retired. Each electricity supplier must retire a number of RECs equal to their annual liability, based on the percentages of retail sales, as described above. If an electricity supplier wishes, they can hold on to a REC for up to three years, or sell the accrued RECs to other electricity suppliers.

In his support of the Maryland Offshore Wind Energy Act, as well as the offshore wind carve-out, Maryland Governor Martin O'Malley focuses on three major points: emissions, homegrown energy and economic impact.[6] Switching from fossil fuel generation to renewable energy generation will likely reduce emissions, but this is not a valid argument for offshore wind carve-outs. The carve-outs displace other forms of renewables, not conventional energy, so the emission impact will likely be zero. The zero-sum gain is an excellent illustration of how the carve-out policies found in the Maryland RES are mere artifacts of industrial policy, meant to favor specific industries, as opposed to environmental policies.

In his pitch for 'homegrown energy' the governor claims the higher transmission costs intrinsic to imported electricity 'raises rates for Maryland ratepayers'.[7] While transmission costs are real, the Governor ignores the costs of offshore wind. Even within the array of renewable energy options, offshore wind is one of the most expensive forms of energy, compared to solar, onshore wind, biomass, hydroelectricity, nuclear and all forms of conventional energy.[8] Yet the Governor supports the state RES, a law that does not allow for new hydroelectricity, one of the most cost-efficient forms of renewable energy.

The focus of this paper is not about emissions or the preference for homespun energy, but rather the economics of the Maryland RES law and its effects on the on the state's economy. The governor has stated that a 200MW offshore wind project would create "850 manufacturing and construction jobs for 5 years and an additional 160 ongoing supply and O&M [operations and maintenance] jobs thereafter."

[6] The Office of Governor Martin O'Malley. Offshore Wind for Maryland. http://www.governor.maryland.gov/wind.html.
[7] Ibid.
[8] AEO2013 LEC.

When the government mandates that citizens purchase a good, it should come as no surprise that jobs will be created in that sector. But the question left unasked is 'what is the net effect to the entire economy?' That is, what are the opportunities foregone by forcing the issue with government mandates? The opportunity cost is manifested in higher electricity costs that individuals and businesses must pay. To identify those costs and to estimate other net economic effects, BHI applied its State Tax Analysis Modeling Program (STAMP®) to the state RES mandate.[9]

[9] Detailed information about the STAMP® model can be found at http://www.beaconhill.org/STAMP_Web_Brochure/STAMP_HowSTAMPworks.html.

Estimates and Results

In light of the wide divergence in the cost estimates available for the different electricity generation technologies, we provide a statistically expected net cost of the Maryland's RES mandate. Each estimate represents the change that will take place in the indicated variable against the counterfactual assumption of no RES mandate. The Appendix that follows explains the methodology. Table 1 displays the cost estimates and economic impact of the 18 percent RES mandate in year 2022.

Table 1: The Cost of the 18 Percent RES Mandate on Maryland (2013 $)

Cost Estimate	Expected Value
Total Net Cost in 2022 ($ million)	474.0
Total Net Cost 2014-2022 ($ million)	3,326.4
Electricity Price Increase in 2022 (cents per kWh)	0.62
Percentage Increase	5.83
Economic Indicators	
Total Employment (jobs)	(3,395)
Investment ($ million)	(67.3)
Real Disposable Income ($ million)	(518.3)

The current RES is expected to impose costs of $474 million in 2022. As a result, the RES mandate would increase electricity prices by an expected 0.62 cents per kilowatt-hour (kWh) or by 5.83 percent. Over the period from 2014 to 2022, the RES mandate will cost Maryland electricity customers $3.326 billion.

The MD-STAMP model simulation indicates that, upon full implementation, the RES law is very likely to hurt Maryland's economy. The state's ratepayers will face higher electricity prices that will increase their cost of living, which will in turn put downward pressure on households' disposable income. By 2022, the state's economy will shed 3,395 jobs.

The job losses and price increases will reduce real incomes as firms, households and governments spend more of their budgets on electricity and less on other items, such as home goods and services. In 2022, real disposable income will fall by an expected $518.3 million. Furthermore, net investment will fall by $67.3 million.

Table 2 on page 7 shows how the RES mandate is expected to affect the annual electricity bills of households and businesses in Maryland. In 2022, the RES is expected to cost families $75 per year; commercial businesses $815 per year; and industrial businesses $4,185 per year. Over the period from 2014 to 2022, the RES will cost families an expected $535; commercial businesses $5,760 per year; and industrial businesses $28,895.

Table 2: Annual Effects of RES on Electricity Ratepayers (2013 $)

	Expected Value
Cost in 2022	
Residential Ratepayer ($)	75
Commercial Ratepayer ($)	815
Industrial Ratepayer ($)	4,185
Cost over period (2014-2022)	
Commercial Ratepayer ($)	535
Industrial Ratepayer ($)	5,760
Industrial Ratepayer ($)	28,895

Sensitivity Analysis

We tested our results by undertaking a "Metropolis Monte Carlo algorithm," which sets a distribution of outcomes for each of the main variables, and then simulates the results. This gives a better sense of what outcomes are likely (rather than merely possible). It also measures the sensitivity of our results to the assumptions about the future values of the input variables.

For instance, we used the EIA estimates of levelized costs of different electricity generation technologies through 2030. However, changing circumstances or market conditions can cause the EIA estimates to vary over the years. For example, no one predicted the steep drop in natural gas prices that took place over the past few years. We then drew 10,000 random samples from the distributions, and computed the variables of interest (rates of return, net present value, etc.). This allowed us to compute a distribution of outcomes, which shows the net present value of benefits minus costs, for the electricity price analysis. The full set of assumptions is shown in the Appendix.

The most important feature of this analysis was that it allowed us to compute confidence intervals for our target variables. These are shown in Table 3 on page 8. Thus we calculated the 90 percent confidence interval for the cost of electricity; in other words, we are 90 percent confident that the true result lies inside this band. To put it another way, there is a five percent chance that the results are higher than the upper bound, and five percent chance they are lower than the lowest bound. In general, our conclusion — that the RES mandate is economically harmful — is supported by our calculations.

Table 3: Sensitivity Analysis (2013 $)

Costs Estimates	Low	High
Total Net Cost in 2022 ($ millions)	(56.21)	1,004.25
Total Net Cost 2014-2022 ($ millions)	(59.50)	6,712.29
Electricity Price Increase in 2022 (cents per kWh)	(0.072)	1.319
Percentage Increase (%)	(0.67)	12.34
Economic Indicators (2022)		
Total Employment (jobs)	390	(7,180)
Investment ($ millions)	7.9	(142.4)
Real Disposable Income ($ millions)	59.9	(1,096.4)
Cost in 2022		
Residential Ratepayer ($)	(10)	160
Commercial Ratepayer ($)	(95)	1,730
Industrial Ratepayer ($)	(485)	8,855
Cost over period (2014-2022)		
Residential Ratepayer ($)	(10)	1,080
Commercial Ratepayer ($)	(90)	11,610
Industrial Ratepayer ($)	(465)	58,260

The results of the Metropolis Monte Carlo algorithm simulation show that there is a 90 percent chance that the total net costs of the RES policy from 2014 and 2022 will be between a net cost of $6.7 billion and a net benefit of $59.5 million. Total employment in Maryland could decrease by 7,180 or increase by 390 jobs by 2022, compared to a baseline of no RES policy. As a result, residential ratepayers in 2022 alone would have a 90 percent probability of seeing their annual bills drop $10 and increase by $160. For the entire period, the same residential ratepayers can expect the RES policy to affect their bills anywhere from an increase of $1,080 or a drop of $10, as the cost fluctuate over the entire period.

To put these estimates in perspective, there is only a five percent chance that the RES mandate will provide a net benefit of $56.21 million or better and a five percent change that it will cost $1.004 billion policy in 2022. These scenarios require extreme values for the input variables of the simulations. For example, the price of biomass power generation must fall to $74.5 per megawatt-hour from $101.42 and the price of natural gas generation must rise to $86.86 per megawatt-hour from $72.78 for the net benefit figure of $56.21 million to be realized. In other words, either of these scenarios is very unlikely to happen. The most likely outcome is the expected values in Table 1.

These cost effects over the course of nine years of the policy illustrate an important point when compared to the single year of 2022. First, over time the EIA projections show the Levelized Energy Costs (LEC) of renewable energy sources decreasing much faster than conventional energy sources, meaning the policy of requiring renewables will be more expensive to meet in year 'n' versus year 'n+1'. Secondly, the models' assumptions treat federal policies, such as the production tax credit and investment tax credit, as permanent. This favors renewable energy production, but becomes a less plausible assumption as time passes and federal debt and deficits force Congress to consider the elimination of targeted tax credits.

For example, during the recent federal budget agreement, the federal production tax credits for renewables were allowed to expire. Although, most analysts expect Congress to renew them this year, it is not a foregone conclusion. Moreover, the renewable energy lobby has been claiming for years that their technologies will not need the production tax credits in the future.[10] Congress may come to believe that the future is now. Despite this, the costs over the nine years are about equal to those in 2022 alone. This means that in the prior eight years the best-case scenario, is that the total cost level is no effect.

[10] CleanTechnica, Solar & Wind Power To Be Cost-Competitive Without Subsidies By 2025 (NREL), While Fossil Fuels Still Subsidized Through Externalities, Internet, http://cleantechnica.com/2013/08/30/solar-and-wind-power-to-be-cost-competitive-without-subsidies-by-2025-according-to-new-study-from-the-national-renewable-energy-laboratory/#ArbQzyk8M4ITSTlb.99.

Conclusion

Lost among the claims of increased investment and jobs in the 'green energy sector' is a discussion of the opportunity costs of RES policies. Gov. O'Malley boasts about the 'jobs, jobs, jobs" that will sprout from an offshore wind mandate.[11] But he does not mention the higher prices that Maryland's electricity ratepayers will face – meaning that every business and manufacturer will endure higher costs, leading to less investment of capital and less hiring of workers. Moreover, every household will also face higher electricity prices that will force them to spend less on things from groceries to entertainment.

Proponents of the RES law are correct. There will be more investment and jobs in the 'green' energy sector, but rarely do they mention the loss of jobs and investment in every other sector in the state. Our methodology in this paper takes all costs and benefits into account, resulting in a very likely outcome of less jobs and lower investment for Maryland.

The RES will continue to generate economic benefits for a small group of favored industries. But all of Maryland's electricity customers will pay higher rates, diverting resources away from spending on other sectors as well as reducing business investment. The increase in electricity prices will harm the competitiveness of the state's businesses, as the costs of inputs increase particularly in the energy-intensive manufacturing industries. Firms with high electricity usage will likely move their production, and emissions, out of Maryland to locations with lower electricity prices. Therefore, the RES policy will not reduce global emissions, but rather send jobs and capital investment outside the state.

As a result, Maryland residents will have fewer employment opportunities as they watch investment flee to other states with more favorable business climates. Policymakers should monitor the utilities RES compliance reports for further cost increases and act, if necessary, to curb the mandates that benefit only a few special interests.

[11] O'Malley, Offshore Wind, http://www.governor.maryland.gov/wind.html.

Appendix

To provide a statistically significant confidence interval for net cost calculations for state level Renewable Energy Standards (RES), we used a Metropolis Monte Carlo algorithm. A Metropolis Monte Carlo algorithm simulation is generated by repeated random sampling from a distribution to obtain statistically significant results. Given the uncertain future of energy policy, the supply and demand of energy production techniques, or even new entrants to the energy market, the Metropolis Monte Carlo algorithm allows us to be confident about our results. With the determination of the range and probability of the cost and percent change outcomes of a policy based on distributions placed on key, specific variables, as discussed in this appendix, we are 90 percent confident, a statistical standard, that the future will fall within our results. Oracle's Crystal Ball software provided an easy-to-use and established methodology for generating the results.[12]

Determining the Levelized Energy Cost Distribution

Determining the mean value and standard deviation of electricity is the first step in building a Monte Carlo simulation. For this we relied upon the U.S. Energy Information Administration's (EIA) Annual Energy Outlook (AEO) Levelized Energy Costs (LEC). The 2013 AEO explains:

> Levelized cost is often cited as a convenient summary measure of the overall competitiveness of different generating technologies. It represents the per-kilowatt-hour cost (in real dollars) of building and operating a generating plant over an assumed financial life and duty cycle. Key inputs to calculating levelized costs include overnight capital costs, fuel costs, fixed and variable operations and maintenance (O&M) costs, financing costs, and an assumed utilization rate for each plant type.[13]

Using this comprehensive and widely accepted methodology, we utilized the detailed regional data set, allowing us to go into extensive depth. We defined LEC for every year between 2014 and 2030, across 22 different regions for 17 different types of electricity generating techniques. For example, the mean cost to produce a megawatt hour (MWh) of power from wind power, in the Northeast Power Coordinating Council/New England, for a plant coming online in 2020

[12] Oracle Crystal Ball, Overview, http://www.oracle.com/us/products/applications/crystalball/overview/index.html.

[13] U.S. Energy Information Administration, Annual Energy Outlook 2013, "Levelized Cost of New Generation Resources," (January 28, 2013) http://www.eia.gov/forecasts/aeo/electricity_generation.cfm.

was calculated, and represented as Mean(Wind, NPCC/NE, 2020). This level of detail enabled the modeling of state specific RES with varying requirements year to year.

Two different data sets were examined to calculate the variables required for the Metropolis Monte Carlo algorithm simulation. The first was the LEC as modeled by the National Energy Modeling System from the AEO2008. The second was the 'No Sunset' version of the same data set from the AEO2013. The No Sunset version was preferable for our analysis because it assumes that expiring tax credits would be extended, which we believe is the most likely scenario.[14] Additionally, since the vast majority of expiring tax credits are for renewable generation sources such as wind, solar and biomass, it makes the projections much more conservative.

Table 4: AEO2008 to AEP2013 Region Matching

AEO 2008 Region*	AEO 2013 Region*
1	10, 11, (½)15,
2	1
3	6, 7, 9
4	3, (⅓) 4, 13
5	(⅔)4
6	8
7	5
8	2
9	12, 14, (½)15, 16
10	17, 18
11	21
12	19, 22
13	20

* Numbers based on Electricity Market Module Regions from the respective AEOs.

Before calculating the mean and standard deviation for each data point, some minor adjustments to the AEO2008 data were required to match with the AEO2013 data. The first step was to grow the AEO2008 numbers, originally in 2006 US dollars, so that they were in 2011 US dollars like the AEO2013 data. To do this, the annual U.S. Consumer Price Index for Energy was employed. The index was at 196.9 in 2006 and 243.909 in 2011, resulting in the AEO2008 prices being multiplied by approximately 1.24.[15] Additionally, the 13 regions from AEO2008 had to be matched up with the 22 regions of AEO2013. For some this was a simple conversion, such as the Florida Reliability Coordinating Council from AEO2008, which did not change in the AEO2013. But others were split up into 2 or 3 different regions, for example

[14] Energy Information Administration, "Issues in Focus," (April 2013) http://www.eia.gov/forecasts/aeo/IF_all.cfm
[15] U.S. Bureau of Labor Statistics, Consumer Price Index, http://www.bls.gov/cpi/.

region 1 in the AEO2008 was split up such that it became region 10, 11 and half of 15 (the other half of 15 came from region 9 in AOE2008). Table 4 above shows our matching.

With the data in the same year and regions, we compared the TOTAL variable from AEO2008 to the TOTAL variable from AEO2013. The AEO2013 added in additional information in the form of ITC/PTC which stands for 'Investment Tax Credit/Production Tax Credit', a negative cost to the producer of the energy. This was added back into the calculations after, as it did not exist in the AEO2008, allowing an 'Apples to Apples' comparison. We calculated the mean for each of these data points. This was accomplished by comparing the projections of LEC from the AEO2008 to those made in the most recent AEO2013.[16] This represents what we believe best corresponds to the expected value around which a normal distribution of possible outcomes is centered.

The standard deviation is likely the most widely used measurement of dispersion of data. To calculate each individual standard deviation, for example Standard Deviation (Wind, 5, 2020), we calculated the sample standard deviation between the AEO2008 and AEO2013 points. With these two calculations completed, the result allowed us to create projections of normal distributions for the LEC of various energy production techniques.

Determining Future Electricity Consumption

As with predicting the LEC of electricity production techniques, predicting future electricity consumption is difficult, yet essential to determining the effects of RES policies. For this reason we again calculated a normal distribution for electricity consumption for the state, by year. We reviewed the last 22 years of State Gross Domestic Product (SGDP) and electricity consumption by state and determined that there is a strong correlation between electricity consumption and SGDP.[17] To determine the strength and interaction we produced the following simple regression:

$$Log(Electricity\ Consumption = \beta_0 + \beta_1\ Log(SGDP)$$

Or

[16] Energy Information Administration, Forecasts http://www.eia.gov/forecasts/aeo/ http://www.eia.gov/oiaf/archive/aeo08/index.html.

[17] See BLS and EIA: http://www.bea.gov/regional/index.htm http://www.eia.gov/electricity/data.cfm.

$$Log(Electricity\ Consumption = 14.24013 + 0.302208\ Log(SGDP)$$

Table 5 below displays some of the relevant regression statistics. The simple regression fits the data quite well, with 73 percent of the variance Log (Electricity Consumption) explained by changes in the independent variable. The test statistic associated with Log (SGDP) is individually significant.

Table 5: Relevant Regression Statistics

Adjusted R^2	0.7337
Prob>T	0.000
Standard Error Log(SGDP)	0.03462
Number of Observations	22

Next, we forecasted SGDP using an ARIMA (Autoregressive, Iterative, Moving Average) model which estimates a regression equation that extrapolates from historical data to predict the future. We used the Log(SGDP) to transform the growing series into a stable series and included Log(US GDP) as an independent variable.

In estimating the regressions, we paid particular attention to the structure of the errors, in order to pick up the effects of seasonal, quarterly and monthly variations in tax collections. This was done by estimating the equations with autoregressive (AR) and moving average (MA) components. The number and nature of the AR and MA lags were determined initially by examining the autocorrelation and partial correlation coefficients in the error term, and then fine-tuning after examining the structure of the equation residuals. For Maryland, the SGDP series conformed to an AR(1) and MA(1) in addition to a constant term. Using the combination of the regression equation and the calculated Standard Error we constructed a normal distribution of electricity sales for each year in our prediction range.

Additional Data

With the distributions of LEC and electricity consumption defined, we turned our attention to the other data points which required estimates. The first was the baseline sales of renewable energy, that is, the level of renewable generation that would have come online without taking into consideration the policy under review. The difference between this baseline and the policy requirement is the amount of renewable energy that has to come online due to the policy itself. The baseline level of renewables was set equal to the total amount of renewable generation in

2003, as the policy was established in Maryland in June of 2004.[18] To err on the conservative side, we include all renewable energy, even though hydroelectric facilities larger then 30MW are excluded. This amount was then grown annually according to the projected growth of renewables in the region per the AEO2003.[19]

The second data point calculated is the distribution of new renewable production that comes online due to the policy. The share of new renewable generation was set equal to the '2010 Maryland Generated REC's by Fuel Source' per the 2012 Annual Report (the most recent year available).[20] The results of our baseline calculations, not using Monte Carlo simulations, are presented below in Table 6.

Table 6: Projected Electricity Sales, Renewable Sales

Year	Projected Electricity Sales MWhs (000s)	Projected Renewable MWhs (000s)	RES Requirement MWhs (000s)	Difference MWhs (000s)
2014	69,886.43	212.71	6,953.70	6,740.99
2015	70,999.39	215.53	7,099.94	6,884.40
2016	72,049.50	213.74	8,645.94	8,432.20
2017	72,967.90	213.98	8,865.60	8,651.62
2018	73,766.94	210.91	10,622.44	10,411.53
2019	74,534.26	211.16	11,664.61	11,453.45
2020	75,319.58	210.91	12,051.13	11,840.23
2021	76,159.18	211.42	12,718.58	12,507.16
2022	76,005.07	213.21	13,680.91	13,467.70

Some types of renewable generation, such as wind and solar power, are considered intermittent power sources. That is, output varies greatly over time, depending on numerous difficult-to-predict factors. If the wind blows too slowly, too fast, or a cloud passes over a solar array, the output supplied changes minute to minute while demand will not mirror these changes. For this reason, conventional types of energy need to be kept as 'spinning reserves'. That is, they need to be able to ramp up, or down, output at a moment's notice. The effect of

[18] Energy Information Administration, "Electric Power Industry Generation by Primary Energy Source, 1994, 1998, and 2003 (2003) http://www.eia.gov/electricity/state/.

[19] Energy Information Administration, Supplement Tables to the Annual Energy Outlook 2003, "Table 82. Renewable Energy Generation by Fuel Northeast Power Coordinating Council / New England" (July 21, 2003) http://www.eia.gov/oiaf/archive/aeo03/supplement/suptab_82.htm.

[20] Public Service Commission of Maryland. Renewable Energy Portfolio Standard Report of 2012, with data from Compliance Year 2010.

this is that for every one MWh of intermittent renewable power introduced, the offset is not one MWh of conventional power, but some amount less. To account for this, we used a policy study from the Reason Foundation which noted:

> Gross et al. show that the approximate range of additional reserve requirements is 0.1% of total grid capacity for each percent of wind penetration for wind penetrations below 20%, raising to 0.3% of total grid capacity for each percent of wind penetration above 20%.[21]

We reviewed the original Gross article, which compiled numerous papers on the topic, and found the Reason Foundation calculations to be very conservative. The result was using their numbers, again to err on the conservative side, with less spinning reserves factored in, being more favorable to renewable sources.

Finally, a calculation of the distribution of conventional energy resources that would be crowded out due to a higher share of renewables is needed. In Maryland, we assumed that coal and natural gas would be the two forms of conventional energy that would be offset. The amount of each was reduced according to the ratio of the usage of the two, with coal being the main source of reduction.[22] In general, natural gas production is utilized as spinning reserve, and we assume that is the case in Maryland for the additional spinning reserve requirements.

Using the above compiled data, we were able to calculate the amount of new renewables that will likely come online due to the policy, as well as the likely conventional energy displaced. Combining this information with the estimated LEC of electricity in each of the studied years yields the total cost of the policy. The total cost of the policy divided by the amount of electricity consumed yields a percent cost of the policy.

Ratepayer Effects

To calculate the effect of the policy on electricity ratepayers we used EIA data on the average monthly electricity consumption by type of customer: residential, commercial and industrial.[23] The monthly figures were multiplied by 12 to compute an annual figure. We inflated the 2011 figures for each year using the regional EIA projections of electricity sales.[24]

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[21] William J. Korchinski and Julian Morris, "The Limits of Wind Power," Reason Foundation (October 4, 2012) . http://reason.org/studies/show/the-limits-of-wind-power.

[22] U.S. Energy Information Administration, Maryland Electricity Profile "Table 5. Electric Power Industry Generation by Primary Energy Source, 1990 through 2010. "http://www.eia.gov/electricity/state/maryland/.

[23] Energy Information Administration, "Electric Sales, Revenue, and Average Price" http://www.eia.gov/electricity/sales_revenue_price/.

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 12,110 kWh of electricity in 2022 and the expected percent rise in electricity to be by 0.623 cents per kWh in the same year. Therefore, we expect residential ratepayers to pay an additional $75.44 in 2022.

Modeling the Policy 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 proposal's 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 RES policy.

Because the policy requires households and firms to use more expensive renewable power than they otherwise would have under a baseline scenario, the cost of goods and services will increase under the policy. 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 policy. 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

[24] Energy Information Administration, "Electric Power Projections for EMM Regions," http://www.eia.gov/oiaf/aeo/tablebrowser/#release=AEO2013ER&subject=0-AEO2013ER&table=62-AEO2013ER&region=3-5&cases=early2013-d102312a.

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.[25]

In order to estimate the economic effects of the policy 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.

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 states' economy. We then averaged the percent changes together to determine the average effect of the three utility increases. Table 6 displays these elasticities, which were then applied to the calculated percent change in electricity costs for the state as discussed above.

Table 7: Elasticities for the Economic Variables

Economic Variable	Elasticity
Employment	-0.022
Investment	-0.018
Disposable Income	-0.022

We applied the elasticities to percentage increase in electricity price and then applied the result to state level economic variables to determine the effect of the policy. 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.[26]

[25] 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).

[26] For employment, see the following: U.S. Bureau of Labor Statistics, "State and Metro Area Employment, Hours, & Earnings," http://bls.gov/sae/. Private, government and total payroll employment figures for Michigan were used. For investment, see "National Income and Product Account Tables," U.S. Bureau of Economic Analysis, http://www.bea.gov/itable/; BEA, "Gross Domestic Product by State," http://www.bea.gov/regional/. We took the state's share of national GDP as a proxy to estimate investment at the state level. For state disposable personal income, see "State Disposable Personal Income Summary," BEA, http://www.bea.gov/regional/.

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