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ESTIMATE OF ECONOMIC AND FISCAL IMPACT OF MARYLAND's "100% CLEAN RENEWABLE ENERGY EQUITY ACT" [1]

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The brief report summarizes the cost, rate, and fiscal impact of providing 100% of Maryland's electricity with renewable sources by 2035 under the "100% Clean Renewable Energy Equity Act of 2018" (HB878, hereafter "100% Act"). A description of each chart is also provided. Electric vehicle related issues (generation, cost, CO_2, etc.) are not included.

These estimates are for a 100% renewable electricity system for Maryland where it continues to be part of the PJM grid that serves the mid-Atlantic region and extends westward all the way to Chicago. Note that both "Business as Usual" (BAU) and the "100% Act" scenarios assume that Maryland's energy efficiency program called EmPOWER that is already in Maryland law will be fully implemented. Since EmPOWER program costs are common to both, they are not included in this analysis, whose primary purpose is comparative.

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[1]The analysis and calculations underlying this report were reviewed by Dr. Elena Krieger, Director, Clean Energy Programs, Physicians, Scientists and Engineers for Healthy Energy. Arjun Makhijani alone, as the author, is responsible for any errors or deficiencies that may remain.

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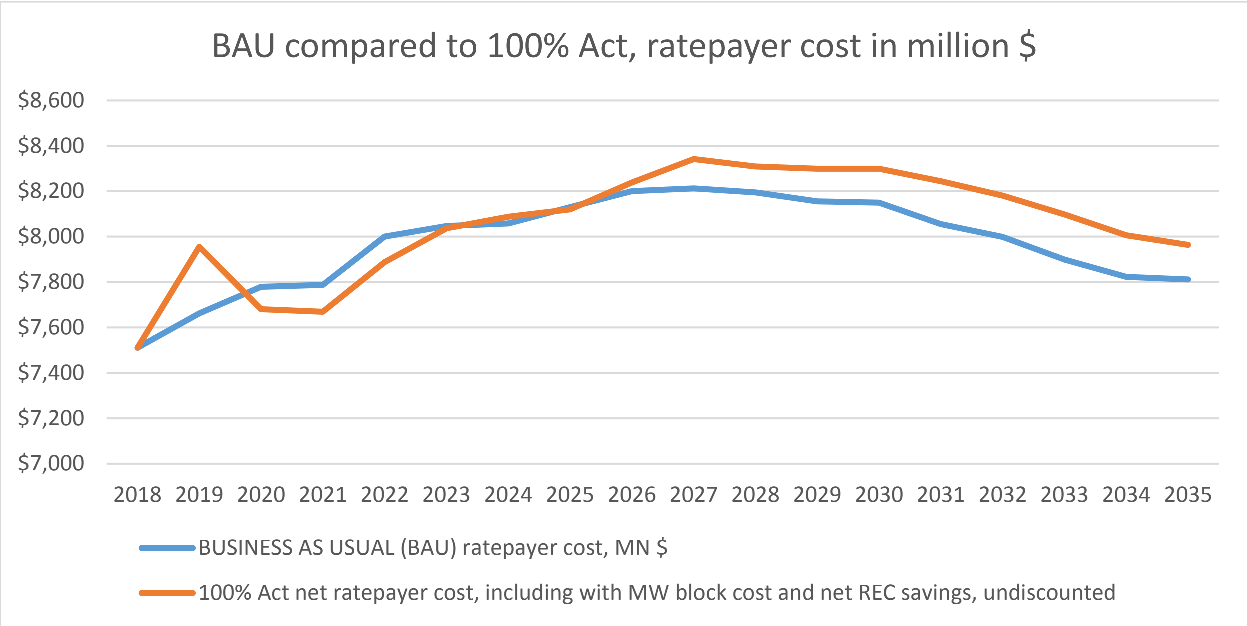
A. Ratepayer and total cost perspectives

a. Ratepayer perspective BAU and 100% Act – without social cost of carbon emissions

Figure 1: Annual business as usual (BAU) electricity costs compared to 100% renewable scenario costs.



- Figure 1 shows costs from a ratepayer perspective[3] – - the costs do not include private investments that are not reflected in electricity bills. Specifically, ratepayers do not see the costs or benefits of private investment in disturbed solar generation. The costs of rebates for solar under the Maryland Megawatt Block Program are part of rates and are included in Figure 1. The program starts in 2019 to provide a needed short term boost Maryland's solar industry.
- The renewable energy acquisition model is changed from acquiring electronic certificates (known as Renewable Energy Credits, RECs) associated with renewable attributes of power generation to Power Purchase Agreements (PPAs), which require the purchase of renewable energy, as well as direct support of local electricity generation via rebates for distributed solar installations. No credit is taken for the value of RECs associated with the PPAs.
- Provision is made for compensating owners of in-state solar installations prior to the 100% Act at $30 per kilowatt (DC) each year for five years, totaling over $200 million.
- PPAs of at least fifteen years are assumed. Renewable energy generation costs are based on the technology review for 2017 published by the National Energy Renewable Laboratory (NREL),[4]

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[3] Business as Usual (BAU) costs are from the Energy Information Administration's (EIA) Annual Energy Outlook 2017 (AEO 2017) estimates for the mid-Atlantic region, normalized to Maryland prices. AEO 2017 is at https://www.eia.gov/outlooks/aeo/tables_ref.php Prices for the mid-Atlantic region are in Table 3.2. Maryland price and other data are from the EIA's state electricity profile for Maryland. Tables can be downloaded at https://www.eia.gov/electricity/state/maryland/index.php
https://www.eia.gov/electricity/state/maryland/index.php

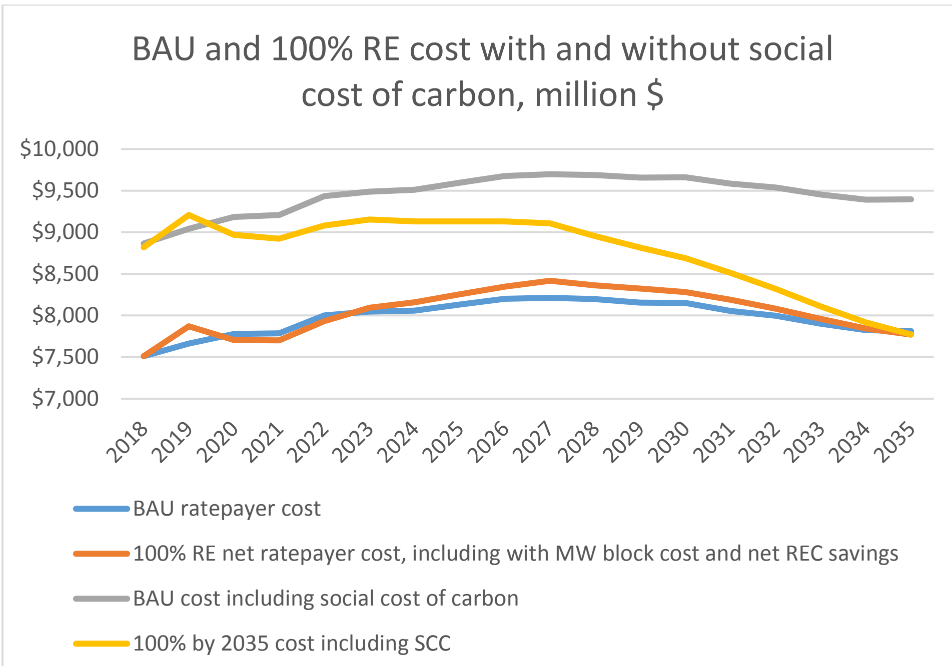
[4] U.S. National Renewable Energy Laboratory, Annual Technology Baseline (ATB), August 2017 at www.atb.nrel.gov

except for offshore wind, which were provided by personal communication, Business Network for Offshore Wind.

- Taxes, transmission and distribution (T&D) costs, and all other costs of distribution utilities are included for utility-scale generation.[5] For distributed solar, the costs of distribution utilities, and all taxes and other charges are included. Distributed solar reduces transmission and distribution losses and the need for transmission capacity. Credit for these has been included.
- Costs of curtailment of renewable energy (rising from 0.5% of renewable generation in 2020 to 8.5% in 2035) are included in the 100% Act scenario (cumulative $4.1 billion, undiscounted). These estimates are based on NREL modeling of high renewable penetration scenarios.[6]
- The cost of the affordability program is not included. It is a transfer payment among Marylanders and has no direct impact overall. It also has a large positive indirect impact due to reduced homelessness, emergency room visits, etc.

b. Ratepayer perspective including social cost of carbon

Figure 2: Annual electricity costs with and without social cost of carbon.



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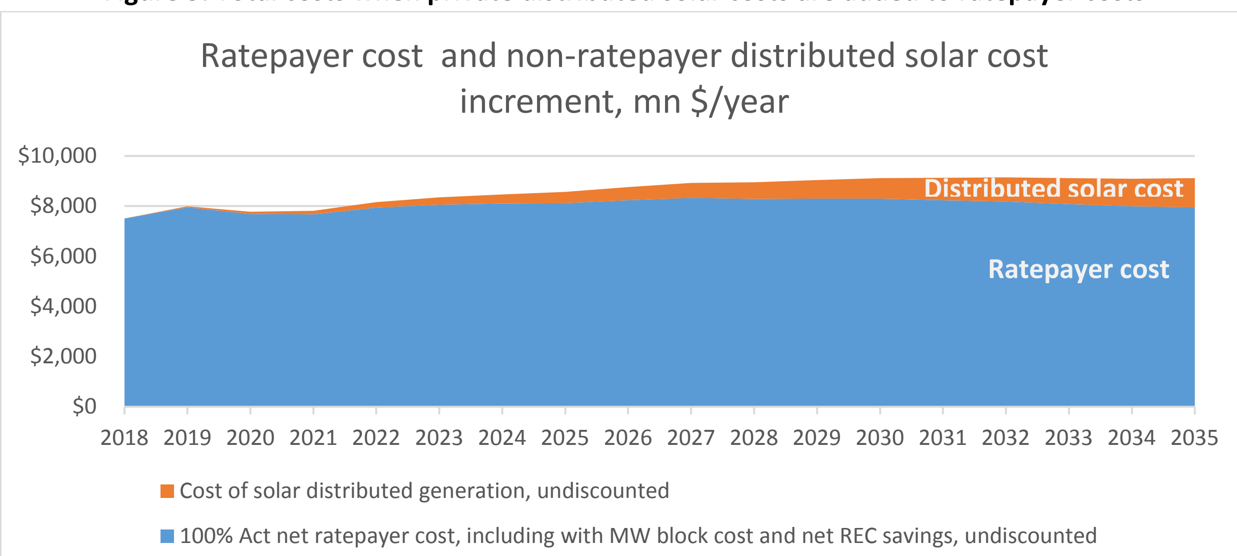
[5] An adjustment is made for the capacity value of renewables by assigning 57% value for solar, 13% for onshore wind, and 24% for offshore wind (PJM values). The weighted average was calculated for each year since the mix varies over the 2020-2035 period. A small fuel price hedge value of solar and wind energy has been included, since these sources have zero fuel costs. Estimates for cost reduction attributable to distributed solar are from a Rocky Mountain Institute Study at https://rmi.org/wp-content/uploads/2017/05/RMI_Document_Repository_Public-Reprts_eLab-DER-Benefit-Cost-Deck_2nd_Edition131015.pdf adjusted to 2016 dollars. GDP deflators are from the St. Louis Federal Reserve at https://fred.stlouisfed.org/series/A191RD3A086NBEA

[6] See slide 25 of https://www.nrel.gov/docs/fy17osti/68349.pdf

- Figure 2 shows costs with and without the “social cost of carbon.” The EPA defines the social cost of carbon as “a measure, in dollars, of the long-term damage done by a ton of carbon dioxide (CO_2) emissions in a given year.”[7] We have used the values corresponding to a discount rate of 3% per year (starting @$45 per metric ton of CO_2 in 2018, going up to $63 per metric ton in 2035).
- The cumulative cost of CO_2 emissions in the BAU scenario, discounted at 3% is estimated at $18.1 billion over the 2019-2035 period, for an average of about $1.1 billion per year; for the 100% Act the corresponding cost is estimated at $8.5 billion. The implied savings of $9.6 billion can be compared to a cumulative direct added cost to ratepayers of $1 billion (@3% discount rate) over the entire 17 year period, 2019 to 2035 (inclusive). In other words, the reduction in damage due to reduced CO_2 emissions, as estimated by the social cost of carbon, is almost ten times the cumulative added cost of renewable energy.
- Damage from severe climate events is already occurring. For instance, Congress appropriated about $52 billion to assist in relief following Hurricanes Irma, Harvey, and Maria and the western wildfires in 2017. Another $81 billion has been proposed.[8] Maryland’s share of these two totals about $2.5 billion. In addition, Maryland is suffering its own damage, for instance from rising sea levels. This damage can be compared to the social cost of carbon of $1.1 billion per year under business-as usual that we have used. This indicates that at levels of damage that are already occurring, a much higher social cost of carbon, and thus a much higher estimate of savings from reduced damage, would be justified.

c. Total cost perspective

Figure 3: Total costs when private distributed solar costs are added to ratepayer costs



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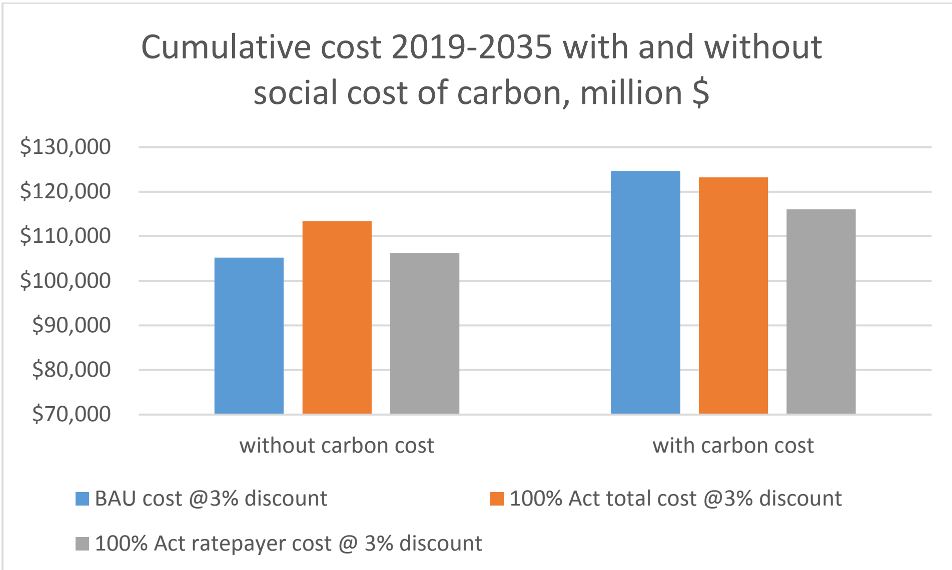
[7] EPA Fact Sheet at https://www.epa.gov/sites/production/files/2016-12/documents/social_cost_of_carbon_fact_sheet.pdf The costs of carbon in this document have been converted from 2007 dollars in the EPA Fact Sheet to 2016 dollars for this report.

[8] Bloomberg, December 18, 2017 at https://www.bloomberg.com/news/articles/2017-12-18/house-gop-is-said-to-agree-on-81-billion-in-disaster-spending

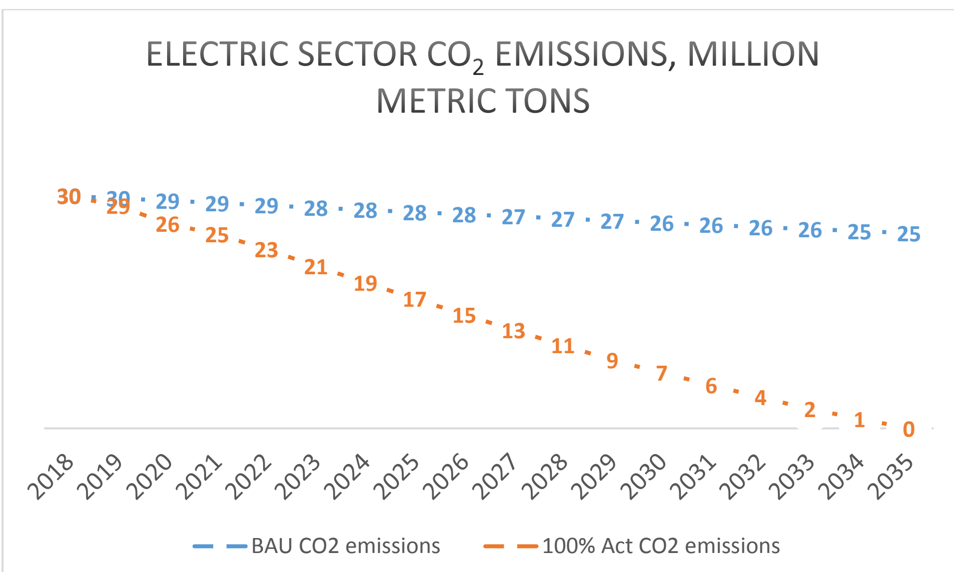
- Figure 3 shows both the ratepayer costs and the costs of distributed solar incurred by private parties. These private party costs are not seen by ratepayers. The costs of rebates for solar are included in the "ratepayer cost." The sum of the two gives a total cost perspective.
- Figure 4 below compares the cumulative costs of the BAU and 100% Act scenarios. Total cost estimates and ratepayer cost estimates are shown, with and without the social cost of carbon.

Figure 4: Comparison of ratepayer and total cumulative costs (2019-2035)



B. CO_2 emissions

Figure 5: Maryland electricity sector CO_2 emissions, BAU and 100% Act

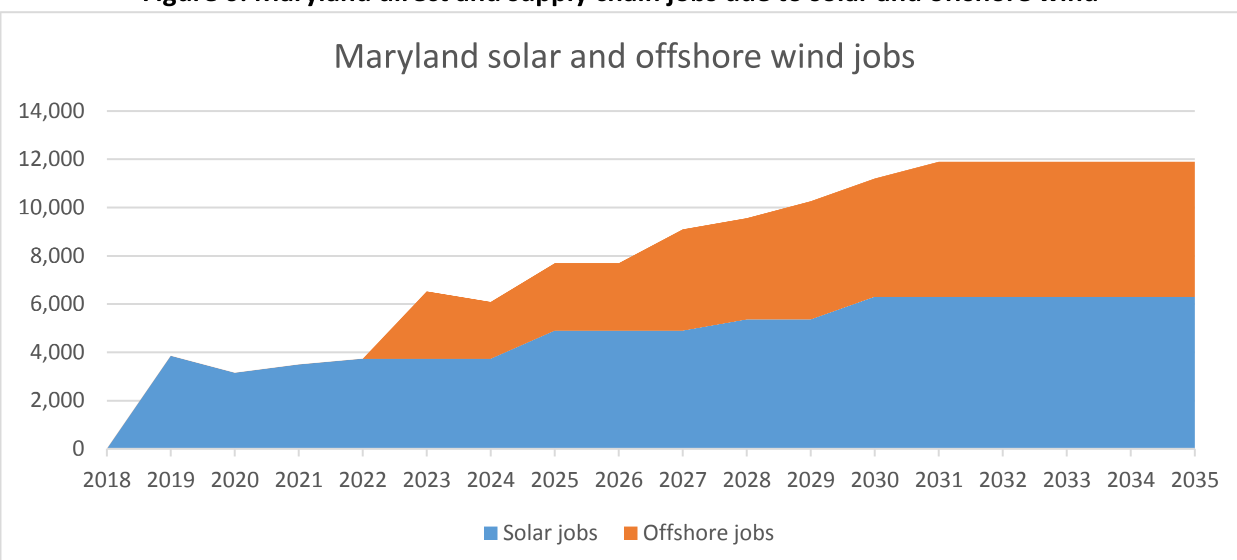


- CO_2 emissions under the BAU scenario are taken as 0.46 metric tons per megawatt hour (MWh) throughout the period. This is slightly less than the 2015 rate to account for mandated growth in solar energy. Total emissions decline due to the effect of the EmPOWER program.
- CO_2 emissions for the 100% Act would start at 0.46 per MWh in 2018 and decline steadily to zero in 2035.
- The cumulative CO_2 emissions would be 494 million metric tons (2018-2035) in the BAU scenario and 256 million metric tons under the 100% Act. The difference of 237 million metric tons (rounded) would be achieved at a direct added ratepayer cost of $1 billion (3% discount rate). The cost of CO2 reductions therefore works out to about $4 per metric ton (rounded), far lower than the weighted average EPA social cost of carbon under BAU of $54 per metric ton over the entire period out to 2035. When the private investment in distributed solar is taken into account, the average cost works out to $34 per metric ton, still much lower than the weighted average social cost of carbon.

C. Jobs and fiscal impact

A large number of jobs would be created by the 100% Act – in construction, in operations and maintenance of renewable energy facilities, notably offshore wind, and in manufacturing and supply chain activities. The workers would spend their income, increasing the size of Maryland's economy. The State of Maryland would also collect income taxes, sales taxes, and user fees when workers spend money. The increased revenues would be spent or invested, creating a stimulus to the economy.

Figure 6: Maryland direct and supply chain jobs due to solar and offshore wind`

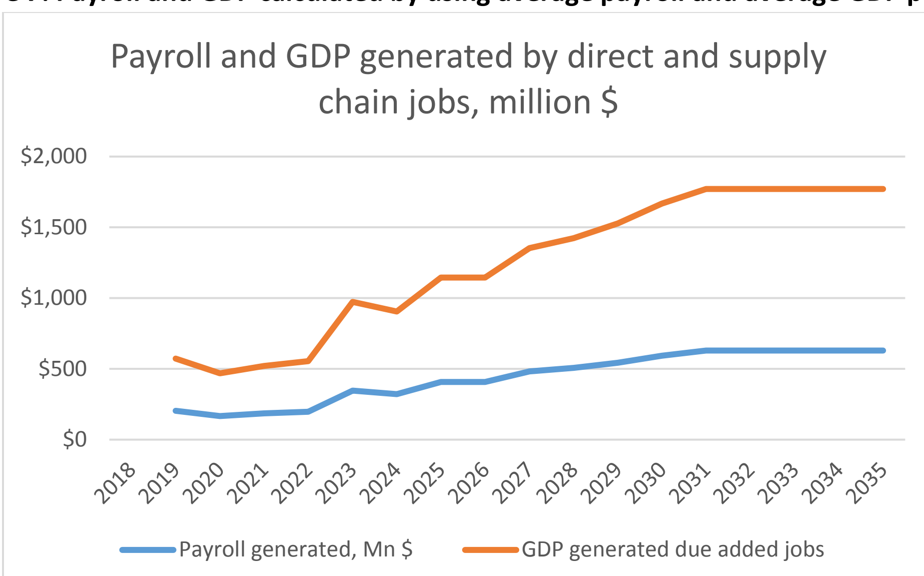


- Figure 6 uses low estimates for direct and supply chain jobs of 7 jobs/MW of solar and 14 jobs per MW of offshore wind. These are lower than short-term job estimates, since costs of both are declining, implying a reduction in jobs per megawatt as the implementation of the 100% Act proceeds.
- Induced jobs are not included. These are jobs that would be created due to the stimulus of spending created by the people employed in the solar and offshore wind industries.

- Jobs associated with imports of renewable energy are not included.
- Jobs are shown in year of project completion. This gives a reasonably good picture for solar, but offshore wind jobs would be created earlier than shown.
- Fossil fuel power plants in Maryland employ about 1,100 workers; the nuclear plant at Calvert Cliffs has about 900.[9] In principle, these plants would not be barred from selling electricity into the PJM grid, since they are deregulated plants that supply their electricity into interstate commerce. But they may be negatively impacted by changing market conditions. The total of 2,000 jobs at existing plants compares to the 12,000 direct and supply chain jobs that would be created by the 100% Act. A transition from present jobs to jobs in the offshore wind industry, including construction, manufacturing, and operations and maintenance is therefore possible. This transition would need to be planned in advance to prevent dislocation of workers and communities.

Figure 7 shows the impact on payroll and Maryland's Gross Domestic Product (GDP) of these additional jobs. Figure 8 shows the fiscal impact.

Figure 7: Payroll and GDP calculated by using average payroll and average GDP per job

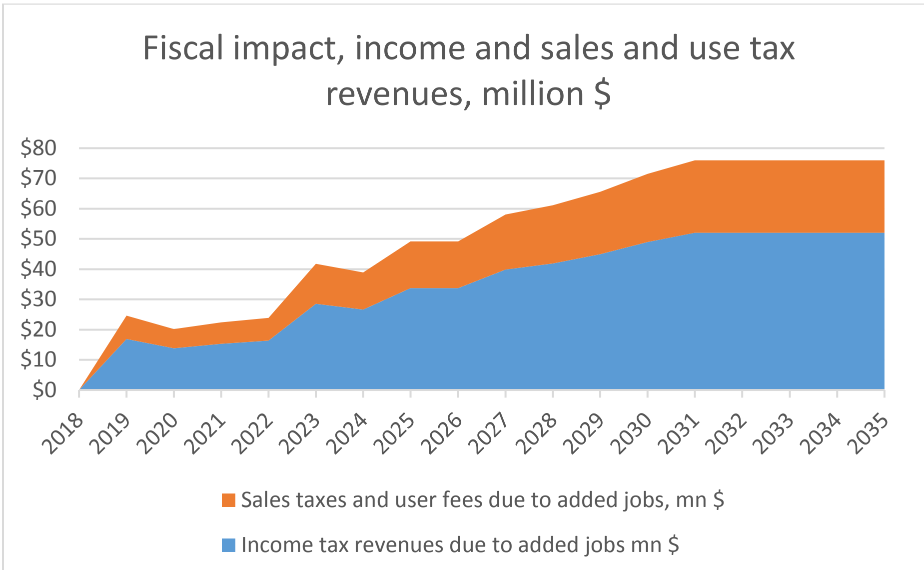


- The impact on payroll is calculated assuming the average wage for all Maryland jobs ($52,900/job).[10]
- The impact on GDP is calculated assuming that each job would have the same impact as the average Maryland job ($148,800/job).[11]

[9] Arjun Makhijani, *Prosperous, Renewable Maryland*. Takoma Park: Institute for Energy and Environmental Research 2016, p. 202.
[10] Maryland payroll and number of jobs are from census data at https://www.census.gov/quickfacts/MD
[11] Maryland GDP is from Maryland state data at http://www.deptofnumbers.com/gdp/maryland/

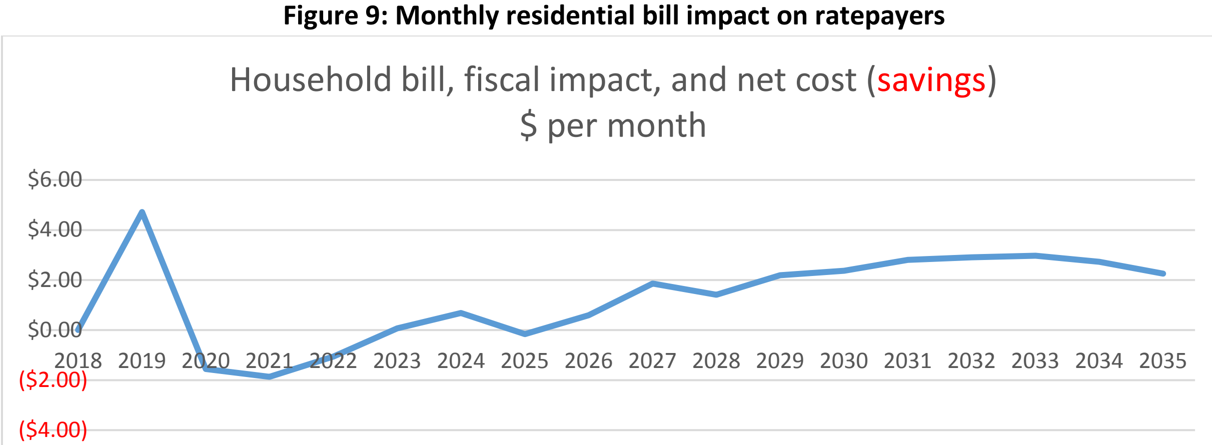
- These average values may underestimate the payroll and GDP impact, especially in the case of direct and supply chain jobs associated with offshore wind.
- The fiscal impact in Figure 8 below is also calculated using average Maryland values per job. Taxes other than direct income taxes, sales taxes and use taxes are not included.
- Income and sales tax revenues are based on average per job values in Maryland ($4,400 and $2,000 respectively).
- The payroll and fiscal impact of induced jobs is not included.

Figure 8: Income, sales, and use taxes due to direct and supply chain jobs



D. Impact on households

Figure 9: Monthly residential bill impact on ratepayers



- The ratepayer impact per month is based on average usage of electricity per month – which is expected to decline slightly due to the implementation of the state's efficiency (EmPOWER) program. The weighted average is about $1.30 per month, which may be conservatively rounded up to $1.50 to account for uncertainties.

- The cost impact in 2019 is due to the short-term stimulus provided for the solar industry.
- The savings in the early years are due to the elimination of the requirement to procure unbundled paper renewable energy credits as well as solar RECs.
- Provision of $30 per kW per year for five years has been made to compensate pre-100% Act owners of solar in lieu of the value of their Solar RECs, amounting to a total of more than $200 million over five years.
- The bulge in costs in the middle period is due to smaller avoided REC savings and early period higher renewable electricity costs. Further the savings due to avoided costs of REC purchases decline since the prices of RECs in PJM are projected to decline and go nearly to zero in the early 2030s.[12] The subsequent decline is due to declining renewable energy prices.
- Low-income households are protected against increased costs. They will actually see a decrease in bills, estimated to average roughly $40 per month, due to provisions in the 100% Act that will limit energy expenses for eligible low-income households to no more than 6% of gross income.
- The costs of the affordability program for low-income households above present assistance are not included. They are transfers among Marylanders with no direct net fiscal impact. The social benefits of reducing bills of eligible households are the same order of magnitude as the direct cost of limiting bills to 6% of gross income. Just the added costs of homelessness and emergency medical care resulting from energy-bill/rent conflicts are roughly half the added assistance cost. This does not include the economic and social impact on productivity, health, and income on two-thirds of the families who lose their homes but move in with friends or family.[13] In addition, families who do stay in their homes will experience better health, better school and work performance, fewer emergency room visits, and more social stability. Those savings are also not included. Finally, the cost of the affordability program will be reduced due to implementation of EmPOWER efficiency improvements in low-income households and when these households acquire solar energy. The 100% Act's Megawatt Block Program has a $60 million provision for assisting low-income households to participate in community solar installations.

Figure 10 shows the overall monthly average impact of the 100% Act on households, including the fiscal stimulus due to added jobs.

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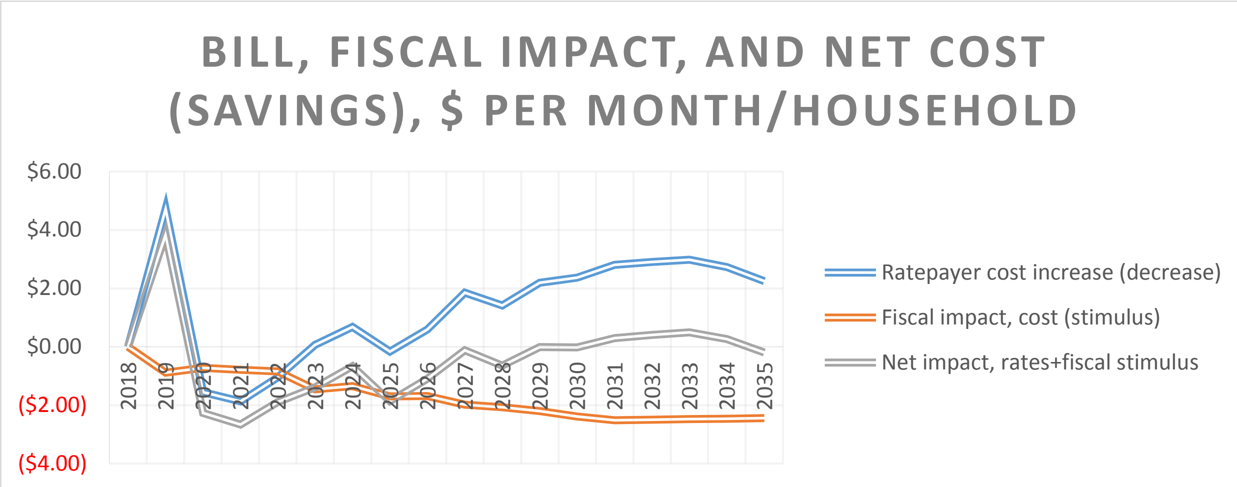
[12] *Long-term Electricity Report for Maryland*, Department of Natural Resources, December 2016, Table K-1, p. K-1. On the Web at http://dnr.maryland.gov/pprp/Documents/LTER-December-2016.pdf

[13] For a detailed discussion see Arjun Makhijani, Christina Mills, and Annie Makhijani. *Energy Justice in Maryland's Residential and Renewable Energy Sectors*. Takoma Park: Institute for Energy and Environmental Research, 2015. See Chapters VIII and IX.

Figure 10: Bill, fiscal stimulus, and combined bill and fiscal impact per household per month



The fiscal impact results in a net revenue increase for the state and hence its residents. This can be represented as a positive stimulus for households (directly and indirectly) in the same way as other state spending. Figure 10 shows that the added cost to ratepayers per month is, overall, more than offset by the fiscal stimulus created by the large number of added jobs. Further, the additional fiscal impact (stimulus) created by induced jobs is not included; the positive impacts are therefore larger that shown.

Figure 9 and 10 are *average* costs (or savings) per month. There will be significant variation among households depending on how intensively they implement energy efficiency, whether they acquire solar energy (and if so how much), and the extent to which they participate in smart grid activities. As noted, low-income households will be insulated from any negative impacts.

E. Electricity system details

Figure 11: Composition of renewable generation

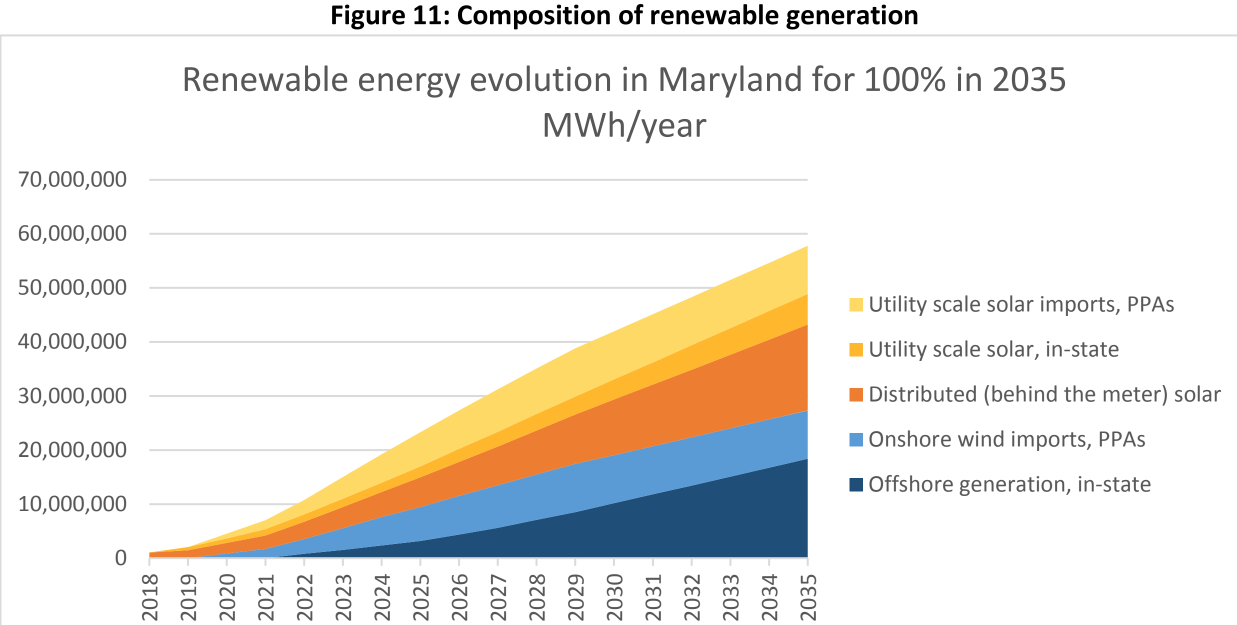


Figure 12: Megawatt block sizes. Block 1 has the highest rebate

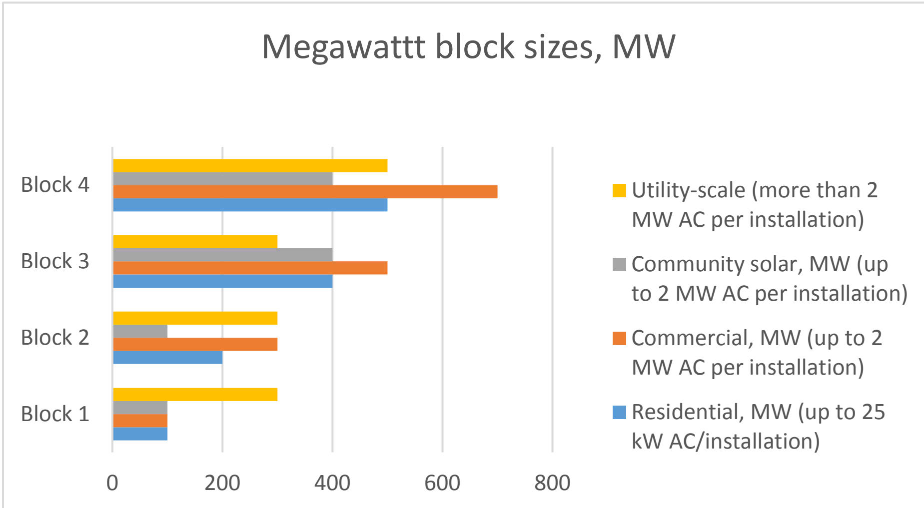
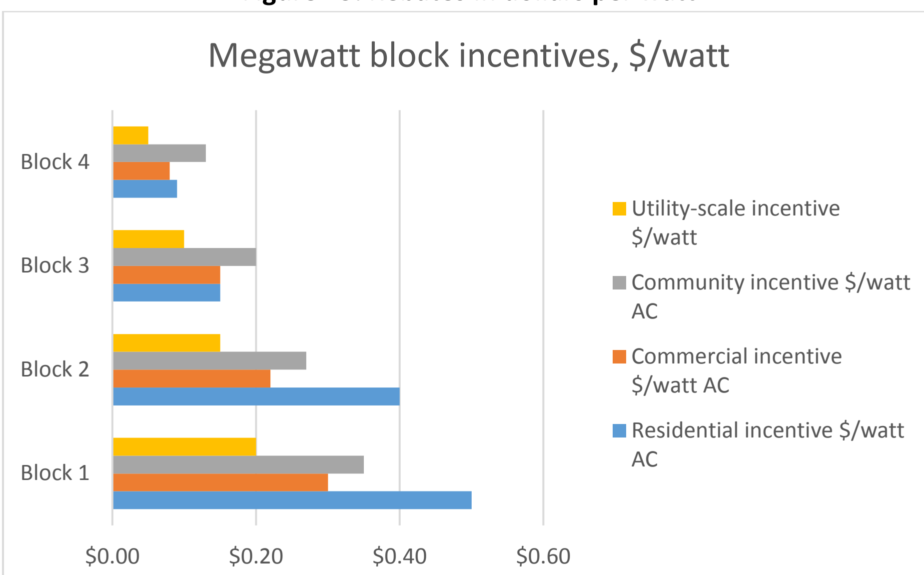


Figure 13: Rebates in dollars per watt



- Community solar rebates are $0.05 per watt more than commercial scale. The additional funds are intended to support low-income households to purchase solar installations or to reduce their cost of solar energy if they choose not to purchase. The total amount dedicated to low-income household solar acquisition or energy cost discounts is $60 million.

F. Summary

1. Weighted average impact on ratepayer is estimated at about $1.50 per month (rounded up to the nearest $0.50) when averaged over the whole period (undiscounted) and about $1 (rounded up) when discounted @3%. There are net savings in the early years except 2019. Cost increases peak at about $3 per month per household in the early 2030s and decline after that to about $2/month in 2035. Under the 100% Act, low income households are protected against cost increases (see below).

2. Jobs would increase steadily to about 12,000 in 2035. These are direct and supply chain jobs. In addition, there would be induced jobs – caused by the economic stimulus of the investment and added jobs.
3. The increased jobs will result in increased tax revenues (income, sales, and use taxes). The stimulus of these revenues will more than offset the ratepayer impact when averaged over the whole period.
4. The above impacts do not include the investment by private parties in distributed solar. They also do not take into account any costs associated with carbon dioxide emissions. When the social cost of carbon and private investment in distributed solar are included, there is a net cumulative gain (savings) of about $1.5 billion (discounted total, discount rate of 3%). This amounts to a savings of about $1.30 per household per month. Moderate estimates of EPA social carbon costs were used (@3% discount rate).
5. From a ratepayer perspective, the cumulative discounted savings are over $8 billion, when the carbon costs are taken into account. The ratepayer does not see the costs of distributed solar investment, but does see the cost represented by the Megawatt Block rebates.
6. Damage from severe climate events is already occurring. For instance, Congress appropriated about $52 billion to assist in relief following Hurricanes Irma, Harvey, and Maria and the western wildfires in 2017. Another $81 billion has been proposed. Maryland's share of these two totals about $2.5 billion. In addition, Maryland is suffering its own damage, for instance from rising sea levels. This damage can be compared to the social cost of carbon of $1.1 billion per year under business-as usual that we have used. This indicates that at levels of damage that are already occurring, a much higher social cost of carbon, and thus a much higher estimate of savings from reduced damage, would be justified.
7. There is a provision in the cost estimates of $45 million in annual payments for legacy solar installations for 5 years to compensate for solar RECs that owners would not be able to sell within Maryland. They could still sell them to other states.
8. The MW block program starts in 2019 to give a short-term boost to the solar industry that is needed to offset the collapse of SREC prices.
9. The costs of limiting bills of low-income households are not included. These are transfers among Marylanders and have no direct net impact. Moreover, the indirect positive impacts (non-energy benefits) are immense. They are protected from the rate and bill impacts under the 100% Act. They would actually see an increase in energy bill assistance of about $40 per month. We assume these funds will come from sources other than ratepayers, since the benefits accrue to society at large, and also to specific groups such as health insurance companies, landlords, etc.[14]

[14] See Chapter IX of Makhijani, Mills, and Makhijani 2015. See also pp. 102-106 for a discussion of the issue of possible non-ratepayer sources of revenue for such a program.