International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2017, 7(6), 112-118.

Incorporating Risk in Analysis of Tax Policies for Solar Power Investments

Thomas R. Harris*†

Department of Economics, University of Nevada, Reno, Reno, NV 89557, USA. *Email: harris@unr.edu

ABSTRACT

Often changes in federal and state tax policies for solar investments are made with little if any concern of risk or variabilities in input or output prices. Tax policy analysis such as the investment tax credit are often analyzed as single data point not as a range of possible net returns. Tax policy analysis for solar investments must analyze impacts of potential federal or state tax credits that not only have the highest positive net returns under average conditions but also yield highest net returns under unfavorable conditions. This article discusses incorporation of risk for tax policy analysis and the use of Monte Carlo simulation to complete a tax policy analysis and provide a range of potential outcome from alternative policies.

Keywords: Solar Energy, Solar Tax Credits, Monte Carlo Simulation
JEL Classifications: H25

† †This material is based in part upon work supported by the National Science Foundation under grant number IIA-1301726 and the White Pine County Commissioners.

1. INTRODUCTION

According to the U. S. Environmental Protection Agency (2017), the largest contributor to U. S. greenhouse gas emissions in 2015 was electricity production at 29% followed by transportation at 27%, and overall industrial output at 21%. Approximately 67% of the nation's electricity is produced from the burning of fossil fuels, which causes these high greenhouse gas emissions (U.S. Environmental Protection Agency, 2017). At the state level, Nevada alone consumed 317.0 trillion Btu's of electric energy in 2015 of which natural gas and coal are the top two sources of energy to produce electricity with 218.7 and 29.8 trillion Btu's, respectively. The rest of Nevada's electric energy is provided by hydroelectric, geothermal, solar and wind energy generation (U.S. Energy Information Administration, 2017).

In order to address greenhouse gas emissions in the state of Nevada, the state adopted the Renewable Portfolio Standard (RPS), requiring for 25% of "electricity sold by an electric utility to retail customers to come from renewable sources" by 2025. However, half of said 25% can come from measures taken to save energy (State of Nevada Public Utility Commission, 2015). As a state, Nevada enjoys an abundance of cloud-free days and could efficiently generate a significant amount of electricity for solar power facilities. Because of these natural advantages, Nevada has everything to gain economically from an industry that not only satiates its own RPS energy requirements, but also creates opportunity for energy exportation. As many states have similar RPS regulations, Nevada is in a prime position to supply a rising demand.

In order to spur solar energy investment and development in the state of Nevada, three tax abatement programs at the federal and state of Nevada level have been employed. Federal programs such as investment tax credit (ITC) and the modified accelerated cost recovery system (MACRS) programs are used to enhance feasibility of solar investments. For the state of Nevada, there is a property tax abatement program where property taxes for solar investments are abated 55% for 20 years.

However, the economic efficiency and viability of these tax programs for solar investments have been controversial. Loris and Tubb (2016) argue that ITC does not make solar energy less expensive. Instead, ITC just transfers the costs of these projects to the public. In addition, ITC remove incentives for solar companies to become more efficient and build better business models that actually could reduce costs. In summation, opponents of these tax policies such as ITC, MACRS, and state property tax abetments for solar investments suggest that market forces should determine energy mix and should not be the responsibility of government.

Proponents of tax credits for solar investments suggest that tax policies such as ITC is one of the most important federal policies to support development of solar energy in U.S. (Solar Energy Industries Association, 2017). ITC was up for extension in 2015 and proponents of ITC suggest that this tax policy provides market certainty to long-run solar investments. With market certainty, proponents assert future market competition and technology innovations in the solar industry will be enhanced which will ultimately yield lower customer costs and reduce the carbon footprint.

Analysis of policy changes such as ITC and other tax programs for solar investments are often analyzed with certainty. Manski (2013) would argue that crafting and analyzing tax policies under certitude does not include uncertainty that exists with short-run and long run forecasts. Manski's principle is to shift analysis of impacts of government programs such as changes in tax code from "incredible certitude" to "credible interval scoring." By introducing principles of "credible interval scoring," risk is introduced into the analysis of tax policies, which is often ignored. Given the current variability in the economy, inclusion of risk into public policies such as ITC has become a valid component (Manski, 2012). Therefore, the primary objective of this paper is to investigate processes that allow Manski's "credible interval scoring" for tax policies for solar investment in the state of Nevada. Specific objectives are:

1. To discuss applications of risk in the analysis of public policies such as ITC and other tax policies,
2. To review the example solar investment project, and
3. To complete a risk analysis of tax policies for solar investment.

2. MONTE CARLO SIMULATION FOR ANALYSIS OF TAX PROGRAMS

Deterministic tax policy analysis of solar investments often ignore price and cost variability and do not incorporate risk. This type of "incredible certitude" provides only a point estimate of key output variables (KOVs). "Credible internal scoring" provides probability distributions of KOV's, which is necessary for effective and efficient tax policy analysis (Pouliquen, 1970; Reutlinger, 1970; Hardaker et al., 2004). Pouliquen (1970) indicates the benefits of Monte Carlo simulation are that it provides decision-makers the extreme values of KOVs and their relative probabilities along with a weighted estimate of the relationships between unfavorable and favorable outcomes. In addition to the risk analysis and how it affects potential solar investments, Pouliquen (1970) suggests that the complete feasibility simulation can be used to analyze alternative tax programs and policies.

Easy to use simulation add-ons for Excel, such as Semitar, @ Risk, and Crystal Ball, are available to convert deterministic Excel spreadsheet models into Monte Carlo simulation models. For this paper, the add-on Excel Semitar package will be used (Richardson et al., 2006b). The Semitar program allows investigators to ask "what if" questions for alternative income tax credit policies.

Richardson (2006a) outlined steps in developing Monte Carlo simulation analysis of policy analysis. First probability distributions for all risky variables must be defined, parameterized, simulated and validated. Second, the stochastic variables from the probability distributions are used in the accounting equations to calculate production, receipts, costs, cash flows, and balance sheet variables for the analysis. Stochastic values sampled from the probability distributions make the financial statement variables stochastic. Third, the completed stochastic model is simulated many times (i.e. 1000 iterations) using random values for the risky variables. The results of the 1000 samples provide the information to estimate empirical probability distributions for unobservable KOVs; such as, present value of end net worth, net present value, and annual cash flows, so policymakers can evaluate the probability of success for proposed tax policies. Fourth, the analysis uses stochastic simulation model to analyze tax policies, and provide the results to the policy makers in the form of probabilities and probabilistic forecasts for the KOVs.

Viscusl (1972) investigated the use of Monte Carlo simulation and stochastic dominance for evaluation of public policies. He found procedures for public investments are similar to private investments. However if expenditures for the investment are correlated to existing government's fiscal balances, these existing government fiscal balances need to be included in the risk analysis.

For this paper, the Monte Carlo simulation analysis will provide a range of potential results for proposed income tax abatement policies. The complete simulation model will be simulated many times (i.e.; 1000 times) using random variables. The empirical probability distributions for the KOVs will be for the internal return from alternative tax abatement programs. From the KOVs' distribution, policy makers are provided information as to a range of results from various tax abatement programs.

3. OVERVIEW OF SOLAR PROJECT

A solar photovoltaic (PV) system investment is being considered for construction in the northeastern Nevada county of white pine. The PV planned system is to be 10 MW facility with the length of analysis being 30 years. Also assumed is that rate of return for investors for the highly competitive energy industry is between 10% and 15%. Usually renewable energy studies estimate annual production, which includes downtime. Following a memo from Bourg (2013), power production for a 10 MW plant in white pine county (Ely TMY weather data) using the National Renewable Energy Laboratory System Advisor Model (SAM) was estimated. Using assumptions from SAM and a default downtime of 4% per year for scheduled maintenance and unscheduled outages, the annual energy production is estimated to be 20,075,482 kWh.

For output prices, the latest benchmark in Nevada for Solar Purchase Price Agreement (PPA) price is $0.09/kWh from the 2011 round of RPS bids. Since PV and concentrated solar power compete with one another, the sales price would be the same for both resources. However, costs have declined for solar projects in the last couple of years and based on what the industry has seen in adjacent states the output price ranges between $0.08/kWh to $0.09/kWh with $0.085/kWh as the mode and with zero annual escalation in PPA prices.

For the deterministic analysis the mode output price will be used which is $0.085/kWh. For stochastic analysis, output prices are simulated using a GRKS probability distribution. The GRKS distribution was named for its developers, Richardson et al. (2007). The distribution is used to simulate random variables with a minimum of information, which are a minimum, a middle value, and a maximum value. The GRKS draws 2.28% of the values below the minimum and 2.28% of the value above the maximum. Random values drawn outside the minimum and maximum values account for low-frequency rare events that could significantly impact a business or what are called Black Swans. The GRKS distribution does not force the minimum or maximum values to be equal distance from the middle so the GRKS can simulate a skewed distribution. For this paper, the GRKS distribution will be employed to estimate random output prices with minimum price of $0.08/kWh, mode price of $0.085/kWh, and the maximum price of $0.09/kWh. The random prices for the model are simulated as a multivariate empirical probability distribution using procedures outlined by Richardson et al. (2000).

The proposed Solar PV plants will be simulated employing three tax policies where two policies are Federal and one from the State of Nevada. The first is a 30% ITC where the plant owner would realize 30% of the plant cost as a tax credit in year 1. The second is the MACRS. MACRS allows solar plants to be depreciated over 5 1/2 years. The first step is to calculate the net basis of depreciation. For the solar PV, it is the total plant cost (including interconnection equipment and transmission lines) minus the one-half times the 30% ITC. This net basis is then depreciated according to the following schedule, which is year 1 at 20%, year 2 at 32%, year 3 is 19.2%, year 4 is 11.52%, year 5 is 11.52%, and year 6 is 5.76%. The third mechanism is from the state of Nevada. This is a property tax abatement of 55% for 20 years for the solar PV system. This property tax abatement will be employed because the hypothetical system is a 10 MW system and qualifies. However, there may be additional requirements for the property abatements under NRS 701A.360 that an actual project needs to consider.

The estimated plant and transmission line cost is assumed to be $26,740,930. It is assumed for the hypothetical plant with a five-mile transmission line to the interconnection point. An inverter replacement cost of $2,500,000 will be accounted for in year 15.

For land purchased, it is assumed 40 acres of land purchased at $2,500 per acre, for land cost of $100,000. For plant investment, it is assumed 30% down or $8,022,279 with the remainder of the debt financed. The length of loan will be 20 years with an interest rate of 5.5%.

Annual variable cost, which includes production, based O&M cost plus insurance will be $230,000. Also assumed is an annual inflation rate of 2%. Federal taxes are included as 35% of income. The corporate owner/tax equity partner was assumed to fully utilize tax credits, depreciation, and tax losses.

For feasibility analysis, internal rate of return (IRR) for the solar PV system investments will be estimated. IRR estimates the rate of interest, which equates the net present value of a projected series of cash flow payments to zero. IRR can be used to rank investments and accept or reject invests based on their IRR. Acceptability of the solar system investment depends upon comparison of its IRR with the investor has required rate of return (RRR). For this feasibility analysis, the RRR has to be between 10% and 15%. Acceptability is based on the following decision rules, which is if IRR exceeds RRR, investment is accepted, or if IRR equals RRR, then investment is indifferent, or IRR less RRR, the investment is rejected.

The owner is assumed to require a 10-15% rate of return from the project. Therefore, for this analysis, an investment will be considered acceptable if its IRR is >10-15%.

4. PRO FORMA INCOME STATEMENT FOR SOLAR PV SYSTEM

Table 1 show year 1 Pro Forma Income Statement for the deterministic analysis where output price is held constant at $0.085/kWh for each year of the 30-year feasibility. The solar PV system generates the following revenues and cost for year 1.

Table 1: Year one pro forma income statement

Item	($1,000)
Revenue/expense line item	
Electric sales	1,706.4
Other sales	0.0
Total revenues	1,706.4
Variable cost	230.0
Property tax	154.7
Total operating expense	384.7
Operating income	1,321.7
Interest	1,035.0
Depreciation	4,546.0
Pre-tax income	−4,259.3
Taxes	−9,513.0
Net income (book)	5,253.7
Project cash flow and benefits	
Pretax income	−4,259.3
+Book depreciation	4,546.0
−Loan principal	539.7
Pretax cash flow	−253.0
Taxes/credits	
Federal taxes	−1,490.8
Less federal tax credits	−8,022.3
Net taxes	9,513.0
Net cash flows	
Operating pretax cash flow	−253.0
State credits/grants	0.0
Federal credits/taxes	9,513.0
Total cash flow benefit	9,260.0

Table 2: 30-year pro forma income statement for deterministic model for solar investment

Category	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Revenues											
Electric sales		1,706.4	1,706.4	1,706.4	1,706.4	1,706.4	1,706.4	1,706.4	1,706.4	1,706.4	1,706.4
Total revenue		1,706.4	1,706.4	1,706.4	1,706.4	1,706.4	1,706.4	1,706.4	1,706.4	1,706.4	1,706.4
Expenses											
Variable costs		230.0	234.6	239.3	244.1	249.0	253.9	259.0	264.2	269.5	274.9
Property taxes		154.7	131.5	111.8	95.0	80.8	68.7	58.4	49.6	42.2	35.8
Total operating expenses		384.7	366.1	351.1	339.1	329.7	322.6	317.4	313.8	311.6	310.7
Operating income		1,321.7	1,340.3	1,355.3	1,367.3	1,376.7	1,383.8	1,389.0	1,392.6	1,394.8	1,395.7
Interest		1,035.0	1,005.3	974.0	941.0	906.1	869.4	830.6	789.6	746.5	700.9
Depreciation		4,546.0	7,273.5	4,364.1	2,618.5	2,618.5	1,309.2	0.0	0.0	0.0	0.0
Pretax income		−4,259.3	−6,938.6	−3,982.8	−2,192.1	−2,147.9	−794.8	558.5	603.0	648.3	694.8
Taxes		−9,513.0	−2,428.5	−1,394.0	−767.2	−751.8	−278.2	195.5	211.0	226.9	243.2
Net income - book		5,253.7	−4,510.1	−2,588.8	−1,424.9	−1,396.1	−516.6	363.0	391.9	421.4	451.6
Project cash flow and benefits											
Pretax income		−4,259.3	−6,938.6	−3,982.8	−2,192.1	−2,147.9	−794.8	558.5	603.0	648.3	694.8
Plus: Book depreciation		4,546.0	7,273.5	4,364.1	2,618.5	2,618.5	1,309.2	0.0	0.0	0.0	0.0
Less: Loan principal		539.7	569.4	600.7	633.7	668.6	705.4	744.2	785.1	828.3	873.8
Pretax cash flow		−253.0	−234.4	−219.4	−207.4	−198.0	−190.9	−185.7	−182.1	−180.0	−179.0
Taxes/credits											
Federal taxes		−1,490.8	−2,081.6	−1,194.8	−657.6	−644.4	−238.4	167.5	180.9	194.5	208.4
Less: Federal tax credits		8,022.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Net taxes		9,513.0	2,081.6	1,194.8	657.6	644.4	238.4	−167.5	−180.9	−194.5	−208.4
Net cash flow											
Capital investment	−26,840.9										
Amount to finance	18,818.7										
Operating pretax cash flow		−253.0	−234.4	−219.4	−207.4	−198.0	−190.9	−185.7	−182.1	−180.0	−179.0
State credits/grants	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Federal credits/taxes	0.0	9,513.0	2,081.6	1,194.8	657.6	644.4	238.4	−167.5	−180.9	−194.5	−208.4
Total cash flow benefit	−8,022.3	9,260.0	1,847.1	975.4	450.2	446.3	47.5	−353.2	−363.0	−374.5	−387.5
Cumulative pretax cash flow		−253.0	−487.5	−706.9	−914.3	−1,112.3	−1,303.2	−1,485.3	−1,667.5	−1,847.4	−2,026.4
Cumulative after tax		9,260.0	11,107.1	12,082.6	12,532.8	12,979.1	13,026.7	12,673.4	12,310.4	11,936.0	11,548.5

Category	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Revenues										
Electric sales	1,706.4	1,706.4	1,706.4	1,706.4	1,706.4	1,706.4	1,706.4	1,706.4	1,706.4	1,706.4
Total revenue	1,706.4	1,706.4	1,706.4	1,706.4	1,706.4	1,706.4	1,706.4	1,706.4	1,706.4	1,706.4
Expenses										
Variable costs	280.4	286.0	291.7	297.5	303.5	309.5	315.7	322.1	328.5	335.1
Property taxes	30.5	25.9	22.0	18.7	15.9	13.5	11.5	9.8	8.3	7.1
Total operating expenses	310.8	311.9	313.7	316.2	319.4	323.1	327.2	331.8	336.8	342.1
Operating income	1,395.6	1,394.5	1,392.7	1,390.2	1,387.0	1,383.4	1,379.2	1,374.6	1,369.6	1,364.3
Interest	652.8	602.1	548.6	492.2	432.7	369.9	303.6	233.7	159.9	82.1
Depreciation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pretax income	742.8	792.4	844.1	898.0	954.4	1,013.5	1,075.6	1,140.9	1,209.7	1,282.2
Taxes	260.0	277.3	295.4	314.3	334.0	354.7	376.5	399.3	423.4	448.8
Net income - book	482.8	515.1	548.6	583.7	620.3	658.8	699.1	741.6	786.3	833.4
Project cash flow and benefits										
Pretax income	742.8	792.4	844.1	898.0	954.4	1,013.5	1,075.6	1,140.9	1,209.7	1,282.2
Plus: Book depreciation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Less: Loan principal	921.9	972.6	1,026.1	1,082.5	1,142.1	1,204.9	1,271.2	1,341.1	1,414.8	1,492.6
Pretax cash flow	−179.1	−180.2	−182.0	−184.6	−187.7	−191.4	−195.5	−200.1	−205.1	−210.4
Taxes/credits										
Federal taxes	222.8	237.7	253.2	269.4	286.3	304.0	322.7	342.3	362.9	384.7
Less: Federal tax credits	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Net taxes	−222.8	−237.7	−253.2	−269.4	−286.3	−304.0	−322.7	−342.3	−362.9	−384.7
Net cash flow										
Capital investment										
Amount to finance										
Operating pretax cash flow	−179.1	−180.2	−182.0	−184.6	−187.7	−191.4	−195.5	−200.1	−205.1	−210.4
State credits/grants	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Federal credits/taxes	−222.8	−237.7	−253.2	−269.4	−286.3	−304.0	−322.7	−342.3	−362.9	−384.7
Total cash flow benefit	−402.0	−417.9	−435.2	−453.9	−474.0	−495.4	−518.2	−542.4	−568.0	−595.1
Cumulative pretax cash flow	−2,205.6	−2,385.8	−2,567.8	−2,752.3	−2,940.0	−3,131.4	−3,327.0	−3,527.1	−3,732.2	−3,942.7
Cumulative after tax	11,146.5	10,728.6	10,293.4	9,839.4	9,365.4	8,870.0	8,351.8	7,809.3	7,241.3	6,646.2

(Contd...)

Table 2: (*Continued*)

	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Total
Revenues											
Electric sales	1,706.4	1,706.4	1,706.4	1,706.4	1,706.4	1,706.4	1,706.4	1,706.4	1,706.4	1,706.4	51,192.5
Total revenue	1,706.4	1,706.4	1,706.4	1,706.4	1,706.4	1,706.4	1,706.4	1,706.4	1,706.4	1,706.4	51,192.5
Expenses											
Variable costs	341.8	348.6	355.6	362.7	369.9	377.3	384.9	392.6	400.4	408.4	9,330.7
Property taxes	13.3	11.3	9.6	8.2	7.0	5.9	5.0	4.3	3.6	3.1	1,062.9
Total operating expenses	355.1	359.9	365.2	370.9	376.9	383.3	389.9	396.9	404.1	411.5	10,393.5
Operating income	1,351.3	1,346.5	1,341.2	1,335.5	1,329.5	1,323.2	1,316.5	1,309.6	1,302.3	1,294.9	40,799.0
Interest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12,676.0
Depreciation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22,729.8
Pretax income	1,351.3	1,346.5	1,341.2	1,335.5	1,329.5	1,323.2	1,316.5	1,309.6	1,302.3	1,294.9	5,393.2
Taxes	473.0	471.3	469.4	467.4	465.3	463.1	460.8	458.3	455.8	453.2	−6,134.7
Net income - book	878.4	875.2	871.8	868.1	864.2	860.1	855.7	851.2	846.5	841.7	11,527.8
Project cash flow and benefits											
Pretax income	1,351.3	1,346.5	1,341.2	1,335.5	1,329.5	1,323.2	1,316.5	1,309.6	1,302.3	1,294.9	5,393.2
Plus: Book depreciation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22,729.8
Less: Loan principal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18,818.7
Pretax cash flow	1,351.3	1,346.5	1,341.2	1,335.5	1,329.5	1,323.2	1,316.5	1,309.6	1,302.3	1,294.9	9,304.3
Taxes/credits											
Federal taxes	405.4	403.9	402.4	400.7	398.9	396.9	395.0	392.9	390.7	388.5	1,405.0
Less: Federal tax credits	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8,022.3
Net taxes	−405.4	−403.9	−402.4	−400.7	−398.9	−396.9	−395.0	−392.9	−390.7	−388.5	6,617.3
Net cash flow											
Capital investment											
Amount to finance											
Operating pretax cash flow	1,351.3	1,346.5	1,341.2	1,335.5	1,329.5	1,323.2	1,316.5	1,309.6	1,302.3	1,294.9	9,304.3
State credits/grants	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Federal credits/taxes	−405.4	−403.9	−402.4	−400.7	−398.9	−396.9	−395.0	−392.9	−390.7	−388.5	6,617.3
Total cash flow benefit	945.9	942.5	938.8	934.9	930.7	926.2	921.6	916.7	911.6	906.4	7,899.3
Cumulative pretax cash flow	−2,591.3	−1,244.9	96.4	1,431.9	2,761.4	4,084.6	5,401.1	6,710.6	8,013.0	9,307.9	
Cumulative after tax	7,592.1	8,534.7	9,473.5	10,408.4	11,339.1	12,265.3	13,186.8	14,103.5	15,015.2	15,921.6	

As shown in Pro Forma Income Statement (Table 1), the project generates a year 1 revenue stream of approximately $1,706.4 thousand, of which $384.7 thousand is used to pay operations, maintenance, and property taxes. This leaves net operating income of $1,321.7 thousand prior to application of depreciation, payment of long-term debt, and taxes. The total after tax cash flow benefit is $9,260.0 thousand in year one. A 30-year pro forma scenario for the deterministic model is presented in Table 2. At a price of $0.085/kWh for each year of the thirty-year feasibility, the project's IRR was estimated to be 35.59%, which exceeds the needed rate of return, by investors of between 10% and 15%. However, analysis of tax policies with only mean or mode prices does not address price variability that occurs in the market. This is an example of analysis of tax policies under "incredible certitude" which is somewhat incomplete.

5. STOCHASTIC ANALYSIS OF SOLAR INVESTMENT AND ALTERNATIVE TAX POLICIES

The stochastic analysis with price variability and using Monte Carlo simulation is an example of Manski's "credible interval scoring" for analysis of changes in tax policy. For the stochastic analysis, the GRKS distribution was employed with price ranging from $0.08/kWh at the minimum, $0.085 kWh at the mode, and $0.09/kWh at the maximum. Figure 1 shows range of internal rates of return with an average rate of return of 39.59%, a minimum of 37.99%, and a maximum of 41.15%. For the investor, Figure 1 shows that for all output prices the minimum IRR of 10-15% is met and exceeded. The range of results from the cumulative density function (CDF) represent "credible interval scoring" of federal and state tax policies and provides decision markers with a range of results for their analysis.

Figure 2 shows the results of a similar Monte Carlo simulation of a solar investment in White Pine County but ITC is removed while MACRS and the state property tax rebate is still included. Figure 2 shows range of internal rates of return with an average rate of return of −0.08%%, a minimum of −0.49%, and a maximum of 0.35%. Simulation results show only 23% of the time would the Monte Carlo simulation without ITC yield positive IRR. Also importantly, results of the simulation run show the IRR never met the investors' requirement of 10% to 15% return. The range of the CDF show the impacts if ITC on the potential feasibility of the solar investment.

Figure 3 shows the results of the Monte Carlo simulation of a solar investment in White Pine County, Nevada where all tax credits are removed. The range of IRR shown in Figure 3 range from a minimum of −0.67%, average of −0.40%, and maximum of −0.13%. Simulation results show for this solar investment simulated over 1,000 times never realizes a positive IRR. As with the elimination of ITC, results of the Monte Carlo simulation without tax credits shows IRR that never meets the investors required 10% to 15% return. As mentioned earlier, proponents

Figure 1: Cumulative density function for stochastic simulation for internal rate of return for solar photovoltaic investment

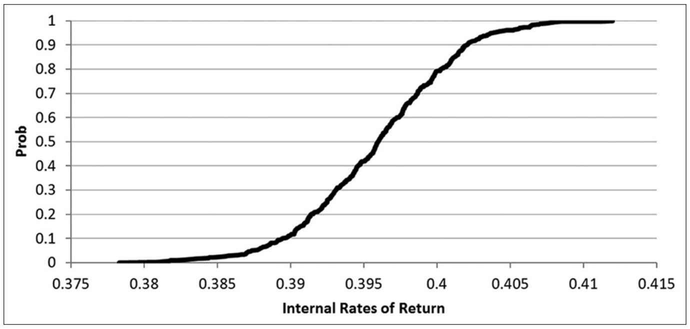


Figure 2: Cumulative density function for stochastic simulation for internal rate of return for solar photovoltaic investment without investment tax credits

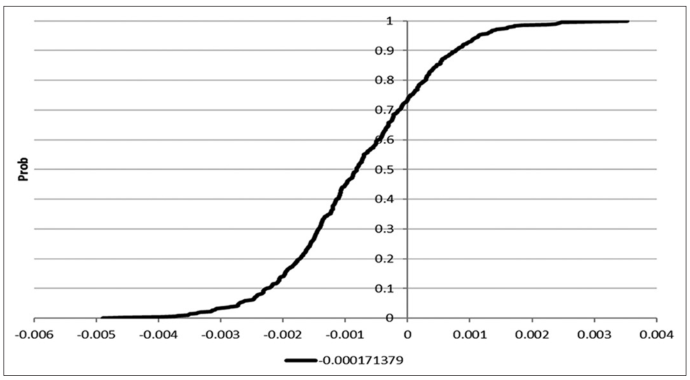
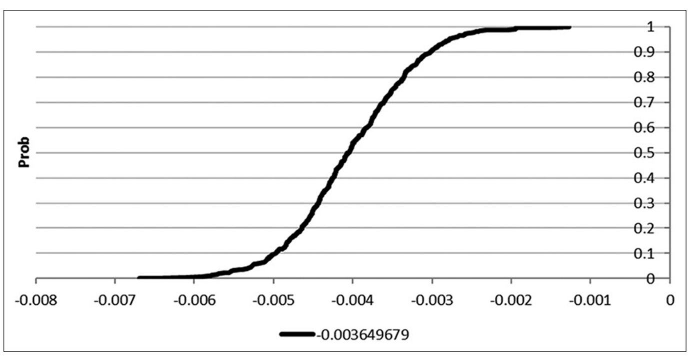


Figure 3: Cumulative density function for stochastic simulation for internal rate of return for solar photovaltic investment with no tax abatements



of tax credits for solar investments provide market certainty for long-run solar power technology investments. It seems that results of the Monte Carlo simulation from a range of possible prices that these tax credit policies both federal and state provide this market certainty. Without these tax credits, technology advances for solar investments may be retarded.

6. CONCLUSIONS

The purpose of this paper was to demonstrate the usefulness of Monte Carlo simulation for evaluating federal and state policies. This follows tax policy analysis as proposed by Manski (2013) where it is by "credible interval scoring" not "incredible certitude." Stochastic values for output were incorporated in the solar power investment model thus facilitating a simulation risk analysis of alternative federal and state tax policies.

The greatest benefit of Monte Carlo simulation feasibility analysis is the methodology explicitly incorporates risk faced by decision makers. By incorporating probability for variables that solar power investors cannot forecast with certainty, the analyst can develop realistic probability forecasts of KOVs. Additional benefits of the methodology include policy makers' ability to see range of KOVs as well as the probabilities of unfavorable outcomes. Charts and probabilities, which can more accurately portray the probable outcomes of alternative federal and state tax policies than a single-point estimate, can be used to convey risky outcomes to policy makers. These charts and probabilities are particularly useful when the inherent risk in proposed tax policy causes the KOV distribution to be skewed left or right or change over time. A federal or state tax policy for a solar investment based only on average values is inherently risky and may give policy makers and the public unrealistic confidence in the proposed federal or state tax policy change. A stochastic analysis shows a range of potential outcomes, which provides policy makers and the public confidence, or realistic skepticism of proposed federal and state tax policies.

REFERENCES

Bourg, J. (2013). "Personal Conversations for Feasibility Analysis for Solar Photovoltaic". Millennium Energy, LLC: Golden, Colorado.

Hardaker, J., R. Huirne, J. Anderson, and G. Lien. Coping with Risk in Agriculture. CABI Publishing: Wallingford, Oxfordshire, U.K., 2004.

Loris, N. and K. Tubb (2016). "Allow Energy Tax Credits to Expire", Heritage Foundation Backgrounder No. 3164, Available from http://www.heritage.org/enviroment/report/allow-energy-tax-credits-expire.

Manski, C. (2012). "Identification of Preferences and Evaluation of Income Tax Policy." National Bureau of Economic Research Working Paper, w17755.

Manski, C. (2013). *Public Policy in an Uncertain World: Analysis and Decisions*. Cambridge, Massachusetts: Harvard University.

Pouliquen, L. (1970). "Risk Analysis in Project Appraisal". World Bank Staff Occasional Paper (11), International Bank of Reconstruction and Development, The John Hopkins University Press.

Reutlinger, S. (1970). "Techniques for Project Appraisal Under Uncertainty" World Bank Staff Occasional Paper (10), International Bank of Reconstruction and Development, The John Hopkins University Press.

Richardson, J., S. Klose, A. Gray. (2000). "An Applied Procedure for Estimating and Simulating Multivariate Empirical (MVE) Probability Distributions in Farm-Level Risk Assessment and Policy Analysis". *Journal of Agricultural and Applied Economics,* 32: 295-315

Richardson, J. (2006a). "Simulation for Applied Risk Management". Unnumbered Staff Report, Department of Agricultural Economics, Agricultural and Food Policy, Texas A&M University, College Station, Texas.

Richardson, J. (2006b). "Simetar: Simulation Econometrics to Analyze Risk". Department of Agricultural Economics, Texas A&M University, College Station, Texas.

Richardson, J., B. Herbst, J. Outlaw, and R. Gill. (2007). "Including Risk in Economic Feasibility Analysis: The Case of Ethanol Production in Texas". *Journal of Agribusiness***,** 25:115-132.

State of Nevada Public Utility Commission. (2015). Renewable Portfolio Standard. Carson City, Nevada. Available from http://puc.nv.gov/Renewable_Energy?Portfolio_Standarad/.

Solar Energy Industries Association. (2017). "SOLAR ITC 101", ITC Fact Sheet, Washington, D.C. Available from http://www.seia.org/research-resources/impacts-solar-investment-tax-credits-extension.

U.S. Environmental Protection Agency. (2017). *Inventory of U.S. Greenhouse Gas and Emissions and Sinks: 1990-2015*. Washington, D.C., EPA 430-P-17-001, Available from http://www.epa.gov/sites/production/files/2017-02/documents/2017_complete_reports.pdf.

U. S. Energy Information Administration. (2017). *State Energy Data System (SEDS): 1960-2015*. Washington, D.C. Available from www.eia.gov/state/seds/seds-data-complete.php?sid=US#Consunption.

Viscusl, W. (1972). "Extending the Application of Dominance Decision Rules". Santa Monica, CA: RAND.