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# Small-Scale Solar Photovoltaic Investment: Payback Periods, Net Present Value, and the Impact of EPA 111(D)

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# Small-Scale Solar Photovoltaic Investment: Payback Periods, Net Present Value, and the impact of EPA 111(D)

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By

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# Abstract

Increasingly, states are using policy and incentive to promote the development of small-scale distributed solar energy generation systems (DG). Net metering is the most common state policy approach (enacted by 46 states), but various states have also enacted other incentives and different approaches to net metering. Investments with faster payback periods are more attractive to investors. In this study we analyze five different state approaches at various projected electricity cost escalation rates with respect to the payback periods for a 5-kilowatt (kW) DG. We also weigh the potential impact that proposed United State Environmental Protection Agency (EPA) regulations to 111(d) of the Clean Air Act may have on payback periods. Using the National Renewable Energy Laboratory's (NREL) System Advisor Model (SAM), we compared the payback periods and net present value of investments (NPV) in each of the respective states over a thirty-year period. When holding other variables constant, including the 30% renewable energy federal tax credit, we find a range of payback periods and NPVs affected significantly by state policies and incentives. To a lesser extent we find that cost escalation rates have an inverse relationship with payback periods, and the proposed EPA 111(d) regulations have little to no effect on payback periods.

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# 1. Introduction

Modern society is reliant on electricity. It can be generated in various ways, but solar photovoltaic systems are a renewable source with great potential for expansion at both the residential and commercial level. High upfront costs have been prohibitive in the past for solar investment. Decreasing solar photovoltaic manufacturing costs have substantially dropped their upfront cost in recent years. However, policy and incentive continue to play an important role in the adoption of small-scale solar photovoltaic systems (PVs) (Darghouth et al 2014).

The manufacturing cost of PV decreased 80% between 2008 and 2013 (Maycock 2012). In addition to manufacturing costs, there are “soft costs,” or application fees, processing fees and installation costs among other possible expenses (Salkin 2011).

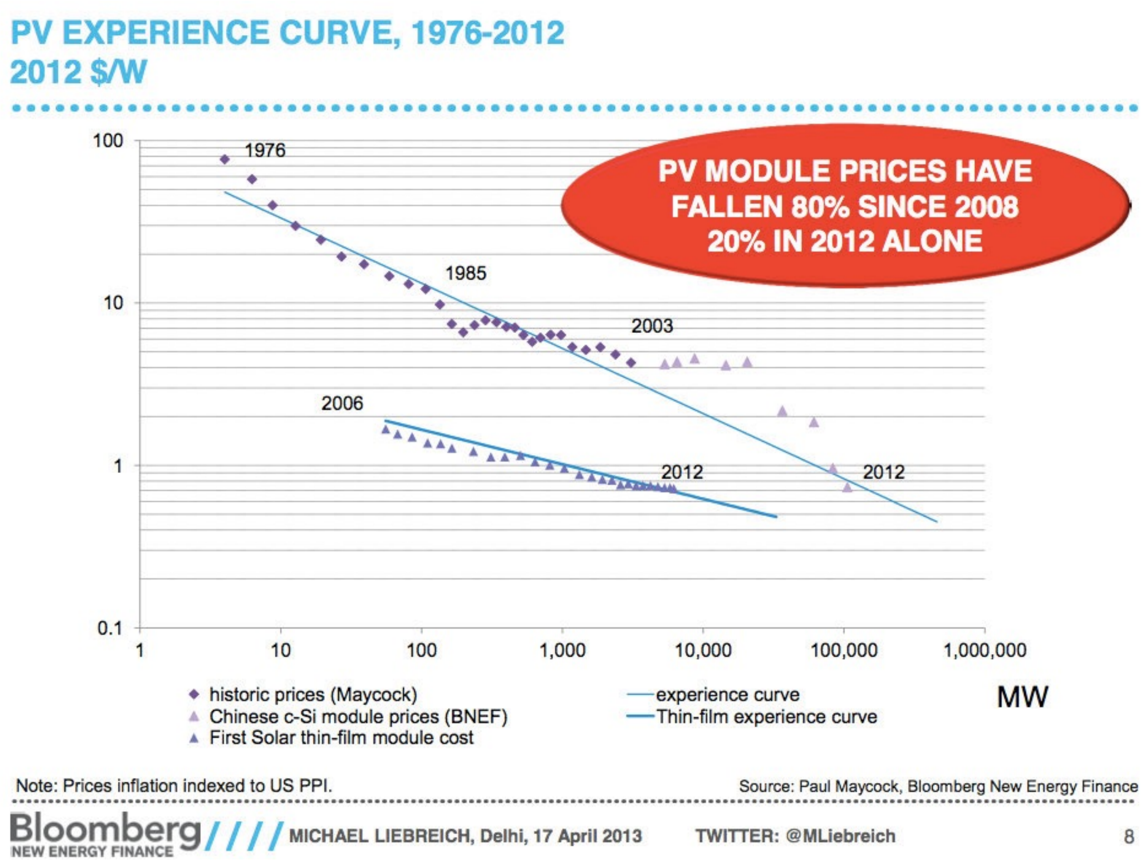


**Figure 1.1:** In 2013, PV manufacturing costs had fallen 80% in six years.

The Public Utilities Regulatory Policies Act (PURPA), passed in 1978 at the federal level, enabled distributed electricity generation systems (DGs) to interconnect to the electricity grid. PURPA mandates that electric utilities must connect to all DGs that comply with interconnection specifications. PURPA also mandates that electric utilities must pay the avoided cost of electricity production per kilowatt-hour (kWh) of excess electricity produced by the DGs, after offsetting the DGs owner's electricity consumption. Additionally there has been a federal renewable investment tax credit of 30% since 2006.

Drawing from the concepts in PURPA, states have demonstrated their policy leadership through the development of Net Metering. Net Metering enables renewable DGs owners to offset the electricity they use with the electricity they produce, effectively paying them retail price for their electricity. This is advantageous for the economic feasibility of renewable DGs such as PV. Net Metering is the most common policy approach amongst the United States to increase the economic feasibility of renewable DGs.

The EPA's proposed regulations to section 111(d) of the Clean Air Act are also impacting the electricity sector. The proposed regulations could be the first federal step to regulate carbon emissions. The electricity industry is preparing for regulations on carbon emissions because the Supreme Court has given the EPA jurisdiction to do so under the Clean Air Act (Utility Air Regulatory Group v. EPA 2014). This is true whether 111(d) is adopted or not.

Though the market for PVs is increasingly attractive, incentive remains necessary to assist PV investors with the upfront costs. Little research is conducted on a regular basis about the current economic outlook of installing PVs. The goal of this thesis is to compare payback periods and net present values with five states' differing approaches to increase PV investments with regard to electricity cost escalation rates, and determine what approaches are most effective. The following sections will provide background information about federal policies, state policies, payback periods, net present values, electricity cost escalation rates, and proposed EPA 111(d) regulations.

## 1.1 Solar Photovoltaic Investment: Federal Policies

The Public Utilities Regulatory Policies Act (PURPA) was established under the National Energy Act in 1978. The electricity industry prior to PURPA was considered a "natural monopoly." PURPA mandated electric utilities to interconnect with non-utility electricity generators, enabling non-utility generators to create electricity through a variety of sources, including PVs. This marked the beginning of the restructuring of the electricity market towards a more competitive model, encouraging new generators. These fundamental changes have shaped the electricity market into what it is today.

The residential renewable energy tax credit was established as part of The Energy Policy Act of 2005 and was later extended by The Energy Improvement and Extension Act of 2008 until January 1, 2017. The investment tax credit is for 30% of the cost of the system and installation. This incentive has been beneficial for businesses and residences because it accounts for almost a third of the system costs. Originally there were limits on the maximum credit amount, but those limits were removed by The American Recovery and Reinvestment Act of 2009. On January 1, 2017, the 30% investment tax credit is currently scheduled to expire for residential PV and decrease to 10% for businesses installing PV.

## 1.2 Net Metering Policy

Forty-four states around the country have implemented net metering policies and two more have utilities voluntarily providing net metering. It the most widely used policy amongst the United States to encourage the development of distributed electrical generation (i.e. PVs) (DSIRE 2015). Net metering is popular because of its favorable political implications: low bureaucratic costs and most of the funding is from private sources (Carley 2009, 2011). Net metering creates a framework where PVs are interconnected to a public or private utility grid through a meter that allows surplus generated electricity to be transferred to the grid, offsetting the costs of power drawn from the utility.

Net metering enables PV owners to offset their power used with power produced by the PV. In addition, PV owners are to be compensated for their excess generation (kWh

produced greater than kWh used) at a minimum of avoided costs. Some state policies' require excess generation to be compensated at the retail rate. Avoided costs has multiple definitions depending on the utility's interpretation of the law, but it generally means avoided cost of fuel (Darghouth, Barbose, Wiser 2011).

States are more likely to adopt net metering policy when neighboring states have adopted net metering (Fremuth 2009). Another geographic influence of state net metering policy may be the states' location relative to the nearest EPA regional office (Stoutenborough and Beverly 2008). One argument against net metering is a DG owner's use of the grid system without fully paying the fees for the grid system. A number of states are considering, or have enacted further net metering legislation to charge DG owners for their use of the electrical grid (NC Clean Energy Technology Center). Uncertainty about the future of net metering policies across the country remains a problem for potential PV owners (Darghouth, Barbose, Wiser 2011, 2014).

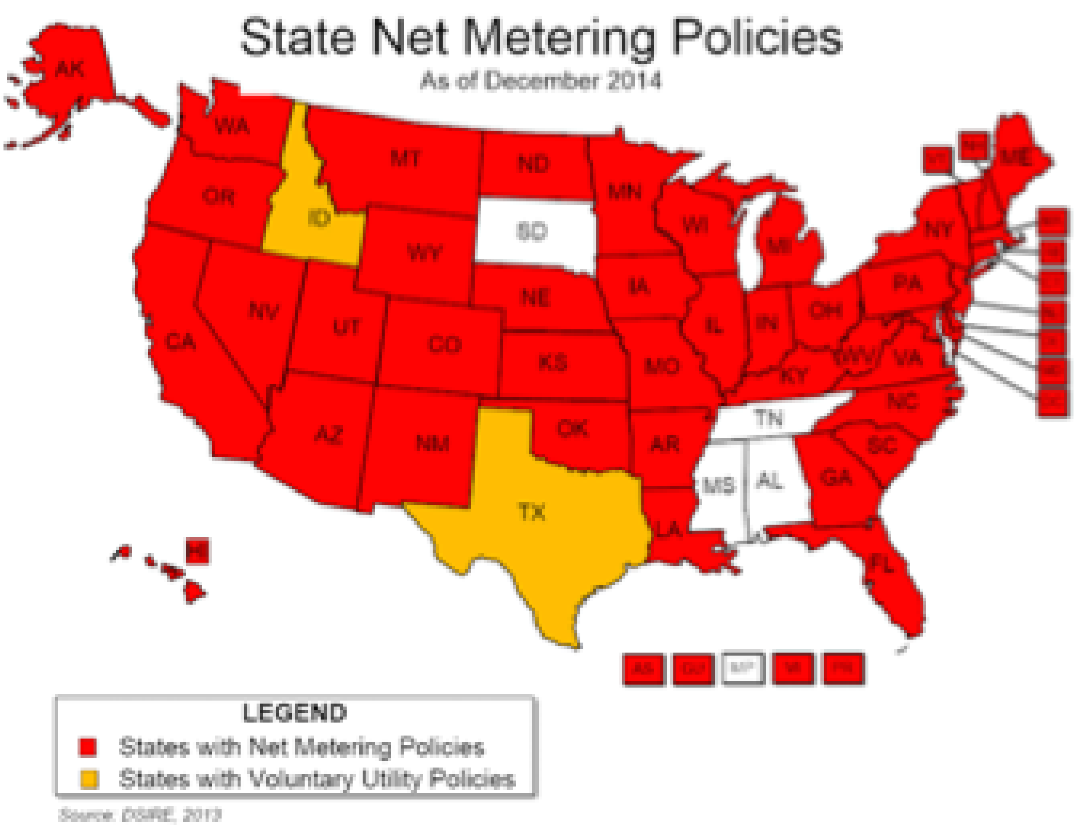


**Figure 1.2:** States marked red have net metering policies, orange have voluntary utility programs, and white means they have no net metering policy.

### 1.2.1 State Policies and Incentives

The analysis was on the five states of California, Colorado, Nebraska, Oregon and South Dakota. Following is a brief summary of the current policy framework in the capital city of each state. Remember, these policies are in addition to the 30% federal investment tax credit.

California has net metering in which excess PV generation is compensated at full retail price with eligible PV size limits of up to 1 megawatt (MW), depending on the PV investor. Sacramento also offers a $500 cash incentive to PV investors.

Colorado has net metering with excess generation compensated at full retail price with eligible PV size limits of 10-25 kW depending on the amount of energy the PV investor uses annually. Denver's utility company, XCEL Energy, prescribes two additional incentives. XCEL Energy pays $1,000 per kilowatt (kW) of PV installed. XCEL also pays $0.02/kWh produced for the first ten years of operation.

Nebraska has net metering with a maximum system size of 25 kW and compensation for excess generation at an average of $0.055/kWh. This is above the avoided cost, as traditionally defined. Lincoln Electric System (LES) has accounted for the ability of PV to help manage peak demand loads. LES pays additional amounts per kWh depending on which direction the PV is facing – West facing panels receive the most compensation because they produce the most during peak demand times in the late afternoon. PVs help manage peak demand loads by creating high electricity output during peak demand times in the afternoon (Wiginton, Nguyen, Pearce 2010).

Oregon has net metering with eligible PV sizes up to 25 kW and they compensate excess generation at full retail price. Oregon also offers up to $6,000 over four years through state tax credits. In addition, Oregon also offers a rebate program of $0.95/Watt installed.

South Dakota does not have net metering nor additional incentives to encourage PV implementation. It will be used as a basis for PV market dynamics in the absence of state and local incentive. A PV investor in South Dakota would still receive only the federal 30%

investment tax credit, and in the absence of net metering would receive avoided cost for total amount of electricity flowing to the grid as opposed to the net amount.

## 1.3 Payback Period, Net Present Value and Electricity Cost Escalation Rate Explained

The payback period is equal to the duration of investment to the break-even point. The break even point occurs where the PV, including tax credits, incentives and electricity produced, has created enough "cash inflow" to pay for itself. Cash inflow is the sum of all monetary benefits received by the PV owner. Due to the high upfront costs of PVs, decreasing payback periods is instrumental in spurring implementation.

The net present value (NPV) of a PV investment is defined as the total difference between the present value of cash inflow and the present value of cash outflow. In contrast, the payback period shows how long it will take to make the money you invested back and NPV shows the profits one can expect at the end of the investment period. NPV accounts for inflation over time, so the value it indicates is the value of today's dollar.

Electricity cost escalation rates (ECERs) indicate the rate at which the price of electricity increases year over year, adjusting for monetary inflation. The United States Energy Information Administration (EIA) projected 1.4-3.6% electricity price escalation rates in 2013 through 2040 (EIA 2013). According to the most recent report, electricity prices are projected to increase by 19-30% by 2040 for the residential sector, 16-27% for the commercial sector (EIA 2015).

## 1.4 EPA Proposed 111(d)

The EPA is responsible for reducing and limiting air-born pollutants due to the Clean Air Act, originally passed in 1970. A ruling in 2007 involving the regulation of vehicle pollution gave way to a US Supreme Court ruling on June 24, 2014 that the EPA has the jurisdiction to regulate $CO_2$ emissions from power plants for the sake of public health. The EPA proposed a new set of rules providing a variety of actions states can take to lower their $CO_2$ emission levels to 30% below 2005 emission levels. The EPA suggests a compliance date of 2030. The rule is to be finalized in June 2015, but there have been more comments than expected (millions) from stakeholders and the public. Once the rule is final and adopted, states will have one year to develop a state plan for achieving the $CO_2$ emission reductions that the EPA must approve. However, if states are working to collaborate on reducing $CO_2$ emissions, they may be granted up to two additional years for planning.

The EPA's proposed 111(D) rule has four main components, or building blocks, that states can use to effectively reduce their $CO_2$ emissions. The first building block aims to reduce the carbon intensity at individual electric generation utilities (EGU) through heat rate improvements. Affected EGUs are only considered to be coal-fired power plants and, as the rule is proposed, does not include oil or other fossil fuel generators. These heat rate improvements enable coal to burn more efficiently, creating more electricity with less input. The second building block involves replacing electricity generation from the most carbon-intensive affected EGUs with less-carbon intensive EGUs. The third building block proposes maintaining all existing nuclear EGUs and deterrence from shutting older nuclear EGUs down. Renewable energies such as wind and solar are also included as an instrumental part to building block three. Finally, the fourth building block of the proposed rule guides states and electric utilities to develop emission reduction plans that utilize demand-side energy efficiency. Demand-side energy efficiency programs have been implemented in nearly every state and have relatively low implementation costs.

In summary, the electric utility industry is preparing to face the reality of carbon pollution regulation. Depending on the form of the regulation that is adopted and the timeliness of the emissions reductions, retail electricity rates could increase at higher rates than the US Energy Information Administration has projected.

## 1.5 Thesis Objective

The goal of this thesis is to determine the role of different policy approaches in determining the economic feasibility of small-scale solar photovoltaic systems with respect to payback period and net present value. The potential impact of proposed EPA 111(d) regulations will also be considered.

# 2. Methods

The objective was to determine the degree to which different policy approaches affected payback periods and net present values. This was found by running each of the five states through the National Renewable Energy Laboratory's System Advisor Model. The results were then simulated at three different electricity cost escalation rates (moderate, high and very high). Once the simulations were conducted, the data was compiled into excel and figures were made to better interpret the results.

## 2.1 State Policies

| Comparison of Policies and Incentives for Model | | | |
|---|---|---|---|
| | Net Metering | Price paid for Excess generation | Other Incentives |
| Nebraska | Yes (25kW max) | ~5.5¢/kWh* | N/A |
| South Dakota | No | ~2.9¢/kWh* (all generation) | N/A |
| Oregon | Yes (25kW max) | ~6¢/kWh* | $6,000 over 4 years plus $0.95 per Watt installed |
| California | Yes (1 MW max) | ~10¢/kWh* | $500 cash |
| Colorado | Yes (10-25kW max) | ~9¢/kWh* | (XCEL Energy) $1,000 per kW installed plus $0.02 per kWh |

**Table 2.1:** State policy approaches for net metering (eligible PV size), the price paid for excess generation and other incentives. *Actual rates may vary

## 2.2 System Advisor Model

The System Advisor Model (SAM) is available for free from the National Renewable Energy Laboratory's (NREL) website. SAM contains different pre-set calculators, we chose to use PV Watts which is the calculator recommended for residential solar investments. The PV Watts calculator has many different inputs, we manipulated only fields necessary for finding the payback periods and net present values of PVs in each state.

The system size was increased to 5 kW from 4 kW and the investment period was increased to 30 years with an annual energy consumption of 7,150 kWh. We assumed a PV investor would take a mortgage for the upfront cost of the system, $16,500, because the interest payments are tax deductible. Each state was then assigned its own specific model based on its respective policy parameters. Climate and solar irradiance information were obtained through SAM's NREL Solar Prospector for each of the five locations. In addition, local electricity rates and monthly charges were found using the OPENEI U.S. Utility Rate Database feature in the SAM. Other metrics were not altered.

Using the models as described above for each state, we simulated the baseline scenario at a 1.5% electricity cost escalation rate. Using the parametrics function, two additional simulations were run to show changes in payback period and NPV with electricity cost escalation rates of 2.5% and 3.5%. The resulting data was then entered into excel to make graphs.

# 3. Results

## 3.1 Payback, NPV with 1.5% Electricity Cost Escalation Rate

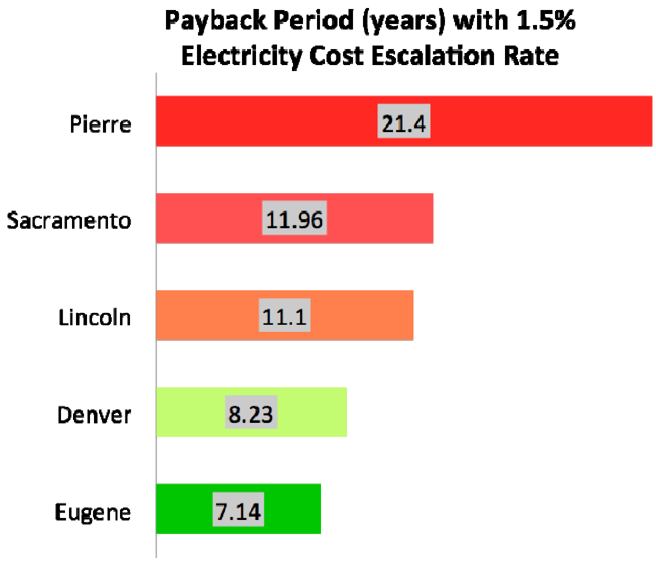


**Figure 3.1:** Payback periods in years with 1.5% electricity cost escalation rate.

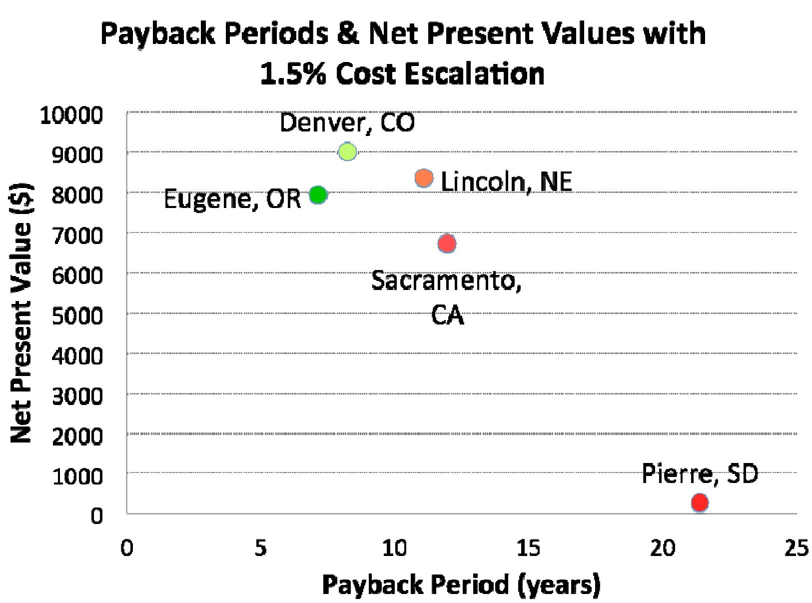


**Figure 3.2:** Payback periods vs. NPVs with 1.5% electricity cost escalation rate. NPVs ranging from $260-$9024.

## 3.2 Payback, NPV with 2.5% Electricity Cost Escalation Rate

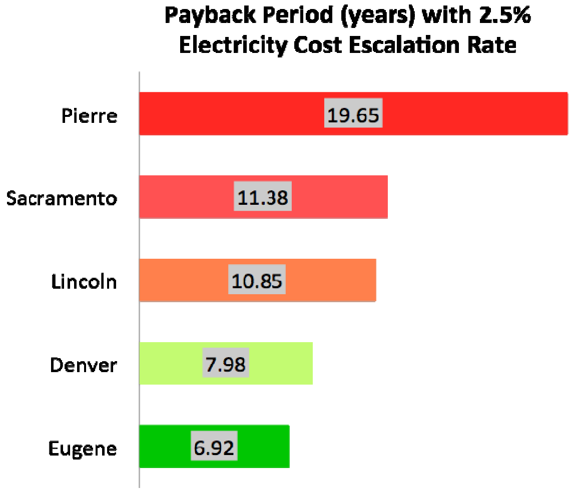


**Figure 3.3:** Payback period in years with a 2.5% electricity cost escalation rate.

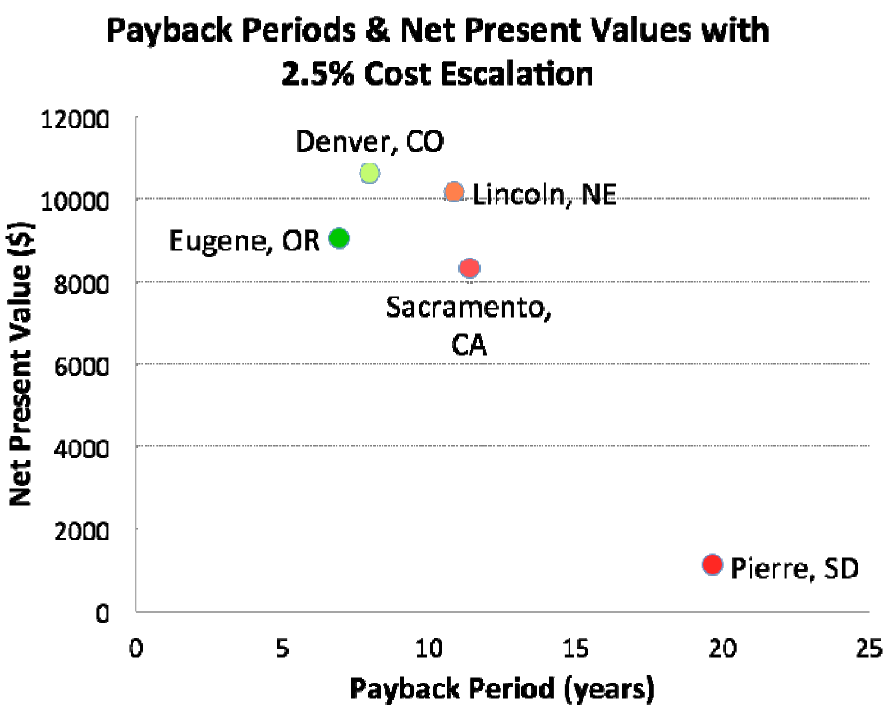


**Figure 3.4:** Payback periods vs. NPVs with 2.5% electricity cost escalation rate. NPVs ranging from $1,133-$10,639

## 3.3 Payback Period, NPV with 3.5% Electricity Cost Escalation Rate

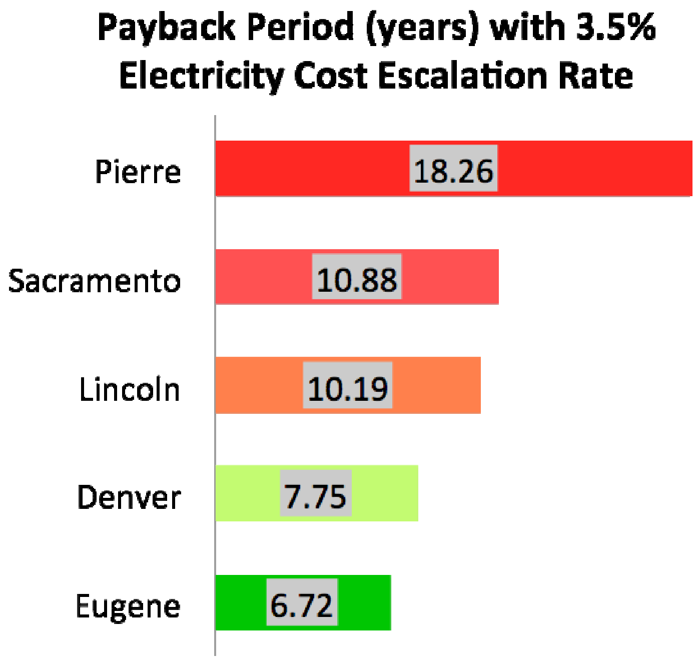


**Figure 3.5:** Payback periods in years with 3.5% electricity cost escalation rate

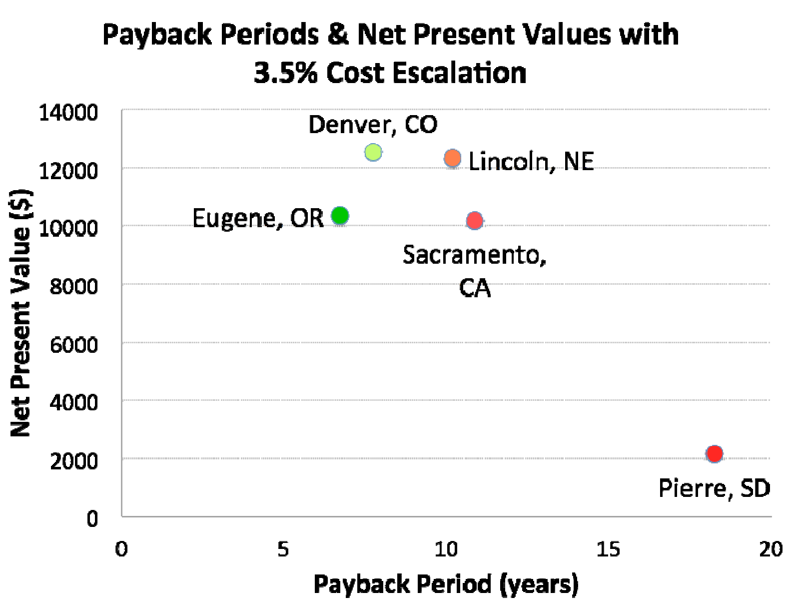


**Figure 3.6:** Payback periods vs. NPVs with 3.5% electricity cost escalation rate. NPVs ranging from $2161 - $12,536.

## 3.4 Summary of Results

**Results Cont.**

| | Cost Escalation Rates | | | | | |
|---|---|---|---|---|---|---|
| | **1.50%** | | **2.50%** | | **3.50%** | |
| | Years | NPV | Years | NPV | Years | NPV |
| Eugene, OR | 7.14 | 7949.33 | 6.92 | 9064.13 | 6.72 | 10373.7 |
| Denver, CO | 8.23 | 9024.28 | 7.98 | 10639.4 | 7.75 | 12536.7 |
| Lincoln, NE | 11.1 | 8358.65 | 10.85 | 10190.3 | 10.19 | 12344 |
| Sacramento, CA | 11.96 | 6733.24 | 11.38 | 8325.63 | 10.88 | 10195.8 |
| Pierre, SD | 21.4 | 260.35 | 19.65 | 1133.88 | 18.26 | 2161.94 |

**Table 3.1:** This table demonstrates a summary of the payback periods (years) and NPVs calculated through running the simulations for each location.

The effect of variable electricity cost escalation rates is apparent in regards to NPV. As electricity prices increase at increasing rates, net metering becomes more profitable because every kWh offset by the PV is worth more money. This effect compounds over time. The effect on payback period is less substantial for states who already have policy incentives that have greatly reduced payback periods. Eugene, OR showed a decrease of only 0.42 years in payback period between 1.5% and 3.5% electricity cost escalation rates while Pierre, SD would experience a decrease in payback period by 3.14 years. Denver has the highest NPV in all three rate scenarios while Eugene has the fastest payback period in all three rate scenarios. Because of the uncertainty of future electricity cost escalation rates, more simulations should be conducted with lower electricity cost escalation rates.

# 4. Discussion

While shorter paybacks are generally correlated with higher NPVs, payback periods are not the only input into NPVs. This was clear when comparing Denver and Eugene. Eugene consistently had paybacks over one year shorter than Denver and 2.5-3 years shorter than in Lincoln. Eugene has the fastest payback in this study because Oregon provides the highest level of incentives of these five states. In contrast, Denver followed by Lincoln had higher net present values than Eugene in all three simulations. After going back through the models I realized that the main difference between these locations was the amount of incoming sunlight. Colorado receives about 133% the annual sunlight that Eugene receives, according to the NREL Solar Prospector. In addition, Denver has the $0.02/kWh production credit for the first ten years of the system, which helps to lower payback and create a higher NPV because kWh produced are worth more than in other states.

The degree of uncertainty surrounding PV policy incentives, both locally and federally, coupled with the uncertainty of future electricity cost escalation rates serve as limitations to this project. The federal 30% investment tax credit is set to expire January 1, 2017. Net metering is coming under fire as electric customers without a PV insist PV owners should pay a higher fixed cost to use the grid. These policy incentives need to be monitored closely due to their current significant implications for payback. Electricity prices may increase by anywhere from 3-30% by 2040, this range implies electricity costs may change only marginally or they may increase by almost a third (EIA 2015). Additional simulations should be conducted and analyzed at lower cost escalation rates in future studies. More states should be included in future analyses to cover a wider array of policy approaches.

According to the EPA's estimates for proposed 111(d) regulations, a 10% raise in electricity prices by 2030 could be possible. However, this amounts to about $0.005 per kWh by 2030, which is insignificant given the range of possible electricity price escalation rates we may observe. If the EPA's projections are correct about the implications of proposed 111(d), it won't significantly impact the small-scale solar photovoltaic system market.

## 5. Conclusion

In this study I found that policy incentives at the sate level, paired with the 30% federal renewable investment tax credit, are primarily responsible for the payback period. While the policies behind payback periods have an impact on net present values, the amount solar irradiance also plays an important role in the net present value of investment, as seen in Denver and to a lesser degree in Lincoln. Electricity cost escalation rates can impact both the payback period and the net present value of a small-scale solar photovoltaic system. Longer payback periods decrease faster than policy environments with shorter payback periods in the face of increasing electricity cost escalation rates. According to the EPA's projections for proposed 111(d) regulations on carbon pollution in the electric industry, a price increase of $0.005 per kWh by 2030 will not significantly impact the economic feasibility of small-scale solar photovoltaic systems. Future research should consider adding more states to the analysis and conducting more scenarios with a range of electricity escalation rates below those that I simulated. Additional research should also be conducted when the fate of the federal 30% tax credit is decided along with any changes to net metering policies amongst the states.

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