Integrating Storage into Rooftop Solar: An Economics and Engineering Approach.

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Overview

In 2008, the Louisiana Legislature (in the United States) adopted a series of income tax incentives directly aimed at increasing rooftop solar. Louisiana households have access to two relatively generous income tax rebates they can call upon to provide financial support for their solar energy installations: a 50 percent state income tax credit and a 30 percent federal income tax credit; which, on a combined basis, amount to an 80 percent credit on all Louisiana residential solar installations less than $25,000 in total value.

Unlike conventional power generation sources, solar power cannot be dispatched when needed if not accompanied by proper storage and, unfortunately, solar energy does not necessarily peak at the same time as electricity demand. Thus, it is not clear whether solar power without the incorporation of battery storage can preclude investment in traditional generation, transmission, and distribution assets (i.e. create a "capacity benefit").

In addition to questions of whether solar can be used to substitute away from traditional investment in power generation, the intermittent nature of solar power can create significant technical challenges on the electric grid. More specifically, solar has the potential to cause voltage flicker, power transmission interruption, or voltage instability. As we will show, for all intents and purposes, these potential problems occur only when the renewable resource accounts for a significant share of generation in an area. But little is known about what share needs to be reached before significant problems begin to arise. Further, this threshold could be very different for different areas within the same state, and even the same utility.

Due to concerns raised by utilities, the Louisiana Public Service Commission (LPSC) set a cap on solar production such that net metering purchases should not exceed 0.5 percent of a utility's retail peak load for these very reasons. Today, every utility in the state has reached this cap. While there are no Louisiana utilities, to our knowledge, that have turned down customers from net metering, it is time for these issues to be addressed and long-term predictable policies to be adopted to mitigate uncertainty for both the solar industry and electric utilities.

But the net-metering cap is not the industry's only source of uncertainty. This past year, in light of budgetary constraints, the Louisiana Legislature capped state's solar tax credits—that offset 50 percent of the up-front installation cost—to $10 million in FY 2015-2016 and FY 2016-2017. In the FY 2017-2018 the cap is further dropped to $5 million. In total, $25 million in credits are available over this three-year period on a "first-come, first-serve" basis. But, by March of 2016 all $25 million of credits were granted to taxpayers. Thus, today, the state solar tax credit is essentially expired until further action is taken.

Methods

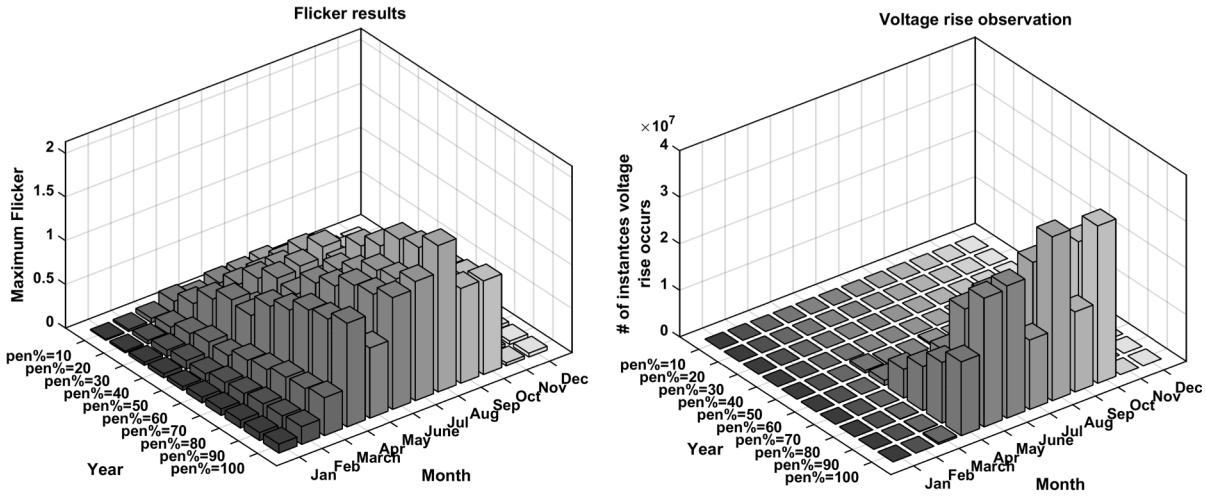
This interdisciplinary analysis will proceed with two major sections. First, a technical engineering analysis will be presented that specifically identifies these distribution grid issues associated with growing behind-the-meter solar. Next, an economic analysis is conducted to assess the implications of changing state tax credits and potential rate design regimes (in lieu of net metering).

The eingieerng analysis utilizes solar production data of a 140-w solar PV panel at the Renewable Energy and Smart Grid Laboratory at Louisiana State University Scaled up to a 7kW system alongside specific engineering distribution system data provided by a local utility that includes bus geographic coordination, substation transformer characteristics, active and reactive powers consumed by each load-bus, resistance, reactiance, and capacitance for reach distribution line. We scale up solar penetration to different levels of penetration and assess the degree to which voltage rise and flicker ocurr on the distribution grid. We then implement a battery dispatch algorithm and test whether these engineering problems can be mitigated through the installation and proper dispatch of a battery.

The economic analysis then assesses how the economics of behind the meter solar changes when (a) the changes in solar tax credits, (b) different rate design regimes (net metering vs avoided cost) and (c) with the incorporation of a battery. We also value a capacity benefit of solar with and without a battery.

Results

Engineering Analysis Results: We find significant levels of voltage flicker on the distributiong grid as solar adoption increase above 20%. Voltage rise problems begin occurring at significantly higher levels of pentration. Preliminary analysis on the incorporation of batteries shows that a 13.5 kWh Tesla Powerwall can mitigate many of these engineering problems, but (as will be discussed in the economic analysis) adds significant cost to the homeowner, and might preclude investment even with generous subsidies.



Voltage rise and flicker for different levels of penetration and months

Economic Analysis Results: We find that with full retail net metering and a combined 80% up-front tax credit, solar PV in Louisiana has a payback period fo about 7 years, providing an IRR of about 15%. Thus, it is unsurprising that solar adoption has grown under this regulatory regime. But, when the 50% state tax credit is removed, the payback period extends beyond the life of the solar system. Thus, unless solar prices continue to fall, or if electricity prices rise significantly (electricity prices are relatively inexpensice - $.10/kWh), solar adoption will likely slow considerably in coming years as the tax credit has expired. We also find that moving from a net metering policy to an avoided cost policy, where customers are compensated wholesale rates for electricity sold back to the grid, does impact the economics from the households perspective, but that solar tax credits are significantly more important. Unsurprisingly, the change in rate design from net metering to avoided cost becomes more important as the average system size grows. We value the capacity benefit of solar with no battery at $1.41 per month. We are currently obtaining results on the capacity benefit of solar with the incorporation of the battery.

Conclusions

The solar industry in Louisiana is at a crossroads. We hope that lessons learned in Louisiana will translate into improved decision making in other parts of the United States and the world.