Regulation to Cool Prices Fomented by Solar Power [1]

1 Introduction

Solar power – a clean electric power generation alternative – is used by an increasing number of consumers. The consumer awareness of solar power expand with the number of installed systems. Elevated awareness itself leads to growing sales. A growing number of solar power generating consumers increases economies of scale in manufacturing / delivery and maintenance operations related to solar systems (panels and the associated equipment such as cables, inverters). Subsequently, the cost of solar systems is steadily dropping. On the other hand, improving solar-to-electricity energy conversion efficiency is allowing for more energy generation with less sunlight. Decreasing costs and increasing efficiencies reinforce growing system sales, which lead to a further decrease in costs. This *virtuous cycle* has become a part of the established wisdom.

Utilities (electricity generators and distributors) in many markets with growing adoption of solar systems are facing dropping sales and reacting by increasing the price to maintain their revenues. Residential electricity prices have risen steadily in the last decade despite the initial prediction for the opposite. This initial prediction of low prices was based on low system costs, high efficiencies and the virtuous cycle. The unexpected price increases can partially be attributed to growing costs of labor, transmission and other infrastructure as well as the pressure for higher profit margins. The effect of residential solar adoption on prices has been empirically shown in Chan and Kiso (2017) and Felder and Athawale (2014); the latter has an example of the coupling between increasing solar adoption and rising prices. According to Casey (2018) and Shellenberger (2018), renewable power is pulling prices up. Nominal residential (US average) prices[2] can be converted to real prices by using consumer price index data[3]. Figure 1(a) shows real prices from 2001 to 2017 and a clear trend of increasing prices. Regionally, prices increased by 51% in Germany during the renewable energy expansion from 2006 to 2016 and by 24% in California during the solar energy build-out from 2011 to 2017; over 100% in Denmark since 1995 when it began deploying renewable (mostly wind) energy (Shellenberger 2018).

Protecting consumers in a region from unaffordably high prices is taken seriously by that region's government and specifically by the (public) utility commission, which regulates the prices while allowing the

[1] Keywords: Solar power harvesters, demand drop, price increase, utility death spiral.

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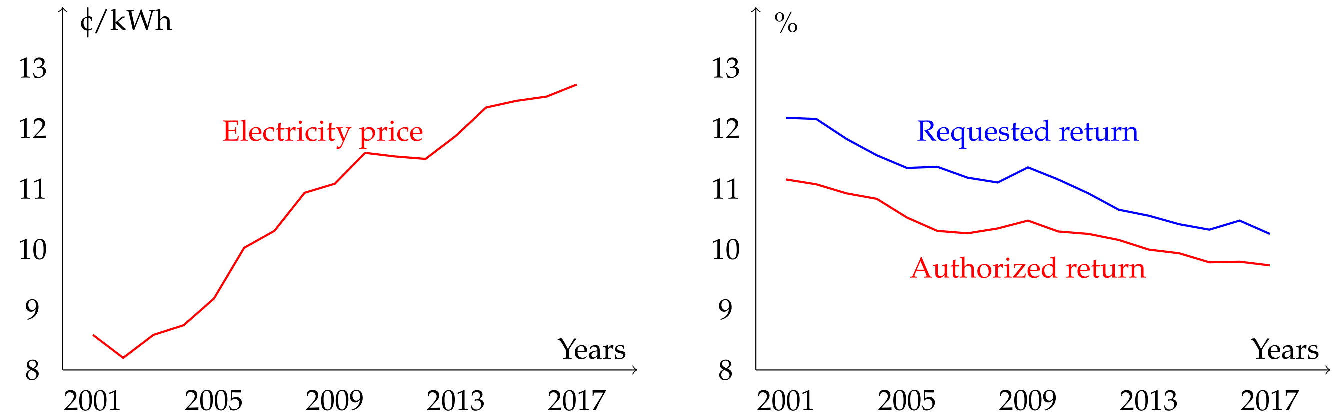
[2] https://www.eia.gov/electricity/data/browser

[3] https://www.minneapolisfed.org/community/financial-and-economic-education/cpi-calculator-information/consumer-price-index-and-inflation-rates-1913



(a) Real electricity prices. (b) Requested & authorized rates of return on equity

Figure 1: Rising electricity prices with dropping rates of return over the same years.

utility of the region to recover its investment (costs) along with a fair return. Granted with a monopoly status in its region, a utility accepts to be regulated and regularly meets with the utility commission to reveal its costs to request a particular electricity price and the associated return. In contrast, the commission (regulator) pulls these requests down towards what is perceived to be fair. The discussions at these meetings are subjective and contentious, and 43% of the rate cases lead to litigation according to Payne (2017), which also says "utility ratemaking proceedings . . . are becoming the new battleground in the transition to clean energy." A ratemaking agreement can include an *adjusted price* (electricity price) that aims to keep electricity affordable for consumers and to ensure an *authorized rate of return* on investment or equity for utilities. Figure 1(b) based on Edison Electric Institute (2017) shows that the average authorized rate of return on equity has a decreasing trend and been around 10%. This is not a high return wrt 27.6% and 35.6% return of S&P 500 and Dow indices in 2017. Decreasing return of utilities cannot be the reason for unexpected price increases. Price increase might then be attributed to another factor – electricity demand reduction caused by residential solar generation.

Governments motivate utilities and consumers to invest in solar system by mostly arranging for the purchase of the solar generated electrical energy at a high (*feed in tariff*) price or providing a tax credit (e.g., 30% of the cost of a solar system). Feed-in-Tariffs are offered for utility-scale projects by many governments[4] all over the world. Italy has one of the detailed incentive plans and offers specific FiT rates for six different intervals of capacity levels ranging from $[1, 3]$ kW to $[5000, \infty)$ kW. These FiTs drop with the capacity of the system: The rooftop solar panel FiT for $[1, 3]$ kW is €0.182/kWh and it is €0.112/kWh for $[5000, \infty)$ kW in Italy. Tax incentives are offered by the US federal government while the state governments have their own renewable energy incentive plans[5]. The regulated utility of a city in the US is likely to offer

[4] https://www.pv-magazine.com/features/archive/solar-incentives-and-fits/

[5] http://www.dsireusa.org/

an incentive plan if it is given a monopoly status in that city. Austin energy offers a price of \$0.09/kWh to buy back energy generated with a solar system, whose capacity does not exceed 2 kW. The FiT and buyback price are similar terms, both refer to the price offered for solar power to the generators. The FiT is used more in the context of price offered by governments to large projects. The *buyback price* is more appropriate when a utility buys electricity generated by a consumer's solar panels.

When solar power adoption leads to high prices, government subsidies and incentives cripple the efforts of regulatory agencies, which are usually affiliated with governments. Regulatory agencies aim to keep the prices affordable by restricting them (or rate of return of utilities). Increasing solar adoptions and rising electricity prices force regulators to be watchful as they may need to argue for strict (binding) regulations on the utilities during ratemaking proceedings.

Price increases induce a financial burden for consumers that do not generate their own power and have to buy electricity. Financially challenged consumers cannot afford solar systems and feel the burden of the increasing prices more than the others. One can argue that these segments are paying for the service of reliable and available electricity more than they should. To mitigate this, various agencies offer solar energy grants (green retrofit grants, tribal energy program, high energy cost grants) to low-income and rural areas, schools and nonprofit organizations[6]. Some consumers cannot install solar systems because they live in apartments or their roofs cannot host systems. With traditional pricing mechanisms, these financially/spatially challenged consumers are allocated a large portion of the cost of the grid (transmission equipment & lines) and power generation facilities. Different pricing mechanisms are needed to allocate a fair share of the cost of reliable electricity service to these consumers and to keep prices in check.

A residence with a solar system harvests solar power and is called a *harvester*. Unlike harvesters, many residences currently do not employ a solar system and are called *ignorers*. A commercial/industrial facility (warehouse, covered car garage) is also considered as a harvester (resp. an ignorer) if it employs a (resp. no) solar system. Hence, a consumer in a market is either a harvester (she) or an ignorer (he). However, we here focus on the residential market. A harvester can generate more energy than her demand and transfer the excess energy to the electric grid to be compensated at the rate of *buyback price* (Alanne et al. 2007). According to (SEIA 2018)[7], harvesters transfer approximately 20-40% of solar energy to the grid and their compensation for this transfer is generally governed by *net metering regulations* (Ackermann et al. 2001). A power producing *utility* firm, rather than the collection of harvesters, provide most of energy to the grid in many markets. Generating significantly more energy than its consumption, a utility is a net producer; similarly an ignorer is a net consumer. Unlike these, a harvester can be a net producer and a net consumer

[6] https://www.letsgosolar.com/solar-panels/financing/grants
[7] https://www.seia.org/solar-industry-research-data

depending on her solar generation. The grid pools electrical energy from the utility and harvesters, and transfers it to harvesters and ignorers.

Harvesters, ignorers and the utility are market participants engaging in transactions facilitated and overseen by their regulator. Although market participants communicate with the regulator, they cannot control it, at least in theory. In some markets, there can be a separate independent system (grid) operator from the regulator. Addressing managerial aspects here, we focus only on the regulator without delving into the important operational roles of the operators. As harvesters buy less energy from a utility, the ignorers are allocated more of the (grid and power generation facility) costs. This motivates more consumers to become harvesters and leaves remaining ignorers to pay a larger portion of the costs. Utilities hence face a *death spiral* involving dropping number of customers, which is reinforced by utility efforts to maintain the revenues by increasing prices. That is a *vicious cycle* caused by increasing number of harvesters and higher prices charged to all. This vicious cycle, despite being absent from the established wisdom, can be a challenging problem for the utilities, ignorers and regulators.

The traditional electricity market is based on the separation of generator and consumer roles and the flow of energy from the utility to consumers. In the traditional pricing mechanism, also known as *volumetric charges*, the utility's compensation is proportional to its sales and price. With a volumetric charge mechanism, a utility is challenged to recover its (especially fixed) costs when the harvesters pull the sales down. Some markets require utilities to be compensated in the form of *capacity charges* which are proportional to the capacity provided by the utility (Kirschen and Strbac 2010). Adding salt to injury, regulations force utilities to buy harvester generated energy back and also at competitive prices. They are often mute on the exact value of buyback prices. Alanne et al. 2007: "At the moment, there is no consensus about the buyback price of electricity .... Actually, it may vary between zero and the full retail price of electricity". There are two emerging practices of setting buyback price equal to the (retail) *market price* (the price charged by the utility) or the *wholesale price* (levelized cost of electricity generation). Currently harvesters generate a very small portion of the energy in many markets, so they do not yet pose a significant threat to their utility. However, this can quickly change with the increasing number of harvesters and can become a matter of survival and death for utilities.

Volumetric charges give the erroneous perception that the only time a consumer uses the utility is when drawing power. In fact, the utility provides each consumer an *insurance* service – a *call option* to use the grid at any time to draw practically any amount of electricity. This requires procurement of ancillary services (such as spinning but unconnected generators) and is costly. The grid has value even for a harvester with much more capacity than her demand as she needs electricity during the night when she cannot generate her own solar power. A harvester also uses the grid to deliver her electricity to ignorers but receives this *delivery* service essentially for free when the buyback price is at or above the wholesale price.

To use aforementioned insurance and delivery services, harvesters can be charged a periodic (e.g., monthly) subscription fee, which can slow down or stop the death spiral. An Arizona utility, for instance, proposed levying a monthly $50 grid interconnection fee[8] for consumers with solar panels. According to Callander et al. (2018) the state utility commission ruled on a proposal to increase the share of costs utilities could recover through "fixed" charges as opposed to volumetric charges.

2 Utilities and Harvesters in Nevada and Beyond

Nevada's electricity market is regulated and is served mostly by the electric utility NV Energy. NV Energy is subject to the federal government's Energy Policy Act (EPACT)[9] of 2005. Section 1251 of EPACT defines *net metering service* and enforces it on utilities including NV Energy. Specifically, it says "the term 'net metering service' means service to an electric consumer under which electric energy generated by that electric consumer from an eligible on-site generating facility and delivered to the local distribution facilities may be used to offset electric energy provided by the electric utility to the electric consumer during the applicable billing period." For example, a harvester that delivers 400 kWh in a month to the grid and that receives 1000 kWh in that month can offset 400 from 1000 to be responsible for 600 kWh for billing purposes. If this harvester goes on a vacation next month and consumes only 300 kWh while still generating 400 kWh, the harvester has a net excess of 100 kWh energy. The net excess is bought by utilities at varying buyback prices that can range from zero, to generation cost, to the retail price and beyond. EPACT delegates the choice of a buyback price to individual states, which may even choose not to pass any regulation on the buyback price or choose to pass somewhat limited regulations.

The state of Nevada's regulation[10] of buyback price was limited to be effective until a 3% net excess cap. Net excess is the total electricity delivered to the grid by harvesters and it can be measured as a percentage of the total capacity of NV Energy. As long as this percentage remained below the cap of 3%, NV had to buy net excess electricity of harvesters at the retail price without charging them any additional fees specific to solar generation. The percentage approached 3% in 2015 and the Nevada's PUC was called into action. After months-long deliberation, the PUC ruled that NV Energy could charge additional fees to harvesters and the buyback price could progressively be reduced to the generation cost from its current value of retail price over 12 years.

SunRun is a residential solar system consulting, financing and installation (CoFiI) company similar

[8]https://theconversation.com/why-rooftop-solar-is-disruptive-to-utilities-and-the-grid-39032
[9]https://www.govinfo.gov/content/pkg/BILLS-109hr6enr/pdf/BILLS-109hr6enr.pdf
[10]https://www.leg.state.nv.us/nrs/nrs-704.html

to SolarCity, Vivint Solar, SunNova and Good Faith Energy [11]. These companies approach homeowners to install solar panels generally on the roofs of houses. They initially study sun's irradiance, the angles of sunlight exposure well as house size and homeowner's electricity bill to find a good panel location and capacity. Panel capacity cannot be too low or high with respect to the consumption of the homeowner. With too low capacity, the solar system becomes ineffective in generating some savings to pay for its own fixed costs. With too high capacity, the harvester generates too much of net excess which has to be delivered to the grid at a buyback price that is already low or likely to drop in the future. Nevada's ruling is an example of unfavorable regulations for harvesters.

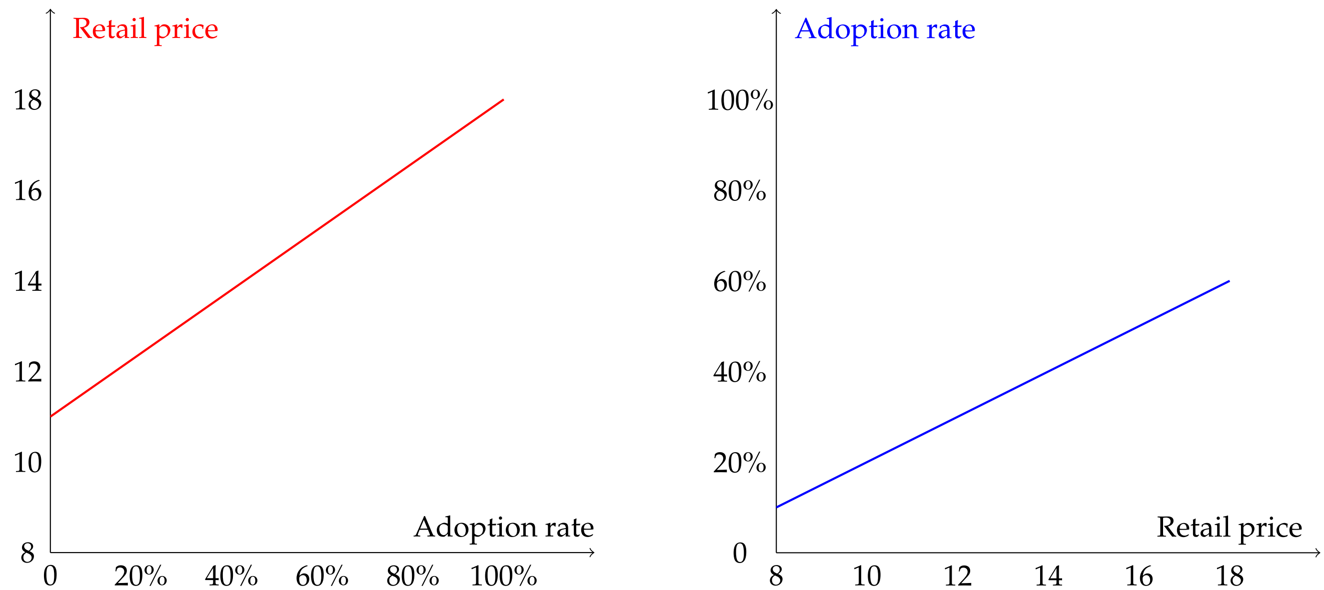
Solar CoFiIs tend to be start ups which require debt or private equity financing. To obtain capital, they present business models to investors and highlight that maximum return is made from panel investments To achieve high returns, CoFiIs tend to suggest solar panel capacities commensurate with consumption levels. Naturally, homeowners with high consumption (large house, large roof, high amperage cable connection to grid) install high capacity panels. Solar CoFiIs, in addition to consulting and installation, can offer financing deals (leasing panels, rent-to-own model) to homeowners or maintain the ownership of installed panels while selling the solar power to homeowners. In both cases, the initial investment cost of a homeowner can be significantly reduced or completely eliminated.

In a homeowner - CoFiI partnership, incentives are generally aligned. Both prefer the application of net metering principles without limitations and as high buyback price as possible. Their risk exposures are different against a drop in the buyback price or an additional solar panel fee imposed by the utility. For example, in the event of a drop in buyback price, the owner (either homeowner or CoFiI) of panels faces the majority of the financial risk. It is possible to combine a homeowner and a CoFiI to consider them as a single entity, as a harvester.

The solar CoFiI business model is not specific to Nevada, it exists in the other states such as Texas. Texas greatly differs from Nevada in that Texas does not enforce a utility to buy net excess sat a positive price, i.e., de facto buyback price is zero in Texas. Having said this, some utilities keen on environmentally friendly sourcing can offer a positive buyback price to residential consumers in Texas.

Utilities and harvesters have opposing interests in the growing residential solar markets. Utilities have large costs (fixed and variable) to recover from harvesters as well as ignorers. They can increase the amount recovered by either increasing retail price, decreasing buyback price or charging a fixed fee. They are bound by federal rules to accept the delivery of net excess generated by harvesters. Whether a harvester delivers a net excess or not, she buy less from the utility than she would otherwise without solar panels. Hence, presence of harvesters bring the electricity demand down. With less demand, the utility is forced

[11] https://goodfaithenergy.com



(a) Retail price responds to adoption rate.
(b) Adoption rate responds to retail price.

Figure 2: Retail price and adoption rate both increasing in terms of each other.

to recover the cost by increasing its retail price. Formally speaking, we can predict that increasing solar panel adoption rate in a market will pull the retail price up in that market; see Figure 2(a). This figure can be thought as an abstracted version of Figure 1(a).

Consumers that can afford solar panels or those can partner with a solar CoFiI company consider having solar panel installations. This consideration is heavily affected by the retail price of electricity. A higher retail price motivates more consumers to become harvesters. Consequently, a higher retail price leads to a more solar panel adopters; see Figure 2(b).

Figure 2 depicts both retail price response and adoption rate response as a function of each other. Both responses are increasing and can be drawn on the same axis as in Figure 3. This figure also shows how a market can evolve from a market with no harvesters at $(0, 11)$ to a market with higher prices and adoption rates. The market can converge to an equilibrium [12]. At this equilibrium, neither the utility seeks a higher market price nor more consumers become harvesters. If the equilibrium is attained early on at low adoption rates such as 10-15%, the utilities can possibly remain profitable. If the market conditions drive towards an equilibrium at 20% or more adoption rates, utilities will lose a significant consumer base and can become bankrupt. Sensing this in advance, many utilities battle with harvesters in front of the PUC (public utility commission) officials or at courts of law.

[12] An *economic equilibrium* as opposed to the *physical equilibrium* of electrons in a p-n junction used in solar panels

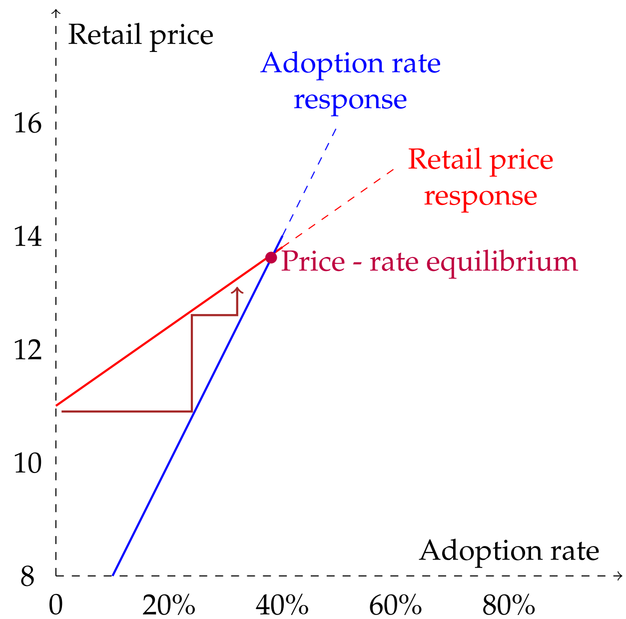


Figure 3: Death spiral: Adoption rate ↑ $\implies$ Retail price ↑ $\implies$ Adoption rate ↑.

3 Harvesters vs. Utilities in the PUC Court

The PUC court (or a court of law) is where utilities periodically make their case for certain retail prices. Utilities list their costs according to the regulations of the state in which they are making the case to justify a price increase. Consumer advocates, solar CoFiI companies and others argue for keeping the price constant. These argument for and against an increase in the electricity rate (retail price) is referred to as *ratemaking*.

Currently, the ratemaking process is subjective and always ends with a settlement price near the midpoint of two prices initially suggested by the utility and its regulator. Payne (2017) criticizes this dependence of the settled price on suggested prices and calls the current process a game that leads to unnecessarily high electricity prices. Subjectivity of the ratemaking process is due to the fact that there is no established objective formulation of ratemaking. Ideally a ratemaking formulation can include objectives of both utilities and harvesters as well as their negotiations. Such a formulation can reduce the room for gaming.

Generally speaking, harvesters by buying less from their utility contribute less to the costs, and this shifts the burden of costs to ignorers and leads to a high price for all. According to Green (2015), "…electricity prices cover the fixed cost …, and those costs have to be paid by someone. Utilities may face a vicious cycle if they try to recover those fixed costs from a declining sales volume, thus raising their prices and making it more attractive to install PV [solar systems]." Detailing and formalizing these above, we reveal the interaction between the price and solar adoption that leads to a death spiral. However, this is only identification of the problem, not a solution to it. What could be reasonable mechanism or a regulation to this problem?

4 Questions to Consider for the Case Discussion

A list of questions is provided below. A case report does not need to address all of these questions but should instead focus on some of these. The report can also identify other issues and provide a discussion of those issues.

1. After Nevada determined to pull the buyback price down from the retail price, is there a state left that enforces utilities to buyback at the retail price? Is there any limitations in that state on when the buyback price regulation applies or ceases to apply? Is the solar panel adoption rate high in that state with respect to the rate in Nevada? You may want to check out a neighboring state with a lot of irradiance.

2. You can investigate solar CoFiI business model in more detail. Are the business models presented above reflecting the reality well? Are solar CoFiI companies suggesting panel capacities proportional to consumption levels? CoFiI companies are subject to regulation risk but are there any measures they can take to reduce this risk? For example, the business model of SunRun and SolarCity are similar but not identical. Is SolarCity doing something different to reduce the risk associated with net metering?

3. Although NV Energy won a battle against harvesters in Nevada, the war is far from over. If you were a business development executive at a utility, you would lose your sleep over the death spiral. Are there any innovative rate structures that a utility can suggest to its PUC to avoid a death spiral?

4. One of the silent population segments in the battle of harvesters and utilities is the financially or spatially disadvantaged individuals. The PUC must protect the interests of this segment, especially ensure that they are not unfairly paying for the utility fixed costs. Are there any innovative rate structure that a PUC can use to protect the underprivileged? Can you think/find of initiatives to support solar project development for underprivileged communities?

This case focuses on the interaction between economics and regulation in the solar power domain. Depending on the background or interests of its author, a case report can focus on some or one of the following aspects: economics, regulations, regulatory risk, social policy.

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