Reduced Tariffs of Net Energy Metering: More Competitive Retail Rates of Electric Utilities Come Next?

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ABSTRACT

This study seeks to analyze competitiveness in electric rates in the U.S. residential sector under a market-based solar sharing network platform and/or a market-based energy trading platform. We argue that under the solar sharing or trading platform there plausibly exist social welfare gains from economics of distributed generation (DG) of renewable energy among grid-connected, photovoltaic (PV) system households. Thus, in this work, we consider a theoretical analysis framework using a model where grid-connected PV-system households are both simultaneously consumers and producers of electricity.

BACKGROUND

Since electricity was introduced by Thomas Edison's very first electric utility, the Pearl Street Station, in 1882 (Schewe, 2007), it continues to serve and meet societal needs beyond its original purpose – electricity for electric light lamps. Starting with use of coal as the primary source of energy, electricity today is generated from many energy sources: from fossil resource (oil) to carbon-free (nuclear) to renewables (hydropower).

Despite advanced innovations on the production side, the electricity market remains rather complex and peculiar on the consumption side. For example, many end-use customers rather just inattentively read their electric bills and pay their due amounts with no second thought.

Rising concerns about climate change and sustainability in the health, environmental, social, and economic domains, result in changes over time in demand for electricity from different energy sources. In the 21st century, renewable energy has become a focal point with respect to meeting growing energy demands in the U.S. and other nations. In particular, great capital investments have been put into renewable energy sources, such as wind and solar power, in the form of distributed generation (DG).

Due to having monopoly characteristics and post-1990s electricity restructuring in the electricity market, electricity customers today pay different retail rates for their electricity consumption by consumer class (business vs. residential), tiered or block rate (block usage), and time-based rate (time-of-use pricing (TOU) vs. variable peak pricing (VPP)). Presently, there are various incentive policies to promote expansion of consumer-based grid-connected renewable energy systems in the residential and commercial sectors.

These incentive policies include government-level subsidies under the U.S. Investment Act, mandated incentive programs such as performance-based feed-in tariffs (FIT),and third-party financial offers such as Solar Power Purchase Agreements (PPA). As a result, under the Net Energy Metering (NEM) mechanism, residential solar PV-systems or solar home systems (SHS) have become a favored proposition for some households who support household power-generation.

OBJECTIVES

The primary objective of this study is to evaluate economic welfare gains and losses from 'newly' modified NEM, community NEM and virtual NEM under solar sharing network platforms and/or market-based energy trading platforms. We anticipate our empirical results could provide important implications for energy policy targeted towards achieving national energy security goals, especially considering the increasing potential future reversals from AC to DC.

DATA

Data analysis will be based on use of available micro-level data* of residential households and/or retail-choice providers compiled by electric and gas utilities who have implemented NEM policies and programs. Ideally, the desired micro-level data would include differentiated net energy metering policies and programs, which offer different types of NEM for different types of customers. In practice, there have been the four types of net energy metering implemented: Conventional NEM, Aggregate NEM, Virtual NEM, and Community NEM. In the current phase of NEM policy changes, policymakers are working on virtual and community NEM with utility companies.

About Net Energy Metering (NEM)

According to National Conference of State Legislatures (NCSL) in 2014, a number of states carry differentiated net energy metering policies, which result to different types of NEM for different types of customers. The following describes types of NEM:

- **Conventional net energy metering**, aka individual net energy metering, connects a generating source to individual single meter, such as a house or building.

*Due to customers' rights and privacy and the time of poster submission, we remain in the process of waiting for full cooperation from utility companies under the condition of non-disclosure-agreement.

- **Aggregate net energy metering** allows for a property owner with multiple meters on one property or adjacent properties to implement net metering, such as with a group of university buildings or adjacent farm properties. At least 16 states have authorized aggregated net metering, but certain states have placed specific requirements on these systems based on customer type (such as Maryland and New York), technology type (such as Nevada and New York), or the distance between meters (such as New Jersey and West Virginia). States have also required customers to request for meters to be aggregated, required customers to cover the expense of meter aggregation or established separate capacity limits for aggregated systems.
- **Virtual net energy metering** expands aggregated net metering, allowing a property owner with multiple meters to distribute net metering credits to different individual accounts, such as to tenants in a multi-family property or condominium owners. Owners of non-adjacent properties can also use credits from production on one property for consumption at another. At least five states have authorized virtual net metering, including California, Connecticut, New Hampshire, Pennsylvania and West Virginia.
- **Community net energy metering**, aka neighborhood net metering, community-based renewable energy or community solar, allows for multiple users to purchase shares in a single net metered system, either located on-site or off-site. For example, this could take the form of residents in a community or condominium buying shares in a medium-sized solar array. At least 11 states and Washington, D.C., have authorized community net metering or pilot projects: California, Colorado, Delaware, Illinois, Massachusetts, Maine, Minnesota, New York, Rhode Island, Vermont and Washington.

Net Surplus Compensation (NSC)

The compensated rate of grid-connected photovoltaic (PV) sales started with premium rates (rates above retail rates) to retail rates to (lower) wholesale rates - known as avoided rates. The electricity generated by renewable system serves the immediate energy needs of households and reduces their monthly electric bills. Any additional electric power households requires—day or night—is automatically supplied by their power company. Thus, any surplus of electricity the renewable system generates, but not consumed by households, will be exported to the electric grid. Depending on State laws, compensated payments are normally made to NEM customers who generate electricity surplus over a specified period, i.e. on a monthly basis subject to a 12-month billing cycle cap. The compensation NEM customers receive— known as Net Surplus Compensation (NSC)—is generally based on a 12-month average of the market rate for energy, or roughly \$0.03 to \$0.04 per kilowatt-hour (kWh). Georgia Power in the State of Georgia offers the NSC rate of \$0.04 per kwh for electricity surplus (see Fig. A).

THEORETICAL FRAMEWORK

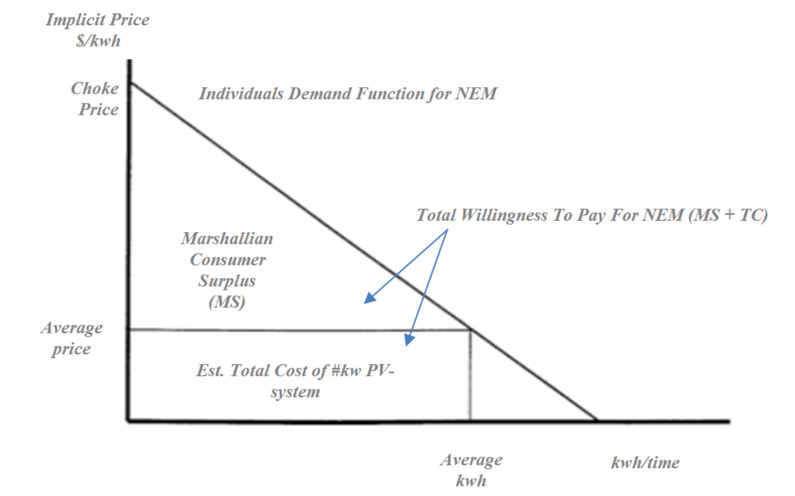
Theoretical Model Under a Perfectly Competitive Market Framework

- ***Consumer-and-Producer Households***: After households (HH) have installed PV system, grid-connected PV households thereafter become either net sellers (generation > consumption) or net buyers (generation < consumption) or balanced users[1] (generation = consumption) of electricity for a given generation interval (hourly[2], daily, weekly or monthly exports and imports).
- ***Household Market Failure***: Household market failure means that markets exist in general but these markets selectively fail for particular households, making the corresponding commodity a non-tradable good for that household (Janvry et al, 1991). According to Janvry et al (1991), price band[3] widths depend on utility wholesale prices/avoided costs, and subsidized or unsubsidized retail sales. For any given price band width, the greater the price elasticity of demand for a household that tends to be a net seller, the more likely it is to stay self-sufficient as supply fluctuates. Conversely, the greater the elasticity of supply for a household that tends to be a net buyer, the more likely it is to stay self-sufficient as demand fluctuates. Also general equilibrium effects that extend the price band width, tend to make all households in a 1-km-radius[4] community net sellers or net buyers in the same time period. Thus, when the energy harvesting day or time (say from solar) is favorable to making it more, likely a household will become a net seller, at the same time, the lower bound of the price band falls (as the household's supply shifts), reducing the likelihood that the shadow price (opportunity cost) of a particular household will fall below sale price and make it a net seller5. Conversely, during an unfavorable energy harvesting day or time when the household would likely be a net buyer, the upper bound of the price band tends to rise[6] , eventually preventing the household from becoming a net buyer. As a result, the thinner local electric utility and retail-choice markets are, the more prices can be expected to be positively correlated with movements in shadow prices, restricting the household's range of self-sufficiency.

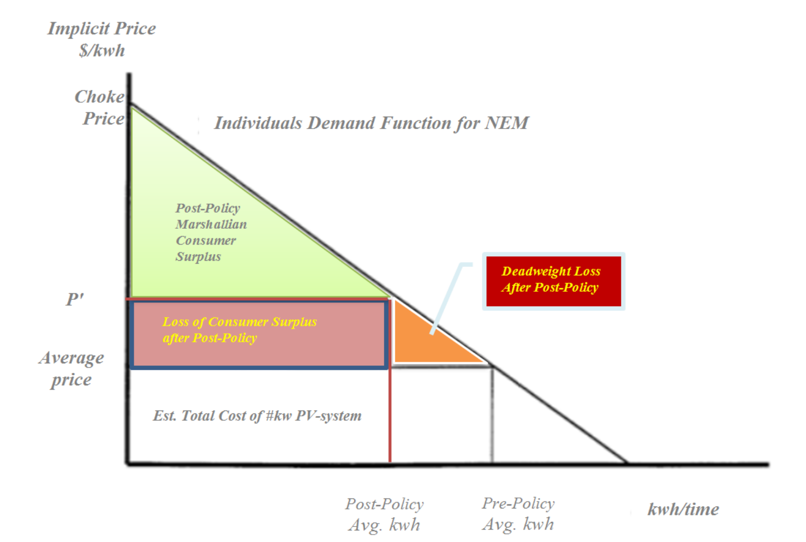
[1]aka autarkic or self-sufficient. [2]California plans to use TOU on an hourly basis for solar customers when NEM 3.0 is implemented in 2019. [3]A price band is a policy instrument that serves to insulate domestic producers and processors when the world price for a commodity falls below a calculated reference price (e.g., a price target comparable to a commodity support level). Protection is provided by imposing a variable import levy on the imported commodity that raises the importer's cost to the reference price (Wikipedia). Alternatively, a price band is a value-setting method in which a seller indicates an upper and lower cost range, between which buyers are able to place bids. The price band's floor and cap provides guidance to the buyers (Investopedia). [4]Solar generation can travel 1000 meters or so. [5]Electric utilities actually push PUCs to revise DG rates from retail- price to (lower) whole sale price or avoided cost. We later want to introduce a platform of "Retail Choice" market into the model as competitive offers when utility companies succeed this suppression. [6]TOUfor installed PV customers, like in California NEM 3.0.

THEORETICAL ANALYSIS

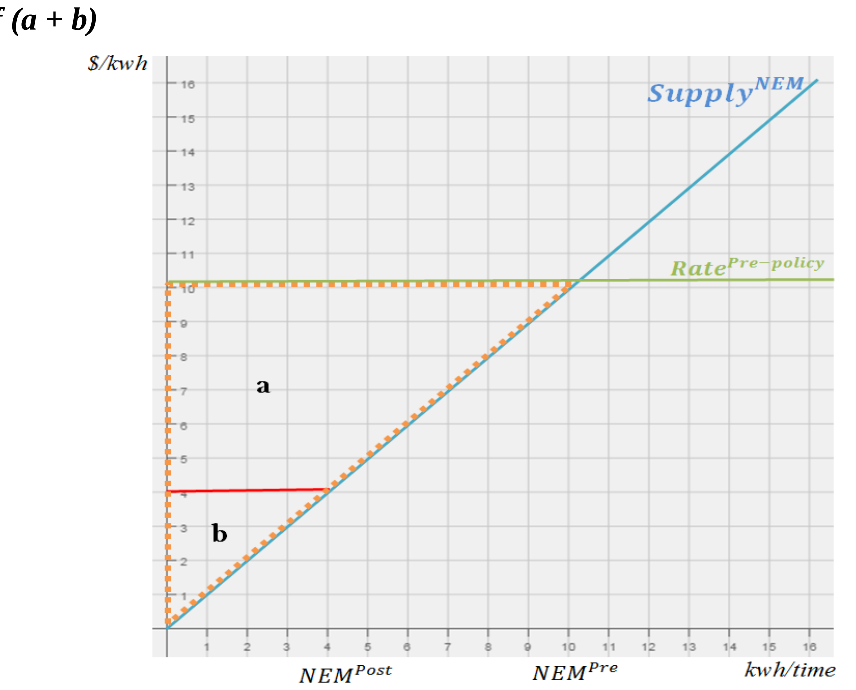
- Pre-NEM Policy: ***Individual's Demand Function & (Implicit) Access Value to NEM in Pre-Policy Condition***



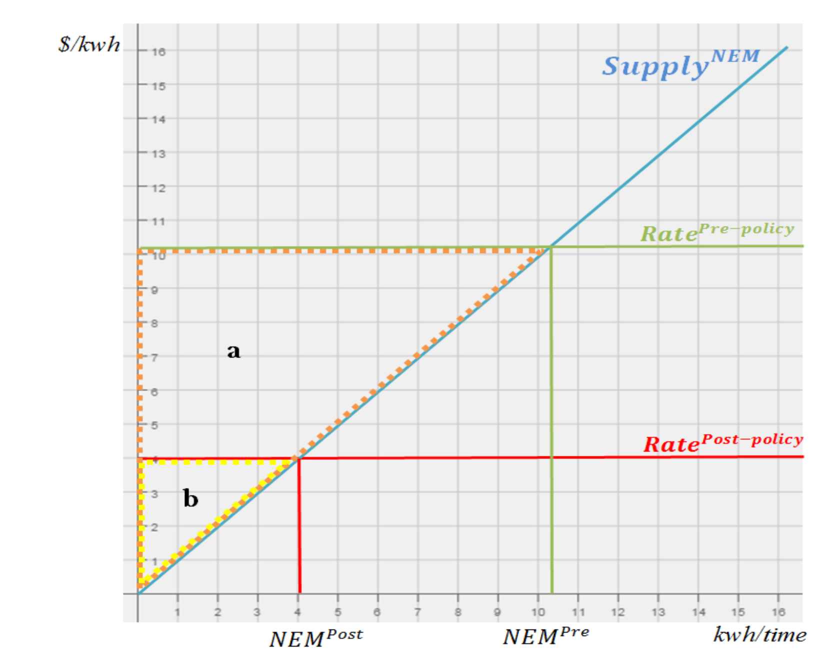
- Pre-NEM Policy: ***Change in MS After Increases in Cost Of PV-System by Post-Policy Changes in Financial Subsidies***



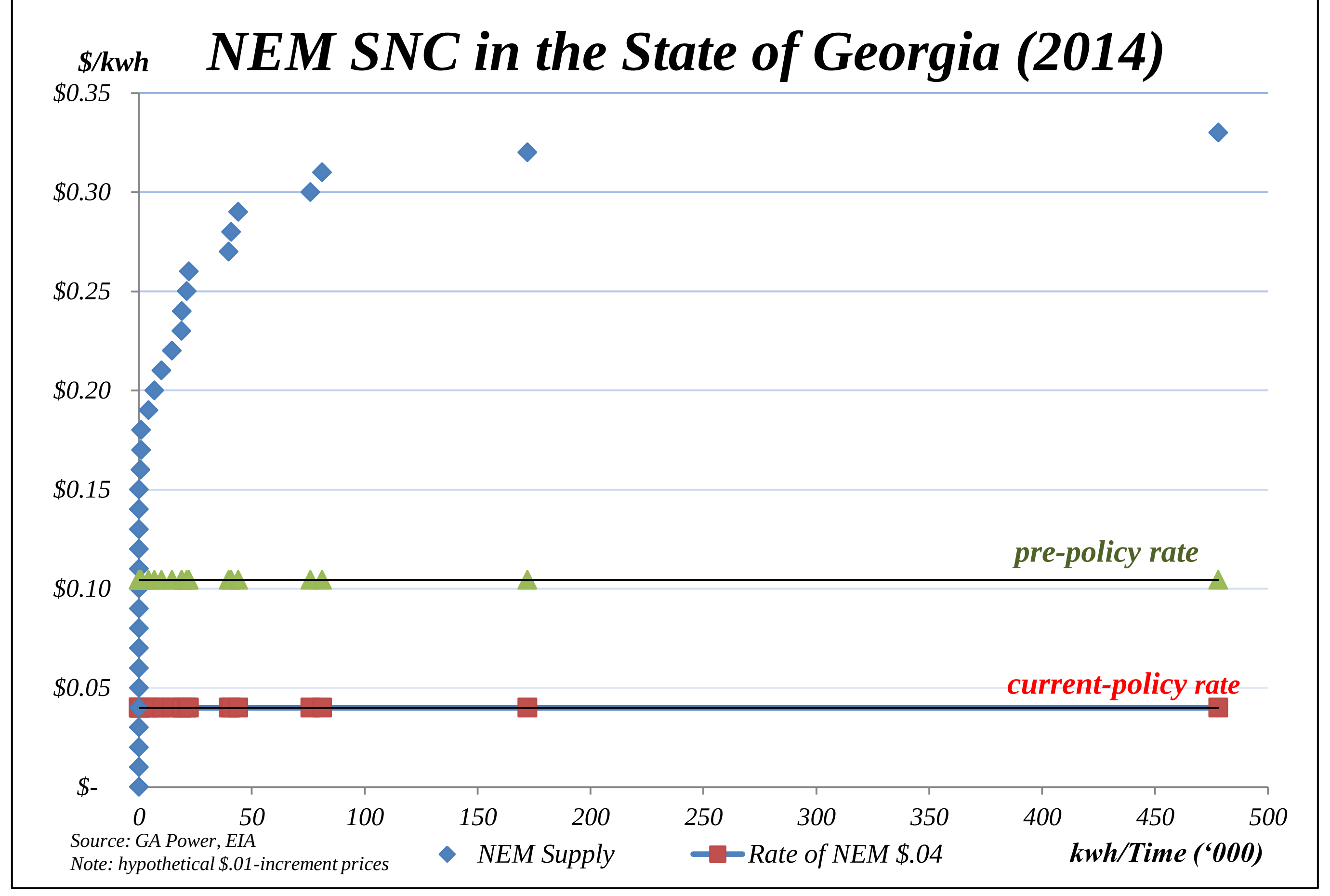
- Post-NEM Policy: ***Surplus in Pre-policy Existing NEM Policy in Net Surplus Compensation (NSC) – Areas of (a + b)***



- Post-NEM Policy: ***Surplus in Post-policy existing NEM Policy in Net Surplus Compensation (NSC) – Areas of b***



- **Figure A:** *SNC Rates and Amounts of Electricity Surplus Exported by NEM Customers in Georgia (2014)*



- Adopted Janvry, Fafchamps and Sadoulet (1991), a model for household (HH) recursiveness between production and consumption decisions is constructed as follows:

The HH is assumed to maximize a utility function subject to an income constraint for the commodities tradable on the market (T), a technology constraint (imposed cap on PV-capacity size), and the equilibrium conditions for tradable and non-tradable goods:

$$\mathbf{Max}_{c,q}\ \mathrm{U}(c, z) \qquad s.t.$$

1. $\sum_{i \in T} p_i c_i \leq \sum_{i \in T} p_i (q_i + T_i) + S$ — cash income constraint
2. $G(\boldsymbol{q}, \boldsymbol{z}) = \mathbf{0}$ — production technology constraint
3. $p_i = \bar{p}_i \quad i \in T$ — exogenously determined market price for tradable goods
4. $q_i + T_i \geq c_i \quad i \in NT$ — equilibrium for non-tradable goods

The Lagrangian for the constrained maximization problem is

$$\mathcal{L} = \mathrm{U}(\mathbf{c}, \mathbf{z}) + \lambda \left[\sum_{i \in T} p_i (q_i + T_i - c_i) + S \right] + \eta \mathrm{G}(\mathbf{q}, \mathbf{z}) + \sum_{i \in NT} \mu_i (q_i + T_i - c_i)$$

On the production side, sale electricity (q_s) and HH consumed electricity (q_h) with two inputs: solar-PV system (q_{PV}) and other inputs such as HH labor (q_l) for maintenance. The production technology G(**q**,**z**) with **q** as the vector of outputs (with positive values: $q_s > 0$ and $q_h > 0$) and inputs (with negative values: $q_{PV} < 0$ and $q_l < 0$), and **z** is a vector of structural HH characteristics. On the consumption side, HH consumes generated home electricity (c_{PV}), distributed grid electricity (c_{grid}), and leisure (c_ι). HH has an initial endowment of time T_ℓ as well as an endowment T_i of any commodity i, along with a cash endowment or receive a transfer *S.* The sale electricity is sold on the market, and the other inputs and the manufactured goods are provided by the market. Thus, the household is a price taker for all these commodities, and situations of market failure are considered for home consumed electricity and/or PV-system hosting.

Conclusion & Policy Implications

- **Expected Results**
  - With pre-policy NEM rates, e.g. the premium/retail SNC rate, electricity consumption will decrease.
  - With post-policy NEM rates, e.g. the wholesale SNC rate, the *rebound* effect can dictate electricity consumption – bending supply curves.
  - Social gains could be realized by lifting restrictions by utilities with sharing or trading platforms, especially under virtual and community NEM policies. For example, even utility consumers without installed systems of renewable energy could also gain from competitive utility rates via these platforms.
- **Policy Implications**
  - NEM policies and projects can lead to less social trade-offs among the four dimensions of each sustainability domain - quantity, quality, distribution, and resilience.
  - If mixed applications of the conversion from DC to AC and the reversal from AC to DC are to be significantly used in the near future, distributed generation (DG) or decentralized/on-site energy will become an important part of a national energy portfolio to mitigate greenhouse gases and reduce the negative effects of climate change on the environment, human health, and socio-economic systems.