Behind the Meter

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January 2025

1. Introduction

There are basically two types of Photovoltaic (PV) systems. Utility-Scale, and Small, Distributed-Scale. The latter frequently have the same name as the above title, abbreviated BTM. This is because each PV array provides power to specific residential, commercial or industrial customer (the latter two are usually grouped and called C&I), and the facility of that customer is metered by its supplying electric utility. Occasionally a PV system produces more power than the load consumes, pushing power back into the grid. This requires a four-quadrant meter, that can separately measure consumption and supply. The other two quadrants are Watts (real power) and VARs (volt-amps reactive or reactive power). The utility tariff (or rate-schedule) for a given customer defines how much the customer pays for consumption and is paid for supply, and for C&I, whether they are charged for supplying too many VARs (via a power factor adjustment).

Behind the meter PV Systems have been rapidly increasing in popularity and volume since 2010, and their costs have been rapidly declining to where their levelized cost are now less expensive than most utility generation. The down-side is that they are variable – they only supply power when the sun is shining, and supply less on cloudy days.

The facts in the above paragraph are why your author (1) has a PV system on the roof of his primary residence, and (2) has a small Battery Energy Storage System (BESS) to help compensate for the PV's variability. My utility (PG&E) also bills me via a Net Energy Metering rate schedule that lets me draw power that I pushed into the grid earlier.

2. Major Societal PV Benefits

Grid operators generally oppose BTM distributed PV because its first impact is to reduces demand for grid electricity. Utilities claim that the remaining customers must pay a higher cost for the remaining demand, mostly because the fixed cost of the transmission and distribution system is now spread over fewer customers. They further argue that only wealthy people can afford BTM PV, so the higher cost of grid electricity disproportionately affects low-income grid customers. Utilities have used this argument to stymie the expansion of BTM PV in many states (e.g., California, Hawai'i, Nevada, Arizona, Utah, and Florida), and countries.[1]

However, the opposite is true. BTM PV lowers electricity, health and climate costs for everyone for at least 11 reasons.

First, *the claim that BTM PV reduces grid electricity demand and, therefore, increases costs to grid customers by spreading the fixed cost of transmission and distribution over fewer customers ignores the realities of the current energy transition, where transportation, buildings, and industry are being electrified and the electricity is increasingly being provided by Wind, Water, Solar & Storage (WWS).*

[1] Mark Z. Jacobson, Stanford University, "Eleven Reasons Why Behind-the-Meter Distributed PV Lowers Electricity, Health, and Climate Costs for Everyone," October 11, 2024, https://web.stanford.edu/group/efmh/jacobson/WWSNoMN/DistributedPV.pdf

In the limit, this results in an overall reduction in energy demand worldwide of about 54.4 percent. However, all remaining energy will be electricity, so electricity needs will almost double. With a doubling of electricity demand, even if 25 percent of the total electricity demand is met with BTM PV, overall grid electricity needs will still increase by 50 percent compared with today. Thus, the assumption by utilities that a large growth in BTM PV reduces demand holds true only for low levels of electrification, not for large-scale electrification, which is needed to address climate, pollution, and energy security problems.

Second, *BTM rooftop PV electricity requires no new land, whereas utility PV needs new land. Thus, most BTM PV reduces land requirements and habitat damage compared with utility PV, benefiting both BTM and grid customers.*

Third, *BTM PV reduces the need for transmission and distribution lines. BTM PV users connected to the grid still need transmission and distribution lines when their PV and co-located battery system do not produce sufficient electricity or when their PV system produces excess electricity, which is fed to the grid through the lines. In contrast, grid customers need transmission and distribution lines for 100 percent of their electricity consumption, and utility PV requires transmission and distribution lines for 100 percent of its generation.*

Fourth, *when a BTM-PV and co-located battery system produces more electricity than the building it serves consumes, excess electricity is sent back to the grid. This helps grid customers avoid blackouts during hot summer days in particular.*

Fifth, *transmission line sparks have led to devastating wildfires, such as in California and Hawai'i. The cost of such fires and undergrounding transmission lines due to the fires have been passed down to customers in California, for example. BTM PV reduces fire occurrence and these costs.*

Sixth, *the addition of BTM PV reduces the mining, processing, and burning of polluting fuels (fossil fuels and bioenergy) for electricity generation on the grid. Reducing polluting fuels reduces exposure of the general population to gases and particles that cause morbidity, mortality, and health costs. Thus, BTM PV directly reduces health costs for both distributed PV and utility-PV customers. Since many electricity-generating power plants are located near low-income communities, the health-cost benefits of BTM PV accrue more to low-income residents than to high-income residents.*

Seventh, *by reducing greenhouse-gas emissions from polluting fuels, BTM PV reduces climate damage to both distributed-PV and grid customers.*

Eighth, *by reducing the use of fossil fuels, BTM PV reduces energy insecurity problems associated with fossil fuels, and this benefit accrues to both BTM PV and grid customers.*

Ninth, *installing BTM PV creates more jobs than installing and running utility PV and other grid-scale electricity generation, and this benefits a state or country as a whole.*

Tenth, *because rooftop PV absorbs 20 to 26 percent of the sunlight that hits it, then converts the light to electricity, less light is absorbed by the building, cooling the building during the day, reducing daytime electricity demand for air conditioning. Such cooling is greatest during summer and during the day, when electricity prices are highest. By reducing demand in this way during peak times of day, BTM PV reduces strain on the grid and the risk of blackout to grid customers. At night, solar PV panels act as insulators, keeping buildings slightly warmer than they otherwise would be, potentially reducing the demand for heating at night.*

Eleventh, *BTM PV facilitates the transition of a building to all-electric, thereby reducing occupant costs in the short run and long run. Normally, two forms of energy, such as fossil gas and electricity, are used in buildings. However, there is nothing that fossil gas can do that electricity cannot do less expensively and cleaner. An issue arises because, the more appliances in a building switched from gas to electric, the greater the electricity demand in the building. Utilities often charge a higher rate for electricity use beyond a threshold. This disincentivizes customers from electrifying more appliances. On the other hand, BTM PV provides the additional electricity at a lower cost than does grid electricity in most places, so electrifying a building that has BTM PV reduces overall electricity cost compared with electrifying and using only the grid for the electricity. Moreover, electrifying reduces outdoor and indoor air pollution from fossil gas use in buildings and producing gas, benefiting both BTM PV customers and grid customers.*

2.1. Additional Benefits of BTM PV

BTM PV results in at least three additional benefits for PV owner and building occupants but not necessarily users of grid electricity:

First, *BTM PV allows building occupants to keep their electricity on during a grid blackout. With one or two batteries co-located with the PV, the building can even continue to function using stored solar electricity at night. During a blackout, utility customers receive no electricity at all.*

Second, *although the wholesale price per unit electricity of utility PV is less than the cost per unit electricity of BTM PV, utility customers do not pay the wholesale price of utility PV. Instead, they pay the retail price plus the price of transmission and distribution, which sums to about four times the cost of BTM PV in, for example, California. As such, a utility-PV customer who adds and uses BTM PV can reduce their daytime cost of electricity by up to a factor of four.*

Third, *builders of new homes with only BTM PV and no fossil gas eliminate the costs of installing fossil gas pipes and digging ditches for them ($3,000 to $20,000) and of a fossil gas hookup fee charged by the utility ($3,000 to $15,000).*

Final author's comment: My electric & gas utility, PG&E, has extremely reliable electric service for my primary residence (in Livermore, CA). Since my BTM PV + BESS has been operating for less than a year, I have not experienced an electric grid outage (that I'm aware of) in Livermore since it has been installed. I'm reasonably sure that an extended outage would be brought to our attention via the neighbors, but a brief outage could easily escape our notice if the PV + BESS bridged the interruption.

Since our BESS is relatively small (10 kWh) during an extended outage we would need substantially curtail electricity use at night in order to stay within the capacity of this unit. I believe our lighting mostly consists of LEDs, but other significant loads include computers (mine is a relatively new laptop that would last overnight from its internal battery with my normal usage, but my wife has a Desktop), TVs with DVR (would our cable service and/or Internet access still be on?), electric range, cooktop and HVAC System. We also have an electric dishwasher, clothes washer and dryer, but don't use these daily, and these could be conveniently curtailed. Our hot water heater and heater for the HVAC System use gas-heating.

Our mountain home (in Arnold, CA at 4,000 ft. in the Stanislaus National Forest) has much less reliable power than Livermore (although PG&E is our electric utility here too), so I have "outage-proofed" it with kerosene lamps, battery-powered lighting and a wood-stove for heating. The first two appliances are only used during outages. The wood-stove is used to reduce our propane bill. The stove also allows limited cooking as a stand in for a stove-top. I am also considering getting a 12-volt inverter so I can use our cars for supplemental AC-power during outages (go through the link below).

https://www.amazon.com/Kinverch-Continuous-Inverter-Converter-Charging/dp/B07KJ184NJ?th=1