What Do We Do When Energy Is Free?

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The phrase "too cheap to meter," attributed to a speech by then AEC Chairman Lewis Strauss in 1954, has been debated as to its actual meaning, has often been used to critically point out the hubris of early nuclear power advocates, and did not escape criticism at the time. One of the criticisms, coming from the president of Cleveland Electric Illuminating, was that the statement did not make sense because fuel costs made up a relatively small share of electric bills (Wellock, 2016).

While even the most fervent renewable electricity advocate does not claim that such generation will be cost free, it is not hard to imagine a future world in which a combination of batteries and intermittent renewables (including hydropower) may become the dominant if not exclusive source of electricity generation. There is an ongoing lively debate over the question of whether flexible fossil fuel generation can still provide value (see, for example, Kane and King, 2017, along with the technical papers cited therein), but it would play a much reduced role, such that marginal generating cost in most hours would depend only on solar or wind.

Favorable government policies such as subsidies and renewable portfolio standards have played a significant role in increasing the proportion of wind and solar electricity on the grid, but the real costs of these technologies (which are essentially all capacity related) have fallen considerably as well. Recent auction results in wholesale electricity markets in the U.S. (see, e.g., Maloney, 2018) indicate that intermittent renewables coupled with battery storage are giving traditional fossil fuel based generation technologies a run for their money. This trend is likely to continue, despite the existing schedule for the gradual elimination of subsidies for renewables.

One potential endpoint of this progression is that a combination of intermittent renewables and batteries becomes the dominant if not exclusive source of electricity generation. In such a system the marginal ("energy") cost of a kilowatt-hour would effectively be zero, including emissions costs. Zero marginal cost electrical energy would raise significant questions regarding the appropriateness of current regulatory approaches. Three important policy areas for regulators in which economic analysis will be critical are pricing and rate design, wholesale market design, and the evaluation of energy efficiency. We consider each in what follows. And while some suggestions will be offered along the way, the primary purpose of this article is to stimulate thinking about some of the more interesting regulatory economics questions that will have to be addressed in a zero variable generation cost world.

Rate Design

In traditional rate designs, residential and most small business customers' rates consist of a basic ("customer") charge per month and additional per kWh energy charges, which may vary by monthly consumption block or by season. Rates for larger customers also include a per kW demand charge, with the billing quantity dependent on some variation of the customer's peak demand. Most customers are served under tariffs that do not include time-varying prices, despite the fact that marginal generation costs differ considerably over a single day. The historical rationale for these rate designs is that the additional cost of interval metering isn't justified by the welfare gains that would result. Time sensitive prices have therefore not been widely applied, despite the inefficiencies that result from charging the same price in all periods. The rapid increase in the number of so-called smart (Advanced Metering Infrastructure, or AMI) meters, which in 2017 accounted for about 52% of residential and 50% of commercial meters (EIA, 2018), is making time-sensitive or demand related pricing approaches possible for a much larger number of customers. Would the ability to charge time-varying prices become more important or less so in a zero marginal cost world?

The advent of increasing amounts of residential rooftop solar customers has caused a number of state regulatory commissions to rethink the pricing of electricity sold back to the grid by such customers, which in turn has opened a larger conversation about rate design in general. The widespread use of net metering, in which a rooftop solar customer is effectively paid the full retail rate for power sold back to the grid, has been claimed to result in subsidies of solar customers by those without panels on the roof. Whether or not that is true is being debated in many states, with the central question being the value of solar. Regardless of the outcome of that particular debate, it has led to a reconsideration of rate design for customer classes that include increasing numbers of customers who have rooftop solar generation. But that process also has broader implications for future rate designs based on zero marginal cost energy.

One of the tenets of good rate design, following basic efficient pricing principles, is to set rates as close as possible to marginal cost, while recognizing that the regulated utility's required revenues must be made up through fixed charges, since the (average hourly) marginal cost of generation is less than the average total cost of providing service. But if energy costs are in fact zero, efficient pricing would call for a per-kWh price of zero. This would require the entirety of electricity supply costs to be recovered through fixed monthly and demand-related charges.

The imposition of demand charges on residential customers has been considered in multiple jurisdictions, in many cases in response to the aforementioned net-metering issue. One criticism of demand charges is that residential and small business customers are usually unable to adapt usage patterns to control peak demands in a way that would reduce the demand charge portion of their bills, but this criticism will lose validity in the future as more appliances (and especially those that impose high instantaneous demands, such as air conditioners, water heaters, and refrigerators) become "smart" and programmable. Another criticism of demand charges is that a customer's peak demands do not necessarily occur at the time of system peak (see, e.g., Borenstein, 2016), but that issue can be more easily accommodated with AMI technology, which can tell us what a customer's demand is at the system peak. (While Borenstein correctly points out that sunk local distribution costs do not change as customers on the local system change their demands, it is nevertheless true that 1) these systems must be built to meet the peak of some localized subgroup of customers, and that 2) if demands in a specific local area increase in the long run, such as would occur with significant increases in electric vehicle charging, distribution capacity would likely have to be increased as well.) A third criticism of demand charges is distributional, in the sense that shifting cost recovery away from the variable rate elements to fixed or demand based elements would harm low-income customers, who typically consume less electricity than higher income households. But many utilities already have low-income assistance measures in place, and there is no reason why similar programs could not be carried out if utility bills are made up entirely of fixed and demand charges.

In short, the debates over rate design in a zero marginal cost world would likely not differ much from those we see today, but they may very well be more intense as more and more revenue will have to be recovered from fixed and demand charges rather than from variable per kWh rates.

Market Design

Markets for wholesale generation have been transformed dramatically over the past 25 years as the old traditional integrated utility model has been dropped in many regions in favor of some form of competitive markets. Regulatory restructuring at the wholesale level has led to the creation of a new set of market participants such as Independent System Operators (ISOs) and Independent Power Producers (IPPs). The recent emergence of significant quantities of low variable cost generation resulting from low natural gas prices and rising penetration of zero marginal generation cost renewables has raised numerous issues in wholesale markets. Low hourly energy prices have contributed to the early retirements of (primarily) large baseload coal and nuclear generating units and have led to some concerns over the adequacy (in terms of both quantity and operational availability) of future capacity additions. What appear to be mostly political concerns have led to efforts at both the federal and state levels to prevent the early closures of plants through various policy approaches, including subsidization and even mandated inclusion of what otherwise would be uneconomic generating units. These problems (if such early retirements are in fact real economic problems) would be exacerbated in a zero marginal generating cost scenario. It is not entirely clear that the capacity markets used in some ISOs, as currently designed, fully alleviate concerns about future capacity adequacy.

We normally think of the day ahead and hourly energy markets operated by ISOs as places where *energy* (i.e., MWhs) is traded; prices are expressed in dollars per MWh. But in a system consisting primarily of zero marginal cost sources, how would "energy only" markets work? Generating units with positive marginal costs would probably be employed under certain circumstances, but only in a limited number of hours. How would generators be able to recover the cost of capacity investments in such a pricing environment? Would hourly energy markets evolve into long-term capacity markets while pure energy exchanges account for only a small fraction of total electricity use? Would long-term bilateral contracts become the dominant form of supply arrangements? These and many other related questions will have to be addressed; clearly, wholesale markets will have to be rethought extensively in a zero variable cost world.

Energy Efficiency

A utility recently proposed cutting its energy efficiency targets in large part because the value of electricity use efficiency would decline over time as the penetration of renewable electricity generation increased, since renewables such as wind and solar have very low (if not zero) marginal costs (Walton, 2018). Although energy efficiency is sometimes thought of as (instantaneous) demand reduction, for the most part efficiency in electricity use emphasizes a reduction in kWh. When a consumer evaluates a potential energy efficiency investment such as adding insulation or buying a more efficient air conditioner, per kWh prices loom large in the calculations, in part because of the current rate designs that are in place. And while some utility efficiency programs are targeted at reducing system peak demands, their overall emphasis tends to be on lowering kWh usage.

How would zero marginal cost energy change the evaluation of energy efficiency from a social standpoint? Efficiency values from the vantage point of a consumer depends on rate design more than on actual upstream generating costs, which often do not correspond very well, especially given potentially large short term variations in the latter. From a social standpoint, however, the value of energy efficiency derives from the avoidance of both capacity and variable energy costs. If variable energy costs fall effectively to zero, "energy" efficiency measures will have value only insofar as they allow the avoidance of capacity (either from generation or storage facilities) costs. While it is true that many energy efficiency measures also reduce the peak demands resulting from a given energy use (lighting, space conditioning, etc.), the avoided fuel cost element of energy efficiency values will be essentially zero. Demand management activities such as pricing strategies (e.g., critical peak pricing and rebates) or the direct load control through smart meters and appliances that are aimed at peak shaving and increasing load factors will take center stage in efficiency efforts, but merely saving a kWh of usage will be of little value.

Conclusion

Energy economists rightly spend their time examining the multitude of technical and policy issues associated with various aspects of today's energy usage, production processes, and markets. But it is worthwhile to occasionally ask what the future holds and how technological advancement can affect the way we think about energy. There are many important ramifications of a zero marginal cost future that have not been considered in this article; our intent has been to touch on just a few that will have important implications for regulators. While these issues may be thought of as problems to be solved, they would seem to be the kinds of problems we would like to have as we learn how to take advantage of the free energy sources nature has provided. To aid in this effort economists should continue to help tailor policies that will best accommodate transformed energy systems, and think about how people will react to them.

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