OLIVER WYMAN

Energy

The Three Laws of Energy Efficiency Economics and Consequences for Utility Strategies

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Political and regulatory leaders are ratcheting up their expectations for what energy efficiency programs will attain and by when. With each raise of the bar, it becomes ever more critical for utility leaderships to understand the unique and sometimes obstreperous economic behaviors these programs exhibit.

For expository purposes, this article distills the most consequential tendencies of energy efficiency programs into three fundamental "laws." While in no-way as monumental as Newton's three laws of motion and the like, our three laws of energy efficiency economics are nonetheless inviolable causes and effects. Gaining an understanding of these dynamics is duly rewarded with insights as to how utilities might respond to this challenge of ratcheting and unprecedented expectations.

The insights offered by energy efficiency economics empower utility leaderships to positively impact legislative and regulatory discussions about efficiency requirements, incentives and penalties, and regulatory process. Utility leaderships are as well better positioned to build up successful efficiency delivery organizations within their companies.

In our experience, three tendencies of energy efficiency programs stand out as the most profound and vexing. We refer to these tendencies as:

The First Law: **Fractional Adoption**

The Second Law: **The Untrodden Production Curve**

The Third Law: **Confounding Response**

Each law is briefly examined in turn.

The First Law: Fractional Adoption

Initiatives to increase the energy efficiency of utility customers—businesses and residences—can be likened to an uphill battle. Several factors particularly conspire to encumber and retard these campaigns and pare down their productivity.

The most important factor is that electricity price signals are strongly pro-use. Contrary to popular belief, electricity is demonstrably inexpensive given consumer preference and utility, and when compared to products and services that are close substitutes for customers. Many quite understandably do not find as compelling entreaties to voluntarily save energy, at least as judged by their actions.

For example, consider that the electricity to use a hundred-watt device for an hour costs only a lowly penny, which assumes a utility rate of ten cents per kilowatt-hour. If the device is replaced with one that is more energy efficient, say twice as efficient, an hour's use falls to half a penny. Most of the public might regard this cost, half a penny, to be of little matter in their busy lives. To the economist, use of the device becomes a "free good," essentially, in that customers are virtually oblivious to there being any cost at all.

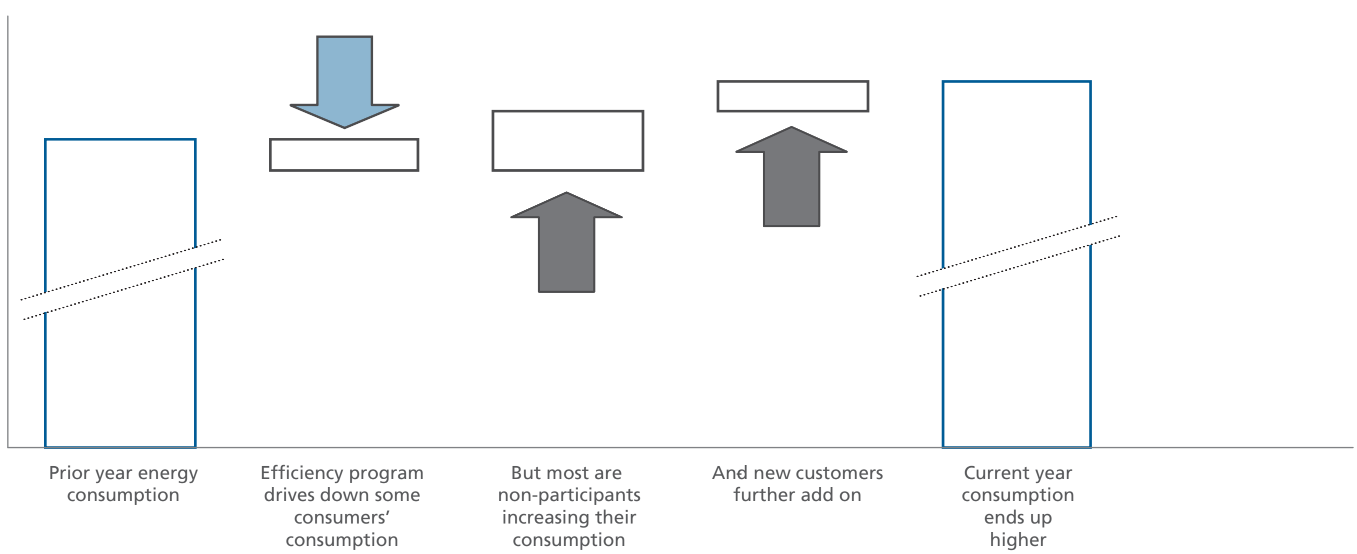
In the extreme, leaving the more efficient device on all the time, every hour of the day, every day in the month, never shutting it off, would cost just over $3 for the month. Such thoughtless overuse for a whole month would cost not much more than one latte or one gallon of motor gasoline. Is it so surprising then that customers have not clamored to reduce their electricity consumption?

Ironically, the evolution of device efficiency exacerbates the relative apathy of consumers apparent in our society. Electrical devices wondrously impart convenience, comfort, entertainment, safety, health and otherwise gratify human needs and wants. Consider how many consumers progress from fans to room air conditioners to central air conditioning, or add large-screen plasma TVs, with relative ease and little thought given to the additional electricity costs when compared to the thought accorded other factors such as devices' purchase costs, functionality, and power.

Then, when electrical devices are made more energy efficient, usage of them becomes cheaper still. After efficiency programs have their intended effect, price signals become extraordinarily pro-use.

Secondarily, factors aside from pro-use price signals also burden efficiency initiatives. Non-participation

Efficiency is a battle



is an indomitable fact of life, eroding and diminishing program impact. Energy efficiency programs generally involve but a fraction of the whole customer population. Then, for the minority of customers who do voluntarily participate, efficiency programs typically impact but a fraction of the participants' electricity usage. The result, a fraction of a fraction, can be unspectacular.

Furthermore, persistent streams of growth in electricity use counteract and offset program impact. Customer populations grow consistently over time in most service territories, and at a compounded rather than linear rate. Both incumbent and added customer populations constantly discover and crave new applications for electricity as well as broader and new uses for existing devices.

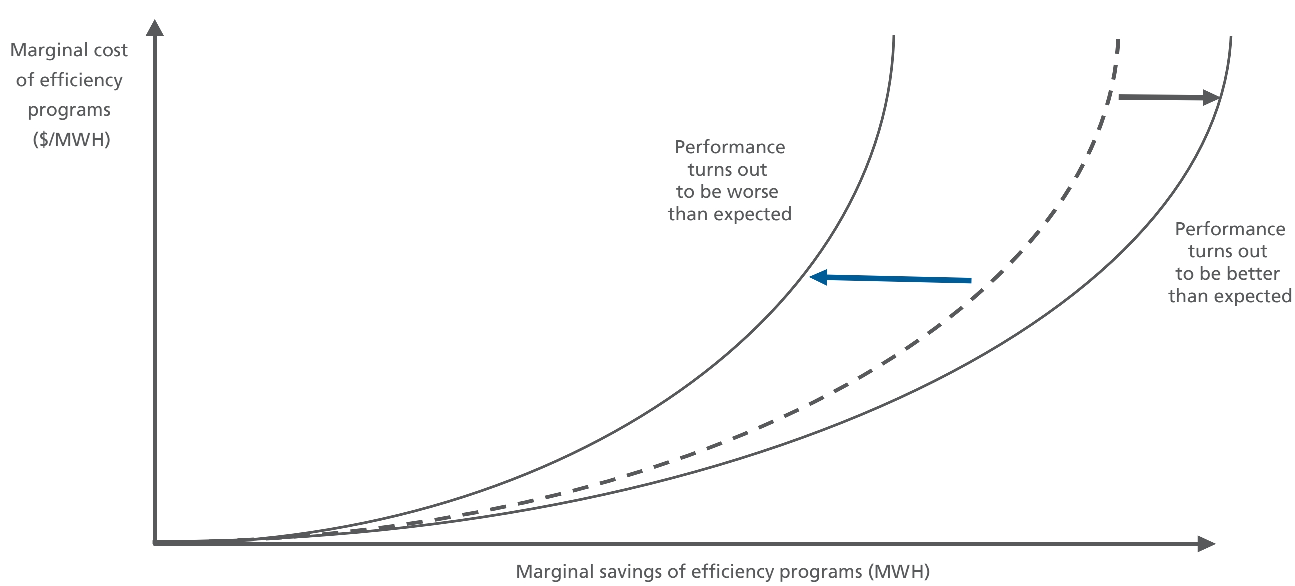
The Second Law: The Untrodden Production Curve

There have now been many studies made of national or statewide efficiency potential. The reports opine on how much savings could be had, in an idealized world, with a 100$ penetration rate and universal acceptance and adoption of more efficient electrical devices and building insulation. The studies then, typically, revise the estimates downward to factor in real world societal and economic obstacles.

What is most concerning about efficiency potential studies is the form of their conclusions, ordinarily a point estimate of savings to be exploited (or narrow range). Too little heed is given to a basic truth of forecasting any future economic activity: Point estimates are inherently misleading and presume greater precision than is justified. Even if unintentional, point estimates imply that political and regulatory leaders have near-perfect foreknowledge about the public's voluntary acceptance and adoption of efficiency products and services in a free society. The track record to support such confident views of the future is hardly extensive thus far.

With the introduction and promotion of products or services of any kind in any market, there are unknowns and uncertainties to resolve and master that can be make-or-break. Market penetration, penetration rates, and marketing costs are revealed and become known with confidence when "the voice of the customer" has spoken through years of real-world experience marketing and selling (though customer science can anticipate real-world experience to an extent).

Efficiency performance is uncertain



Energy efficiency is no different. The efficacy of many existing efficiency programs is unquestionable. However, their scale by any measure is generally miniscule in comparison to the raised bar of political and regulatory leaders. No reference case exists that demonstrates the aspired market penetration, penetration rates, and marketing costs are achievable. One simply does not know whether the future will bring instead lesser penetration, slower rates, and greater costs.

Efficiency potential studies are already evolving, albeit uncertainly. Expected market penetration of efficiency versus marketing costs can be represented with a production cost function, or production curve, an analytic framework borrowed from the toolbox of micro-economists. One can exhibit types efficiency improvements, expressed in expected megawatt-hours to be saved, in a graphical form of the production curve. The kinds of improvements (e.g., upgrading commercial customers with more efficient lighting) are shown in monotonically increasing order from lowest to highest expected marketing costs, expressed in average dollars per megawatt-hour to be saved.

Constructing such a production curve is complicated by three issues:

1. How does one account for exogenous efficiency improvements? Should utilities' production curves incorporate the promise of more efficient building codes and appliance standards? Utilities can have no more than an indirect effect on whether stricter building codes and appliance standards are ordered and full and timely compliance is compelled.

2. How does one account for timing and uncertainty? An efficiency production curve misrepresents the challenges ahead if it is static, treating the future as a single homogeneous time period, assuming away the sequence and Bayesian conditional effect of developments over time. A curve also misrepresents if it is deterministic, assuming away uncertainties.

3. How does one incorporate regional variation? Utility service territories have dramatically different experiences to date as far as improving energy efficiency is concerned. Just as dramatic are the differences in climate, building styles, and economic mix that should sharply differentiate their efficiency production curves.

Instead of a single production curve, a set of discrete scenarios represented along a central continuum becomes necessary. A set of such scenarios can communicate how much efficiency can be counted on, with what degree of confidence, to meet customers' needs next year and in each succeeding year; and what are the implications of credible upside and downside scenarios.

In California, for example, utility investment in customers' efficiency programs has been atypically high for several years. Has the proverbial ore that once lay on the ground in plain view been picked up, leaving only more difficult and costly efficiency improvements for utilities to explore for? Or are more-seasoned California utility efficiency organizations better apt than those elsewhere to dig and discover rich new seams of efficiency to be mined?

We expect the sophistication of such studies will evolve, increasingly acknowledging and dealing with the messy complexities of energy efficiency economics. Only then will political and regulatory leaders take as seriously as is merited the unknowns and uncertainties about how much efficiency can contribute to sating customers' electricity demands (alongside the provision of electrical energy), by when, and at what costs.

The Third Law: Confounding Response

Even as we come to appreciate the tenets of the frictions holding back public acceptance and adoption of efficiency and the uncertainties in forecasting efficiency "markets," we find there are also challenges merely to understand how efficiency behaves at the micro level, customer by customer. In particular, the link between what efficiency programs do directly and how they perform relative to political and regulatory bottom-line objectives is complex indeed.

The end goal of efficiency programs, after all, is the suppression of certain energy use outputs, megawatt-hours of consumption and, ultimately, tons of carbon dioxide emissions. Yet, the programs actually suppress energy use inputs. Through many means, programs essentially reduce customer devices' watts per function principally, and cut devices' usage time secondarily.

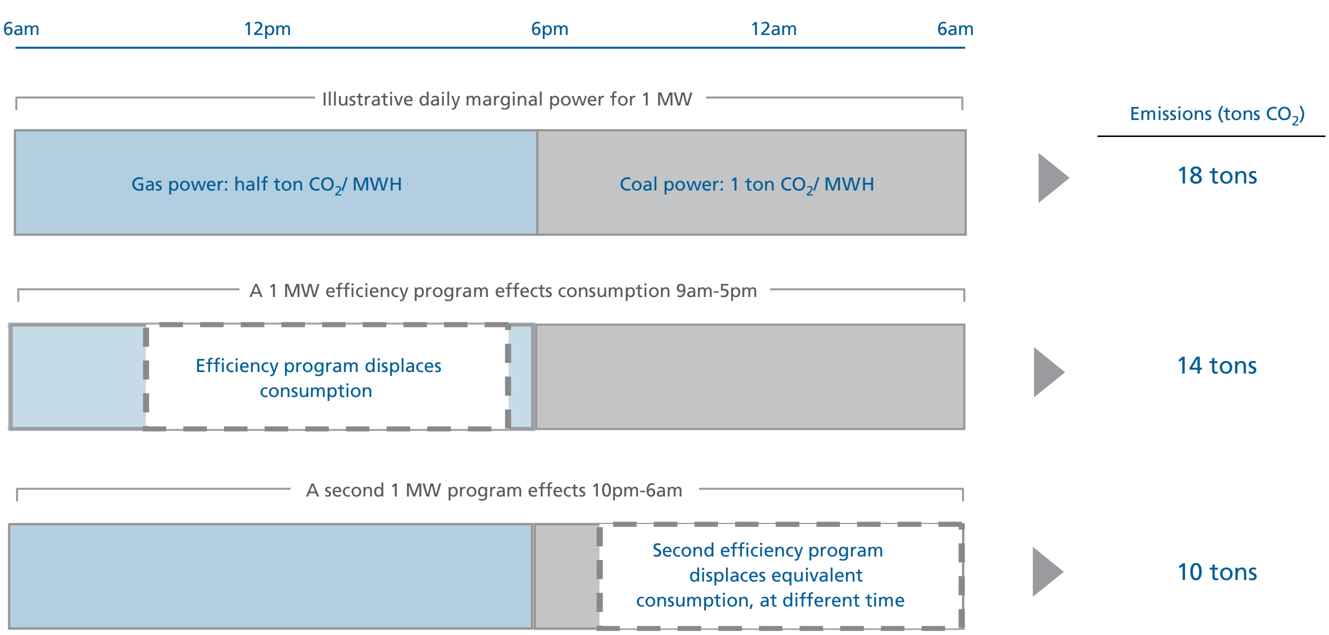
However, the social and economic mechanism connecting these outputs and inputs is complex and inscrutable. So what will happen to consumption and emissions, given a level of investment in efficiency, directly applied to customer devices' watts per function and usage time, is not just difficult to predict, it is difficult to assess.

Suppose, for instance, that an efficiency initiative supplies an efficient electrical device to both customer A and customer B to replace their inefficient devices that draw twice the watts per function for a given usage time. Further assume customer A unplugs the inefficient device, connects the efficient substitute and otherwise changes usage of the device and any associated devices by not one whit. But what if customer B does not unplug the inefficient device, does not connect the efficient device, or does change usage of the device or associated devices? The energy savings might be quite different, of customer A versus that of customer B.

As another example, suppose efficiency initiative C displaces the necessity to generate one megawatt from 9 a.m. to 5 p.m. every day, and initiative D the necessity to generate a megawatt from 10 p.m. to 6 a.m. every night. Each program saves 2,920 megawatt-hours per year, but each may affect emissions quite differently, as the displaced energy provision during daytime may be entirely natural-gas-fired and during nighttime entirely coal-fired. The savings are equivalent, but initiative D would have twice the impact on emissions.

Furthermore, current usage monitoring is inadequate. To date, there has been very little tracking of customer devices' watts per function and usage time. With the installation of millions of advanced meters nationally (assuming regulators do allow the considerable costs of this transition), the base of customer information will someday become much richer.

The emissions link is inscrutable



Emissions impact can vary widely because of several factors, including relation of usage time to power supply mix

Efficiency Emerges as a Capital Investment

We expect a paradigm shift in the way political, regulatory, and industry leaders view energy efficiency. The shift underway is to efficiency as a capital investment.

Efficiency programs do produce megawatt-hours of savings. Though soon, efficiency will be seen more as the building up over time of megawatts of capacity, which permanently renders as unnecessary streams of energy provision for multiple years or decades. Efficiency will then be considered as a capital investment of a long-lasting durable nature, rather than as an expenditure on transient perishables.

> *"So an idea that I thought was particularly compelling that came out of the group was to allow utilities to think of the efficiency that they cause in their customers, to treat it in the same way as the capitalization that they do of a new plant."*
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> *– Eric Schmidt, CEO, Google Inc.,*
> Wall Street Journal*, November 24, 2008, page R6,*
> *participant at the* Wall Street Journal *"CEO Council."*

In this light, efficiency programs build up over time some firm capacity plus more non-firm capacity. Much like renewable generation capacity, efficiency capacity does not require fuel to produce its output and needs little operating and maintenance, expensed or capitalized. Efficiency's hourly output is intermittent but perhaps more predictable than renewable generation capacity. As with other energy resources, we can measure efficiency capacity by metrics such as maximum non-coincident total capacity, maximum coincident capacity, firm coincident capacity, average capacity factor, load factor, and characteristic chronological load curve.

Finally, privacy issues may stand in the way of this needed customer data base. Here in the good old US of A, we have long treasured privacy traditions. Many customers would likely object to the big brother aura of their utility tracking with precision changes in devices' watts per function and usage time, from which private personal behavior could be inferred.

Consequences for Utility Strategies

Taken together, the three laws humble those who would confidently predict with certitude how much efficiency initiatives can achieve and by when. The first law teaches us that our best efforts to improve customer efficiency can be swamped and overcome by formidable forces such as pro-use prices, population growth, and proliferation of electrical devices. The second law teaches that our knowledge is so incomplete that it is treacherous footing for integrated resource planners who commit to so many megawatt-hours of added savings for a given out-year. The third law teaches that as we imbue efficiencies in devices and building shells the black box that then reduces consumption and emissions remains fairly mysterious and not very susceptible to tracking (not yet anyway).

It is then imperative that the political and regulatory process molding efficiency policy respect these limits on what we know so far and thus essential that utilities compellingly make this case. And as utilities ramp up the intensity of their efficiency organizations, it is just as essential that these become flexible learning organizations that invest sufficiently in understanding and acting upon the voice of the customer. ❖

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