Why Demand Growth is Out, Energy Efficiency is in, and the Important Implications of the Two

By Fereidoon P. Sioshansi*

There are growing signs that electricity demand growth, traditionally assumed as "a given," may be slowing to unprecedented low levels, partially as a result of continued gains in energy efficiency. This, plus a number of other trends has important implications for the electric power sector – whose traditional business model has been predicated on steady growth.

Demand Growth is Out

Following the Second World War, U.S electricity demand was growing at near double digits, which meant that installed capacity had to double roughly every 10 years (Table 1). The power sector not only managed to keep up with the growing demand, but it did so while improving reliability and reducing per unit costs of electricity for extended periods during the industry's so-called *golden years*.

But as happens with all mature industries, demand for electricity in the U.S. – and other mature OECD economies – is not growing anywhere as fast, as steadily, or as predictably as it used to. The explanation for the steady decline in demand growth is complex and varied, but is driven by a number of powerful trends further described in this article.

Decade	Ave. U.S. Electricity Demand Growth, %	Rough Time Needed to Double Capacity, Years
1950	9.3	7
1960	7.4	9
1970	4.4	16
1980	2.8	25
1990	2.4	29
00-10	1.0	69
Projection*	0.7	99

*Latest EIA projection
Source: Energy Information Administration

Table 1
Electricity Annual Demand Growth, in %, and Number of Years to Double Capacity

Electricity demand growth in the U.S. has been on a downward trajectory for quite some time (Figure 1). The current official forecast by the Energy Information Administration (EIA) is 0.7% average annual growth under a business as usual (BAU) scenario, which assume no policy changes, for example to further strengthen appliance energy efficiency standards or tighten building codes. In other words, 0.7% is what we'll get if we don't do anything beyond what is already in the pipeline. Others believe that the rate of growth will be slower, 0.6% or lower. At this rate, it will take over 100 years to double U.S. electricity consumption – rather than the 7-10 years it took in the 1950s. For an industry whose business model has been strongly tied to steady demand growth, these are trying times indeed.

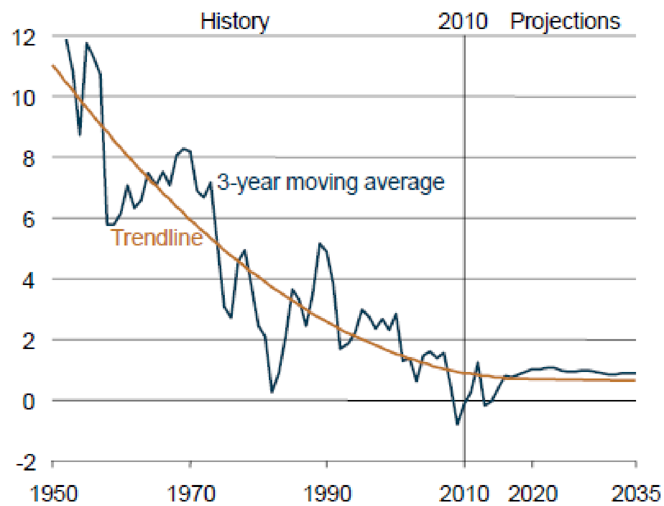

Figure 1
U.S. electricity demand growth, 1950-to present with projections to 2035 in %, with 3-year moving average

Source: Annual Energy Outlook 2012, EIA, June 2012

Among the fundamental reasons for the decline is that mature and maturing OECD economies are becoming less energy-intensive as they continue to shift to services. Historically, for example, roughly 1/3rd of the electricity consumed in California was used by the industrial sector. That percentage is now close to 10% – mostly because the industrial sector has not grown while the overall size of the pie has, resulting in a shrinking industrial portion. This may be part of the explanation for the difference between the energy intensity of California and U.S. (Figure 2).

Other explanations include an aging population, changing lifestyles, shrinking number of occupants per dwelling and smaller houses. Finally, monitoring and managing energy consumption is becoming easier with advancements in technology, allowing consumers to use electricity more productively *and* sparingly. The net result of these and other trends is a virtual flat per capita electricity consumption profile for the U.S. as shown in Figure 3.

Another example where the future growth pattern may be deviating from the past is the average size of the typical new home built in the U.S.. As noted by John Caldwell, as per capita income increased, so did the average size of the new homes (Figure 4). But speculation is growing that the correlation may no longer apply even after the current recession comes to an end.

While many affluent Americans will continue to build ever-larger homes and mansions, there are powerful trends that suggest that not all Americans will want

* Fereidoon Sioshansi is president of Menlo Energy Economics. He can be reached at fpsioshansi@aol.com
See footnotes at end of text.

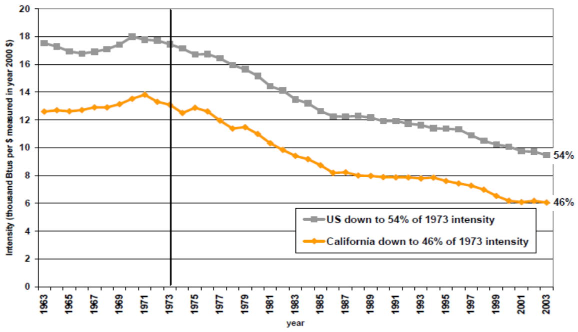

Figure 2

Energy intensity of California vs. the U.S., 1963-2003

Source: 2013 Building Energy Efficiency Standards, CEC, 31 May 2012

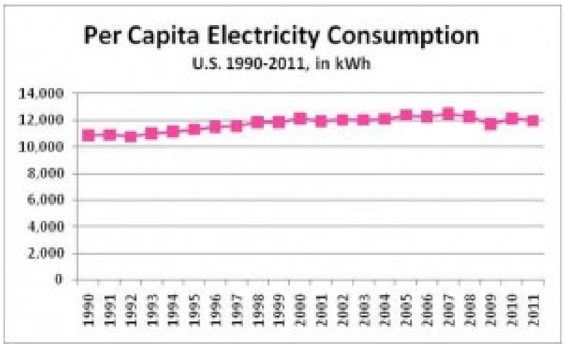

Figure 3

U.S. per capita electricity consumption, kWhrs/person, 1990-2011

Source: Chris King's blog, eMeter, 6 April 2012

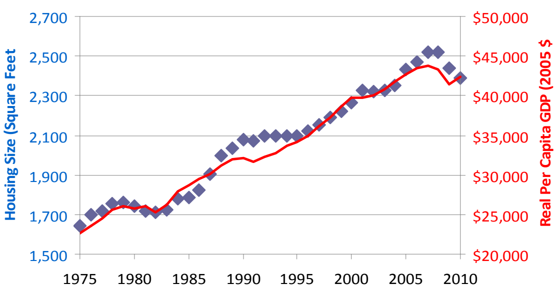

Figure 4

Correlation between income and size of new dwellings built in the U.S., 1975-2012

Source: John Caldwell, Edison Electric Institute

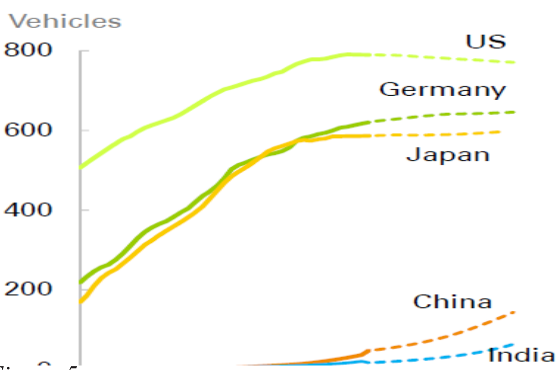

Figure 5

Car ownership in selected countries, cars per 1,000 people

Source: BP Energy Outlook 2030, Jan 2012

bigger homes even when their incomes grow. In 1950, roughly 4 million Americans lived alone, according to U.S. Census data. Today, an estimated 31 million live alone. Would a single person need, or necessarily want, a 2,500 square foot house even if he/she could afford it?

Currently, a third of all U.S. households have a single occupant and over 5 million adults below the age of 35 live alone. Many of these people with no kids prefer to live in smaller homes or apartments closer to work and to the urban amenities they enjoy. Bigger homes in distant suburbs still appeal to large families with kids but this may be a shrinking segment of the population.

Smaller households, smaller dwellings, better insulated homes, and more efficient appliances suggest lower electricity consumption trends. The effect of more stringent building codes and appliance energy efficiency standards, combined with the demographic trends and structural shifts away from energy intensive industry points to declining demand growth rates.

Today, the average U.S. house owns more than 2.5 TVs, and an increasingly number of these are flat-screen TVs, which are getting bigger in size and are electricity guzzlers – the second biggest contributor to the rise of electricity consumption in the residential sector. But if a growing number of homes have a single occupant, how many more TVs will be needed, and more important, how many will be on in a given house at any given time if there are fewer occupants?

It must be noted that the per capita saturation of demand for electricity is not unique. In many advanced economies, the phenomenon of demand saturation is observed in car ownership, number of miles driven, gasoline consumption, beer consumption and so on. As illustrated in Figure 5, car ownership in the U.S., Japan and Germany has flattened. The explanation is that there are simply not enough licensed drivers. With average fuel efficiency of U.S. cars projected to reach 54.5 miles/gallon by 2025, gasoline consumption will further drop. Higher gasoline prices are also contributing to the decline in gasoline consumption. These and other trends are likely to become more pronounced in a number of mature OECD economies with aging populations in the years to come.

Energy Efficiency is In

As anemic as the business-as-usual electricity demand growth already is, there are compelling reasons to believe that it can be further reduced. Not only is such a scenario technically feasible, but by most indications, it will be cost-effective, even excluding the environmental benefits.

A recent study by the Institute for Electric Efficiency, for example, suggests that by simply applying more stringent building codes and appliance energy efficiency standards, U.S. electricity consumption can be flattened or lowered from the current level by 2025 (Figure 6). Getting by on less energy, of course, is nothing new or novel. In his latest book, *Reinventing Fire*, Amory Lovins, presents a scenario where the U.S. can essentially eliminate its reliance on fossil fuels by 2050 while sustaining high living standards *and* economic growth.[5]

Another study by the same institute concludes that energy efficiency budgets at U.S. utility companies are up 80% since 2007 with more state regulators adopting favorable policies that enable utility companies to pursue efficiency as a sustainable business (Figure 7). This has been a major hurdle because under traditional regulations, utilities *lose* revenues if they encourage their customers to conserve. "In the face of successive years of double-digit increases in electric utility company electric efficiency budgets, expenditures, and associated energy savings, we expect continued evolution of regulatory frameworks that support utility efficiency investments," according to Lisa Wood, Executive Director of IEE.

While progress is slow and piecemeal, a growing number of state regulators now allow partial or full recovery of legitimate expenses associated with energy efficiency programs including *lost revenues* (Figure 8). These developments are likely to result in further erosion of demand growth with potentially significant cost savings for consumers, and benefits to the environment.

Another promising development is a requirement that all new residential units built in California must meet a *zero-net-energy* (ZNE) standard starting in 2020, 2030 for new commercial buildings. The definition of ZNE is that the building must generate as much energy as it consumes. As ambitious as this sounds, there are already many examples of developments that meet the ZNE standard – and the marginal costs do not appear onerous. Since California is often a leader in adopting innovative regulations, ZNE-type requirements may become commonplace if California's experience proves feasible and cost-effective.

Moreover, the potential for cost-effective energy efficiency is simply enormous and is not limited to the U.S. A recent study by UK's Department of Energy & Climate Change (DECC), for example, concluded that UK can cut its electricity consumption by 38% by 2030 by implementing cost-effective energy efficiency policies. For those who claim much of the low-hanging energy efficiency opportunities has already been picked, a survey of energy use in large buildings in New York City concluded that some buildings were using 5 times as much energy as others.

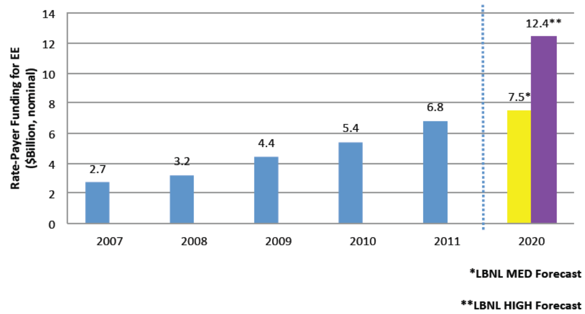

Figure 6
Baseline projection of U.S. electricity demand with 2 alternative scenairos, 2009-2025, in TWhrs
Source: IEE white paper, May 2011

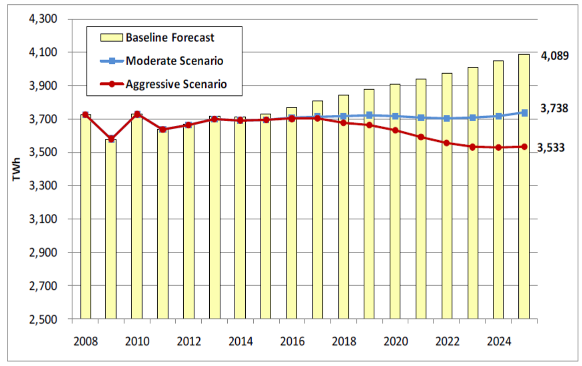

Figure 7
U.S. electric utility energy efficiency budgets, 2007-2011 with forecasts for 2020, in nominal $ billion

Source: 2012 State Electric Efficiency Regulatory Frameworks, Institute for Electric Efficiency, July 2012

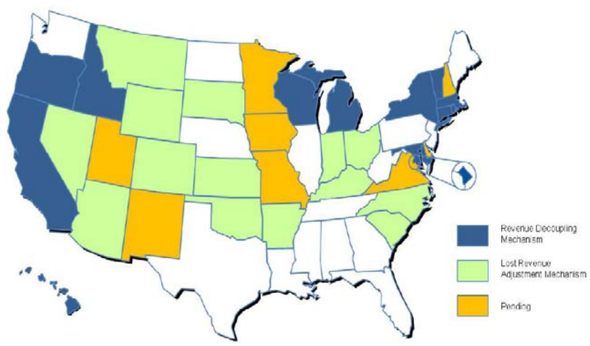

Figure 8
States with regulations allowing lost revenue recovery and decoupling

Source: 2012 State Electric Efficiency Regulatory Frameworks, IEE, July 2012.

Traditional Utility Business Model: Out of Synch

The traditional utility business model, predicated on continued demand growth, made perfect sense during the industry's *golden years*, a period of rapid expansion *and* declining average costs. It made sense to recover costs through a flat volumetric charge.

That business model, however, appears increasingly out of synch with the changing business environment. Costs are rising while demand is not. A big component of the cost is fixed – for example, maintenance of the transmission and distribution network does not vary with volumetric consumption. If consumption flattens or falls over time, as seems to be the case, the volumetric cost-recovery mechanism becomes untenable.

Moreover, two other developments are changing the fundamentals of the electric power business:

- **Rise of "prosumers" –** Rapidly falling costs of customer-side distributed generation (DG), most notably rooftop solar PVs, is likely to turn an increasing number of consumers into prosumers. During certain periods, for example sunny afternoons, Prosumers may generate more than they consume, which they can generally feed into the grid.
- **Net metering –** Current *net metering* policies tend to be generous to consumers who invest in DG, who can buy a shrinking number of kWhrs from the grid at the regulated retail tariff while selling their excess generation, when available, typically at a premium to the gird.

The net effect is that for many prosumers, the electric "bills" dwindles and in some cases may approach nil. However, these customers continue to depend on the grid to balance their usage and generation, which means that the fixed costs associated with grid maintenance remains the same while the revenues derived from the prosumers drop. Clearly, a tariff based on volumetric consumption makes no sense when there is little or no *net* consumption.

Tier	Volume of use	PG&E	SCE	SDG&E*
Tier 1	Within baseline	13	13	14
Tier 2	101-130%	15	16	16
Tier 3	131-200%	30	24	24
Tier 4	201-300	34	28	31
Tier 5	>300%**	34	31	NA

* SDG&E has slightly different rates for summer and winter, making it more compli cated for consumers

** PG&E shows 5 tiers but the price for the top 2 tiers is shown as the same

Table 2
California's current tiered residential rates, in cents/kWh for the 3 large investor-owned utilities

Source: Utility websites

Among the factors contributing to the rise of prosumers is rising tiered pricing, which is a dominant feature of residential tariffs in high cost California and has become contentious. As shown in Table 2, under a rising tiered residential tariff, high consumption consumers face higher rates at the margin, which motivates investment in energy efficiency and/or rooftop solar PVs.

There are a number of other factors encouraging energy efficiency in ways that were not practical or feasible until recently:

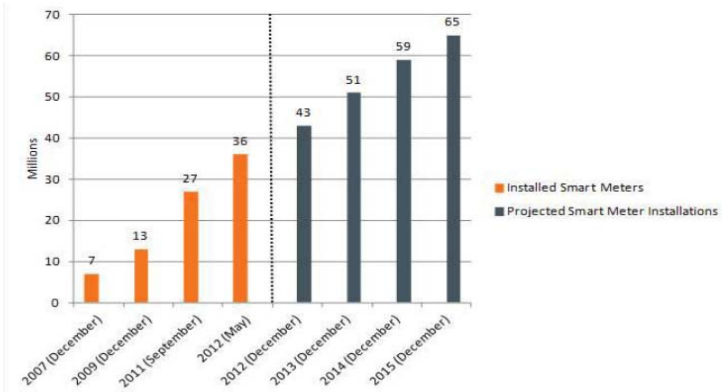

Figure 9
Smart meter installations in the U.S., 2007-2015, in millions

Source: Utility-Scale Smart Meter Deployments, Plans, and Proposals, IEE, May 2012

- **Prices to devices –** A revolution in how electricity is priced, and how smart price signals can directly communicate with smart devices – allowing consumers to be essentially bypassed – is quietly in the making. Many who have examined consumer behavior have reached the conclusion that the best way to proceed is through automation with little or virtually no human interface, the so-called "set-and-forget" principle.[11]
- **Smart meters –** The promise of *prices to devices* is now within reach as increasing numbers of households are fitted with smart meters and two-way communication technology, which can deliver the price signal to devices within the customers' premises. IEE predicts that roughly half of U.S. consumers will have smart meters by 2015 (Figure 9), with similar projections for many OECD countries.
- **Consumer engagement –** For many, the notion of the consumer as a passive agent at the receiving end of the industry's long value chain is outdated. Only recently, however, has the industry focused on turning things around by *reengaging* the disengaged consumers.
- **Demand response –** Interest in demand response (DR) programs, broadly defined as anything that influences consumers to reduce load during peak demand periods and/or shift load to off-peak periods usually in response to incentives or price signals, is on the rise.

New Business Paradigm

The main points of the preceding discussion can be summarized as:

- Future electricity demand growth in mature economies is asymptotically approaching zero;
- Rise of distributed generation will turn many consumers into prosumers with net metering policies determining the scope and speed of the migration;
- The long-term impact of smart meters, smart prices and smart devices is significant especially if assisted by regulatory endorsement of dynamic pricing; and
- The effect of energy management technologies is likely to be considerable as a new generation of companies master the art of not merely *informing* but *enabling* consumers to become proactive and *engaged*.

The information revolution, which has thus far only superficially penetrated the electric power sector, is likely to make a pronounced impact in how electricity is delivered, measured, priced, monitored, consumed and managed. There are three major steps in the evolution of information technology:

- First is better ways of *measuring* what is delivered, not just how many kWhs, but when it is consumed. This is now possible with sophisticated smart meters.
- Second is consumer *enablement*, becoming trivial with ubiquitous communication technology, allowing consumers or their designated agents, to monitor and manage what devices use – or in the case of prosumers – produce energy.

- Third and final piece of the puzzle, currently in its infancy but predicted to turn into a burgeoning industry, is consumer *engagement*, allowing consumers – or their designated agents or programmable smart devices – to respond and react to the signals received in ways that reduces costs and improves service quality and reliability.

Clearly, the volumetric basis for cost-recovery seems out of place in an environment where most costs – much of generation, virtually all transmission and distribution assets – are fixed. As Ralph Cavanagh has observed, if we were to design a scheme for utility cost recovery from scratch today, it would most likely not be solely or mostly based on volumetric sales and flat cents/kWhrs[2].

Footnotes

[1] John Caldwell, Edison Electric Institute, posted e-mail

[2] It must, however, be noted that the trend toward smaller number of people per dwelling tends to increase – not decrease – per capita consumption. Yet the energy efficiency gains could overcome this, resulting in lower net consumption per household.

[3] U.S. has more cars than licensed drivers.

[4] IEE white paper, May 2011

[5] Reinventing Fire, Amory Lovins, 2011.

[6] A new development at UC Davis, called West Village, housing 3,000 students reportedly meets the ZNE definition suggesting that entire communities generating as much electricity as the consume are feasible.

[7] Capturing the full electricity efficiency potential of the UK, DECC, July 2012

[8] Office of Long-Term Planning & Sustainability, NYC City, July 2012

[9] This has become a major concern because consumers on net metering tariffs are essentially allowed to bypass paying the considerable costs associated with grid maintenance– which is among the factors, which encourages consumers to become prosumers in the first place. By doing so, the fixed costs associated with the maintenance of the grid as well as the lost revenues for consuming fewer kWhrs are passed on to the remaining consumers, resulting in further rate increases for consumers without DG.

[10] Net Metering, Diane Caldwell, New York Times, 4 June 2012

[11] Customer view of smart grid – Set and Forget? Harper-Sloboszewics, P. et al, in Smart Grid, Sioshansi, F. (Ed.), Elsevier, 2011.

[12] To highlight the point, consider a distribution company with little or no generation or transmission and no retailing business. Such stand-alone distribution companies actually exist, for example, in Australia, where this is already the case.