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STRATEGIC CONSULTING | Energy

Light at the End of the Tunnel

Light-Weight demand growth - Impact of two light technologies

White Paper

LIGHT AT THE END OF THE TUNNEL

Will electricity demand ever emerge from the darkness of its current no-growth tunnel? That question has confounded utility executives since the 2008-2009 recession pushed electricity demand growth into negative territory—breaking a string of steady, if not spectacular, growth that began with the end of World War II. The Energy Information Administration thinks it sees some light at the end of this tunnel, projecting that electricity consumption will climb by roughly 1 percent annually through 2035—not great, but upward nonetheless.

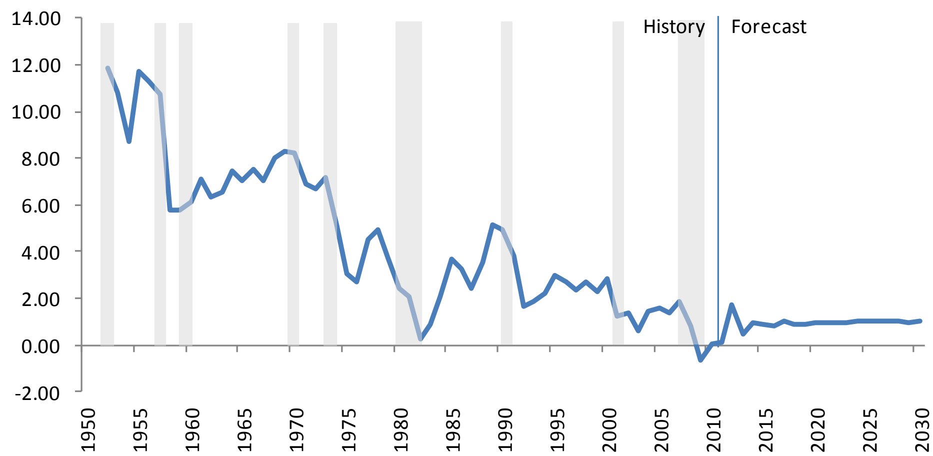

Figure 1: Three‐Year Rolling Average Electric Consumption Growth Rate

However, that light may not be new growth at all. Rather, it may be an oncoming train bringing two technologies that could reshape the electric industry. Once these developing technologies—LED lighting on the demand side and rooftop photovoltaics (PV) on the supply side—arrive, and it won't be long, even 1 percent annual growth may be a wildly optimistic forecast. Coupled with the long-term downward trend in electric demand growth recorded during the past 50 years (see EIA's three-year rolling average in Figure 1) due to structural changes in the economy and significant efficiency improvements, utility executives in a number of areas could soon be facing a new and disquieting prospect: negative load growth.

All Aboard ς The Future of Light

Whatever it is, lighting's future will not include the flicker of fluorescent tubes. The Department of Energy estimates that fluorescent lighting accounts for less than 25% of the total indoor lighting market and not even 11% of the residential market. The reasons are varied (see inset), but the overriding problem is that homeowners have not warmed up to fluorescents. Compared to incandescent bulbs, fluorescent lighting fails in many regards—it is more costly, exhibits harsh light quality, and includes a small amount of hazardous material in each bulb. Taken together, these drawbacks have significantly slowed its penetration of the residential market. Today, LEDs suffer from only one of these drawbacks, high price. Where fluorescent lighting is a mature technology, LED is an emerging technology with vast potential for cost reductions and design improvements.

	 Light Emitting Diode (LED)	 Compact Fluorescent	 Incandescent
Watts	4-5	13-18	60
Life Span	50,000 hours	8,000 hours	1,200 hours
Current Cost (approx.)	$20-$40	$4	$0.75
Frequent On/Off Impact	No Effect	Shortens Life	Shortens Life
Instant On	Yes	No	Yes
Durability	Drop/Shake Durable	Fragile	Fragile
Heat Emission	3.4 BTU/hr	30 BTU/hr	85 BTU/hr
Sensitivity to Temp	No	Yes	No
Sensitivity to Humidity	No	Yes	Yes
Hazardous Material	No	5 mg Mercury	No

Since LEDs are based on silicon chip technology, they have benefitted from parallel improvements in computer semiconductor technology, optical physics, miniaturization, and material science. Similar to Moore's law in computer chip technology, the breakthroughs in these areas have allowed exponential improvement in LED technology as well. In 2000, Dr. Roland Haitz of Agilent Technologies presented a history of the development of red LEDs and the status at the time of white LEDs in terms of the cost and light intensity. His analysis demonstrated that the cost of red LEDs was falling by an astounding factor of 10 per decade and the light emitted per red lamp was increasing by an equally astounding factor of 20 per decade; this became known as Haitz's Law. Figure 2 shows the most recent update of his analysis showing that white light LEDs are improving at an even faster rate. In a 2010 follow-up article, published in *Physica Status Solidi*, Haitz wrote: "by 2020…the cost of the basic LED lamp element will become insignificant compared with other cost factors such as the cost of the metals, plastic, inventory, and distribution cost" of LED light bulbs. This implies that by 2020 LED light bulbs will cost less than $2 apiece, last 20-30 years, and use less than 10% of the energy consumed by current incandescent bulbs of similar light output. Other LED benefits include the ability to design complex lighted shapes, specify light color, and allow for remote control. At the 2011 Lightfair Convention, Brett Sharenow, CFO of Switch (a Silicon Valley LED company) was similarly upbeat: "Light is something people have always needed…this is a light source that people will *want.*" Within the next 10 years, LEDs are a potential no-brainer replacement for the fluorescent and incandescent bulb.

The History of LEDs

Electroluminescence was first discovered in 1907 by H.J. Round of Marconi Labs in Britain. The first visible-spectrum (red) LED was developed in 1962 by Nick Holonyak Jr., while working at General Electric Company. In 1968, the Monsanto Corporation was the first to mass-produce red LEDs for indication purposes with Hewlett Packard the first company to introduce commercial products using the technology. In 1993 Shuji Nakamura of Nichia Corporation introduced the first high brightness blue LED, which when combined with a phosphorous coating, produced a warm white light. Nakamura was awarded the Millennium Technology Prize for his invention in 2006.

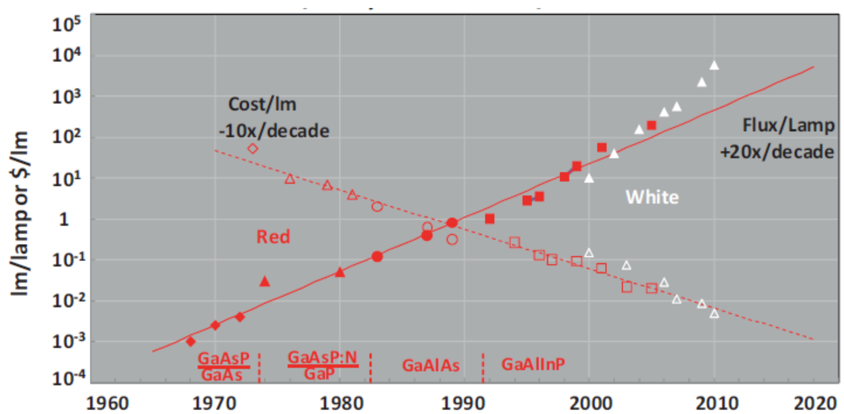

Figure 2: Haitz's Law

In 2010, EIA estimated that residential and commercial lighting accounted for 13.5% of total electricity consumption in the U.S. Adding industrial lighting puts the number at 16% or close to 600 billion kilowatt-hours (kWh) annually. Based on DOE's 25% penetration estimate for fluorescent bulbs in the indoor lighting market and the energy savings of LEDs, 525 billion kWh of energy consumption *per year* is at risk—more than 14% of total current demand. At a 60% load factor, this potential loss of demand puts close to 100,000 MW of generating capacity at risk.

Next Stop – The Rooftop

Recent headlines have been filled with stories of solar manufacturer failures, including Evergreen Solar, SpectraWatt ól·ƴ Intel spinoff), and ̗ of course, Solyndra. ¢Kƛă has prompted many to dismiss PV, saying that the technology is not ready ƒ2Ⓝ the commercial prime time. But in reality the bankruptcies indicate just ΰKŜ opposite: Costs are declining sharply across the industry, spawning fierce competition between PV manufacturers. Solar PV is here, with capacity additions rising at a compound annual growth rate of more than 50% during the past five years. (See figure oúф With prices plummeting, this growth is likely to continue for the foreseeable future. In the past 24 months, for example, PV panel prices have declined ōề more than 70%, and are now below $1/watt.

> ### *The History of PV*
> The photoelectric effect is the creation of a voltage (or a corresponding electric current) in semiconductor materials upon exposure to light. The photoelectric effect was first observed by Alexandre-Edmond Becquerel in 1839. Albert Einstein received the 1921 Nobel Prize for physics for his theories describing the photoelectric effect. In 1955, Western Electric began selling commercial licenses for silicon photovoltaic materials; the first commercial application was a 14 mW, 2% efficient cell for $25, or $1,785/watt. By 1960̗ cell efficiency had increased to 14%. In the 1960s-1970s solar PV found a home in space applications with the first 1 kW array launched in 1966. In 1967, Soyuz 1 became the first manned space craft powered by solar PV panels. With the help of Elliot Berman, Exxon was able to reduce the cost of solar PV from $100/watt to $20/watt in the 1970s, opening PV solar to broader commercial applications. The first thin-film solar cell was developed in 1980. In 1985, the University of New South Wales developed the first solar module to exceed 20% efficiency. In 2006, the 40% efficiency barrier was broken in the lab.

On top of this, the Chinese have entered the PV market in a major fashion, ensuring that the recent fierce price competition will continue, likely pushing prices down even more. In a recent review of China's latest five-year economic development plan, which has a large solar section, UBS' Steven Chin wrote that: the Asian giant is targeting t± panel production capacity of between 15 D [2] ΰ2 20 GW *per year* by 2015; it is looking to ō22ăΰ the efficiency of its mono-crystalline t± ǕJl·ƴŜƒă by 15% and its multi-crystalline ǕJl·ƴŜƒă ōề нр̂ ̗ and it is banking on solar ăèăΰŜϒ Ŏ2ăΰă 2ƒ $2.35/watt or $0.13/kWh by 2015 and $1.55/watt or $0.09/kWh by 2020.

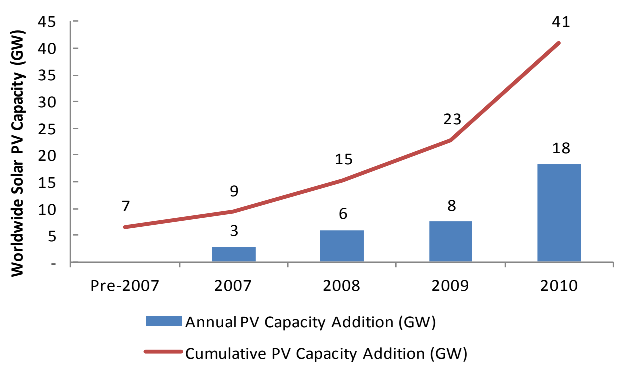

Figure 3: Worldwide Solar Capacity Additions

The superficial interpretation is that the Chinese are expanding their PV industry to install a massive quantity of panels in China, where electricity consumption is booming. The numbers tell a different story.

EIA's *2011 International Energy Outlook,* released in September, projects that installed solar capacity in China will increase from 7 GW in 2015 to 21 GW in 2035. If China expects to have PV panel production capacity of 15 GW to 20 GW by 2015, that is 300 GW to 400 GW of potential production over the 20 years to 2035. The vast majority of this production likely will be used to serve PV markets in North America and Europe.

DOE's National Renewable Energy Laboratory in Colorado estimates that installation costs for rooftop PV systems in residential and commercial settings are currently about $0.75/watt. Coupled with China's targeted 2020 system cost of $1.55/watt, this would bring rooftop PV solar into the U.S. market at a total delivered cost of less than $0.13/kWh—a veritable bargain in many areas of the United States. Based on *current* residential and commercial electric rates reported to the Federal Energy Regulatory Commission, approximately 484 billion kWh of electricity—about 13% percent of annual consumption—are sold at rates above $0.13/kWh. In addition, this number is almost certain to climb in the near future as utility rates increase to replace aging infrastructure and comply with new environmental regulations and renewable generation mandates from state and federal initiatives.

We Have Reached our Final Destination

When this technological train arrives is a matter of debate, but come it will, and when it does, utility executives will be staring at the potential of losing a significant amount of lighting demand while also distributing some peak demand to the home. The combination poses a threat that cannot be ignored.

While it may be 10 years before both threats are manifest, prudent utility executives need to begin looking at these issues now, examining, among other things:

- Economics—When will the two technologies be competitive in a given market;
- Consumer choice—Who will adopt these technologies, at what rate and why;
- Infrastructure implications—Can these two technologies help bolster reliability and/or reduce grid congestion, or will they require ancillary investment in order to facilitate integration;
- Scenario planning—What range of outcomes are possible, how could each affect the utility's long-term strategies and investments; and
- Business model—How does the regulatory model need to change to accommodate these potentially transformational technologies, how will the utility need to change it business model the adapt to a future impacted by these technologies?

Utilities that do not begin examining these issues today are likely to be left standing at the station as this technology train speeds by, defending their shrinking rate base to stunned investors and restive regulators.

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