By Peter M. Curtis

Peter Curtis is the president of Power Management Concepts, LLC, in Bethpage, NY, and an associate professor at New York Institute of Technology.

The Externalities of Quads, Gigawatts, CO_2, and the Smart Grid

Energy, power, global warming, and power distribution are related

Annual global energy consumption worldwide is expected to increase to approximately 750 quads by 2035 from the 500 quads we use today. That is 500 quadrillion BTUs, or 500,000,000,000,000,000 British thermal units, of which 120 quads or 4000 gigawatts (GW) are used to meet electrical demand.

An increase in greenhouse gases (GHG) emission is one consequence of this growth. For example, CO_2 levels were at 280 parts per million (ppm) during the preindustrial age and have climbed to 390 ppm in 2010. While the debate over global warming continues, remember that power plants, manufacturing facilities, and mines were shut down during the 2008 Summer Olympics in Beijing due to severe air pollution. No matter the truth of the case on climate change, we still have a serious situation on our hands—one that requires a new and smarter energy infrastructure.

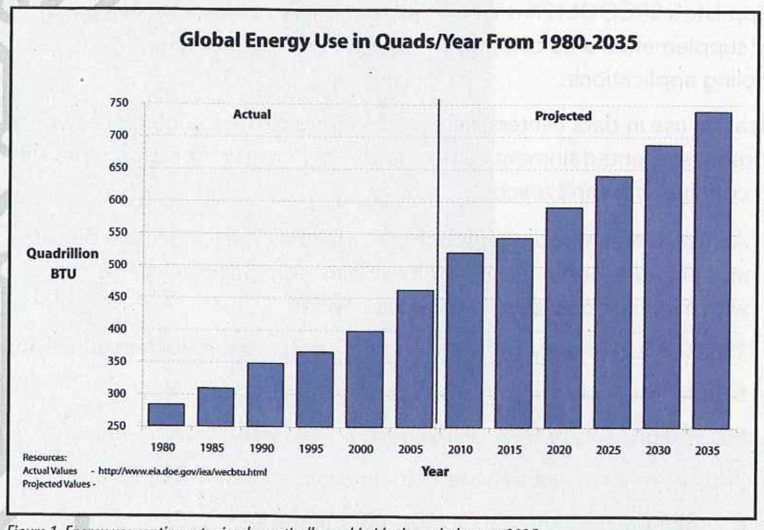

Figure 1. Energy use continues to rise dramatically worldwide through the year 2035

Electricity supports our modern life, and yet the infrastructure is too fragile to continue to supply our growing digital needs. Between 2006 and 2011, server demand is expected to double to 12 GW, which would require an additional 10 power plants, according to a 2007 U.S. Environmental Protection Agency report to Congress on data centers. Demand from these facilities is expected to double again by 2016. A doubling every five years would mean that by 2035 server load alone would approach 400 GW. These projections don't include demand from digital devices used outside the data center.

Digital devices are more and more common as chips are embedded in more appliances, tools, and gadgets and as web-enabled applications and cloud computing continue to gain a larger market share. The digital economy is the most rapidly growing sector of energy demand globally today.

Society's growing dependence on, and preference for, digital information also means our energy supply will need to be made more secure, to ward off both physical and cyber attacks. Today's proposed Smart Grid is expected to meet these needs while also improving efficiency and reducing costs.

However, I have concerns as to whether or not we can actually execute a Smart Grid strategy because of the lack of progress over the last three decades. Obviously eliminating conventional energy sources is not the answer; however, part of the solution is to use today's technology to provide a new front-end with dashboard-type features for the utilities—one that allows for more efficient generation, transmission, distribution, and control. This change will help utilities make better use of the existing capacity while we aggressively make a concerted effort to meet new demand with clean, renewable supplies.

Roughly 8 percent of today's U.S. energy supply comes from naturally renewable sources; substantially increasing this percentage will require some expanded thinking. It's important that we understand the true cost of energy, including all of the externalities associated with moving it from source to end user. Just as a "well-to-wheel" analysis is performed for vehicles, we must also consider the full "well-to-chip" energy path. This includes not only how much primary energy we start with but also how much energy resources are required to transport and convert that primary energy into electricity and losses incurred moving that electricity to the end user, and ultimately to the chip where it becomes the 'ones' and 'zeroes' that make up our digital data.

When comparing renewable energy projects with conventional methods, it's important to be deliberate in defining externalities and quantifying the consequences of investing in the wrong areas. We cannot continue to use the status quo financial analysis because it doesn't always reflect the true costs. As we have learned from the recent financial crisis, you can make numbers mean whatever you want. Fortunately, the green movement

Continued from page 10

is having some impact, critical facility designers and managers are now using power usage effectiveness (PUE) and its reciprocal, data center infrastructure efficiency (DCiE), to gauge overall data center efficiency. The new metrics have limitations, however. They are geared only for all-electric facilities. Some non-traditional data center designs might incorporate combined cooling, heating, and power systems that use a primary fuel, such as oil or natural gas, as the input energy. Such systems can make far more efficient use of "well" sources of primary energy so we need to look at the power source entering the data center as well.

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Obviously, there are costs associated with improving efficiency, and financial managers are always considering ROI on any capital expenditures. This is complicated by the volatility of today's energy prices, making lifecycle analyses and long-range forecasts especially challenging. While the cost of solar or wind power is more expensive than grid-supplied electricity today, at least its cost is more predictable long term. And, fortunately, the large corporation that wants to show its environmental responsibility is a growing trend. So going green apparently has some added value, even though it's not exactly quantifiable. There are many other energy-related externalities that are also not readily quantified, but they can have serious consequences to our environment and society, for instance consider the following:

- Oil and gas exploration can have some very significant unexpected costs as witnessed by recent oil spills. Cleanup expenses can be astronomical and the environmental damage can be incalculable.
- Hydraulic fracturing is a technique that is becoming more common to increase the output of natural gas wells. However, environmental safety and health concerns have emerged because this practice is now suspected of causing groundwater contamination.
- Coal mining can also result in a number of adverse effects on the environment. Surface mining of coal completely eliminates existing vegetation, destroys the genetic soil profile, displaces or destroys wildlife and habitat, and degrades air quality.

Although nuclear energy does not produce pollutants or GHGs, there is still no consensus on how to dispose of spent nuclear fuel rods. With deliberate attacks a growing threat, even the transport of spent fuel rods to a central disposal site may represent an unacceptable risk. The lasting effects of a nuclear accident make any kind of fossil fuel mishap pale in comparison.

While these costs don't usually show up on any balance sheet, the consumer and our environment will ultimately pay for these kinds of externalities. We can no longer just look at simple payback—a comprehensive engineering, economic, and environmental analysis will have to become the norm. This is the only way all the energy-related externalities can be taken into account so that green projects are put on a level playing field where their true ROI can be evaluated. This will obviously require a new mindset, more aggressive corporate research and development and increased government funding of renewable energy projects that can serve to meet the growing digital energy demand with one caveat; both analyses must include all energy-related externalities so that we capture all costs to society and the environment. ■

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