Global Cooling: Electricity Peak-shaving Techniques to Offset Climate Change

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ABSTRACT

Electricity is the "power to succeed." However, the United States faces a hidden electricity crisis, i.e., the "power to fail." As the economy grows at 2-3 percent per year, the total demand for electricity has grown in tandem at 2.1 percent per year over the 1994-2004 period. Inversely, however, electricity capacity margins, the percent of "spinning" supply above demand, have declined consistently over the last decade from 25-30 percent in 1992 to about 15 percent today. In fact, the Eastern Independent Power Grid, with nearly 75 percent of total U.S. electricity demand, has only a 13.9 percent capacity margin. Additionally, the North American Electric Reliability Counsel (NERC) forecast in 2006 that overall electricity demand will rise 19 percent by 2015 but overall electricity capacity will rise only 6 percent. This compound total demand growth coupled with declines in utility plant capacity margins only masks the serious underlying problem: peak electricity demand, typically for summertime air conditioning, is growing at 2.6 percent per year, consistently as fast as total electricity demand. While the nation considers the need for energy independence critical due to the fact that half the nation's oil consumption is imported, the resulting economic consequences of a peak electricity shortfall would be as bad or worse given the nation's reliance on electricity to cool, light, and power motors and computers. That is the nexus of this article: the available energy technologies and programmatic procedures to reduce electricity peaks or peak-shaving in the U.S.

INTRODUCTION

To meet the accelerating level of electricity demand growth and simultaneously offset the significant decline in capacity margins, the electric utility industry, for example, is planning 138 new coal-fired power plants nationally, or the equivalent of $108 billion of new coal-generation capacity. In particular, the American Electric Power Company (AEP) has approved a major new electricity transmission line from West Virginia through Maryland and Pennsylvania to New Jersey to satisfy the largest electricity demand region in the country: PJM (Pennsylvania, New Jersey and Maryland). The explosive growth of electricity in the PJM is mirrored in the adjacent region of northern Virginia. Over the last decade, and projected to continue in the future, this electricity growth has placed Virginia Dominion Power's ability to provide reliable electric service severely at risk. Virginia Dominion Power, along with its partner, Allegheny Power, plans to add to its capacity by building a 240-mile high-voltage transmission line from West Virginia to northern Virginia. The new transmission line will bring additional electric capacity from the companies' Mt. Storm, West Virginia, power station. In addition, the companies will access electric capacity from a wind farm and low-cost western generation. "Recent forecasts show that demand growth in Dominion's system in just the next five years will be like adding more than 1 million houses. This growth is driven by:

- Residential construction in some of the fastest-growing counties in the nation.
- Larger homes to heat and cool with computers, plug-in gizmos, and restaurant-sized appliances.
- The army adding 22,000 employees at Fort Belvoir, doubling its size.
- Expansion of Metrorail and Tysons Corner—a potential doubling of office space in the region.
- Expansion of Washington-Dulles International Airport to handle twice the commercial traffic.
- Construction of numerous energy-intensive data centers.[1]

Similarly, the Energy Policy Act of 2005 (EPAct of 2005) grants up to $13 billion in subsidies to the nuclear industry to build new facilities. Entergy, one of the nation's largest utilities, has plans to add reactors to existing plants at Port Gibson and St. Francisville, near Baton Rouge, Louisiana. To date, there are plans for 19 new nuclear plants, while only three new reactors were under consideration in 2005 and there were no new plants built at all since 1978.

DISCUSSION

This compound total demand growth coupled with declines in utility plant capacity margins only masks the serious underlying problem: peak electricity demand, typically for summertime air conditioning, is growing at 2.6 percent per year, consistently as fast as total electricity demand. In fact, the October 16, 2006, report of the North American Electric Reliability Council (NERC) predicts that total United States electricity demand will increase by 19 percent over the next 10 years while total electricity capacity will rise only 6 percent. "Capacity margins are projected to drop below minimum target levels in Texas, New England, the Mid-Atlantic area, the Midwest, and the Rocky Mountain area, in the next two to three years, with other portions of the northeastern U.S., southwest, and western U.S. falling below minimum target levels later in the period." [2] While the nation considers the need for energy independence critical due to the fact that half the nation's oil consumption is imported, the resulting economic consequences of a peak electricity shortfall would be as bad or worse given the nation's reliance on electricity to cool, light, and power motors and computers. That is the nexus of this article: the available energy technologies and programmatic procedures to reduce electricity peaks or peak-shaving in the U.S.

"To tell what would be right is the purpose of this book." [3] As depicted by John Kenneth Galbraith in *The Good Society,* "there is no chance for the better society unless the good and achievable society is clearly defined." [3] For Galbraith it was the achievable, not the perfect, that he described in his work. So too this article strives to illustrate the achievable off-peak or peak-shaving electric future. "The real world has constraints imposed by human nature, by history and by deeply ingrained patterns of thought. There are also constitutional restraints and other long-established legislative procedures as well as the controls attendant on the political party system." [3] For the electric energy future, however, there are some attractive incentives that will define the achievable or real world according to Galbraith. First, there are the efficiency options, renewable energy production, and tax promotions found in the EPAct of 2005. And second, there are the electric price signals through higher levels promoting fuel switching and peak-shaving.

For Galbraith, the good society must overcome a "seemingly decisive constraint here, in fact, is a political attitude that supports and sustains the very conditions that require correction." [3] The political attitude today, however, is ripe for change in the electric environment.

FUEL-SWITCHING ALTERNATIVES TO PEAK ELECTRICITY USE

According to the United States Department of Energy (DOE), there are over four million commercial buildings in the United States (US). The largest commercial building sector is the mercantile and facilities sector, consisting of 22 percent, followed by the office building sector, comprising 16.4 percent, non-refrigerated warehouses at 14.6 percent, and assembly and education buildings each at 12.6 percent. Overall, the total market for energy in the commercial sector is fully 33 percent.

In the space conditioning segment of the commercial energy market, electricity comprises a 95 percent market share. Natural gas, however, has only a 5 percent market share of the commercial market for space cooling. This creates a key fuel-switching opportunity to replace peak summertime electricity with off-peak summertime natural gas. In addition, the majority of commercial space cooling equipment is interchangeable between electricity and natural gas. This is evident in the fact that the primary cooling systems utilized in commercial buildings consume electricity or natural gas in the following categories: central cooling systems in 37 percent of commercial buildings, 31 percent utilize individual air conditioners, 24 percent utilize packaged air-conditioning units, and 10 percent use air-source heat pumps. Further, 75 percent of the commercial buildings cooled utilize duct forced-air distribution systems, while only 11 percent use fan-coiled units.

Natural gas cooling systems are cost-effective, fuel-switching alternatives to peak electricity space conditioning. Gas cooling technologies are broad-based and extend from existing lithium bromide-based single- and double-effect absorption technology to engine-driven (rooftop and water chillers) and desiccant (silica gel dehumidifying) systems. Advances in natural gas technologies include: 1) triple-effect absorption, 2) residential engine heat pumps, 3) GAX absorption, 4) adsorption, 5) solid desiccant materials, 6) liquid desiccant systems, 7) chemisorption, 8) I.C. free piston engines, and 9) Stirling engine technologies.

In general, natural gas cooling systems have three complementary energy characteristics: 1) they are good for the natural gas industry, 2) they are good for the electric industry, and 3) they are good for the environment.

Utilizing natural gas for cooling in either the residential or commercial markets will raise summertime troughs and increase off-peak revenues for the natural gas industry. In particular, natural gas heat pumps will reduce wintertime peaks and raise summertime valleys. Off-peak natural gas use in the summertime will also be priced at lower, more attractive rates in the summertime when demand is low, as opposed to higher wintertime rates when demand is high, thereby improving the customer's energy bill, as well.

For the electric industry, natural gas cooling systems offer the customers of summer peaking electric utilities a more cost-effective alternative to adding expensive new electric generation, transmission, and distribution systems. The over-utilized summertime electric generation system can be minimized by consuming natural gas from the underutilized summertime natural gas distribution system. This strategy can more efficiently maximize both the electric and natural gas capital infrastructure, including the transmission and distribution systems, thereby reducing on-peak electricity consumption and producing the least-cost energy mix.

And since natural gas cooling systems do not use any chlorofluorocarbons (CFCs), the environment is protected as there are no destructive CFCs emitted, which destroy the earth's fragile ozone layer. Natural gas cooling systems also reduce sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon dioxide (CO_2), and particulate emissions.

Natural Gas Cooling Technologies

Absorption chillers are typically single-effect or double-effect systems. The coefficient of performance (COP), or the efficiencies of these systems, range from 0.95-1.0. Generally, absorption chillers are double-effect systems with a COP of 1.0. These double-effect systems generate a higher COP by cycling the refrigerant twice to improve the efficiency over single-stage absorption technologies. The refrigerant is usually water, not materials containing CFCs. They are commonly used in central cooling plants in large commercial buildings. The equipment costs range between about $400 per ton to nearly $1,500 per ton. The equipment sizes range from 20 tons to as much as 1,500 tons. Tonnage size is inversely proportional to equipment cost. For example, the larger the tonnage exhibits the lower cost per ton.

Engine-driven chillers use a natural gas engine to drive a refrigerant compressor. These systems are mechanical cooling "vapor compression" systems that remove heat from the indoor air and release the heat outdoors. The heat is transferred through a loop or piping system that circulates a refrigerant fluid. That fluid changes in temperature and pressure as it circulates, causing it to change between liquid and vapor. Heat is either absorbed or given off, and the evaporation of liquid to vapor creates a cooling effect. Conversely, the condensation of vapor to liquid gives off heat. Energy is provided by the compressor to reduce the refrigerant vapor to a liquid. The fuel-switching opportunity arises in the fact that a natural gas engine, instead of an electric motor, can be used to turn a rotating shaft which, through a coupling, powers the compressor. Generally, the refrigerant is a hydrochlorofluorocarbon, or HCFC, that has a lower ozone depletion factor, thereby greatly reducing the negative effect on the earth's ozone layer. Most HCFCs have life spans in the earth's atmosphere of less than 100 years, but are banned from commercial production by the year 2030. These engine-driven chillers are the most efficient natural gas cooling systems. Since engines are highly efficient at part-load and most cooling applications require part-load operation, natural gas engine-driven chillers provide superior performance to electric cooling systems, particularly at part-load. Natural gas engine systems cost approximately $500 to $900 per ton and range in size from 30 tons to 460 tons. Similar to absorption systems, as tonnage sizes rise, tonnage costs decline.

Direct expansion natural gas systems are rooftop or split technologies that heat and cool the conditioned space. These systems combine natural gas heating with natural gas engine-driven vapor compression. The compressor-drive engine is powered by natural gas and can also drive the condenser fan. Heating is provided by an induced-draft type natural gas furnace with an intermittent pilot ignition system. Equipment sizes are of the smaller type and range from 15 tons to 25 tons. Equipment costs reach as high as $1,200-$1,300 per ton for smaller-scale systems, and about $800 per ton for the larger systems.

Desiccant natural gas systems are dehumidification systems that introduce natural gas as the drying source. The desiccant-based dehumidifier operates on two counter-current air streams flowing typically through a high-performance rotating wheel treated with a desiccant agent. Outdoor air is drawn through the rotating wheel while the desiccant agent absorbs moisture from the water-saturated, humid air stream. The warm, dry air stream is then chilled by a traditional electric compressor, placing dry, cool air into the conditioned space. "As the wheel rotates into the regeneration section, heated outdoor air removes the moisture from the desiccant surface, which is then exhausted to the outside." [4] Natural gas is used to dry the desiccant material. Typical desiccant materials used in heating and ventilation systems (HVAC) are in solid or liquid forms. The liquid form is lithium bromide and the solid form is silica gel. These materials have a high preference and capacity for water vapor. Air is dried more completely with natural gas desiccant systems than traditional vapor-compression systems. As the desiccant material absorbs moisture from the air, its vapor pressure rises and its attractiveness for water vapor declines. When the water vapor pressure and the air vapor pressure reach equilibrium, the desiccant material can absorb no more water. Natural gas heat is then introduced, which further raises the vapor pressure of the desiccant until it exceeds the vapor pressure of the surrounding air. This causes the moisture absorbed in the desiccant material to be released to the outside air. The desiccant material is cooled, and the process repeated. "The current gas desiccant system carries a COP of 0.3 (with vapor decompression the COP is 0.6, i.e., recovering condenser waste heat). The installed cost assumed for the 30-ton desiccant system is about $1,200 per ton. This cost will vary by location and facility." [4]

Supermarkets are attractive applications for natural gas desiccant systems because supermarkets use four times as much energy per unit of floor space as most commercial buildings. Supermarkets require lower store air temperatures, i.e., lower sensible cooling loads, because of the need for refrigerated cases for frozen foods. There is also a large dehumidification load, i.e., latent cooling load, that causes the air conditioning system to overcool. "Typically, the AC system overcools the air to condense the moisture, resulting in excessive electric power consumption. By using natural gas equipment to control humidity, the AC equipment, duct work, and fans can be downsized. Some of the other commercial buildings which could benefit from desiccants are hotels/motels, restaurants, and medical buildings." [4]

Thermal Energy Storage Technologies

Ice energy storage, i.e., thermal energy storage (TES), for refrigerant-based air-conditioning systems can be applied to residential and commercial building applications for both new and retrofit facilities. Electric bills and the attendant electric consumption can be cut significantly by shifting the demand for electricity associated with cooling the air during the peak afternoon times of the day to the off-peak morning and/or nighttime periods of the day to make ice instead. "Not unlike the ingenuity of the ancient Romans that ported ice from the mountains to cool their villas, energy stored in a block of ice is the modern emerging low cost, clean energy solution to satisfy the daytime air conditioning demand." [5] "Electric thermal energy storage systems reduce the peak-load energy use by shifting electricity consumption for mechanical refrigeration of water or ice from peak to off-peak hours. The water or ice is kept typically in large insulated storage tanks for use during the next peak usage period." [5]

However, there is now a distributed energy storage product for air conditioners in the smaller, compact 50-ton hour size (45 tons latent and 5 tons sensible) that reduces up to 10kW of on-peak electricity demand. This downsized, commercial facility-type product shifts 50 kWh of electricity consumption to off-peak, or the equivalent of operating a 10-SEER (seasonal energy efficiency rating), 5-ton electric air conditioner at full load for eight hours. The product is a water-filled thermal battery that operates with any condensing unit and evaporator coil. It is simply installed in a few hours to a new electric air-conditioning project. The product also 1) boosts the efficiency and cooling capacity of the new electric air-conditioning system, 2) eliminates evaporator coil freeze-ups, 3) consumes off-peak kW, and 4) uses an equal or lesser amount of total daily electricity than a conventional electric air conditioner of comparable size. Generally, thermal energy storage systems require large storage tanks, have low first costs, are custom designed for most applications, operate most efficiently at projected design days, i.e., the warmest day experienced in terms of cooling degree days, postpone the need for new electric generating capacity, operate for an expected lifespan of 20 years, and avoid electric rate demand charges, i.e., 30-50 percent of the total monthly electric costs. Also, these systems operate at the greatest cost effectiveness when as much cooling is stored as is needed for the following day's cooling load.

In addition, there are a number of large-scale TES systems. These include district cooling utilities and industrial customers where TES applications are used for electricity on-peak demand management. Some newer, large-scale systems include turbine inlet cooling (TIC) for hot weather power enhancement of natural gas power plant turbines. These "TES systems are often designed for lower than traditional supply temperatures, or dual-designed for initial conventional supply temperatures but also for potential future lower temperatures with higher system capacities." [6] These types of design characteristics also have a twofold benefit: 1) the energy efficiency of large-scale TES systems is improved for both on-site as well source efficiencies, and 2) the total system economics, both capital costs and operating costs, are improved because large-scale TES systems are often installed at times of either new facility construction or chiller plant capacity expansion/rehabilitation.

"In addition to those TES applications already operating at supply temperatures in the mid and low 30s degree [*sic*] F, there has been a very strong trend among recent large new TES applications for the TES tank to be specified and pre-designed for two distinct operating conditions: first, a conventional supply temperature of 39 to 42 degree [*sic*] F in initial stratified chilled water service, and second, a reduced supply temperature in the low 30s degree [*sic*] F after conversion to stratified low temperature fluid (LTF) service. In this way, the CHW supply-to-return Delta T and the TES ton-hour capacity can be significantly increased (often by 40 to 70 percent or more) without any increase in the TES volume, in order to meet future growth in system cooling loads." [6] While there are some inherent inefficiencies in large-scale TES systems, such as heat gain into the TES tank, TES charging temperatures lower than TES discharging temperatures and added pump work associated with charging/discharging, overall these inefficiencies are more than offset by the following efficiency gains:

1. Reductions in on-site energy or source energy use at the electric utility power plant, resulting in lower atmospheric pollutants and greenhouse gases.
2. Heat rejection and chiller plant operations during cooler nighttime ambient temperatures.
3. Operating at high load factors, reducing energy consumption of chiller auxiliaries (cooling tower fans and pumps).
4. Reductions in the energy consumption of chilled water pumps and air-side fans due to lower available supply temperatures.

Economics

Both natural gas technologies and thermal energy storage systems exhibit attractive economic scenarios. "One example of a comparison of gas cooling and thermal energy storage applications is the Pond View Corporate Center in Farmington, Connecticut. Plans for the design and operation of the heating and cooling systems compare three HVAC systems: electric centrifugal chiller and hot water boilers; a gas absorption chiller/heater; and a thermal ice storage system and hot water boiler." [4] The simple payback periods are calculated relative to the installed costs of the electric centrifugal system with a hot water boiler at $580,300. The two 200-ton Hitachi natural gas absorption chiller/heaters had installed costs of $612,350 and total energy costs of $70,090 with $40,000 in rebates. The thermal ice storage system with a hot water boiler had installed costs of $613,200 and total energy costs of $90,605, including $40,000 in rebates. The $25,242 in energy savings for the natural gas absorption system provided a 1.1 year payback and the $4,727 total energy savings for the thermal energy ice storage system gained a 2.2 year payback. In large-scale TES systems, due to their inherent economies of scale, cooling applications for sensible heat exhibit a much lower capital cost than latent heat chiller systems, and equally important, a considerably lower capital cost structure than equivalent traditional non-TES electric chiller capacity. The net capital cost savings for TES systems in new construction, in capacity expansion, or in capacity rehabilitation is in the magnitude of millions of dollars, and therefore fairly rapid payback periods.

Conservation/Energy Policy Act of 2005 (EPACT of 2005)

"Many analysts believe that power prices that vary hour by hour or even minute by minute, abetted by smart meters, are the shape of things to come."[7] The comprehensive array of conservation alternatives that are found in the Energy Policy Act of 2005 (EPACT of 2005) and that create electricity peak-shaving results including smart meters are as follows:

1. Solar (active/passive)
2. Wind
3. Wave
4. Geothermal
    a. DDC
    b. LEED "green" buildings
    c. Demand response
    d. Real-time pricing
    e. Temperature setbacks
    f. Ventilation control
    g. Boiler optimization
    h. Lighting products/systems
    i. Smart meters
    j. Reflective roof coatings
    k. Cold-water detergents
    l. Radiant-heated flooring
    m. Concrete construction material
    n. LED (light-emitting diodes) lights

Global Warming

Global average temperatures, i.e., combined annual land, air, and sea temperatures, have been increasing over the 1860-2005 time period. "In fact, if you look at the 21 hottest years measured, 20 of the 21 have occurred within the last 25 years." [8] The year 2005 was recorded as the hottest year over this time period. Peak electricity consumption has a double-edged sword effect with respect to its impact on the environment. It both increases environmental degradation and, at the same time, it is accelerated by environmental factors. Consequently, if peak electricity consumption could be reduced, the negative effects on the environment could be curtailed. Similarly, if the environmental accelerants to increased peak electricity consumption were mitigated, peak electricity consumption could decelerate. Thus. a positive environmental strategy towards electricity consumption would be a win-win strategy for electricity and the environment overall.

CONCLUSION

In a recent best-selling book of non-fiction, *The Tipping Point* by Malcolm Gladwell, the author retells an historical American legend. In April, 1775 a young livery stable boy in Boston, Massachusetts, overheard a British officer state that there would be "hell to pay tomorrow." The stable boy told the silversmith, Paul Revere, who quickly jumped on his horse and began his "midnight ride" to Lexington, Massachusetts, to warn the American militia that the British were coming. "The news spread like a virus as those informed by Paul Revere sent out riders of their own until alarms were going off throughout the entire region." [9] To Malcolm Gladwell, this was the tipping point in the revolt for independence. It embodied: "The three rules of the tipping point—the Law of the Few, the Stickiness Factor, the Power of Context—offer a way of making sense of epidemics." [9] "The possibility of a sudden change is the center of the idea of the Tipping Point."[9]

Also, there are three characteristics of an epidemic.

"These three characteristics—one, contagiousness; two, the fact that little causes have big effects; and three, that change happens not gradually but at one dramatic moment—are the same three principles that define how measles move through a grade-school classroom or the flu attacks every winter. Of the three, the third trait—the idea that epidemics can rise or fall in one dramatic moment—is the most important, because it is the principle that makes sense of the first two and that permits the greatest insight into why modern change happens the way it does. The name given to that one dramatic moment in an epidemic when everything can change all at once is the Tipping Point."[9]

Essentially, peak electricity demand in the U.S. is reaching crisis of epidemic proportions. A report released by the California Energy Commission in 1996 concluded that it is 8-30 percent more efficient for two major California utilities to produce and transmit a kWh during off-peak hours than during on-peak hours. The use of more efficient base load generation plants during off-peak hours also lowers transmission and distribution line losses. In addition, cooler nighttime temperatures create more efficient nighttime generation. Also, there are environmental benefits. For example, Ashok Gupta of the Natural Resources Defense Council noted that an off-peak generation installation in New York City results in lower emissions, because some of the plants used to meet demand peaks are among the dirtiest in the city. In response to these findings, California's 2005 release of the Title 24 energy code will surely drive designers to use more efficient, off-peak power because the relative costs are three to four times as high on summer afternoons. The cost of electricity will be priced at the relative cost of energy for every hour of the year (instead of a flat rate as allowed in California's 90.1), otherwise known as "time dependent valuation."

The similarity here is the fact that a small increase in peak electricity demand could cause a catastrophic and or an epidemic crisis in electricity demand across the country. As Paul Revere spread the word like an epidemic, he initiated the revolt's tipping point. Applying Gladwell's three rules of the tipping point through the load-shifting techniques detailed in these chapters, the tipping point of a peak electricity crisis or an epidemic in the U.S. can be avoided.

References

[1] Paul D. Koonce, Dominion, Letter to Northern Virginia Residents, January 18, 2007.

[2] North American Electricity Council, 2006 Forecast Report, October 16, 2006.

[3] John Kenneth Galbraith, *The Good Society: the humane agenda*, 1996.

[4] Richard L. Itteilag, *A Guide To Natural Gas Cooling,* The Fairmont Press, Inc., Lilburn, GA, 1994.

[5] Ice Energy Inc., Product Manual, Windsor, CO, www.ice-energy.com.

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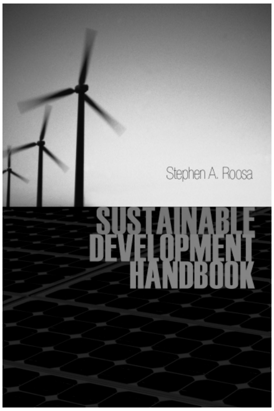

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[6] John S. Andrepont, *Thermal Energy Storage (TES): Optimizing the Economics of Energy and Capital,* Energy Engineering, Vol. 104, No. 1, 2007.

[7] Electricity: Going Metric, *The Economist,* December 16-22, 2006, www.economist.com.

[8] Al Gore, *An Inconvenient Truth,* 2006.

[9] Malcolm Gladwell, *The Tipping Point,* 2006.

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