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発行人　公文 俊平　　　編集人　上村 圭介
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Beyond the Hype: Likely Y2K Impacts on U.S. Electricity Service

Daniel P. Dolan

要旨

先進国の社会基盤の中でも、信頼できる電力供給サービスは最も重要なものである。アメリカでは、2000年問題論者の多くが、西暦2000年における停電や電力不足の可能性について特に憂慮している。また、専門家以外には、多くは流言や噂に基づいたものではあるが、全く電力が失われ壊滅的な影響をもたらすだろう予測する者もいる。このようなシナリオは、電力の専門家の多くには一笑に付されるものであるが、市民団体、業界、エネルギー省によって電力設備の徹底的な調査が行なわれている。2000年問題への対応状況を問われた企業が、流通と電力サービスが耐えられさえすれば、問題は生じないと回答するケースも一般的になり、電力業界に対するプレッシャーをさらに高めていると言える。政府のレベルでは、1998年5月1日にエネルギー省長官Federico PenaがNorth American Electric Reliability Council（NERC）に宛てた書簡の中で、アメリカの電力サービスについて「国家の安全と安定のために重要」であり、2000年問題に関連して「失敗や誤算はほとんど許されない」と指摘した。

本稿では、（a）電力サービスにおける発電および送電の特徴、（b）2000年問題によって最も影響を被ると見込まれる電力サービスの側面、（c）停電および電力不足のシナリオ、（d）NERCの2000年問題協調活動および影響予測、という諸点を分析することで、西暦2000年におけるアメリカの電力サービスの安定性の見通しについて論ずる。

1. Introduction

Among all of the many key components of any developed country's social infrastructure, reliable electricity service is perhaps the most important. In the United States, many Y2K observers are particularly concerned about the possibility of electrical blackouts or shortages in the year 2000. Some extreme predictions by non-experts, usually based largely on conjecture and rumor, tell of years without any electric power at all, resulting in catastrophe and devastation. Although such scenarios have been characterized as ridiculous by most power engineers willing to comment, electrical utilities have come under strong scrutiny by citizen groups, private industry and the Department of Energy. Adding to the pressure, it has become a common refrain among corporations quizzed about Y2K readiness to claim that there should be no problems as long as suppliers and electrical service are dependable. At the government level, in a May 1, 1998 letter to the North American Electric Reliability Council (NERC), Secretary of Energy Federico Pena referred to electricity service in the U.S. as "vital to the security and well-being of the Nation," and emphasized that with regard to Y2K, electric utilities can afford "little margin for error or miscalculation."
In this essay I describe the prospects for reliable electric service in the United States in the year 2000 by analyzing (a) main features of electric power production and distribution, (b) aspects of electricity service most likely to be affected by Y2K, (c) electricity blackout and shortage scenarios, and (d) NERC's Y2K coordination activities and impact forecasts.

2. U.S. Electric Power Production and Distribution

The production and delivery of electricity in North America is very complicated. According to NERC, there are approximately 3200 separate electric utility entities in North America, with approximately 198 involved in the bulk production and transmission of electricity and 2888 focusing on the distribution of electricity to customers. All of these entities are tied together in three large electrical grids: the Eastern, Western, and ERCOT interconnections. The Eastern interconnection is the largest, covering the eastern two-thirds of the U.S. and eastern Canada. The Western interconnection covers the western third of the U.S., Western Canada, and the Baha California area of Mexico. The ERCOT (Electric Reliability Council of Texas interconnection includes most of Texas. These three regions are referred to as "interconnections" because they are separate, highly integrated power grids tied together by weak direct current links. The advantage of this design is that electric utilities within one interconnection can cooperate by borrowing or lending electricity among each other as required by customer demand.

There are four main features of electricity service: production (or generation), transmission, distribution and load (consumption). Production facilities in North America rely mostly on fossil fuels, hydro, and nuclear power for energy. There are 103 operational nuclear reactors in North America, contributing 22% of total electricity production. Production facilities transmit electricity at high voltage along a series of substations connected by power lines.

These substations act as controls on the transmission of electricity, and contain many switches, voltage regulators, meters, and communications equipment. From substations, electricity is transmitted to load centers where transformers reduce voltage to levels acceptable for delivery to customers. Distribution systems handle this low-voltage electricity, sending it to commercial and residential customers. Managing the complexities of electricity production, transmission and distribution are 200 control centers, which are highly dependent on communications systems for constantly monitoring power grid conditions such as supply and demand.

3. Features of Electricity Service Most at Risk

Difficulties associated with Y2K will not impact the North American power grids in a uniform way. Although transmission and distribution systems generally involve less digital functions than production systems, most transmission facilities use at-risk, digital Supervisory Control and Acquisition (SCADA) and Energy Management Systems (EMS) to monitor supply and demand and other grid characteristics, as well as embedded date-sensitive controls in transformers and breakers. However, some experts believe that EMS and SCADA unites are not vital to power service and could be shut off or at least operated more conservatively during January 2000 to protect against Y2K problems. Relay devices in the transmission network are also at risk, but digital relays apparently account for only a very small amount of the total relay switches.

Far more at risk of Y2K failure are telecommunication services and equipment and electricity production facilities, especially those facilities with Digital Control Systems (DCSs). Telecommunications systems are used by utilities to monitor real-time performance of electricity transmission and distribution. Data communications are critical in providing generating units and control centers with the information required every few seconds to balance electrical generation to demand. However, according to NERC a "significant portion" of voice and data communications used by electric utilities is provided by telecommunications companies, many of which lack the resources to conduct extensive tests of their equipment and services before 2000. These include local and long distance carriers, Internet service providers, paging and cellular systems, and satellite broadcasters. The result is that utilities have little control of the Y2K readiness of their data communication systems, putting in question the ability of electric utilities to manage the real-time functions of the power grid without interruption. NERC therefore advises electric utilities to install Y2K-compliant telecommunications systems if possible, and to be ready for manual operations of systems if necessary.

DCSs control nearly all aspects of power generation, automating what are otherwise very labor-intensive processes and procedures. DCSs contain many embedded computer chips and, according to NERC, rely on time-dependent algorithms that may result in unit trips. Perhaps most critically, DCSs are "vendor-dependent," meaning that electric utilities must rely on the expertise and personnel resources of DCS vendors for cooperation in Y2K testing. NERC has publicly admitted that, as with telecommunications providers, DCS vendor resources are not adequate for testing and upgrading of all critical DCSs before January 2000. Another reason that DCSs are of great concern is because they have the potential for causing what power engineers call "common mode failure." Common mode failure in electrical service is most often associated with weather, for example the 1977 New York city blackout and the Auckland, New Zealand blackout of 1998. However, DCSs could become sources of common mode failure in electricity production facilities if critical and Y2K-sensitive embedded chips are not discovered and replaced in time.

There are other, less technical features of electricity service at risk from Y2K, most of which are likely to cause problems in the summer of 2000 when electricity demand is at a peak and production margins are most vulnerable. One external factor is the reliable transportation of fossil fuels to production facilities. Most cargo ships depend on Global Positioning Satellite (GPS) navigation equipment, which is governed by date-sensitive software. Pipelines for oil and natural gas are also monitored and regulated by computers that may become compromised by Y2K.

Another external factor is the ability of electric utility customers to pay their bills, and the potential impact on utility business operations. The performance of financial institutions in the year 2000 is still uncertain, and it is possible that the price of electricity could increase many times if availability and rationing become necessary. For example, in July 1998 there were a series of power shortages in the Midwest U.S., and the price of electricity went from $0.05 per kilowatt-hour to $7.00. At such prices, not everybody can afford power for extended periods of time. Finally, there is the question of sufficient numbers of electric utility workers to take over the functions of computers and other digital devices that might fail or need to be removed from service for precautionary reasons.

4. Electricity Service Blackout and Shortage Scenario

Power engineer and Y2K analyst Dick Mills makes the following predictions regarding the availability in the United States of electrical power in the year 2000:

(1) "Prepare for blackouts in the first days of January 2000, lasting up to 72 hours."
(2) "Prepare for shortages of power in the warm summer months of 2000."[1]

Mills argues that the currently popular notion of localized power blackouts is inaccurate. According to Mills, power blackouts refer to the sudden, unpredictable and complete loss of power over a large section of a power grid. Power shortages refer to the inability of utilities to generate sufficient power to meet consumption demands. Because of the architecture of the power grid system in the United States, Mills proposes that there is not much chance of long-term power blackouts. Specifically, he argues that electric power operators can and will increase the safety and reliability of the grid during Y2K stresses by deciding when to island particular plants by cutting connections to other plants, and if islanding is necessary when to re-establish interconnections. He uses the analogy of beginning ice skaters sometimes linking arms for stability and sometimes letting go, depending on moment to moment conditions and quick decisions regarding how to maximize the chances of remaining upright. Mills believes that even if there are blackouts, power will be restored to most customers in the United States within 24 to 72 hours.

Mills predicts that carefully regulated power shortages eventually affecting most U.S. electricity customers is much more likely in the year 2000 than uncontrolled localized power blackouts. The odds of power shortages are particularly high during the summer of 2000, especially if the summer is hot in most areas of the United States (summers are always peak power demand seasons). Power shortages result when power generation "margins" dip below 0%. Margins of 15-30% are standard for the industry in the United States, meaning that generation capacity is usually 15-30% larger than demand. But Mills believes that in the year 2000 Y2K problems might force some utilities to shut down periodically for repairs, putting generation stress on margins that have grown increasingly small even without Y2K over the past decade. It also is possible that due to economic considerations, power shortages will be more likely for electricity customers least able to afford the cost of huge rate increases that probably would accompany severe power shortage forecasts in 2000. In this sense, geographically localized power shortages are less likely than economically localized shortages. Power shortages are therefore planned responses to known and usually predictable difficulties, and are best understood as related to financial rather than technical difficulties at utilities.

5. NERC's Y2K Coordination Activities

The North American Reliability Council (NERC) is a non-profit, organization founded in 1968. NERC consists of ten regional councils, representing all types of electric utilities in the United States. NERC's scope is international, because some electric utilities in Mexico and Canada are part of the U.S. electrical grid.

In May, 1998, The U.S. Department of Energy (DOE) requested NERC's assistance in coordinating Y2K activities among all utilities that make up North America's electrical grid. In a letter to NERC, the DOE asked that by July 1, 1999, NERC provide written confirmation that critical systems in the North American grid have been tested and will function in the year 2000. NERC's Y2K coordination strategy is based on the concept of what it calls "defense-in-depth," in which multiple defense barriers are established to reduce to very small probability levels the risk of large scale failures, and to lessen the severity of any problems that do occur. The strategy has four main components:

(1) Identify and fix known Y2K problems. NERC is working closely with utilities to maintain a database of known Y2K problems and solutions, and to share this information with all utilities through the activities of the ten regional councils.
(2) Identify worst case conditions. NERC is coordinating simulations in an attempt to

draft moderate and worst case scenarios for electricity service. Systems associated with the identification of worst case scenarios are being examined with particular care.

(3) Prepare for the worst. NERC is coordinating the training of utilities personnel to operate systems safely even under worst case scenarios.

(4) Operate systems cautiously during critical Y2K transition periods. Examples include putting into service all available transmission facilities, increasing the number of utility operation staff, maintaining a mix of digital and analog production control units, and reducing the level of planned electricity transfers between utilities.

The four Y2K strategy components outlined above are taking place within a three-phase program established by NERC. Phase One (May-September 1998) consisted of a review of Y2K readiness status among North American electric utilities and planning for phases two and three. Phase Two (September 1998-July 1999), which is currently underway, consists of attempts to fix known Y2K problems among utilities and related engineering testing and simulation studies designed to identify worst case scenarios. Phase Three (July 1999-January 2000) will involve reviews of operating procedures and contingency plans, including final drills and simulations.

NERC also announced in a May 24, 1999 press release that NERC "strongly endorses" the recently launched Y2K Community Conversations Campaign sponsored by the President's Council on the Year 2000 Conversion. The Campaign makes available on its website a toolkit for use by citizens or groups planning Y2K information meetings, and lists various local meetings that already have been scheduled.

6. NERC'S Y2K Impact Forecasts

In its written request to NERC, the DOE asked that NERC submit two status reports--one in September 1998 and one in July 1999. The first status report, which marks the end of Phase One of NERC's Y2K coordination strategy, was made available to the DOE on September 17, 1998. Based on a survey response rate by all North American electricity generation and distribution facilities of just over 75%, NERC concluded that "the impacts of Y2K on the operation of electrical systems may be minimal" (p. 1). NERC also suggested the following:

1. With proper contingency planning, sufficient generating capacity is anticipated to be available to meet demand during critical Y2K transition periods, including additional reserves and quick start units.
2. Nuclear generating facilities are expected to be available to supply their share of energy needs and all their safety systems are expected to be fully ready for Y2K.
3. Transmission outages are expected to be minimal and outages that do occur are anticipated to be mitigated by reduced transfers established as part of the contingency planning process.

4. Distribution systems may be the least sensitive to Y2K anomalies, but may have the least options for redundant supplies and facilities. Increased risk of isolated, local electrical outages is a possibility, but requires further evaluation.
5. Telecommunications from external service providers and sustained fuel supplies are the areas in which the electric industry is most dependent on others. Extensive coordination with support industries is required in these areas.
6. Availability of voice and data communications, not the loss of electrical facilities, is expected to be the greatest operating challenge (pp. 2-3).

Phase Two will end with the submission of NERC's July 1, 1999 status report.

However, in addition to those two reports, NERC decided to submit quarterly reports due to the need for timely information regarding electrical utilities' Y2K preparations. NERC released the first of these additional status reports on January 11, 1999, and made available the most recent report on April 30, 1999. NERC's January assessment is based on survey data provided by approximately 98% of electricity supply and delivery organizations in North America. This figure includes a 100% response rate by operational nuclear reactors, which reported through the Nuclear Energy Institute. Once again, the main conclusion drawn by NERC in both the January 1999 and April 1999 status reports is that year 2000 date-sensitive software and components will have "minimal impact" on the ability of U.S. electric utilities to provide reliable and safe electrical service. Support for this consistent forecast is bolstered by figures in the April report claiming that remediation and testing completion among utilities surveyed has increased on average from 44% complete as of November 30, 1998 to 75% complete as of March 31, 1999. NERC also points out in the January status report that because December 31, 1999 is a Friday and January 1, 2000 a Saturday, electricity consumption loads and the production needed to meet these loads should be light. The most recent and most optimistic forecast of likely Y2K impacts on U.S. electric utilities comes from a May 24, 1999 press release in which NERC president Michehl Gent claims that "the bottom line is that for the typical person or business in North America, the supply of electricity will be like that on any other New Year's Day."

Even so, NERC's confidence has been criticized by some observers who claim that other data released by NERC in the reports do not support a minimal impact scenario. Specifically, some observers remain concerned about potential Y2K impact on electric utilities' telecommunications systems and on DCSs. According to NERC's January 1999 status report, "the dependence on voice and data communications directly affects real-time operations and control of electric systems and therefore requires the greatest attention in contingency planning and preparations" (p. iii). NERC's strategy for dealing with what it refers to in its April 1999 status report as "a very unlikely, but critical contingency" is "to operate using a manual transfer of a minimum set of critical information over redundant voice systems such as microwave, radios, satellite voice systems, and privately owned phone networks. This information typically includes power flows on key transmission lines, voltages, and Interconnection (grid) frequency. Qualified field personnel at critical substations can read this information locally and convey the information to system operators in control centers.

The essential generation and demand balancing, frequency control, and transmission security functions required to monitor and control the transmission system and generating units can be sustained indefinitely in this manner. A similar type of operation can be performed in electric distribution systems, although the focus is more on switching activities (p. 42).

To test this strategy, on April 9, 1999 NERC facilitated a drill simulating partial loss of data and voice communications within the power grids of North America and Canada. According to NERC approximately 200 power generating facilities and more than 2000 utility employees took part in the drill, which included oil, coal, gas, hydro, and nuclear facilities. Officials monitoring the simulation reported the following problems: outdated phone numbers on some important procedural lists; noisy, congested, and sometimes faulty back-up voice transmissions; and the need to better train employees on the use of satellite voice systems. NERC called the drill "extremely valuable," and announced plans for a second, more ambitious Y2K drill scheduled for September 8-9, 1999. Regarding DCSs, NERC notes in the January 1999 status report that the cause of some electric generation plant failures (tripping off-line) during Y2K testing that has been completed are thought to be due to "lock up of an unremediated DCS system" (p. 21). Of course, transmission and distribution of electricity become meaningless or at least complicated if production ceases or is disrupted.

In summary, the prospects for safe and dependable electricity service in the United States in the year 2000 remain uncertain, but assuming that NERC's survey data are reliable it appears that industry-wide Y2K activities are increasing. However, despite endorsement of their efforts from the DOE, there is not much evidence to support NERC's conclusion that Y2K will have "minimal impact" on power production and consumption in the United States, particularly when NERC has not defined operationally what "minimal" means in this context. In addition, as Mills has pointed out, it is not possible to meaningfully predict a physical outcome like Y2K impact on electric utilities by asking a trade association such as NERC to survey utilities about their Y2K readiness. There also are some important figures cited in NERC's January 1999 status report that reveal an industry in potential trouble. According to NERC, approximately 46 percent of survey respondents reported that they likely will miss the industry-imposed Y2K readiness deadline of June 1999. Sixteen percent of this 46 percent do not expect to be Y2K-ready until the 4th quarter of 1999. These figures do not include 20 nuclear power facilities that reported that they expect not to meet the June 1999 target date. There are perhaps better grounds, based on power engineering principles, for concluding not that "minimal impact" is likely, but rather that long-term electricity blackouts due to Y2K alone are unlikely.

Finally, with much yet unknown about the potential difficulties utilities will encounter in the year 2000, one of the most important questions concerns a fundamental dilemma that the electric utility industry has been facing for the past decade--the ability of utilities to maintain sufficient, long-term electricity production margins despite increasing consumption demands and occasional unpredictable stresses to the grid. Whatever the magnitude of impact Y2K eventually has on electricity service in the United States, it surely will contribute negatively to this critical equation.

Notes

[1] Summary of 1998 Power Prognostications, January 8, 1999, Powerful Prognostications. Online at http://www.y2ktimebomb.com/PP/RC/dm9901.htm

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Daniel P. Dolan（ダニエル・P・ドーラン）
国際大学グローバル・コミュニケーション・センター
主任研究員／講師