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How Availability Changed in a Competitive Market

A new competitive wholesale electricity market opened in New England on 1 May 1999. There were early indications that power plant availability might have declined as a result.

Did power plant availability change in New England? If so, why? How does a competitive market affect generating unit availability? This article, which provides at least partial answers to these and related questions, is based on a year-long study sponsored by ISO New England and performed by Merrill Energy LLC [1]. This study included the creation and analysis of the most detailed and complete database known to exist on generating unit availability in New England spanning the creation of the competitive market. We conclude the following.

- Important changes in power plant availability have occurred recently in New England.
- There are physical (non-market) causes for some of the changes.
- Some new units have very poor availability.
- There is statistical evidence that plant availability responded to market signals.

Source Data

When this study began, there was no adequate availability g database for New England. An extensive database was created for the period 1995-2000. As it is kept current, it will allow additional studies of this kind. Source data included:

- ISO-New England's NEPOOL automated billing system (NABS), through April 1999
- ISO-New England's market information system (MIS), beginning May 1999
- The North American Electric Reliability Council (NERC) GADS database
- FERC Form 1 data on maintenance expenses
- Monthly fuel cost data from the U.S. Department of Energy (DOE)
- Plant equipment census data from Utility Data Institute
- Hourly market price, demand, weather, and other data from ISO-New England files.

In addition to creating and analyzing a database, project team members interviewed senior staff at seven power plants totaling 32% of New England's fossil-fired capacity.

Changes in Power Plant Availability

Weighted equivalent average generating unit availability in New England declined from 1995 to 1997 and then rose again, with availability in 2000 slightly higher than in 1995 (Figure 1). *Weighted* means that averaging is proportional to unit size, so a 100 MW unit counts ten times more than a 10 MW unit. *Equivalent* means that both deratings (partial outages) and full unit outages are counted, proportional to the megawatts that are unavailable. Data for 1999 is for May-December only. Changes in record keeping on 1 January 1999 prevented the creation of availability data for January- April 1999. The data for the competitive market, which began on 1 May 1999, is complete through the end of the study period (31 December 2000). Though we do not have data for the last 4 months of the traditional market, the data for the previous four years (1995-1998) is ample for a before-vs-after comparison.

This overall decline and increase are due to effects of nuclear outages, notably long outages of the three Millstone Point nuclear units. They are so large, and their outages were so long, that they dominate the availability statistics (Table 1).

Average availability of all New England generating units, excluding nuclear units, was about 6 percentage points lower in 1999-2000 than in 1995-1998 (Figure 2).

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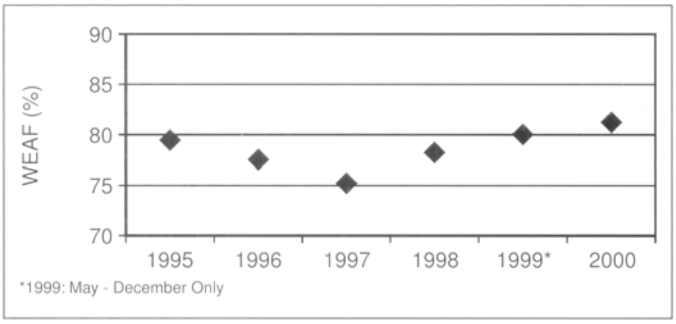

Figure 1. Weighted equivalent availability factor (WEAF) for all New England Generating units

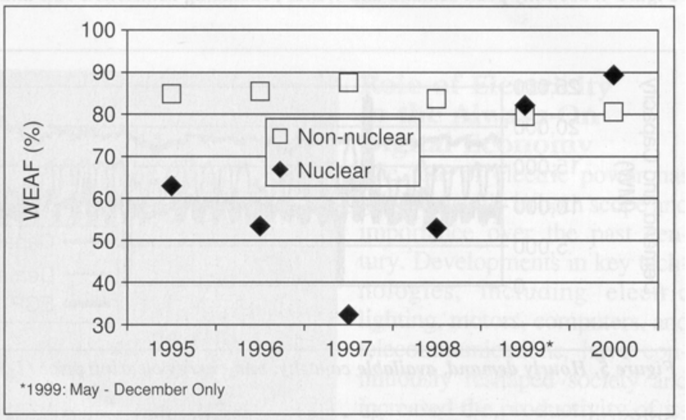

Figure 2. WEAF for nonnuclear and nuclear generating units

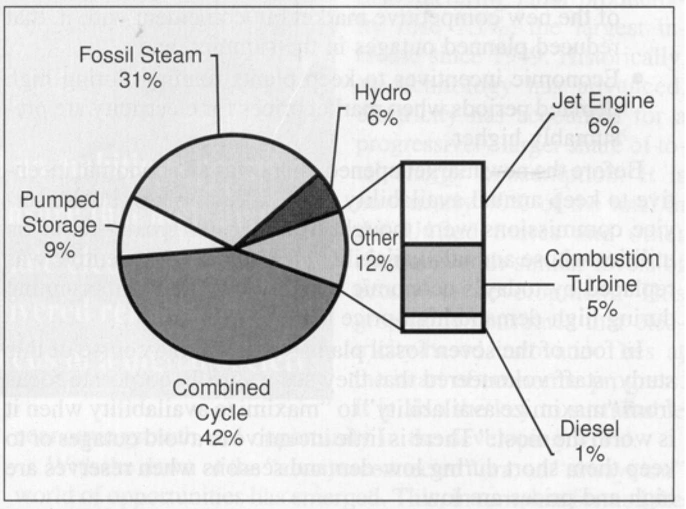

Figure 3. Sources of 6% decline in nonnuclear availability from

Table 1. Long outages of the Millstone Point nuclear units		
Outage	**Began**	**Ended**
Millst 1	November 1995	November 1997, retired
Millst 2	February 1996	May 1999
Millst 3	March 1996	June 1998

Physical Causes of Availability Decline

The decrease in availability from 1995-1998 to 1999-2000 was common to all classes of New England's generating units except for nuclear units. Figure 3 shows that some classes of units contributed more than others, however.

Combined Cycle Units

A notable observation was the influence of combined-cycle availability. In May 1999, combined-cycle units accounted for approximately 17% of New England's nonnuclear capacity.

Combined-cycle units were responsible for more than 40% of the decline in availability. Seven new combined-cycle units entered service between 1999 and 2000, most of which had very poor availability (Table 2).

New England has 19 "old" combined-cycle units that have been in service since at least 1995. A twentieth came online in 1996. Seven "new" combined-cycle units were built in 1999-2000, almost doubling New England's combined-cycle capacity in 2 years. Fifteen (75%) of the old units are smaller than 200 MW. Most (five of seven) of the new units are larger than 200 MW. Fifteen additional combined-cycle plants have entered service since January 2001 or are under development.

The technologies of the old and new units differ greatly. This difference in technology undoubtedly accounts for some of the differences in availability shown in Table 2. In 2000, only one of the new units had an equivalent availability factor (EAF) above 81%. Only one of the old units had an EAF below 81%.

Table 2. WEAFs for old and new combined-cycle units

	1995	**1996**	**1997**	**1998**	**1999[1]**	**2000**
In service before 1 Jan. 1999: WEAF	90%	92%	92%	89%	91%	89%
Entered service after 1 Jan. 1999: WEAF					32%	63%
All combined-cycle units: WEAF	90%	92%	92%	89%	77%	78%
Capacity[2] (MW)	2712	2706	2728	2760	3675	4957

WEAF is first computed by unit (some entered service in midyear), then by year.

[1] 1999 data: May-Dec.

[2] Capacity is average maximum monthly claimed capacity for each year.

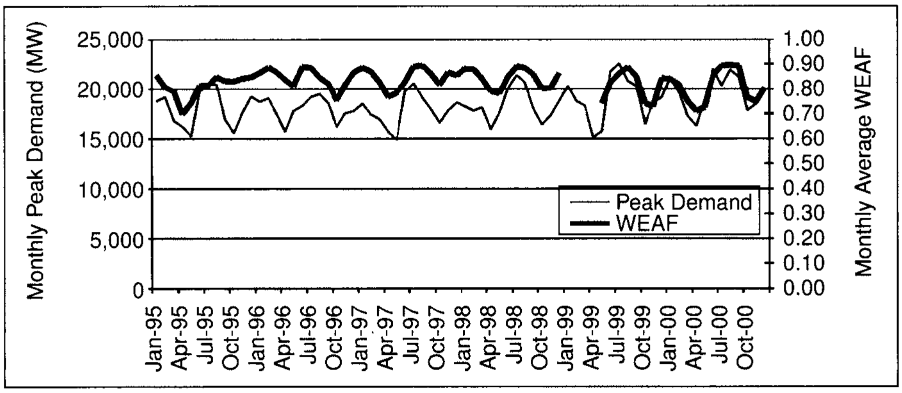

Figure 4. Monthly peak demand and WEAF, excluding Millstone Point units

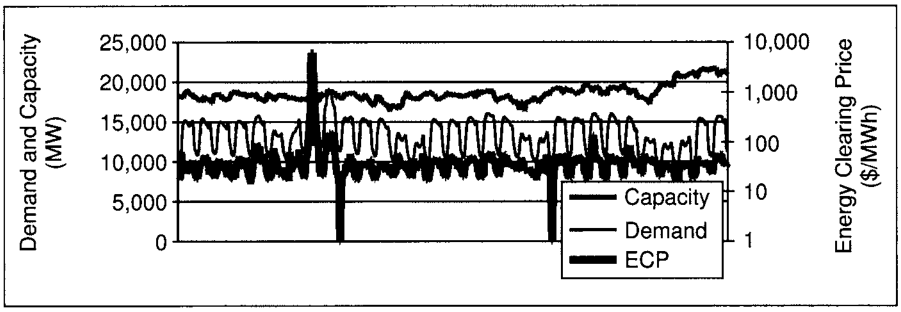

Figure 5. Hourly demand, available capacity, and energy clearing price (1-31 May 2000)

Fossil Steam Units

Figure 3 shows that fossil steam units were also an important part of the overall decline. Some fossil units were run harder (higher capacity factor, temperature, and pressure) and with less maintenance to make up for the nuclear outages in the mid-1990s, stressing the units. Their availability declined after 1997.

Other Nonnuclear Units

Declines in availability of other classes of units contributed little to the overall decline in average nonnuclear availability. Inaccuracies are possible (in fact, likely) in event reporting for small hydro, combustion turbine, and diesel units. The availability data for small units is also less meaningful because they tend to have low capacity factors.

Market Effects

Seasonal Availability

The seasonal availability matches the demand better in the new market. Figure 4 shows more pronounced peaks and valleys in 1999-2000 than in earlier years. From 1995 to 1998, the correlation coefficient, R, between average monthly WEAF and peak monthly demand was 0.52. From May 1999 through December 2000, the correlation coefficient was 0.82. This improved matching was likely due to:

- Changes in ISO-NE maintenance scheduling, independent of the new competitive market but coincident with it, that reduced planned outages in the summer, and
- Economic incentives to keep plants running during high demand periods when market prices for electricity are presumably higher.

Before the new market opened, there was an economic incentive to keep annual availability as high as possible. Public service commissions were thought to look with greater favor on utilities whose annual availability was high. This incentive was replaced by today's economic incentive to keep units running during high-demand/high-price seasons.

In four of the seven fossil plants visited in the course of this study, staff volunteered that they see a shift in corporate focus from "maximize availability" to "maximize availability when it is worth the most." There is little incentive to avoid outages or to keep them short during low-demand seasons when reserves are high and prices are low.

The combined effect of these changes in incentives may be a reduction in annual availability. This is not necessarily bad for the customer if it results in lower prices due to reduced maintenance costs associated with less overtime during off-peak months, etc.

Hourly Availability

Figure 5 shows available capacity, demand, and energy clearing price (ECP) for each hour in May 2000, when New England experienced its highest-ever price spike. The driving force for the price spike was unusually high demand when available capacity was not very low.

In Figure 5, *the* ECP curve hides the demand curve for Monday, 8 May, when the price reached $6,000/MWh. The demand peaked at 18,696 MW when available capacity was 17,765 MW. The next day both peak demand and available capacity were higher (18,883 and 18,716 MW, respectively) but ECP peaked at $ 151/MWh. That night the ECP was negative. Figure 5 also shows the extreme volatility of ECP. Note that the ECP axis is logarithmic. The authors know of no other commodity whose price is so volatile that it must be plotted using a logarithmic scale, but that is a topic for another article.

Figure 5 also reveals a faint weekly availability cycle, with WEAF slightly lower on weekends. Planned outages, which may be of several weeks' duration, often begin on Friday or Saturday and end early Monday morning, so they may overlap on weekends.

Figure 5 shows little or no evidence of hourly cycles of availability on a day-today basis. This is because random forced outages or curtailments can occur at any time and hence are not cyclical. Planned outages or curtailments of significant duration are scheduled well in advance to fit the seasonal demand cycles.

Business Practices

The authors' study was a technical effort to examine unit availability, not a market power analysis. Nonetheless, certain observations on business practices can be made.

Figures 4 and 5 show no sign of unusual patterns of outages. Plants are responding benignly to a market opportunity by increasing the capacity available during peak-demand months when the price can be expected to be higher.

Conclusions

Power plant availability in New England changed at about the time when the new competitive bulk power market opened in May 1999; it declined from 1995, bottomed in 1997, and rose the next 3 years. Much of the change in availability had physical causes.

- The overall decline and increase in availability were statistically attributed to several long nuclear unit outages.
- Availability of nonnuclear units peaked in 1997 and has declined slightly thereafter.
- Part of the decline in fossil unit availability was due to stress on units that were called upon for high output during the nuclear outages in the mid-1990s.
- Much of the decline observed in 1999 and 2000 in nonnuclear availability was due to very poor reliability of a number of brand-new combined-cycle units.
- In the new market, unavailability tracks seasonal demand better than it did in the past. Power plants seem to be trying to maximize their availability during high demand periods,

Acknowledgments

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Reference

H.M. Men-ill, G. Lawrence, and S. Lawrence, *Understanding New England Generating Unity Availability.* Prepared for ISO New England, Inc., 21 June 2001. Available: http://www.MeiTillEnergy.com and http://www.ISO-NE.com.