Exploring an Enhanced Data Viewing Facility for Building Operators

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Introduction

Recent advances in desktop computers will allow building operators to access vast amounts of hourly energy data captured from Data Acquisition Systems (DASs) and even Energy Management and Control Systems (EMCSs). Advances in computer hardware are occurring so rapidly that the same PCs used for word processing can also be used to interactively poll, view and analyze complex hourly energy use data--a task that previously required more expensive dedicated systems.

Commonly used data viewing techniques include 2-D time series, X-Y scatter plots and even complex 3-D surface plots, which are often enhanced with color to help display details. However, data densities exceeding 1,000 data points per square approach the limits of a meaningfully display. Even with the best video displays and printers, certain trends remain hidden in existing plots because data points become overlaid upon each another masking details behind a black cloud of data points.

This paper explores some techniques which may help building operators better understand hourly energy data by enhancing the display of data, and thereby improve a building operator's ability to diagnose operation and maintenance problems.

Putting the Data in Motion: Animated Plots

In Figure 1 a commonly used X-Y scatter plot displaying 3 weeks of hourly chilled water energy use versus ambient temperature is shown. This figure displays hourly chilled water energy use for a large engineering center located at a university in central Texas. The expected increase in chilled water consumption with increasing ambient temperature can be seen in the central portion of the graph.

In Figure 2 the hourly chilled water energy data from Figure 1 has been binned to create contours of the of hours of occurrence. The contours provide additional insight into the "cloud" of data points. Although Figure 2 improves the viewer's ability to read the density of the data points, in this building trends still remain hidden in the data that require additional processing. One method we've found that seems to help identify time-dependent trends is to animate the contour plots. An animation of the

contour plots can be obtained by breaking-up a larger period into smaller time intervals, creating contour plots for each interval, and slide the time frame forward between each plot. When these plots are viewed in succession, the image of a moving contour is obtained.

Figure 3 shows a sequence of contour plots. In this figure successive contours of the chilled water data have been animated with commercially available software. Each plot displays contoured densities of three weeks of hourly data that is slid forward in time between frames. On top of the enhanced detail that the contouring provides, the animation of the contouring allows one to view how the contours are changing with time.

In general, the use of animation allows one, two and three-dimensional static graphs, to include one more dimension--changes over time. Animation, in effect, becomes the time dimension. This is an especially effective way to convey time-dependent information because we intuitively understand that time is passing when we view an animation. Animation allows the time-dimensionality of the data to be recast in its true form and not as an abstraction. In addition, this procedure has the advantage of simplifying data graphics from a complex static display to a more easily understandable moving display.

Animation can also help improve 3-D plots of a large amount of data. 3-D surface plots of a building's energy use are shown in Figure 4 for a large engineering center located at a university in Texas. In these plots the x-axis is the day of the year, and the y-axis (i.e., into the page) is the time of day. The energy use is the height of the profile above the x-y plane. These plots are helpful in identifying energy use characteristics that are linked to the time of day of day of the year, and can be produced with several commercially available software packages.

In Figure 4 three successive plots of the electricity use are shown. Each plot displays eight weeks of energy use, sliding forward in time between successive plots. These successive plots are then fed to the animator which quickly displays one bit map after another to create the moving image. Scrolling through the 3-D plots with an 8-week time increment allows a more detailed view of one year or more of energy use than could have been provided if all
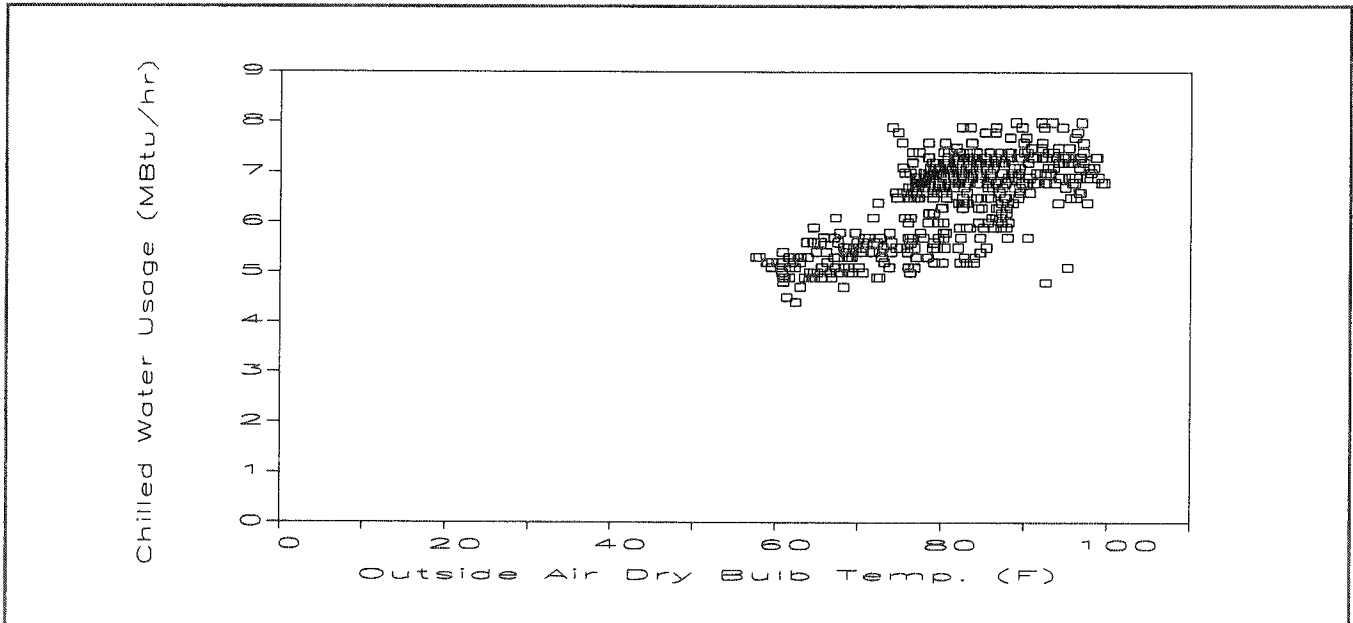
Figure 1. Commonly Used X-Y Scatter Plots Displaying 3 Weeks of Hourly Chilled Water Energy Use Versus Ambient Temperature. This figure displays hourly chilled water energy use for a large engineering center located at a university in central Texas.
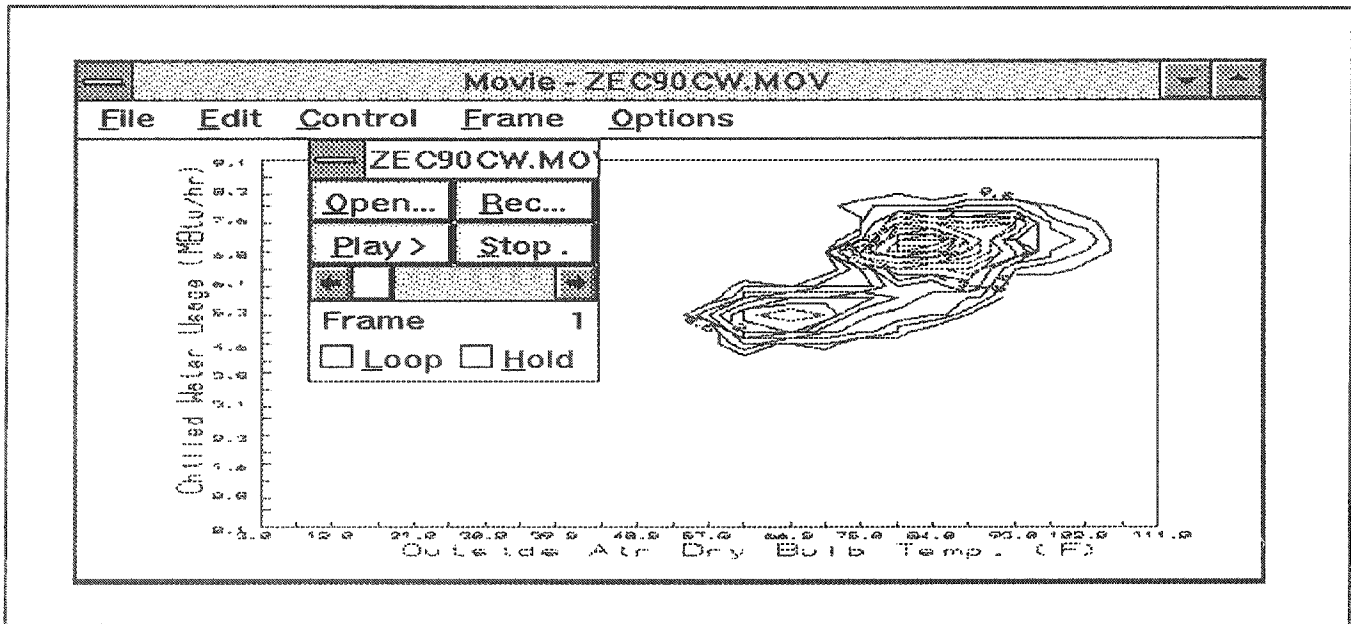

Figure 2. Contour Plot of Hourly Chilled Water Use Versus Ambient Temperature. In this figure the hourly chilled water energy usage from Figure 1 has been binned to create contours of the of hours of occurrence.

the data were being viewed simultaneously. Multiple views of the data from different angles can be simultaneously sequenced to further assist in the viewing.

Thoughts About the Future

Our explorations into animating a building's energy use have provided new insight into some commonly used plots. We can clearly imagine several areas where the
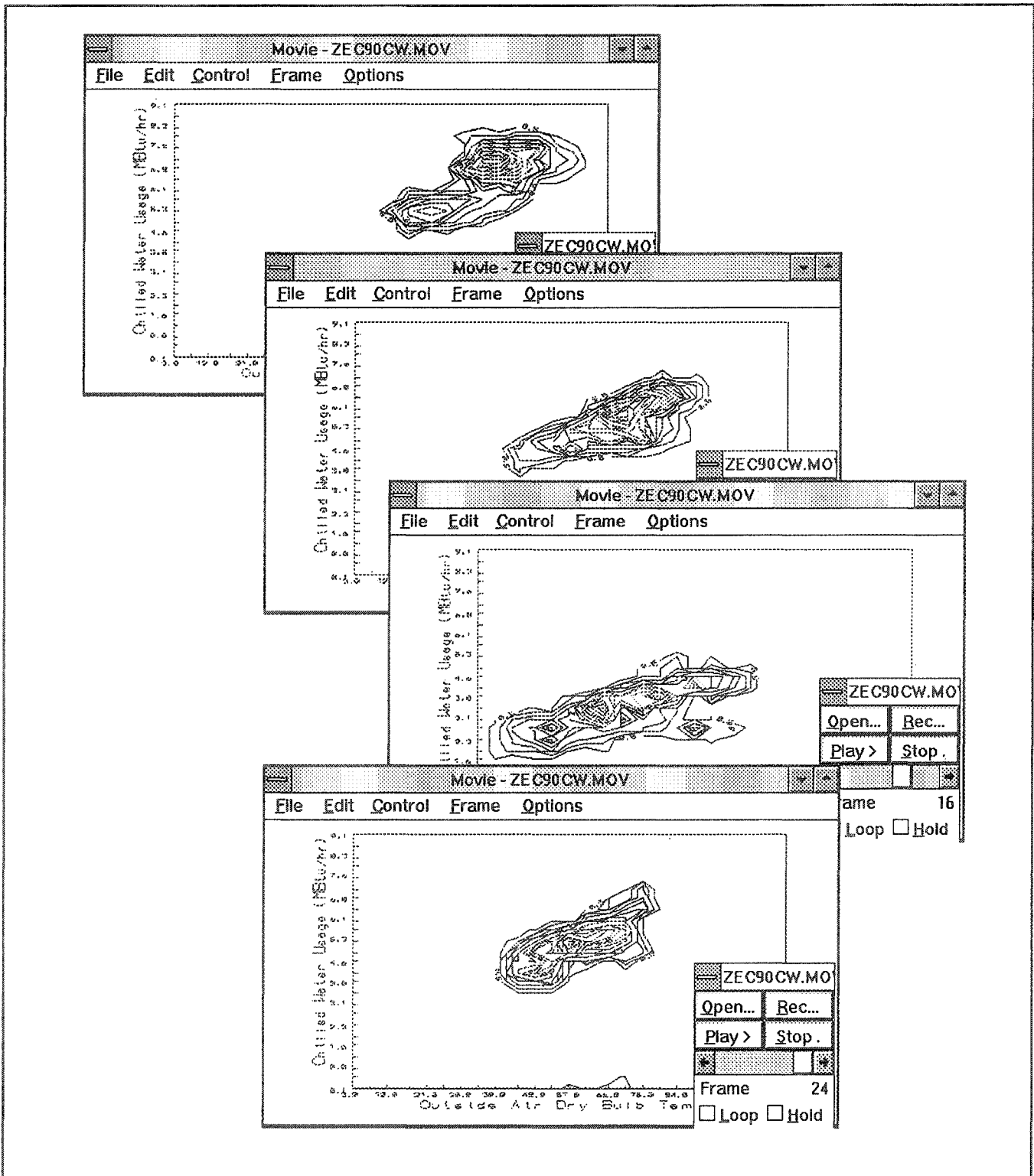
Figure 3. Animation Software Displaying a Sequence of Contour Plots. This figure shows successive contours of the chilled water data that have been animated with commercially available software. Each plot displays contoured densities of three weeks of hourly data that is slid forward in time between each frame.
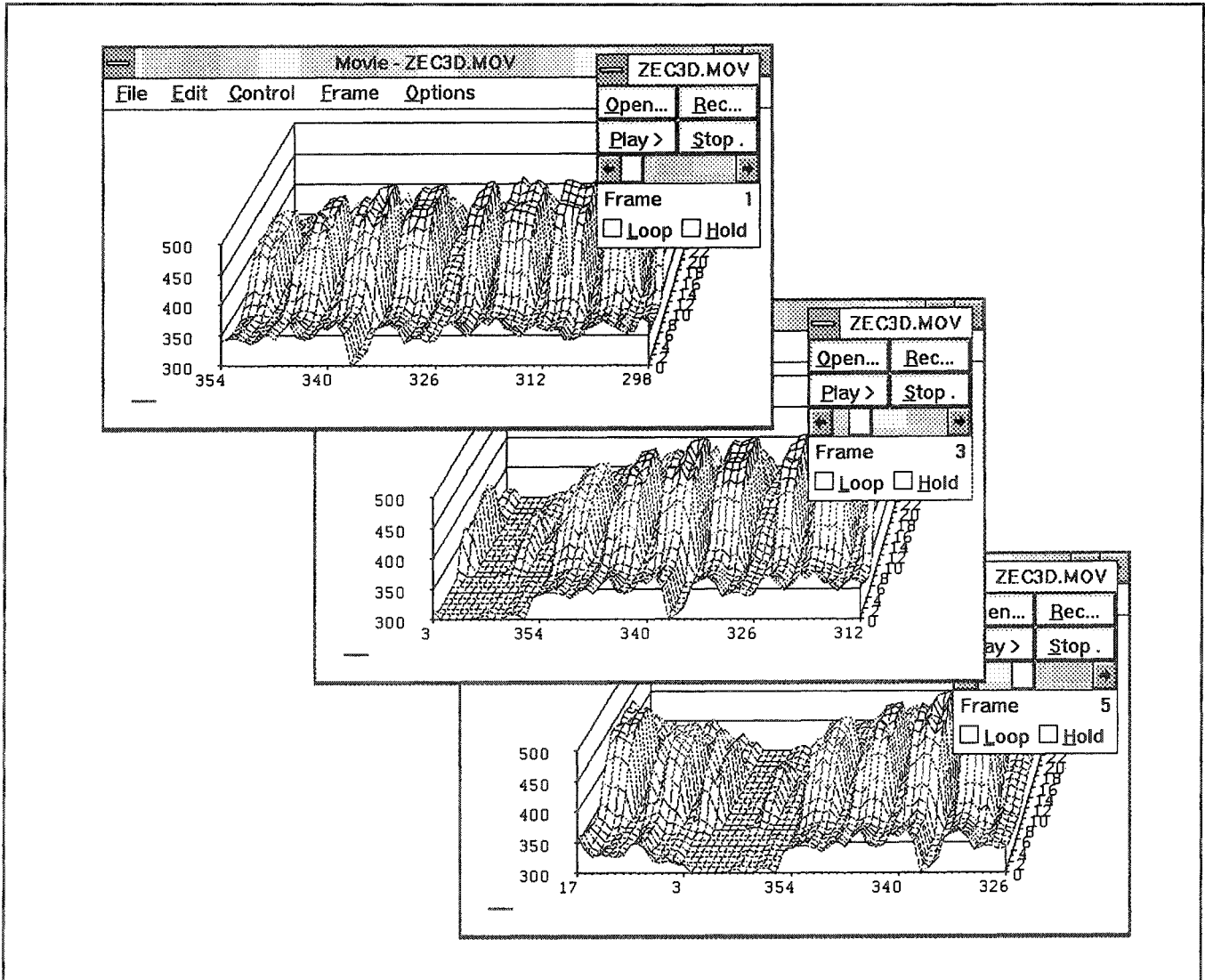
Figure 4: Animation Software Displaying a Sequence of Three 3-D Plots. This figure shows three successive plots of the electricity use of a large engineering center at a university in Texas. Each plot displays eight weeks of energy use, sliding forward in time between successive plots, in other words, one week of data is rolled-off the end of the plot and one week of data is added to the beginning of the plot.

animation might provide additional insight into how a building is consuming energy, including: calibration of simulation programs, and viewing multiple interactions such as temperature, solar, wind, and humidity. We are now at work developing public domain automatic animation routines that can be assigned the task of polling a logger in the evenings, and reducing the data into sequential plots which are ready for the operator to view first-hand every morning.

Acknowledgments