Utility Data Web Page Design—Mining the Data

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ABSTRACT

This article focuses on how to design a utility data web page interface that is both intuitive and easy to use. Users need to be able to quickly drill down through the data with minimal mouse clicks to investigate changes in meter data. Using the correct combination of options and links, hundreds of reports can be produced easily and quickly from one interface. Just like the dashboard of an automobile informs us of the inner workings of our cars, this interface can inform users of the inner workings of any facility or complex of facilities. This method, combined with interactive reports as described in Utility Data Web Page Design—Presenting the Data from *Information Technology for Energy Managers—Volume I*, makes an intuitive and robust utility reporting web application part of an energy information system (EIS). It helps us discover relationships, such as trends in our energy consumption over time or comparisons between similar facilities, which might otherwise go unnoticed.

INTRODUCTION

Mining information from a complex database of utility data can be a difficult and cumbersome task. WEBOPEDIA at http://webopedia.internet.com/defines *data mining* as:

> A class of database applications that look for hidden patterns in a group of data that can be used to predict future behavior. For

example, data mining software can help retail companies find customers with common interests. The term is commonly misused to describe software that presents data in new ways. True data mining software doesn't just change the presentation, but actually discovers previously unknown relationships among the data.

What is needed is a data mining interface that suits both the novice user as well as the expert user. The utility data interface described in this article provides a means to select specific data and create custom reports from them on demand. Novice users can create and modify reports quickly and easily using the options and links available. Expert users will quickly recognize additional strengths of the application and be able to compare and analyze data patterns that might not have been clear before. This tool helps reduce the complexity and confusion involved in using utility data as part of a successful energy management program.

WHY CREATE AN ENERGY INFORMATION SYSTEM (EIS)?

If you examine successful energy management programs, you will generally find someone who champions the effort. However, there are several other pieces to the energy puzzle that must be in place for the energy management program to be sustainable. First, executive management must be committed and support the energy management program with resources and a budget. The next important piece is a facility-wide sense of ownership and accountability for energy usage. Everyone can help the energy program by identifying energy waste instead of assuming that it is someone else's responsibility. Once the desire and motivation to reduce energy costs is in place, there must be sufficient technical resources available, generally a combination of in-house, vendors, and consultants that come together to evaluate methods for reducing energy costs. Finally, there must be an energy reporting tool, a "report card" that tracks energy usage to budget to determine how well each area is doing. This is where the EIS comes into the picture. The EIS must be easy to use and provide the answers regarding how well each area is doing relative to a budget, benchmark, or other areas. The EIS should rank the areas from best to worst, and the resulting competition that results helps drive the process forward. The areas that are not perform-

ing are the source for further investigation by the energy management technical experts. The areas that are doing well should receive recognition from executive management. Examining utility data determines the degree of success of an energy management program.

UTILITY DATA AND REPORTING FORMAT

Utilities gather data on energy use by the minute, hour, month, year or any other increment desired. These data span the realm of physical locations from individual meters to large complexes of buildings. For reporting purposes, the data may be organized into groups by physical location or some other criteria. Data will need to be reported in detail as well as summarized over these many time periods and groups. Comparisons need to be made between time periods and groups. It might be desirable to normalize the data by some other known value, such as floor area (square footage). "For most building types, floor area is traditionally the primary normalization variable for comparing building energy use and past work of this type has been based on it."(1) However, the data may also need to be normalized on a per day basis for utility billing data that has a varying number of days from month to month.

Utility data are represented in many different units. Electricity alone may be recorded and reported in watts, kilowatts, megawatts, kilowatts hours, kilowatt hours per day or any other unit of electrical measure. Often, the data are recorded and stored in one unit of measure while the data reports use one or more other units. This requires conversion algorithms within the reporting application.

A wide variety of reports are needed to monitor all aspects of energy use across the many time periods, groups, and units available. Users of an EIS may not be familiar with utility data and its units. These users may simply be trying to conserve energy by making informed decisions based on recorded data. They probably don't have a lot of time to spend on the task either. A few minutes a day, a few hours per week, or one day per month may be all the time needed to make good informed decisions if the data are made available in a convenient manner. The amount of data collected for any one complex may become quite large, so data has to be filtered to create effective reports.

More and more data become available as automation takes hold

of our facility infrastructure processes. Automated metering devices make collecting and storing energy data very easy. Thomas Jefferson University, near Philadelphia, is a good example of a large complex of facilities whose energy use is monitored using real-time automated metering technology and intranet reporting. (2) The problem for most is how to sort out all the meter data and present it in a way that is useful to many people. Many people need the information to make good, well-informed decisions about energy use and conservation.

UTILITY REPORTING GOALS

There have been many attempts at building customizable query tools that return user specified data from a database. They really don't provide much flexibility in reporting, much less an interactive report with links to sort, filter, and graph trends. For an example, take a look at Advanced Query Tool at http://www.advancedquerytool.com/index.html. Another method is to create a multitude of reports customized to a specific need and added to a long menu. This makes it difficult to decide which report to choose from and still doesn't open the door nearly wide enough to accommodate all user demands as quickly as needed. Another example is InfoSurfer by GanyMede Systems, Inc. at http://www.infosurfer.net/infosurfer.htm (registration required to view demo). We have efforts at opposite ends of the spectrum of possibilities today.

Users of an EIS need to be able to reach into the massive database of utility data available and grab specific pieces of data and report the results quickly and effectively. A single point of entry into the database is a welcome change from a long menu of diverse *hard-coded* reports. The ability to search for data is important. Report templates can give novice users a start in designing reports to compare values by time periods and groups.

The reports must have the ability to summarize data by time period and group as well as provide detailed information. Users should be able to choose which units to display and specify the content of the report as much as possible. They should be able to quickly filter data by pertinent criteria. Users should be able to save their newly designed reports to a list of existing named reports for later use.

An ideal web page design would produce a printable report while

keeping the selected options that drive the report visible to the user. Selection of options must be controlled so that the user cannot pick invalid items. An intelligent logic will present the user with only those options that are appropriate to the previously selected options.

Any utility reporting interface should be easy to use but flexible enough to gain access to any and all data collected and stored in a utility database. It should be robust in design so that users can access the data in any number of ways to produce a clean report. It also needs to be the focal point of the EIS, providing a starting point for exploring and reporting utility data.

UTILITY REPORTING SOLUTION

Utility Data Interface

The utility data interface acts as the front end to an energy information system (EIS). It could be compared to the dashboard of a car in that it provides information in a timely manner with little or no interaction on the part of the user (driver). Information on an automobile dashboard tells us the status of our car, its location, speed, temperature, and many other bits of data important to our ability to drive safely and comfortably. A utility data interface, working in conjunction with the processes of an EIS, can provide information about facility energy consumption. Even though EISs are more likely to provide information on a day-by-day basis rather then a minute-by-minute basis, this allows facility managers to make well-informed decisions regarding energy conservation. Readers should note that the utility data interface will likely require some customization for each different organization. There is also a great deal of potential for enhancement beyond what is presented in this article. The web page design of the utility data interface is well suited to customization and enhancements.

OVERVIEW

The utility data interface consists of HTML frames. One is the title/options frame across the top of the page. The other is the display frame. The title/options frame contains HTML elements, such as radio buttons and form fields, called option selection elements, to allow the

Title / Options Frame

Display Frame

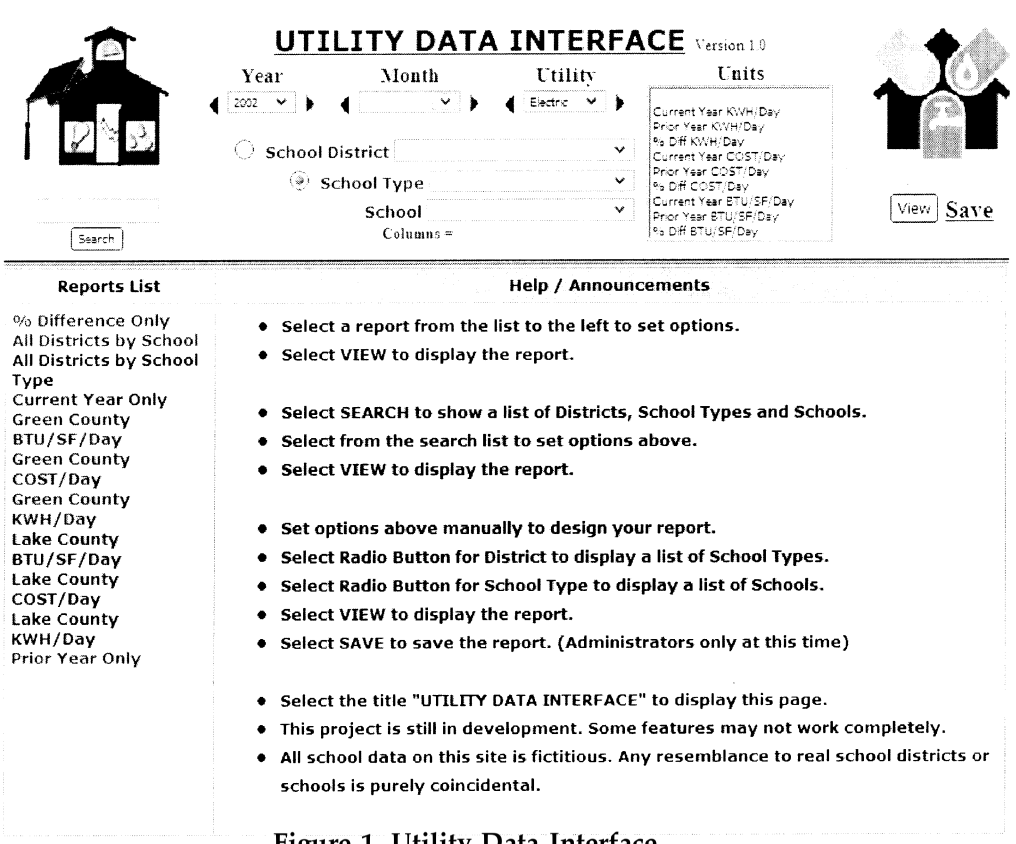

Figure 1. Utility Data Interface

user to select options that drive the database query and reporting. It also contains the application logo, title, time period option selections, a search field, other option selection elements and buttons to view or save the report.

The display frame is used for listing menu items, instructions, and announcements, as well as displaying reports and graphs generated from the data. The utility data interface design allows selected options to remain visible in the title/options frame while a printable report or graph is displayed. It represents a single entry point into the vastness of a utility database. The HTML frames allow users to configure and re-configure reports as needed without losing track of the selected options. The design does not require the user to generate a stack of data pages piled one on top of the other. The option selection elements used to query the database and design the report remain visible in the title/options frame at all times. The display frame contains only the information necessary to produce a printable report or graph without the option selection elements which would of course be quite a distraction. The title/options frame is really the best place to start designing a query and report since the user must select at least some options to produce the report desired.

TITLE/OPTIONS FRAME

The title/options frame spans the top of the web page for the complete width of the browser window. It contains the title of the application, which is probably the name of the EIS. In this case, it is "utility data interface." It may also contain a logo. The remaining space is for options used to filter the data, such as time periods and locations. It also contains a search field.

The search feature allows searches of the database for any instance of the text entered into the search field. For example, the result of a search for the word "middle" is a page displaying all the middle schools with their associated types and districts along with any other pertinent information that may be used to quickly set options. Selecting links in the search list is a quick way to set multiple options in the title/options frame. This list is drawn from a table of valid option combinations called a data catalog. The data catalog is simply a list of all the possible option combinations without the values, or readings,

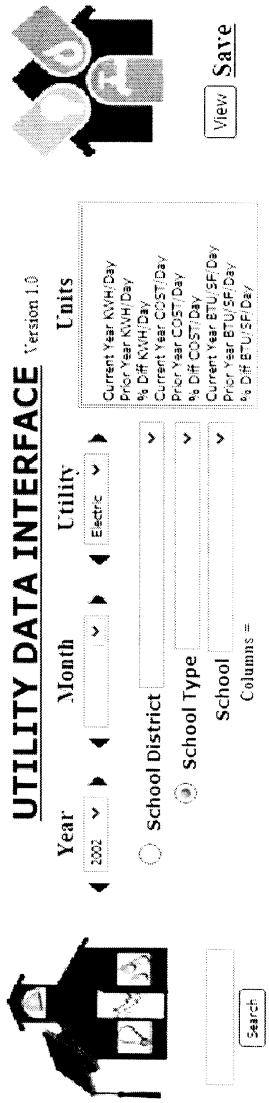

Figure 2. Title/Options Frame

associated with them. The data catalog is used to populate other option selection elements with valid data. Valid options are important to designing a report quickly and easily.

As mentioned earlier, summarizing and filtering are two very important aspects of utility reporting. The radio buttons on the utility data interface represent control over the summaries. The form fields allow filtering control. Summarizing is performed on particular groups. A group might be a time period, a location, or any other characteristic of the data. For instance, the radio buttons on the title/options frame in Figure 1 provide the ability to summarize by district, school type, or school, depending on which radio button is selected. Of course, only one of these three groups may be selected at a time. The form fields allow the user to select the district, school type, or school by which to filter the data. Other form fields for year and month are used to further refine the reports. In our example, year and month fields both filter and summarize, since summarizing by time period is the focus of this particular example. The radio buttons could very well be placed above the time period fields as well for more flexibility in summarizing. EIS administrators may want to add date and hour fields also. For a date form field, a good calendar date picking tool called **Tigra Calendar** is available from SoftComplex at http://www.softcomplex.com/products/tigra_calendar/. This tool makes entering a date much easier. Other options further define the report.

The main purpose of the other options is to define which data to display. This is accomplished by using the utility and units form fields. The utility and units form fields give the user a great deal of flexibility in creating the report. The title/options frame also contains the view button used to display the report. The report is displayed according to the options selected and, more importantly, the utility and units selected.

The utility list controls which data are shown on the report—electric, gas, water, etc. This typically affects the title of the report as well. The units list controls which units are shown as columns in the report: kWh, therms, gallons, cost, etc. Units for prior year data may also be listed, such as prior year kWh, prior year cost, etc. Choices for baseline data can be included here as well. Also, normalization data can be added in this way, such as kWh/day or kWh/square foot. Selecting these units determines which columns of data will be displayed. The order in which they are selected dictates the order in which the columns will appear on the report from left to right. Since the units list may be

quite large, it might be helpful to select other options first, since this will limit the possibilities for valid units. Using the data catalog described before, the options lists are filtered to contain only those items that apply to the previously selected options. For instance, if the year 2002 is selected and there are no electric data for 2002, then electric would not show up in the utility list. If electric data are available for 2002, but not for 2001, then prior year kWh will not show up in the units list. If electric rates are not available, cost will not show up in the units list. This intelligent logic insures all of the radio buttons and form fields are compatible with each other.

The combination of the radio buttons and the other form fields make the utility data interface very flexible in its ability to summarize or drill down into the data. For instance, selecting the radio button for district would produce a report showing all of the school types for the selected district, and a grand total line at the bottom for the entire district. Similarly, if the radio button for school type is selected, data for each of the schools of the selected type will be displayed along with a summarization line at the bottom for the selected type. If no school type is selected from the list, data for all schools will be displayed along with summarization lines for each school type.

Let's look at an example. Selecting 2002 from the year list and picking May as the month sets those options for the report. Selecting the radio button for district and picking a district from the list will produce a report for all school types in the district. Select units from the units list as needed, say kWh/Day, Prior Year kWh/Day, and % Diff kWh. Now, if the view button is selected from the options frame, a report will display the data for May, 2002.

As you can see, the number of reports available to the user is nearly limitless. Remember that the radio buttons relate to grouping and summarization, and the form fields relate to filtering. Grouping controls the level of detail in the report. Filtering is fairly straightforward. The database is filtered by whatever items are selected in the form fields. Users can combine radio button and form field options to compile a report as needed.

Reports are created/configured and displayed in this manner at the users' discretion. Once a report is created that fits the users' needs, it can be saved by name and added to a list of saved reports. These reports can be retrieved immediately by selecting them from the report list initially shown on the display frame.

GREEN COUNTY PUBLIC SCHOOLS			Electric
≤ MAY, 2002 ≥			
	Current Year kWh/Day	Prior Year kWh/Day	% Diff kWh/Day
Total ALTERNATIVE EDUCATION	8659.95	9809.97	–11.72%
Total ELEMENTARY	626565.63	699039.63	–10.37%
Total GREEN EDUCATION CENTER	69595.64	78385.79	–11.21%
Total HIGH SCHOOL	271382.15	313424.96	–13.41%
Total MIDDLE SCHOOL	332007.22	364658.321	–8.95%
Total NINTH GRADE CENTER	3138.08	3852.48	–18.54%
Grand Total GREEN COUNTY PUBLIC SCHOOLS	1311348.71	1469171.15	–10.74%

Figure 3. kWh/Day by School Type

DISPLAY FRAME

The display frame initially holds the list of saved reports, instructions, and any program announcements. This acts as a kind of home page for the utility data interface, as well as the EIS. Customized report templates can be added to the reports list to help users get started in designing their own. The display frame is used to display the reports and graphs. Links programmed into the reports with HTML elements simply refresh the same frame with a new report or graph. The links provide a method of instant sorting or graphing for trend analysis.

CONCLUSION

The difficult part of mining data from any database is doing it in a way that is comprehensive enough to get at all of the data, yet simple enough for the majority of users. Typical EIS users need to be able to access the complete data set from a single entry point. Preferably, this

Reports List	Help/Announcements
% Difference Only All Districts by School All Districts by School Type Current Year Only Green County Btu/SF/Day Green County COST/Day Green County kWh/Day Lake Count Btu/SF/Day Lake County COST/Day Lake County kWh/Day Prior Year Only	• Select a report from the list to the left to set options. • Select VIEW to display the report. • Select SEARCH to show a list of districts, school types and schools. • Select from the search list to set options above. • Select VIEW to display the report. • Set options above manually to design your report. • Select radio button for district to display a list of School Types. • Select radio button for school type to display a list of Schools. • Select VIEW to display the report. • Select SAVE to save the report. (Administrators only at this time). • Select the title "UTILITY DATA INTERFACE" to dis play this page. • This project is still in development. Some features may not work completely. • All school data on this site is fictitious. Any resemblance to real school districts or schools is purely coincidental.

Figure 4. Display Frame

single entry point takes advantage of the common characteristics of all utility data in an effort to make querying the data easier for novice users. Hopefully, it is more than just an opportunity to return raw data from database tables. It needs to be a powerful analytical tool configurable at the click of a mouse button. It also needs to have the ability to store commonly used queries and report designs for later use. The ability to return instantly to a known configuration does have its advantages. Expert users will likely want to create new reports by modifying existing ones. Therefore, the utility data interface approach to data mining is somewhat in line with the needs of EIS users.

The utility data interface attempts to bridge the gap between other

efforts by combining a database query tool with a report design tool. Utility data are unique in that they are always dependent on some date or time value, and are related to some physical location or characteristic. This is why the utility data interface is a more descriptive and easier to use query tool. It has powerful configuration capabilities for summarizing and filtering data into a custom report that is interactive. The report itself contains powerful sorting and filtering features as well as trend analysis. Once reports are designed, the users can save them for quick retrieval at a later date. The UDI provides a single entry point into the utility data database, as well as a report design tool that suits both novice and expert users. This should be enough to provide many EIS users the opportunity they need to make well-informed decisions about energy use and conservation. A demo of the utility data interface is available at *http://www.utilityreporting.com/udi.*

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