Green Analytics to Improve Operations

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With green analytical tools, supervisors and managers can see when and where energy is consumed, empowering them to better manage equipment, energy load, and energy-related improvements. Noblis' Total Emissions Analytics is one such tool.

Historically, corporate interests in the environmental arena have come and gone, focusing on either environmental risk or social responsibility. But more recently, companies are finding opportunities for long-term cost savings and even new business opportunities. Perhaps more significant, they are taking note of regulatory action, which is moving toward enforcing green practices and holding companies responsible for reporting their energy consumption and greenhouse gas (GHG) emissions.

Green analytics—the use of tools and techniques to make emission-reduction and energy-consumption efforts more efficient—can provide insights into the most beneficial green practices and can serve as a road map for creating healthier and more productive work environments. Researchers are already at work producing the next generation of such tools, which will have feedback loops for all electrically powered equipment so that enterprises and municipalities will clearly see how and where they are expending energy. The sidebar "Modernizing Energy Management & Control" on p. 25 describes some of the capabilities that a modern energy management and control system (EMCS) can provide, including being able to automatically change operating parameters to conserve energy.

Inside Track

- The Department of Energy lists nearly 300 tools in its software directory—all of which are readily available for building owners and operators to improve operations and reduce energy use.
- For many buildings or professional services enterprises, purchased electricity is one of the largest categories of energy use. It is also one of the ripest for applying sophisticated efficiency tools.
- Total Emissions Analytics (TEAL) uses an adaptive-branch model to collect data. Enterprises can enter actual data from their utility bills or make estimates on the basis of what they do know.
- Once users enter inventory data for a location, TEAL displays the corresponding site on a single map depicting net carbon emissions across sites using a geographic information system.

A larger group of buildings equipped with smart meters and EMCSs, say, in a metropolitan area, can form a smart grid, with green analytics as its backbone. The vision is to have a smart grid deliver electricity from suppliers to consumers using digital technology to save energy, reduce cost, and increase reliability. "Toward Net-Zero Energy Installations" on p. 42 describes the smart grid vision in more detail.

The federal government is already promoting such a network as a way to address energy independence and global warming issues. According to a recent study,[1] developers and manufacturers of products to support the smart grid constitute one of the fastest growing sectors in the green technology market. The Department of Energy lists nearly 300 tools in its software directory—all of which are readily available for building owners and operators to improve operations and reduce energy use.

Green analytical tools are being used in a variety of ways, but all applications aim to reduce the enterprise's environmental impact and costs. The most common environmental benefit is reduced energy use and thereby fewer GHG emissions. Reduced environmental impact means that the enterprise uses fewer natural resources, such as fossil fuels, which in turn means less exploration, extraction, and transmission of that fuel, and less invasive impact on the environment.

Using those tools effectively will become increasingly important, which is why any enterprise that aims to benefit from smart grid technology and maximize efficiency opportunities will need a systematic approach to tool use that considers the data to populate the tool, monitoring and decision support, and quantifying and reporting methods. To support the latter task, Noblis has developed an analytical tool to quantify and report GHG and energy use. Total Emissions Analytics, or TEAL, is a web-based, software-as-a-service application that provides a methodology for calculating emissions and energy use at the enterprise level. TEAL supports a range of activities—from collecting, organizing, and forecasting data to building a GHG inventory to calculating return on investment. A geographic information system (GIS) enables carbon-profile mapping, which helps an enterprise visualize emissions across its sites. TEAL follows accepted guidance for quantifying and reporting GHG emissions and removal, enabling enterprises to generate energy and GHG reports that are suitable for documenting progress toward federal goals, such as those in Executive Order 13423.

Data collection

To populate a green analytical tool, such as TEAL, enterprises collect data from a variety of inputs and use other data to put their findings in perspective.

Common data categories

To understand how their operations relate to energy consumption, enterprises typically collect data in three categories. *Facility and operations* data consists of the building and space dimensions, construction materials, people, lighting, and equipment, as well as a simplified description of building geometry and construction characteristics.

Energy use data is the information about electricity purchased to power cooling and heating plants and air-handling and heat-delivery systems, as well as sources of direct fuel combustion such as diesel or coal fired boilers to produce steam, backup generators, or fleet vehicles.

Water use data covers areas such as cooling, kitchen and bath, and exterior and landscaping, as well as initial, annual, cyclical, replacement, and operating costs. Some tools aim to optimize a specific element of building operations, such as data centers, that require additional data input or connectivity to a smart meter to get more frequent and more refined data input.

Data can be collected for a single building or across an enterprise and then analyzed for trends and performance indicators. Many of the GHG protocols categorize emissions data into the three scopes in Table 1—direct, indirect, and other indirect—each of which has categories. For the typical modern, metropolitan office building or professional services enterprise, purchased electricity is one of the largest energy-use categories. It is also one of the ripest categories for applying sophisticated efficiency tools.

Data entry and analysis

Use data can be entered into green analytics tools manually through a web-based application, by a direct feed from utility companies, or by pulling metered interval data directly from advanced meters or smart meters installed in the building. If data is not available, an enterprise can elect to have most input values default to user-entered preferences, or personnel can quickly enter them on the basis of either proposed values or performance measurements from site audits. Typically, tools that can provide data include component libraries and validation checks for quality assurance. Other tools can provide extensive context-sensitive guidance for all input categories to assist the user and ease the burden of data entry. In addition, built-in logic checks help users catch inconsistent data entries.

Table 1. Emissions categories within the three scopes specified in GHG protocols.

Emissions Scope	Emissions Category	Typical Sources
Scope 1: Direct	Stationary	Emergency generators, natural gas heating in buildings
	Mobile	Fleet vehicles
	Fugitive	Refrigerants, dielectric fluids
Scope 2: Indirect	Purchased electricity	Electricity used in buildings and other facilities
Scope 3: Other indirect	Employee commuting	Emissions from employee travel
	Business travel	

To understand the significance of the data being reported and aid in forecasting consumption trends, enterprises should collect weather data—daily temperature observations that reflect the energy necessary to heat or cool a business. There is a defacto standard for heating and cooling: an outside temperature of 65 degrees means that no heating or cooling would be needed inside a building. The difference between 65 degrees and the mean outside temperature is a *degree day*. The mean temperature—the midpoint between the high and low temperature of that day—is a reliable indicator of the day's conditions. The degree-day system has been used for decades and is considered a reliable measure for heating and cooling needs and for understanding differences in temperature and energy use.

Cost data—the price paid per unit of energy—also provides insights into the return on investment of various energy-reduction efforts. An enterprise should consider both mortgage data and the cost of fuel and energy-conservation measures.

Monitoring and decision support

Green analytical tools support decisions about resource use by examining an individual building's energy and water use, GHG emissions, and expense data. Such tools enable a comparison and benchmarking of operating efficiency against other buildings in a similar class. By comparing buildings and aggregating data across all facilities, an enterprise can spot trends and savings opportunities and identify facilities and operations that fall outside the normal use and cost range.

Because data centers consume more electricity than any other part of the building, an enterprise must know what percentage of electricity use comes directly from the data center building or portion of the building housing the data center so that decision makers can directly address a data center's unique needs. "Green Data Center Management" on p. 26 describes some energy-saving strategies.

Quantifying and reporting

The reports generated from green analytical tools enable decision makers to compare the cost of different energy types normalized to British thermal units and to track energy use and cost against weather trends. Current tools also produce real-time reports that may be viewed on screen, stored, or printed. Visualization is used to a large extent to show energy use, benchmarking, and forecasting. Graphs generated from dynamic forecasts can compare selected alternatives and hourly variables.

Typical reports

- model energy use over time and peak demand,
- establish cost projections,
- identify savings opportunities, and
- provide emissions impacts.

Green analytics in action

To give a flavor of green analytical tool capabilities and application, we offer examples from TEAL, which is based on the World Resources Institute's corporate accounting and reporting standard and the International Standards Organization's (ISO) 14064-1 *Greenhouse Gases—Part 1: Specification.*

Table 2 lists TEAL's architectural components.

Data collection and entry

TEAL uses an adaptive-branch model to collect data, which allows enterprises to enter actual data from their utility bills or make estimations on the basis of information known. Decision makers can create multiple scenarios and increase the level of information fidelity as refinements are made to their enterprise. Figure 1 shows how the model accommodates both the known and unknown.

TEAL collects data on purchased electricity; direct fuel consumption, such as diesel or gasoline; business travel; commuting; water; and emissions offsets.

Table 2. Architectural components of TEAL.

Component	Key Elements
Application	▪ Apache web server, ▪ PHP scripting language to allow dynamic web pages, and ▪ Javascript and XML to validate, parse, and display data.
Database	▪ PostgreSQL relational database management system to store and manage data.
Geographical information system (GIS)	▪ OpenLayers application programming interface using the Mapnik toolkit for map development, ▪ TileCache for pluggable caching and rendering, and ▪ PostGIS to spatially enable the PostgreSQL database.

Users enter the information into web forms such as that in Figure 2 using the format that TEAL used during data collection: monthly values for known quantities, such as utility bill data, and averages and estimates for unknown values. In addition to energy use, users enter energy cost information for each site. TEAL tabulates and displays emissions by category as users enter data into the system.

To increase information fidelity, enterprises needs to collect data on employees' energy habits, such as commuting distance and model and year of car driven. To fill this function, TEAL allows those managing the enterprise's energy-reduction efforts to launch web surveys and manage them through the TEAL interface at either a site or for the entire enterprise. Figure 3 shows sample results from a telecommuting survey. Final survey results can be imported into an enterprise's GHG inventory. With results in hand, decision makers can easily analyze cause and effect relationships of different commuting scenarios, such as peak and off-peak travel time, and corporate policies related to workspace lighting and computing.

Carbon profile mapping

TEAL automatically geocodes sites as users enter the addresses into the web application. Once users enter inventory data for a location, TEAL displays the corresponding site on a single map

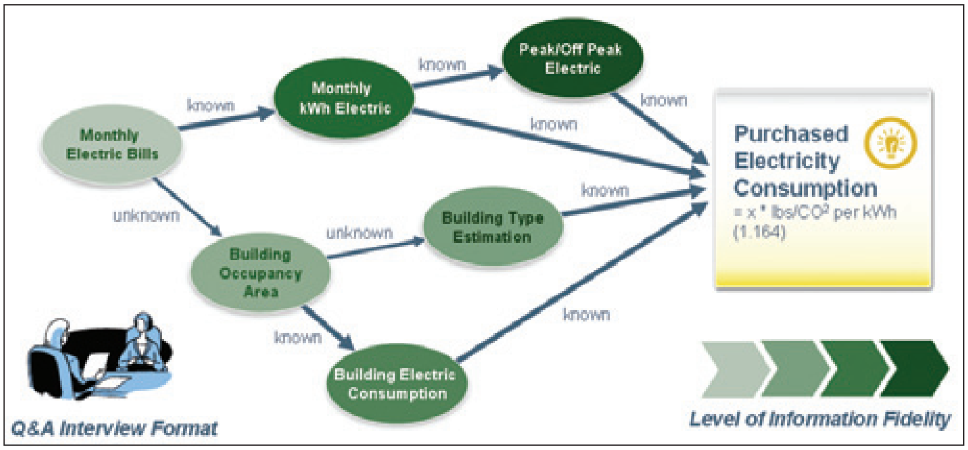

Figure 1. Adaptive branch model in TEAL. The model attempts to collect the most accurate information first, such as electric bill data. If utility bills are unavailable, the model proceeds to an estimation method based on building occupancy area. As refinements occur, the level of information fidelity increases.

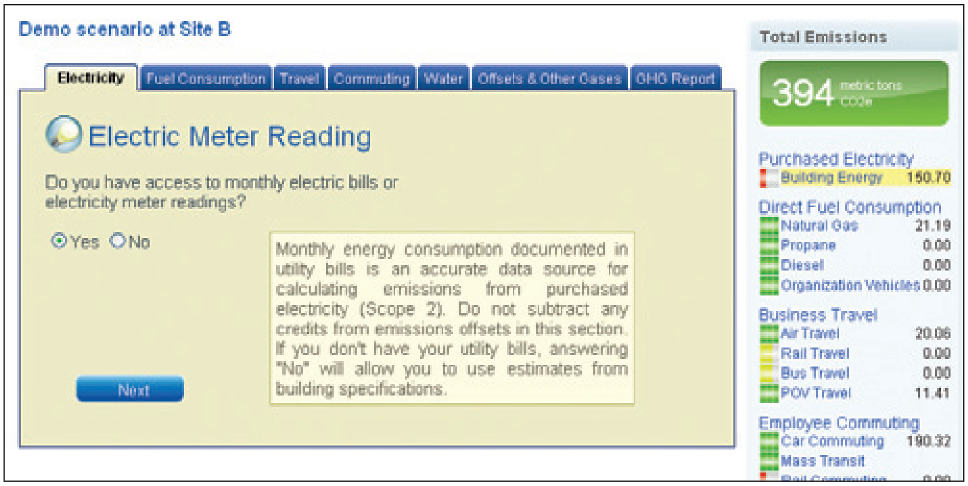

Figure 2. TEAL data input form. Through an interview format, users answer questions aimed at obtaining monthly values for known quantities, in this case electricity consumption. Similar questions elicit information on sources of greenhouse gas emissions in other categories, such as fuel consumption and fugitive emissions. Each category comes with instructions (text box) and context-sensitive guidance. TEAL also tabulates emissions (right) as the user completes questions in each category.

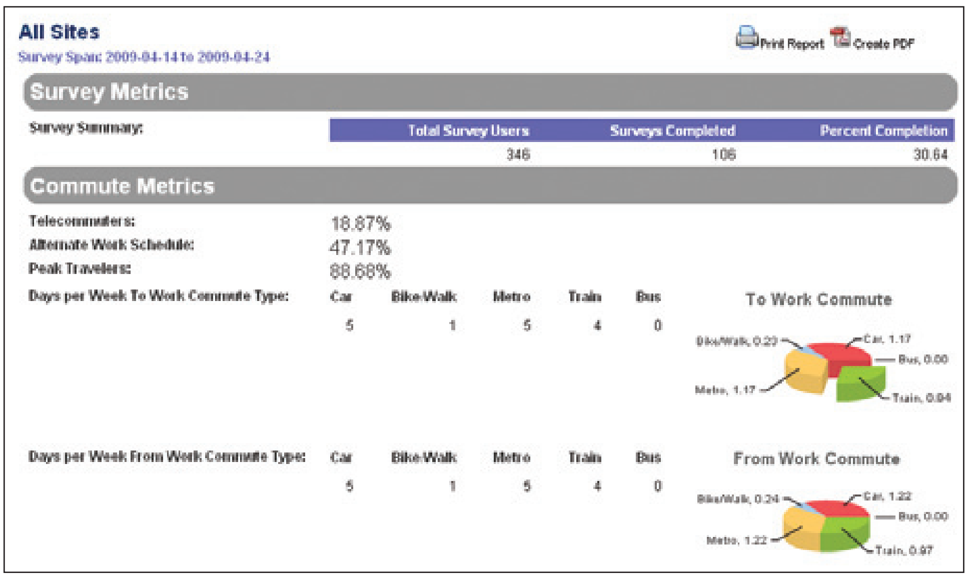

Figure 3. Viewing survey results in TEAL. Decision makers can launch and manage surveys, such as the employee survey depicted here. Metrics include percentage of survey participants, and displays are both tabular and graphic. In this subsection of the survey report, TEAL shows statistics for commuting methods and number of days for each method, separating peak-hour commuters, commuters on an alternate work schedule, commuters using mass transportation, and telecommuters. Surveys on workspace behavior, such as lighting and computing use, are also possible.

Figure 4. Geographic view of carbon profiling in TEAL. Enterprises are able to see each facility's carbon profile as well as that of nearby facilities. In this view, the user has hovered over Site B, viewing the related emissions data and site profile for that location (upper right). Sites are color-coded according to the amount of emissions produced at the site relative to other locations, so the view clearly shows that Site A's emissions are lower than Site B's. Planned enhancements will make it possible to see a building's LEED certification status as well.

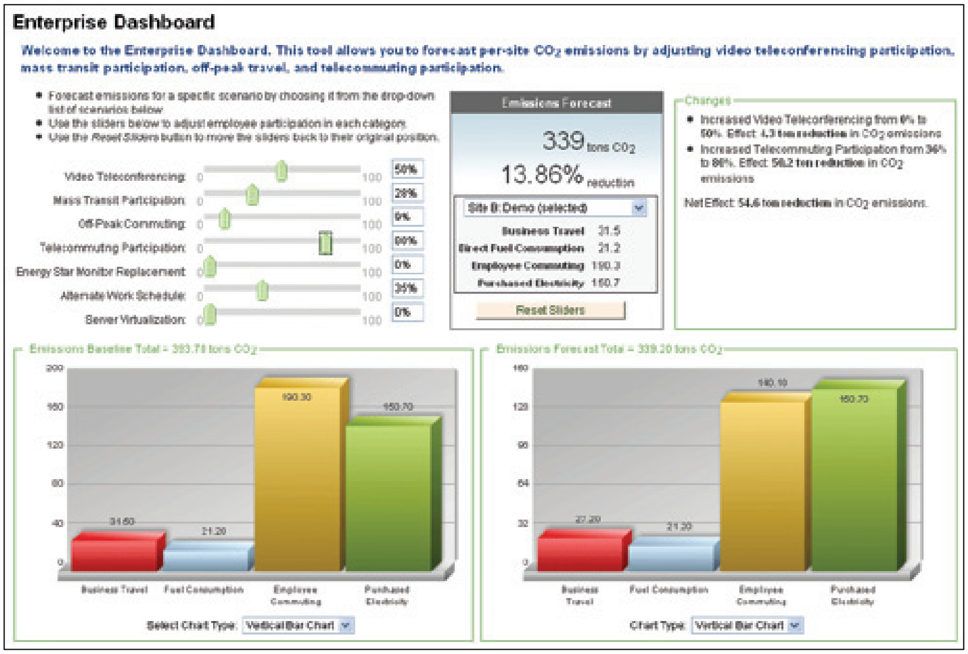

Figure 5. TEAL Enterprise Dashboard. Using sliders to change values (upper left), users can instantly see the effects on carbon dioxide (CO_2) emissions of changing any one parameter, in this case, percentage of telecommuting, alternate work schedules, business travel, server virtualization, and Energy Star equipment upgrades. In this view, the user is exploring two scenarios. The first (left) is an increase in video teleconferencing from 0 to 50 percent, which replaces air travel for mid-length flights. The result (upper right) is a 4.3-ton reduction in CO_2 emissions. The second scenario is an increase in telecommuting from 36 to 80 percent, resulting in a 50.2-ton reduction. The emissions forecast (center) is a 13.86 percent reduction in CO_2 emissions.

Figure 6. Report generation in TEAL. An annual energy consumption report is one of many reports that TEAL can generate. Decision makers can see multiple views of energy use and associated costs, including electricity, gasoline, diesel, propane, natural gas, and water. Here, the user sees annual energy costs by category along with the distribution of water consumption for kitchen and bath, cooling, and outdoor use, such as landscaping.

depicting net carbon emissions across sites using a GIS. Figure 4 shows a sample carbon profile map. An organization with several sites can see the location of the larger polluters at a glance, essentially identifying which facilities might need additional work on energy efficiency and emissions reduction.

Noblis plans to enhance the GIS carbon profiling feature by having it also display a building's Leadership in Energy and Environmental Design (LEED) certification and if the building is leased or owned.

Visualizing key metrics

Being able to see metrics at a glance and in real time allows business owners to view the effects of changing corporate practices or standards such as telecommuting, core work hours, and lighting. TEAL's Enterprise Dashboard incorporates several slider controls, allowing decision makers to forecast energy use and emissions that result from modified policies or practices, viewing the baseline energy use and emissions against the forecast. For example, decision makers can see instantly the effect on GHG emission reduction by increasing telecommuting participation 10, 20, or 30 percent over the baseline. Figure 5 shows the Enterprise Dashboard interface.

Calculating return on investment

TEAL provides a return on investment (ROI) calculator to help users quickly calculate annual and 10-year savings, ROI, and payback for green investments in interior and exterior lighting, solar power, and computing equipment. The calculator lets deci-

Modernizing Energy Management & Control

Energy management and control system (EMCS) technology has evolved over the past three decades from pneumatic and mechanical devices to direct digital controls or computer-based controllers and systems. Today's EMCSs consist of electronic devices with microprocessors that make liberal use of powerful, low-cost microprocessors and standard cabling communication protocols.

An EMCS can also have a global supervisory controller to perform high-level tasks, such as adjusting temperature set points according to building conditions at that time and scheduling on/off times.[1] The use of sophisticated software enables office and building systems to intercommunicate and allows disparate networks building-wide to interconnect. Effective energy-efficient building design can include the use of low cost passive infrared sensors to switch-off lighting when areas, such as lavatories, corridors, and conference rooms are unoccupied.

An EMCS can also be used to monitor lighting using daylight sensors linked to the building's lighting scheme to switch on/off or dim the lighting to predefined levels to take into account the natural light and thus reduce consumption.

By linking all these functions in one centralized computer, an EMCS can control an entire building's power requirements. Although these systems are fairly mature, their enhancements are being refocused from proper operation to optimizing energy efficiency.

They will be the building blocks of the smart grid that will eventually control and manage many EMCSs across an entire city.

References

1. D. Hatley et al., *Energy Management and Control System: Desired Capabilities and Functionality*, Pacific Northwest Laboratories, Apr. 2005.

sion makers see, for example, that a compact fluorescent light bulb with an Energy Star qualification will save approximately $30 over its lifetime and pay for itself in about six months because it uses 75 percent less energy and lasts about 10 times longer than an incandescent bulb.[2]

Implemented at the enterprise level, this type of low-cost green investment can provide significant savings. Replacing 2,000 40W fluorescent bulbs with 25W compact fluorescent bulbs, for example, yields an annual savings of $11,232.78.

Generating reports

Reports are essential to inform decisions at both the enterprise and facility levels. TEAL provides several kinds of reports, including

- annual GHG report compliant with the *GHG Protocol* and ISO 14064-1,
- annual energy consumption,
- annual energy costs,
- year-to-year comparisons of emissions,
- employee commuting and energy behavior patterns, and
- benchmarking.

Figure 6 displays a report generated after data collection.

Without green analytics to provide benchmarking, forecasting, data manipulation, and reporting and graphing, the potential of energy efficiency measures and emerging green technologies, such as smart meters, will not be fully realized. Green analytics provides the tools to enable decision making within the enterprise. The capability to see when and where energy is consumed allows facility managers and policymakers alike to better manage equipment, energy load, and the effect of energy-related improvements.

Noblis is currently researching the feasibility of having TEAL report energy use in near real time through an advanced metering infrastructure that will allow direct data feeds on energy consumption. The focus is on industry-standard communication protocols for advanced metering infrastructure, smart grid hardware, and optimizing reproducibility. The goal is to implement a power management module that will provide decision makers with automatic daily loads of energy-consumption data, automatic carbon calculation, detailed energy consumption reporting and variance analysis, and quicker ROI results for implementing energy-saving measures.

Our aim—and the aim of all green analytical tools—is to get the right information to the individuals best equipped to make lasting change. Although these changes might seem small, collectively they can make significant progress toward renewing the world's environmental health. For the enterprise itself, the changes can be profitable both in cost savings and more efficient operations. ■

References

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Robert S. Wassmann is the author of "The Climate Is Right for Green." His photo and biography are on p. 19.

Mile K. Corrigan is guest editor of this Sigma *edition. Her photo and biography are on p. 9.*

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