

Arch Rock Energy Optimizer™ in Action

Commercial Building



Business Perspective

Corporate sustainability policies associated with national and regional regulations and mandates are accelerating the adoption of green building practices in commercial, industrial or institutional contexts. However, the implementation of these energy saving principles and practices has been hampered by a lack of fine-grained information that allows facility managers to efficiently manage their energy bills without impacting the productivity or necessitating prohibitive and invasive installation steps. The critical factors influencing the cost of energy consumption are captured by utility billing mechanisms that include incentives and rebates, on the one hand, and penalties and prohibitive rates, on the other. Today, Facilities and IT managers are keen to continuously benchmark, calibrate and visualize the energy consumption and environmental behavior of their buildings, if given a chance to do so while not jeopardizing the existing stability of their facilities and while not incurring invasive and costly instrumentation steps as would be the case with wired and AC-power dependent devices.

Facilities or IT managers responsible for sustainability and Green policies can quickly evaluate the business benefits they can generate from an energy efficiency program, by using Arch Rock's Energy Optimizer (AREO) solution. They can quickly and easily deploy the Arch Rock IP-based wireless sensing and sub-metering solution that provides fine-grained visibility and continuous energy monitoring through an energy visibility portal. The knowledge obtained from AREO will let them take appropriate action toward improved energy efficiency and reductions from past baselines, to achieve:

- Financial savings - the powerful motivator for reducing energy-related expenses – or at least keeping them from growing at the rate of business or activity growth.
- Capacity planning – Optimized usage of “Demand Response” programs, off-peak rates and Time-Of-Use pricing, as well as extension of the useful life of an energy-intensive facility like a Data Center where maximum available power may be capped.
- Regulatory mandates – national or regional, they require demonstrating reduced energy usage levels from a past baseline to a target future time, often with continuous year-over-year

improvement requirements, necessitating permanent sub-metering instrumentation and analysis.

- Sustainability policies – enhancing the company image with the local community, the customer constituency, the investor base and the employees alike.

Deploying the AREO Solution

Once the business justification of an Arch Rock Energy Optimizer adoption is established, the next step is to understand the environment in which AREO is deployed. As an example, let's examine a typical AREO set-up in a San Francisco commercial office occupying a four-floor building (see Figure 1). An initial phase will most likely involve a consultative dialogue between the project team and Arch Rock personnel or an Arch Rock authorized partner, to establish the goodness of fit and the benefits of the AREO solution towards the desired business goals (savings, compliance, facility life extension, readiness for Demand/Response programs, etc.).

Next, a detailed design and planning phase involving the project team and Arch Rock includes a survey of the facility, of the major energy load consumption points, and of the electrical diagrams and floor plans of the facility. This process generates a list of sensing points and associated locations where power and energy measurements will take place, along with the electrical characteristics of each such sub-circuit (voltage levels, phase count, maximum current levels), as well as a list of sensing points where environmental monitoring will be performed to report on the ambient conditions resulting from the energy management efforts. A second by-product of this phase is a wireless network design that will lead to reliable and scalable operation of the meshed wireless network made of the IP-based wireless sensing points. A proper and methodical process for such an assessment allows a quick and painless instrumentation of the building, as wireless sensing nodes, infrastructure devices, and applications can now be set-up.

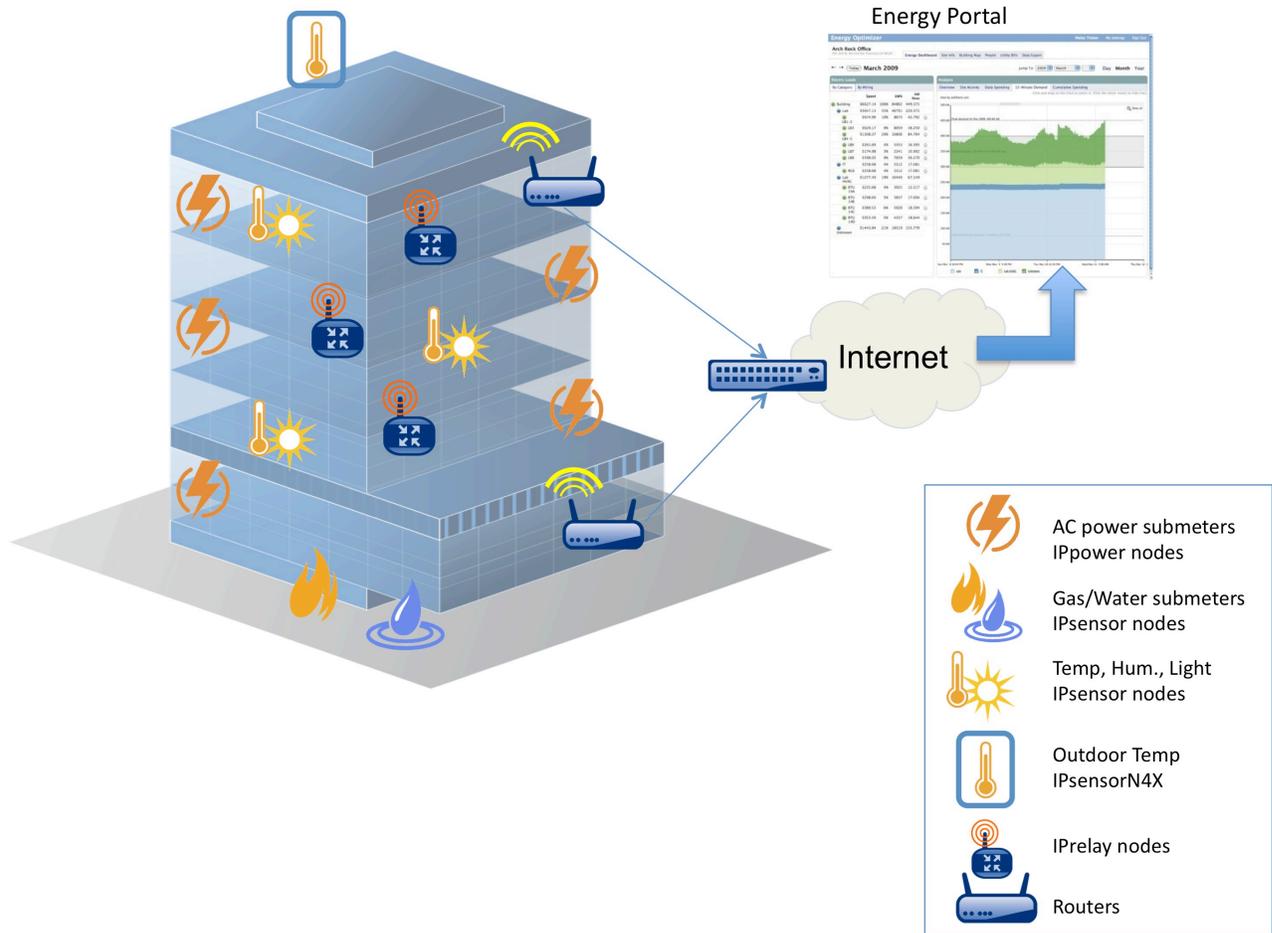


Figure 1 AREO in action -- Commercial office building

Sensing Nodes

Arch Rock wireless sensing nodes enable the real-time monitoring of electricity, gas and water usage as well as ambient indoor or outdoor conditions such as temperature, humidity and light. Their deployment in this sample configuration consists of:

- IPpower Nodes with properly sized current transformers and voltage taps get installed at the desired measurement points down the electrical distribution tree, and typically located around each floor's electricity panels, yielding real-time visibility into the energy consumption of the major electrical loads throughout the building, such as heating and cooling equipment loads, air quality management equipment loads, the wiring closet and computer-related equipment racks, indoor or outdoor lights, and power plugs.
- IPsensor Nodes, with their embedded ability to convert external metering device pulse outputs into meaningful flow rates, get connected to the pulse output of the water meters for real-time water consumption monitoring.
- IPsensor Nodes with their integrated temperature, humidity and light sensors are positioned throughout each floor wherever visibility is desired in meeting rooms, open work areas or

wiring closets and labs, thanks to the tremendous flexibility afforded by the “no wires” operations of these battery-powered and wireless-meshed sensing nodes.

- An outdoor IPsensor Node is placed on the roof for external temperature and humidity information, thanks to the battery-operated and wireless deployment flexibility benefits, and yielding precious context to the heating, cooling and air ventilation related energy loads being spent within the building.

Infrastructure Devices

An AREO solution relies on Arch Rock’s proven PhyNet infrastructure of standards IP-based and web services-based elements that provide reliable wireless mesh networks, data backhaul, collection, management and export, turning the sum of individual data points generated by the deployed Sensing Nodes into valuable time series of information that can be exploited by application layer software for visualization and analysis. These infrastructure elements include:

- IPrelay Node – In most in-building deployment cases, the AREO Sensing Nodes such as IPpower Nodes and IPsensor Nodes get spatially laid out such that they form a connected and redundant wireless mesh by relying on each other’s ability to act as relay nodes in the mesh, to forward each other’s sensing information up to the destination of the data (e.g., server performing the data collection and analysis), in addition to being sensing nodes for their local power consumption or temperature or humidity levels. However, when inter-node distances between Sensing Nodes exceed the radio range or when obstructions cause radio signal degradation, as may be the case when two Sensing Nodes are several floors apart or separated by obstructing metallic structures within a building, then dedicated IPrelay Nodes can be added to aid the connectivity between sparse patches in the wireless mesh network of Sensing Nodes, or simply to augment the robustness and resiliency of the mesh network by offering alternative wireless paths for contingency scenarios. In this example, we may well be deploying one or two IPrelay Nodes per floor in the four-floor building, thus strengthening the connectivity between the IPpower Nodes deployed near electrical panels, the IPsensor Nodes deployed throughout the floor, and upper and lower floors in the building.
- PhyNet Router – links the 6LoWPAN/IEEE802.15.4 wireless mesh network to the building Intranet or the Internet. In our example, two PhyNet Routers are connected to a dedicated Ethernet LAN (or VLAN) configured on the building’s LAN switches. They may be located in the wiring closets of the bottom and top floor, for instance, allowing load sharing and redundancy in the connectivity between the building-wide sensing points and the data collection and analysis server.
- PhyNet Server – collects data from all the sensing nodes throughout the facility, stores and stages the data for visualization and analysis applications such as the energy portal, in order to deliver valuable energy-saving insights, and enables flexible export of the data in a wide range of formats such as CSV (used in Excel-style spreadsheets) or SQL (used in most relational database management systems) or XML and HTML (used by most modern-day web services-based enterprise applications). Additionally, the PhyNet Server helps perform the entire lifecycle management functions for the wireless infrastructure, giving the user constant visibility into the performance of the wireless sensor network. The PhyNet Server may be deployed as an appliance on the premises, simply as a standard server on the network, or else

it may be hosted by Arch Rock and remotely accessible by the user through a secure web mechanism.

Applications on Energy Portal

Once all sensing and infrastructure equipment is in place and configured, the user can focus on configuring the AREO energy portal to suit the energy manageability goals and business goals being served by the AREO solution. Thus, the user can configure IPpower Node-based energy measurement points with meaningful names such as “HVAC Module 1” or “Floor-2 Common Area Lighting” or “Computer Rack 5”, following physical wiring hierarchies (e.g., F2.1 for branch 1 on floor 2), as well as functional hierarchies and budget categories (e.g., Lighting, HVAC, Labs, Cafeteria, Manufacturing Floor) or even departmental names (e.g., Engineering Servers, Engineering Offices, Marketing Demo Room).

Equally, the user can configure energy consumption or maximum load goals against which the building performance can be tracked and notices and alerts generated when appropriate. Event logs can also be entered to match events against their energy impact, such as observing the energy-saving effect of changes in the set point on the HVAC thermostat systems by a few degrees, or the effects of new idle power-off strategies for lab equipment or servers or desktops, or of modifications in the lighting system schedules. These planning-oriented capabilities are of tremendous value towards avoiding utility billing penalties such as Demand Charges and Demand Ratchets, and towards being ready to participate in incentive-carrying load-shedding programs such as “Demand/Response”, while realizing the energy savings in ways that are least disruptive to the business and operation of the building. The energy portal is offered in “Software as a Service” form, in which the user accesses the private portal (hosted by Arch Rock) via a secure web access, or as an on-site appliance located on the corporate network. Whatever the selection, the data can be transmitted fully protected using the standard IPsec encryption mechanisms for securing Internet Protocol traffic over private or public networks.

Business Benefits

After deploying the AREO solution and spending a little time getting familiar with the energy portal, it will become a simple task to monitor the building’s energy use on a daily or more frequent basis. As in any change management process, it is important to record the initial baselines and to set control points to evaluate the benefits of specific actions in order to quantify the full benefits made possible by the use of Arch Rock’s Energy Optimizer. In light of the various capabilities previously discussed, one or more of the following benefits can be realized:

- Financial savings – After defining a desired threshold of dollar or energy savings or power peak reductions from the initial baselines of these parameters (either from AREO data or also usually available from past utility bills), it becomes easy to measure progress against goals with AREO. Several studies [FEMP] have shown that of 8%-12% could be expected through awareness of usage and simple actions, such as with the following timely awareness facilitated by the AREO Energy Portal:
 - Facility managers can set and receive alerts on the hourly, daily, weekly and monthly peak demands, ensuring the peak swing stays low.

- Facility managers can receive timely alerts regarding how they're trending towards weekly or monthly goals, while remedial action or more drastic changes can still be put into effect to influence the outcome at the end of the period.
- Financial executives or operations executives can see the real-time correspondence between the instant power use and the dollar impact of that use pattern, with the time-of-use energy pricing structures factored in.
- Employees can visualize the energy consumption data through the office intranet and modify how they act to conserve energy.

Combining energy and corresponding environmental data can provide precious insights enabling reduction actions while maintaining acceptable levels of service in the facility. For example, changes in temperature set points in the HVAC system can lead to significant savings yet the facility manager needs to ensure that the local temperature in the wiring closet does not exceed the temperature that ensures reliable operation of the computing equipment.

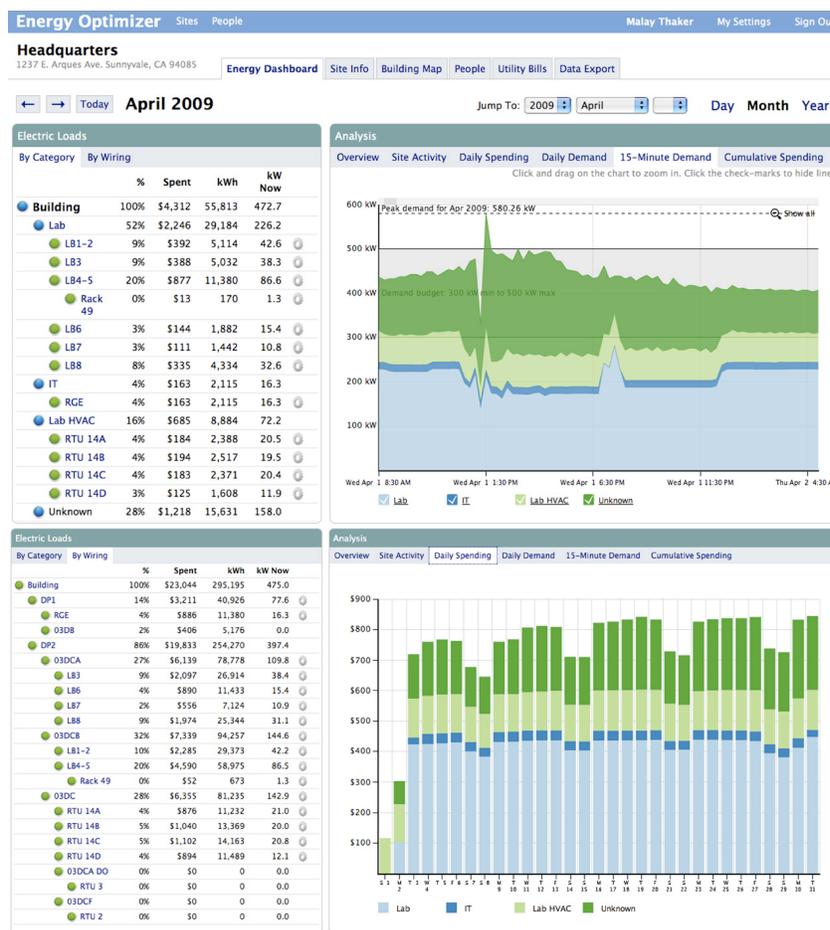


Figure 2 AREO energy consumption display

- Capacity planning – By following the electrical branch circuits and measuring electric consumption and real-time peaks on each sub-branch of interest, circuit-level sub-metering instrumentation disaggregates energy consumption into its constituent "spatial" or

"functional" components, in addition to its "temporal" patterns: a given floor or a wiring closet or even a section of the lab, and how their energy footprint ebbs and flows during the hours of the day or days of the week or the seasons of the year. Once a facilities manager knows where and when power was drawn and energy consumed, and how energy has peaked and ebbed in the facility over the hours and days (and takes into account utility time-of-use tariff structures and demand-response curtailment incentive programs), he or she has a rich picture of the key areas on which focus should be applied in order to achieve direct savings or take advantage of incentives, while maintaining "service levels" for the desired levels of safety, comfort, activity and productivity throughout the facility.

- Regulatory mandates – It is generally agreed that commercial and light industrial buildings are responsible for at least 40% of energy use in most countries [WBCSD]. Through various national mandates (e.g., US EISA 07 and EPAct 05) in the US, Europe, Japan, China and elsewhere – or local and regional mandates (e.g., California AB32), explicit schedules to reduce energy consumption or to increase energy efficiency of the facility's output are defined, often requiring sustained year-over-year efficiency improvements over long periods. Existing as well as new commercial offices have to comply with those regulations. But without real data, it can be difficult to baseline a building, not to mention to track its evolution against the desired efficiency goals over time, in timely manner to anticipate whether goals will be met or not while something can still be done about the outcome. By analyzing the data from AREO, it becomes possible to understand a building's behavior, demonstrate that the mandate is achieved, and with a direct result of increasing the lifetime of your assets or reducing operating expenses, or both.
- Sustainability policies – most if not all enterprises and public administrations have defined sustainability policies or programs. But despite the messages advertised on information panels or company annual reports, it may be difficult to get all employees fully engaged in such programs. By showing real-time data from the energy portal – for example on the company Intranet welcome page or on Digital Media Systems located throughout building lobbies or offices, an AREO deployment can greatly help in the development of a "community spirit". As a result of seeing real life data and the gratifying effects from results-driven reinforcements and feedback, people often find it easier to change their behavior and keep raising the self-driven efficiency bar, especially when it is visible that others around them do the same.

Conclusion

In this paper, we have discussed the various drivers and benefits associated with reduction in energy use and increase in energy efficiency or commercial buildings. Achieving these benefits starts first with the ability to deploy instrumentation that generates detailed visibility into the patterns of energy consumption and the associated ambient and environmental conditions. AREO's ultra low power wireless network PhyNet technology embedded in its suite of energy and environmental sensors presents facility managers with the first true option of achieving detailed visibility without the daunting costs and effects of previous wiring-based highly invasive instrumentation systems. What "wasn't worth it" due to the high costs and disruptions of wiring dozens of sensing points is now "worth it", with the ease of deployment and placement of sensors and energy sub-meters.

Next, the visualization, analysis, goal setting, and tracking capabilities of the AREO energy portal turn the raw sensor data points into actionable information, enabling the extraction of new insights, patterns and associations in order to save energy.

Last but not least, users can often apprehend their energy data in more ways than any one vendor-provided analysis tool can provide. It is therefore critical that the instrumentation system be built with end-to-end open standards at the network layers and application and data access layers. With its standards-based open IP networking throughout, and its open and flexible data export mechanisms, AREO allows users to benefit from its analytical capabilities while also allowing them to put their energy “in broader context” by applying their preferred IT analysis tools (spreadsheets, databases, decision support systems, data mining tools, statistical and forecasting tools) not only to the data generated by AREO but also to combined data sets where AREO-generated data can be “mashed up with” and correlated against relevant enterprise data such as factory activity levels or human occupancy or trading activity or outside weather data, to name a few, thus maximizing the value that is latent in the facility and energy data by enriching it with business-specific context.

Product List

- IPpower node – power sub-metering
- IPsensor node – indoor temperature, humidity and light, water sub-metering
- N4X IPsensor node – outdoor temperature and humidity
- IPrelay node – IP Wireless Sensor Network infrastructure
- PhyNet router – IP Wireless Sensor Network infrastructure
- PhyNet server – Data export and IP-WSN management
- Arch Rock Energy Optimizer Portal or Appliance – Energy data monitoring

For more information

To find out more about Arch Rock Energy Optimizer, please visit: <http://www.archrock.com>

References

- [FEMP] U.S. Department of Energy's Federal Energy Management Program's (FEMP) – [Metering Best Practices guide](#)
- [WBCSD] World Business Council for Sustainable Development (WBCSD) Energy Efficiency in Buildings - [Summary report](#)