Wireless Sensors and Energy Efficiency at Alcoa

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***Abstract*—Inexpensive wireless sensors developed under a DOE Building Technology Program (BTP) project have proven to be robust enough for harsher environmental and RF interference-laden locations found in industrial settings. Coupling with Alcoa-ORNL activities pertaining to optimization of energy utilization at Alcoa facilities these sensors, and an associated ORNL-architected instrumentation network fabric, were selected for deployment at an Alcoa facility in Warrick Indiana – on the banks of the Ohio River. The Warrick facility was chosen as the demonstration site principally for the fact that a 750MW power plant, a rolling mill and a smelter system are all coresident at this location. This paper presents a description of that deployment at Alcoa's Warrick IN facility as well as Alcoa's vision for implementing inexpensive, standards-based wireless devices for reducing energy consumption.**

Keywords-sensors; instrumentation; wireless; energy efficiency

I. INTRODUCTION

Inexpensive wireless sensors focused on building management systems integration were designed and developed under a DOE Building Technology Program (BTP) project. The devices leveraged technology that was developed under prior DOE Industrial Technology Program (ITP) projects to deliver wireless sensors that provide robust operation in harsh ambient (physical, RF) environments at a price that is approximately an order of magnitude less than current commercial offerings. A network fabric was architected whereby the wireless sensors may operate in resilient clusters with connectivity provided by a backhaul network leading to systems that are highly extensible and quick to deploy in a variety of commercial building and industrial settings.

A demonstration of the BTP-funded sensor project at Oak Ridge National Laboratory (ORNL) to a variety of interested parties showed the ease of deployment and operation in indoor and outdoor settings (concentraing on energy efficiency requirements of the BTP project).

In mid-April 2011 an ORNL/ITP sponsored Global Energy Summit meeting was held at ORNL. Attendees to the Summit were informed of the BTP-sponsored robust inexpensive wireless sensor developments. Alcoa approached ORNL and ITP indicating that they had a variety of energy assessment needs in their ongoing efforts for facility operation optimization. Central to their efforts was the corporate high priority need for finding an inexpensive "solution" for their "lost energy – lost profits" measurement needs throughout their fleet of plants. Coupling ORNL's ITP-sponsored energy audit expertise and the BTP-funded inexpensive wireless sensor devices, Alcoa and ORNL embarked on a fast-tracked network design and proof-of-concept deployment project whereby the aforementioned wireless sensors and robust backhaul architecture would be deployed at an Alcoa facility.

The Alcoa facility in Warrick Indiana – on the banks of the Ohio River – was chosen as the demonstration site principally for the fact that a 750MW power plant, a rolling mill and a smelter system are all coresident at this location. The network design and deployment of "The Suitcase[1]" occurred in mid-June (5 weeks after the project began). Alcoa personnel determined the locations of the wireless gear with the single request from ORNL of "choose your harshest environments, choose the locations where the commercial devices you've mentioned failed for we wish to show you that a truly inexpensive, robust, secure suite of wireless sensors have been developed and meet your needs".

"These inexpensive DOE+ORNL sensors were up and operational within 30 minutes. We were taking energy related measurements on the other side of the plant in an electrical substation, then relaying the readings across the plant within an hour. This demonstration shows that wireless sensors for energy measurements can be inexpensive, quick to deploy and work in tough environments.", Ray Chatfield, Alcoa.

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[1] "The Suitcase" was the name coined to describe the readily deployable – and easy to redeploy – wireless sensor systems.

Figure 1. The 791-megawatt Warrick Power Plant, with state-of-the-art wet flue gas desulphurization, provides power to the entire facility.

II. EASE OF USE

The Alcoa Global Energy Summit meeting (held at ORNL, 28-30MAR11) highlighted the need for a suite of easy-to-deploy low cost devices and systems to assist Alcoa (and similar organizations) in their quest for increases in energy and productivity efficiency. These devices would be 'nominally temporary' devices used for data collection, not process control. They would substantially replace the need to take manual field readings. Subsequent discussions between ORNL and Alcoa have focused on how the private sector's offerings of wired and wireless sensors that could possibly be used to meet the aforementioned needs are fragmented and difficult to deploy. ORNL's leadership position in wireless sensors, international standards organizations, technical and practical efforts with an array of private, public and academic organizations – when coupled with the expertise in the development of trustworthy wireless systems – allows for us to serve as a Honest Technology Broker (HTB) for devices and systems that will meet Alcoa's requirements.

Oak Ridge National Laboratory (ORNL) in collaboration with Alcoa designed a "suitcase of wireless sensors and backbone devices" that are applicable for easy deployment at Alcoa various facilities. The wireless sensors measure energy usage parameters as well as providing information pertaining to (machine) asset health. The primary components use COTS equipment providing an accurate representation of current state-of-the-art wireless devices. ORNL augmented this suite with low-cost wireless devices designed and built at ORNL. The final piece in the delivery "suitcase" is a software application that presents a modest visualization of the measured parameters (plus providing a level of alarm and information integration with other HMI software). ORNL also provided Alcoa with technical guidance in the deployment of "The Suitcase" components at two different segments of their organization (a processing and a production facility).

The project goals were to design and recommend a demonstration package that will allow Alcoa to understand the capabilities or limitations of each type of wireless sensor components and systems listed above. Some examples are:

- Device environment limitations: Magnetic fields, temperature extremes, dusty dirty abrasive, corrosive, etc.
- Life Cycle information: cost to purchase, install, operate and maintain; expected life of devices
- Do devices meet existing industry standards
- Accuracy of data acquired (based on components selected). In general we would have a range of acceptable accuracy based on our intended application

Once identified, Alcoa coordinated a proof-of-concept deployment at the Alcoa Warrick Operations in Evansville, Indiana. [It is envisioned that "The Suitcase" will be replicated and deployed at additional facilities. Discussions with Alcoa include the following possible locations: Alcoa Tennssee Operation (Alcoa, TN), Alcoa facilities in California/New York/Wisconsin/Louisiana, Alcoa World Alumina (Western Australia), Alcoa La Coruña (Spain).]

Figure 2. Warrick Operations is one of the world's largest integrated aluminum complexes. It includes power generation, aluminum smelting, casting, rolling and finsihing for customers who serve the food and beverage industry. The facility's flat-rolled aluminum is also used by customers in the lithographic printing industry.

Alcoa defined Success Criteria as being:

1. provide answers to questions pertaining to various technologies used in wireless,
2. bring "visibility" to their Warrick Operation of as many of the measurement parameters as possible,
3. demonstration of the portability of "The Suitcase" by taking measurements at one area of the Warrick Operation, then remove the devices and redeploy them at another location within the Warrick Operation.

Figure 3. An employee at Warrick Operations prepares a coil of aluminum for shipment to one of Alcoa's customers.

III. ALCOA AND BTUS

Alcoa clearly stated that they are losing millions of BTUs – millions of dollars – per quarter in accounted for energy uses/losses <u>just in the evaporation side of their business.</u> Their need is shown in Figure 4. Interpretation of Figure 4 is probably warranted: The left hand side shows the change from Quarter to Quarter (last to current) for the facility's accounting for energy expenditures (BTUs and $$). This information is then mapped into the right hand side of the figure where the financial data just for the Alcoa named "evaporation economics" is presented. As Mr. Chatfield stated (paraphrased), "Alcoa attempts to follow and implement the Alcoa and DOE Best Practice Guidelines for various aspects of energy efficiency". They have sensors, both financial and physical, that track where the energy is being used (or in their parlance "consumed"). The right side of Figure 4 shows the difference between their tracking of energy and the financial reality of how much their spending on different processes within their facility fleet.

The losses – or "unaccounted energy expenditures" – need to be addressed to allow Alcoa to optimize their operation.

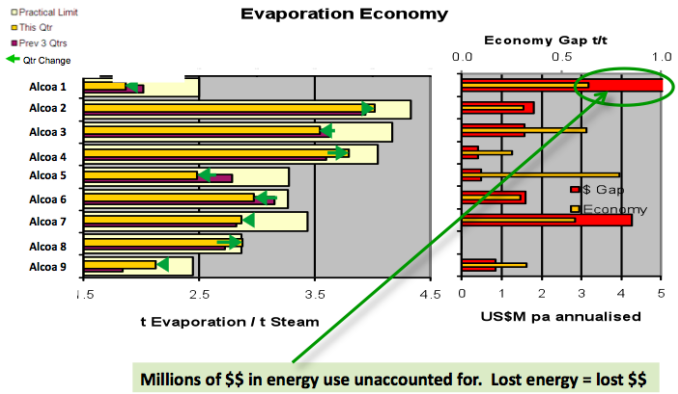

Figure 4. Alcoa energy/financial losses associated simply with their use of evaporators is in the millions of dollars per quarter. Data is presented for a number of Alcoa facilities. The data is for Q4/2010 and Q1/2011 timeframe.

As is suggested from Figure 4, Alcoa is a progressive company utilizing DOE best practice guidelines for enery efficiency. They have determined that they have unaccounted for energy use that they'd like to monitor through a suite of deployed sensors. To that end Alcoa looked at the ITP guidelines for sensors and instrumentation on industrial heat transfer systems.

While the Best Practice guideline recommends using seven (7) measurement instruments per heat trasnfer stage, as reported by Chatfield, typically only 2 to 4 are installed because of the expensive cost of the instrument. Chatfield continued by stating that "Alcoa 3 main liquor circuit as ~ 100 heaters, plus many more outside the main liquor circuit."

<u>The role of the BTP inexpensive wireless sensors for Alcoa's energy efficiency needs:</u>

Alcoa solicited bids from automation companies regarding the cost to install measurement instrumentation for the liquor circuit heaters. As Chatfield relayed to the Alcoa+ORNL meeting attendees, *"Wired conventional instrumentation will cost about $20,000 per point for this installation -> $140,000 per stage -> $14M for Alcoa 3.* With this ORNL inexpensive wireless sensor solution, given our installation costs, we see that the "*Wireless 'health monitoring' instrumentation will cost ~ $100 per point -> $70,000 for Alcoa 3. (not $14M !!)"*.

<u>Epilogue</u>: Post the demonstration project, Alcoa has formed a worldwide team to determine exactly which facilities, and what places inside the facilities, should be monitored using the inexpensive wireless sensors. They are currently stating a Q4/2011 rollout of the deployments.

IV. Summary

Oak Ridge National Laboratory's Extreme Measurement Communication Center (http://trustworthywireless.ornl.gov) was asked to design an integrated sensor-instrumentation network that would provide users with seamless operation and levels of interoperability. The "suitcase" design presented represents a best effort on the part of EMC^2 personnel. Wireless sensors and systems that could possibly meet the functional requirements specifiction (FRS) were compared with EMC^2 weighting the key performance attributes of ease of deployment and use, network extensibility, cost, longevity. The devices deployed at the Alcoa Warrick Operations facility leveraged wireless sensor network devices developed under a Building Technology Program – which were designed to provide inexpensive, robust, scalable sensors for energy management use - with EMC^2 wireless instrumentation network architecture designs.

References

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