Eaton Wireless Sensor Network for
Advanced Energy Management Solutions

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Outline

Eaton Wireless Sensor Network for Advanced Energy Management Solutions

- Objectives
- Project Summary
- Barrier-Pathway Approach
- Project Status
- Future Plan
- Commercialization Plan
- Q&A
The Eaton Wireless Sensor Network team will research, test, develop and deploy a Wireless Sensor Network (WSN) for the purpose of enabling significant energy savings and Advancing Energy Management Solutions in the Industries of the Future (IoF).

The WSN will support open wireless protocols and be self-configuring, robust and secure in industrial environments.
Eaton Wireless Sensor Network
for Advanced Energy Management Solutions (CPS# 14225)

Goal: Enable significant energy savings for Advanced Energy Management Solutions (AEMS) in the Industries of the Future (IoF).

Challenge: Creation of an open architecture, low-cost, robust, self-configuring wireless network that will gather relevant data in the industrial environment for the IoF.

Benefits: The wireless-enabled power management system is broadly applicable to all 8 IoF. Deploying WSN to the electrical distribution and power control system enables quantifiable energy savings. Estimated energy savings greater than 279 trillion Btu/year in 2020 for targeted IoF.

FY05 Activities: This phase will extend the baseline by addressing four issues critical to fielding a robust wireless industrial network: Ultra low-power sensors/Power harvesting, Security, RF transmission in industrial environments, and Power-Aware routing.
Barrier-Pathway Approach

Eaton Wireless Sensor Network for Advanced Energy Management Solutions (CPS# 14225)

**Barriers**
- Cost of networking the equipment using conventional field signal wiring across the Industries of the Future.
- Lack of robust, secure, and cost-effective communication networks to enable collection of critical monitoring and diagnostic information in energy management solutions.
- Lack of well-written standards that promote interoperability.

**Pathways**
- Development of robust, self-configuring wireless sensor networks for advanced energy management solutions.
- Advanced modeling to develop and design energy management systems using distributed data.
- Eaton’s positioning as thought leaders and industry drivers through IEEE802, IEEE1451, WINA and the ZigBee Alliance.

**Critical Metrics**
- 80% cost saving in the deployment of wireless vs. wired sensors.
- 11% to 18% energy reduction in industrial motor energy consumption by 2020.
- Creation/Adoption/Development of Wireless Industrial Communications Standard

<table>
<thead>
<tr>
<th>Benefits (est.)</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Savings</td>
<td>&gt;279 trillion Btu</td>
</tr>
<tr>
<td>Cost Savings</td>
<td>$1300 millions</td>
</tr>
<tr>
<td>Pollutant Reduction</td>
<td>116 Million lbs</td>
</tr>
</tbody>
</table>
**Project Status**

**Phase I**
- Requirements Specification
- Technology Assessment
- Development of Baseline WSN Test-bed

**Phase II**
- Advanced WSN
- Performance Testing
- Validation and Field Testing

**Phase III**
- Commercialization Plan

**Timeline**
- 2004
- 2005
- 2006
- 2007
- 2008
Technology Assessment

**Relevance:** Enable quick assessment to the current state of wireless technologies.

**Approach:** Centralized database of compiled information on wireless technologies, facilitating ongoing assessment of new information as soon as it becomes available.

Task Progress: **First Release Completed**
- Developed and deployed technology assessment process.
- Completed assessment of wireless technologies using the tool.
- Generated summary report for the phase of technology selection.
There are a lot of wireless technologies...
Eaton leads development of standard wireless technologies for the industrial application space.
**User Requirements**

- **Understand and quantify where/how the cost savings occur from a wireless solution**
  - Cost model quantifies opportunities and provides insight into product and network architecture design alternatives
- **Understand customer requirements and constraints**
  - Customer surveys being conducted to gain insight and understanding on how to make the product most useful
  - Determine how to best deploy the wireless approach to compliment existing strategies for condition based monitoring and energy management
- **Understand product requirements to provide a useful solution**
  - Acceptable pricing
  - Optimal network architecture
  - Optimal product form
- **Improve performance and competitiveness of industry**
  - Energy management
  - Productivity

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Early user involvement supports Eaton’s commercialization plan
Baseline Wireless Sensor Network
Baseline Wireless Sensor Network

Eaton’s Wireless Sensor Network Architectural Concept

Motor Control Center

Motor

Driven Load

3 phase AC power
(no control/signal wires)

[Temperature]
[RPM]
[Vibration]

Eaton’s Wireless Sensor Network Architectural Concept
Closing the Loop on Energy Savings

Motor efficiency improvements 4.5%
System efficiency improvements 9.6%

Areas of focus

Eaton’s WSN enables continuous energy savings!
Electric motor driven process in US
- Accounts for 23% of all US electricity sold
- 98% of motors are <200hp
- Consumes 71% of electrical energy used in industrial process plants

Application of mature technology
- Improving motor rewinding practices
- Reducing system load requirements
- Reducing or controlling motor speed
- Matching component size to load
- Upgrading component efficiency
- Improving maintenance
- Properly sizing motors to applications

Focus Area | Energy saved
---|---
Motor efficiency
- Upgrade motors to meet fed std | 2.4%
- Use most efficient motors available | 1.2%
- Improved process to rewire motors | 0.9%
System efficiency and speed control
- Correct for motor oversizing | 1.2%
- Pump systems | 4.9%
- Fan systems | 0.8%
- Compressed Air systems | 2.7%

Most of these areas can be measured by component level monitoring of the motor only.

WSN removes cost barriers enabling application of proven technology realizing 11% to 18% energy savings in industrial process systems.

Eaton’s Energy Savings Approach: Conservative Estimates

- Savings related to electrical energy management only.
- Based on 10% energy savings (vs. DOE est. of 11% to 18%).
- Realized savings based on capitalization schedule.
  - Assume 6 to 10 yr motor life
  - 100% R&R by 2020.
- DOE OIT report based data
  - Fuel Consumption tables per industry segment (SIC).
  - Industry segment growth rates.
- Calculation using DOE/Energetics tool set.

Using conservative DOE-based data yields significant electrical energy savings of 279 Trillion Btu’s year.

<table>
<thead>
<tr>
<th>Industry Segment</th>
<th>Petroleum (trillion Btu's)</th>
<th>Aluminum</th>
<th>Chemical</th>
<th>Forest Products</th>
<th>Glass</th>
<th>Casting</th>
<th>Mining</th>
<th>Steel</th>
<th>Total Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical energy savings</td>
<td>29.8</td>
<td>14.9</td>
<td>78.7</td>
<td>33.5</td>
<td>7.7</td>
<td>4.4</td>
<td>99.0</td>
<td>10.9</td>
<td>279.0</td>
</tr>
<tr>
<td>Pollutant Reduction (million lbs)</td>
<td>12.4</td>
<td>6.2</td>
<td>32.7</td>
<td>14.0</td>
<td>3.2</td>
<td>1.8</td>
<td>41.2</td>
<td>4.5</td>
<td>116.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Assumptions</th>
<th>% of Market Impacted</th>
<th>100%</th>
<th>100%</th>
<th>100%</th>
<th>100%</th>
<th>100%</th>
<th>100%</th>
<th>100%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Growth Rate</td>
<td>4.8%</td>
<td>-0.8%</td>
<td>2.4%</td>
<td>1.6%</td>
<td>2.7%</td>
<td>-0.8%</td>
<td>6.4%</td>
<td>-0.8%</td>
<td></td>
</tr>
<tr>
<td>Market Penetration Curve</td>
<td>10 Year</td>
<td>10 Year</td>
<td>10 Year</td>
<td>10 Year</td>
<td>10 Year</td>
<td>10 Year</td>
<td>10 Year</td>
<td>10 Year</td>
<td>10 Year</td>
</tr>
<tr>
<td>% Electrical Energy Saving</td>
<td>10%</td>
<td>5%</td>
<td>10%</td>
<td>10%</td>
<td>10%</td>
<td>10%</td>
<td>10%</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>Yearly Production (x100,000) ton</td>
<td>990</td>
<td>4.6</td>
<td>364.2</td>
<td>88.1</td>
<td>20</td>
<td>14.1</td>
<td>5570</td>
<td>107</td>
<td></td>
</tr>
</tbody>
</table>

Energy & Environmental Benefit in 2020

Using conservative DOE-based data yields significant electrical energy savings of 279 Trillion Btu’s year.
### Online Sensors & Controls Project Evaluation Tool

http://www.energetics.com/sensor_tool/

**User Inputs**

<table>
<thead>
<tr>
<th>Sector:</th>
<th>Petroleum</th>
<th>% Energy Savings:</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of Market Impacted:</td>
<td>100.0%</td>
<td>Natural Gas:</td>
</tr>
<tr>
<td>Annual Growth Rate:</td>
<td>5.0%</td>
<td>Electricity:</td>
</tr>
<tr>
<td>Year of Introduction:</td>
<td>2006</td>
<td>Coal:</td>
</tr>
<tr>
<td>Market Penetration Curve:</td>
<td>10 Year Market Saturation</td>
<td>Solid or Liquid Wastes:</td>
</tr>
</tbody>
</table>

#### Assumptions

Inputs based on DOE & other reports

#### Calculations

Calculations based on inputs above

#### Energy Impacts for Petroleum

(Based on the inputs provided above, this technology will have the following impacts)

<table>
<thead>
<tr>
<th></th>
<th>2005</th>
<th>2010</th>
<th>2015</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MARKET PENETRATION</strong></td>
<td>N/A</td>
<td>21.1%</td>
<td>70.7%</td>
<td>95.6%</td>
</tr>
<tr>
<td><strong>MARKET (Million tons)</strong></td>
<td>340</td>
<td>1,465</td>
<td>2,511</td>
<td></td>
</tr>
<tr>
<td><strong>ENERGY SAVINGS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Natural Gas Energy Savings (trillion Btu)</td>
<td>N/A</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Electricity Savings (trillion Btu)</td>
<td>4.049</td>
<td>17.316</td>
<td>29.883</td>
<td></td>
</tr>
<tr>
<td>Coal Energy Savings (trillion Btu)</td>
<td>N/A</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Fuel Oil Energy Savings (trillion Btu)</td>
<td>N/A</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td><strong>TOTAL ENERGY SAVINGS</strong></td>
<td>4.049</td>
<td>17.316</td>
<td>29.883</td>
<td></td>
</tr>
<tr>
<td><strong>POLLUTANT REDUCTIONS (lbs)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon (MMTCE/yr)</td>
<td>N/A</td>
<td>0.0769</td>
<td>0.3290</td>
<td>0.5677</td>
</tr>
<tr>
<td>Nitrogen Oxides (NOx)</td>
<td>N/A</td>
<td>1,433,378</td>
<td>5,129,722</td>
<td>10,570,627</td>
</tr>
<tr>
<td>Sulfur Dioxide (SO2)</td>
<td>N/A</td>
<td>190,307</td>
<td>813,340</td>
<td>1,404,507</td>
</tr>
<tr>
<td>Carbon Monoxide (CO)</td>
<td>N/A</td>
<td>20,245</td>
<td>86,573</td>
<td>149,415</td>
</tr>
<tr>
<td>Volatile Organic Compounds (VOCs)</td>
<td>N/A</td>
<td>40,491</td>
<td>173,157</td>
<td>238,831</td>
</tr>
<tr>
<td>Particulates</td>
<td>N/A</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Other (million tons)</td>
<td>N/A</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

#### User Explanations

- **Technology Description**: Develop a wireless network for DOE's IoT
- **Market Percentage**: 6 to 10 year life on 0 to 200 HP motors, upgrade to energy management when R&R
- **Introduction Year**: Beta test in 2 years, product intro 1 year after beta
- **Energy Impacts Percentages**: the major impact will be on electrical. Not sure how to include wellness in this calculation
- **Other Wastes and Pollutants**: Possible reduction of non-combustion pollutants on restart
Develop product introduction plan covering manufacturing, marketing and introduction of WSN into energy management system.
Concluding Remarks

Eaton’s WSN strategy will yield an 11% to 18% energy reduction in industrial motor energy consumption by 2020.

Eaton understands the technical aspects and the economics of the problem. 80% cost reduction vs. wired sensors proven by our costing tool.

Eaton’s understanding of the needs of the end user community is based on a thorough customer needs definition process.

Eaton understands wireless technology and are thought leaders within industry and standards organizations through IEEE802, IEEE1451, WINA and the ZigBee Alliance.

Eaton has business units serving IoF well positioned to bring products to market.
# Industrial Wireless Sensor Network

## PAN Coordinator Type MA

## Technical Data

### Nutrition Facts

<table>
<thead>
<tr>
<th>Amount Per Serving</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Calories</strong></td>
<td>0</td>
</tr>
<tr>
<td><strong>% Daily Value</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Total RAM</strong></td>
<td>Minimal</td>
</tr>
<tr>
<td><strong>Total ROM</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Simplicity</strong></td>
<td></td>
</tr>
</tbody>
</table>

* Percent value is based on actual implementation using Model Based Protocol Stack design techniques
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Thanks!

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