

Permanent Power for Wireless Sensors

*Active RFID, RTLS & Sensors
Networks 2008*



Wireless Sensors Can Drive Significant Energy Savings



- Wireless Sensor Nodes could contribute to U.S. energy savings of \$82B and \$320B globally in homes and businesses



- Energy harvesting in Wireless Tire Pressure Sensors would contribute saving 97,800,000 tons CO₂ per year



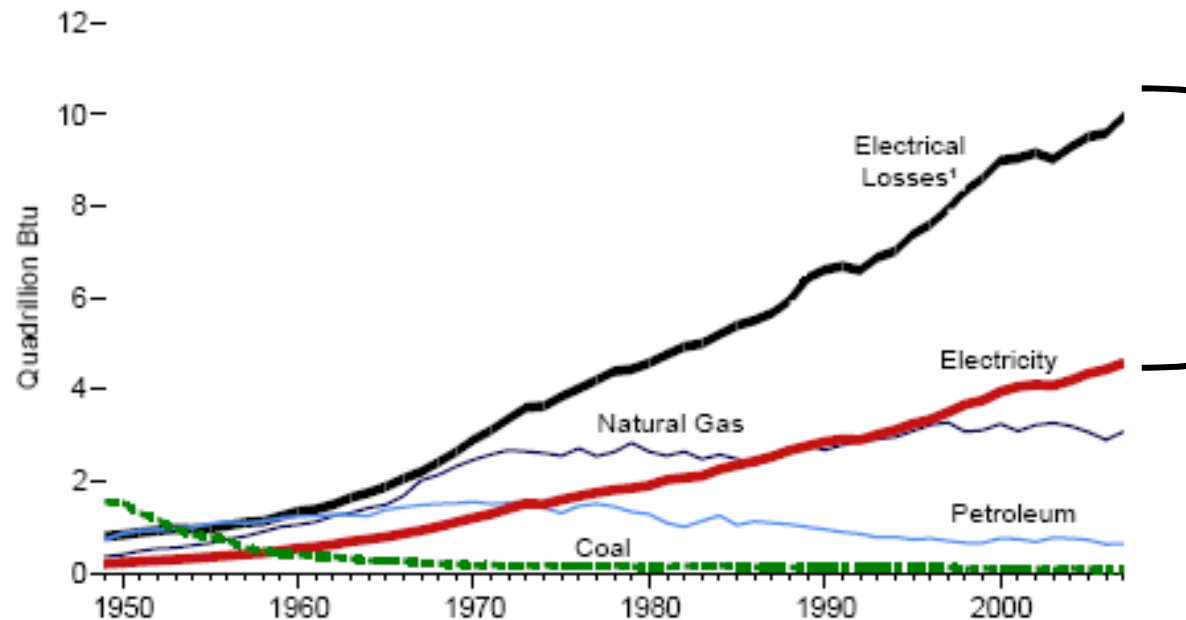
- Energy Harvesting could replace a large portion of the 30,000,000,000 coin cells sold each year

Saving Electricity Pays Significant Dividends



Leveraging energy saving techniques enabled by Energy Harvesting is essential as every electrical BTU saved at the point of delivery saves the 2.5 BTUs wasted by Parasitic Losses on the electrical Grid...

Commercial, By Major Source



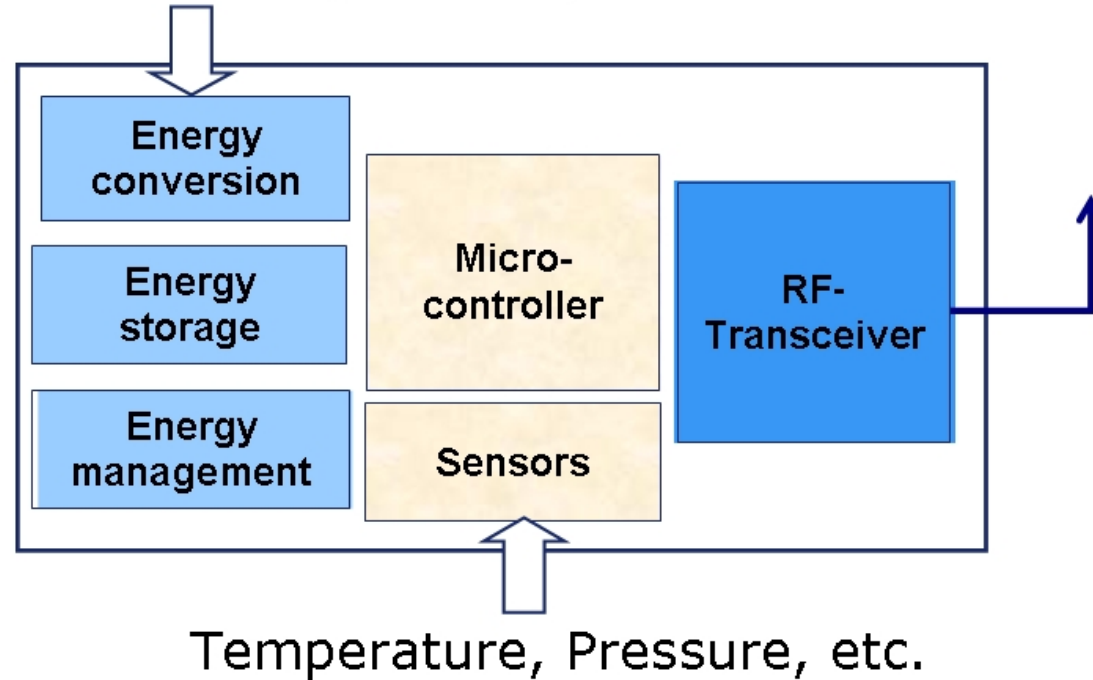
**2.5 BTU is
lost for every
1 BTU
delivered**

(1) Energy Information Administration / Annual Energy Review 2007

Self-Powered Wireless Sensor Block Diagram



Ambient Energy:
Motion, Vibration, Light, Temperature etc.

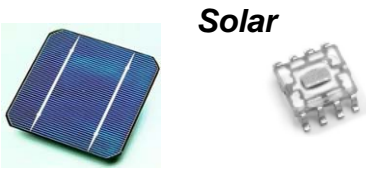


Energy Harvesting Transducers



Energy Source	Challenge	Estimated Power <i>(in 1 cm³ or 1 cm²)</i>
Light	Conform to small surface area Wide input voltage range	10μW-15mW (Outdoors: 0.15mW-15mW) (Indoors: <10μW)
Vibrations	Variability of vibration	1μW-200μW (Electrostatic: 50μW-100μW) (Electromagnetic: <1μW)
Thermal	Small thermal gradients	15μW (10°C gradient)
Piezoelectric	Capturing pressure or motion	~ 200μW
RF & Inductive	Coupling & rectification	Various

Source: EE Times



Solar



Peltier - Thermo Life

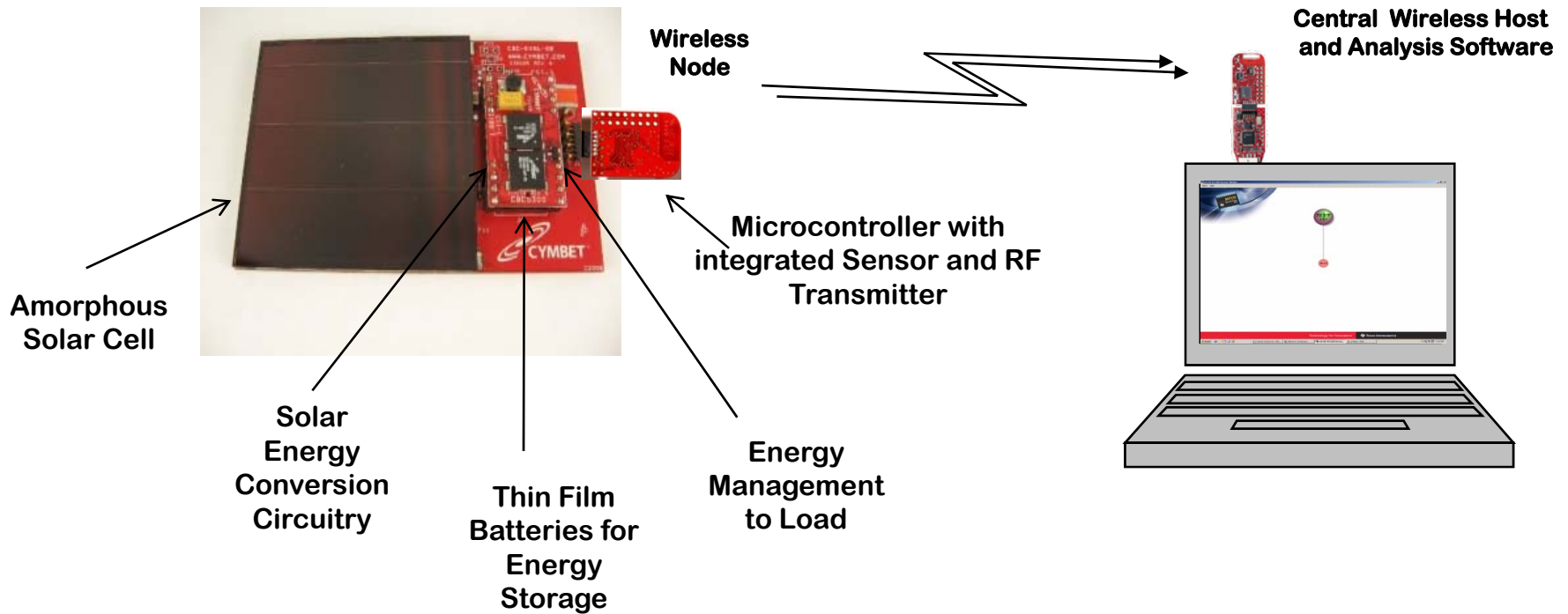


Kinetic – Adaptive Energy

Self-Powered Wireless Sensor: *Real World Example*



Solar Energy Harvesting Wireless Sensor



Transducer and Sensor Advancements Are Needed



- Transducers
 - Increase Energy Production
 - Increase Energy Efficiency
 - Reduce Size
 - Reduce Cost
- Sensors
 - Reduce Energy Use
 - Reduce Size
 - Reduce Cost

Electronics Advances Are Also Needed

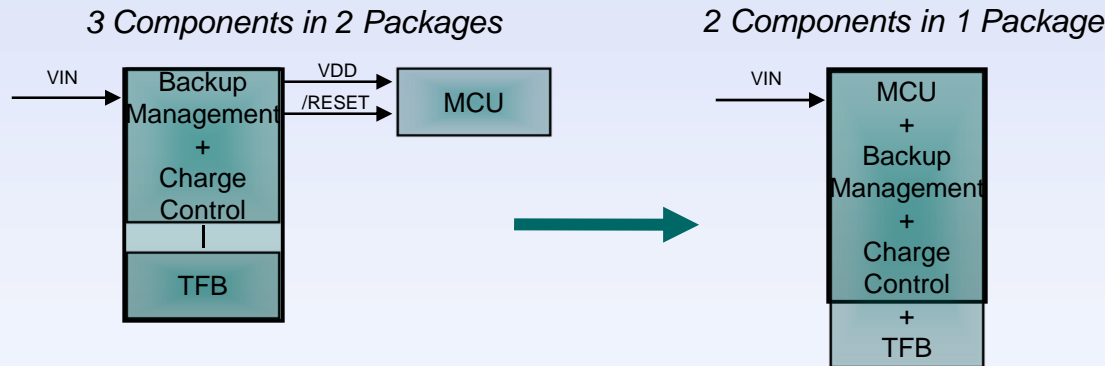


- Improve power conversion and delivery efficiencies
- Combine all Power Mgmt and Energy Storage Functions into a single package
- Combine Microcontroller, RF Transceiver and possibly Sensor into single chip
- Combine all functions into single package
 - Now possible using thin film battery technology that is SMT and reflow tolerant like ICs.

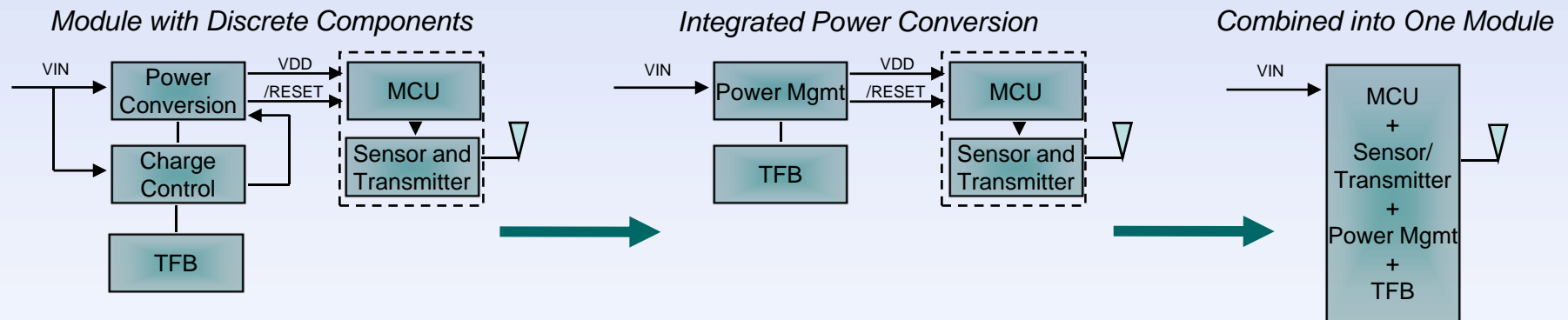
Self-Powered Wireless Sensor Integration Evolution



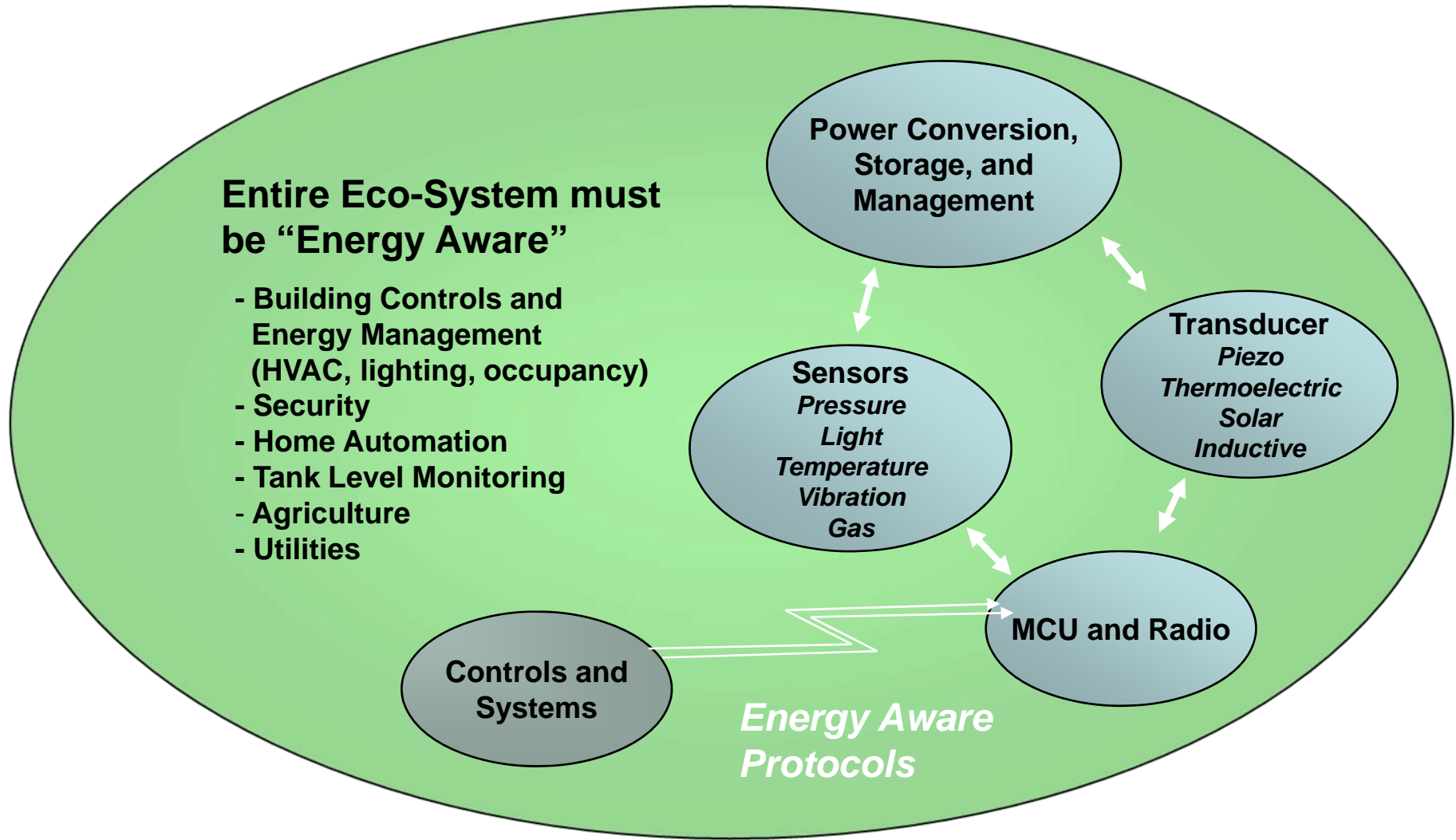
Integrated, Low Power Backup Solution



Integrated Energy Harvesting



Wireless Sensor Network – Ecosystem Development



- Self-powered Wireless Sensors drive significant savings and will become widely deployed in many applications
- Energy Harvesting and permanent power storage devices are “self-power” enablers
- All system components need to be “Energy Aware”
- Using solid-state thin film batteries packaged with ICs can significantly reduce the cost and size of Self-powered Wireless Sensors.