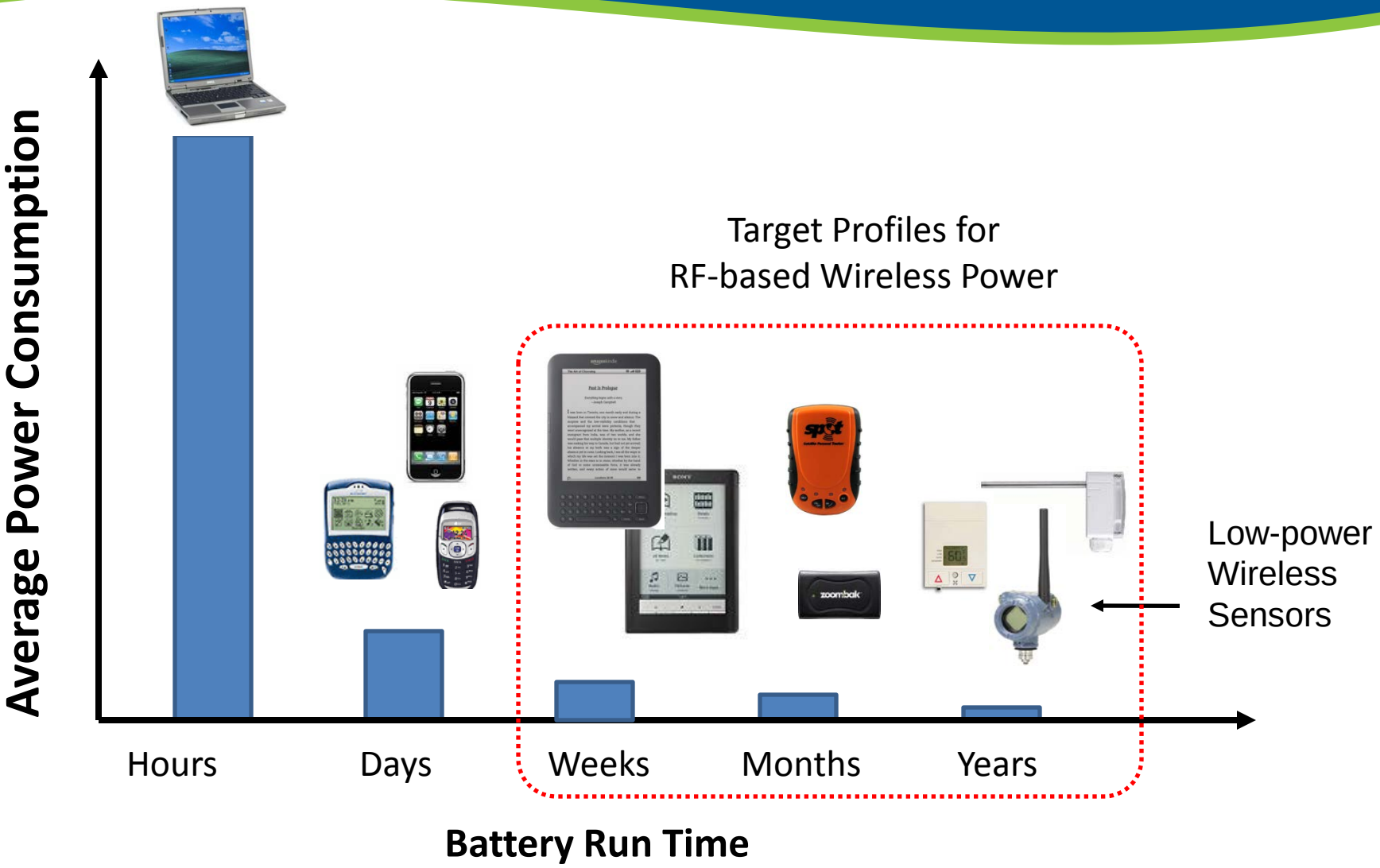
RF Energy Harvesting and Wireless Power for Low-Power Applications

Powercast Technology Overview

- Power over distance using common radio waves
  - Microwatts (µW) to low milliwatts (mW)
- Ideally suited for:
  - Trickle-charging batteries
    - For devices with long or frequent charging periods
  - Powering battery-free devices
    - For continuous operation or power-on-demand
- Received power is determined by multiple factors:
  - Power of RF source
  - Distance from RF source
  - Size / performance of receiving antenna
  - Transmission frequency (e.g. 915MHz)

Target Device Power Profiles



Powercast Value and Benefits

- **Minimizes Operating Costs (Industrial End Users)**
  - Enormous cost to supply and maintain power to wireless sensor networks (WSN) via batteries or hardwiring
  - Eliminates downtime caused by depleted batteries
  - Reduces battery handling and disposal

- **Improved Product Design (OEMs)**
  - Sealed devices – less expensive enclosures and manufacturing
  - Embedded power – eliminate wires, cables, connectors
  - Reliability – improved durability, reduced product failures, eliminate ESD

- **Convenience and Usability (Consumer End Users)**
  - Placement flexibility – no charging mats or charging stations
  - Transparent charging – no user action required
  - Embedded power – eliminate wires, cables, connectors

Why RF Power? ....

RF power presents compelling advantages

Wireless Power Over RF a Unique Solution	
Wire-free Operation • Untethered placement and mobility • Operates anywhere in range of RF power source	***Simple Scalability*** • Many-to-many network relationships • Abundant sources of ambient RF today • Omni-directional or focused RF beam
Low-cost Set-up and Maintenance • Life-time solution • No wires or battery replacement required	***Reliable and Controllable*** • Power source can be controlled • Available on demand • Minimal effects from weather / time-of-day
"Green" Solution • Batteries pose serious environmental and heath risks due to hazardous raw materials • U.S. and European governments have implement regulations on how batteries are transported, stored, and disposed	

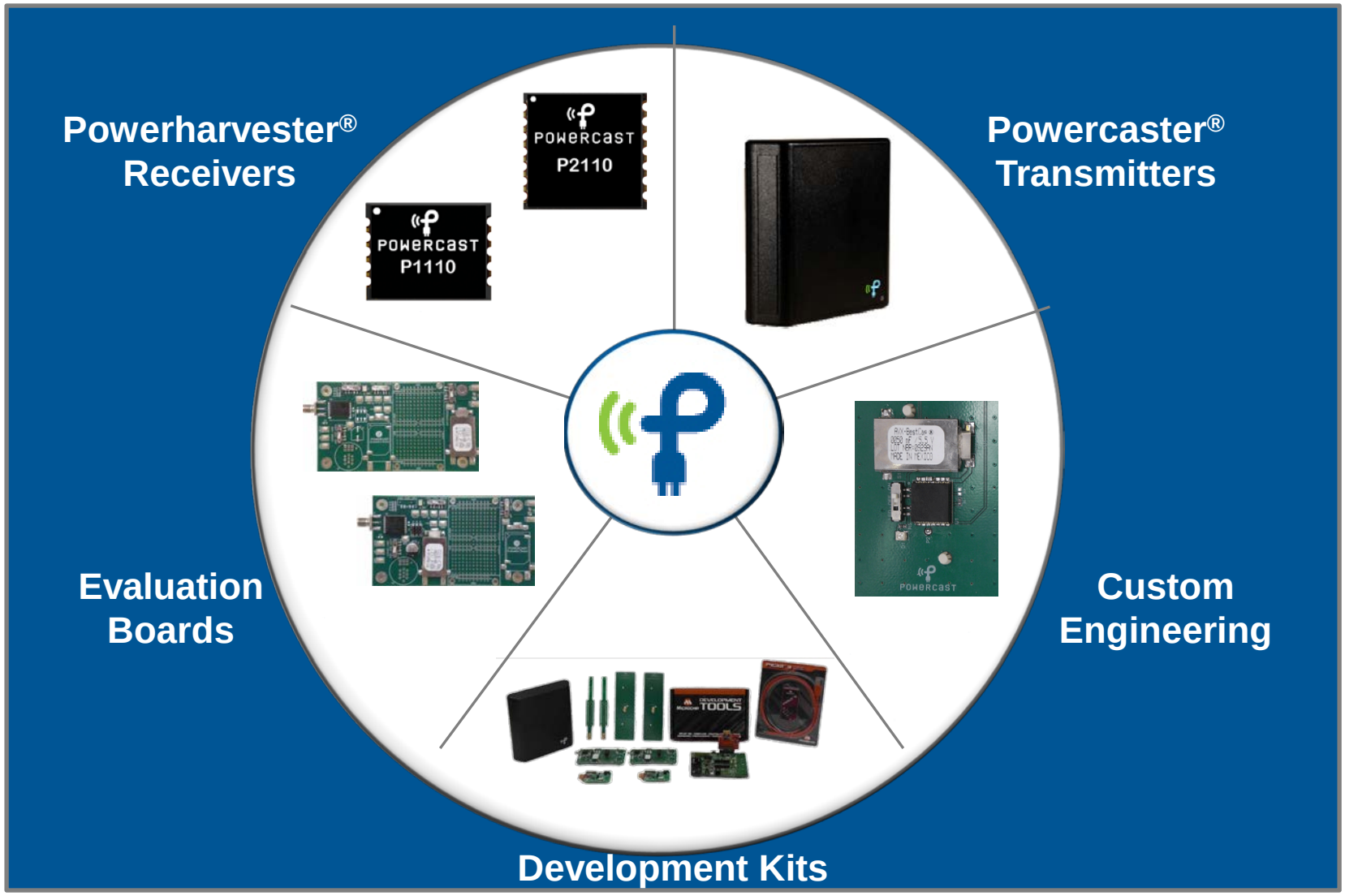
RF Power Sources

Intentional

Anticipated

Unknown

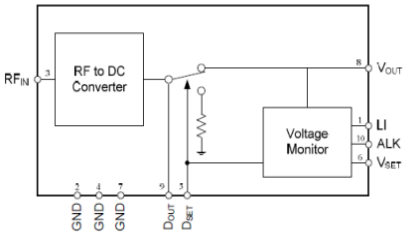
Full Suite of Wireless RF Solutions

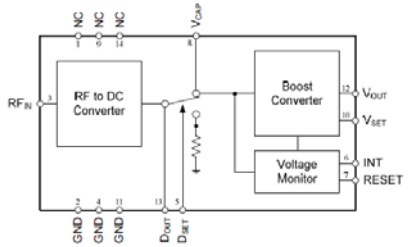


Powerharvester® Receivers

- Convert RF input to DC current
- Provides power management
- Optimal frequency band: 902-928MHz
- High conversion efficiency of up to 70%
- Designed for industrial temperatures (-40 C to 85 C)
- RSSI and Data output
- Designed for standard 50Ω antennas

P1110 Block Diagram





P2110 Block Diagram

P1110

Continuous Power Output

– RF range: -5.0dBm to 20dBm
– Output voltage: 1.8V to 4.2V (configurable)
– Range of at least 3 meters
– 10-pin configuration

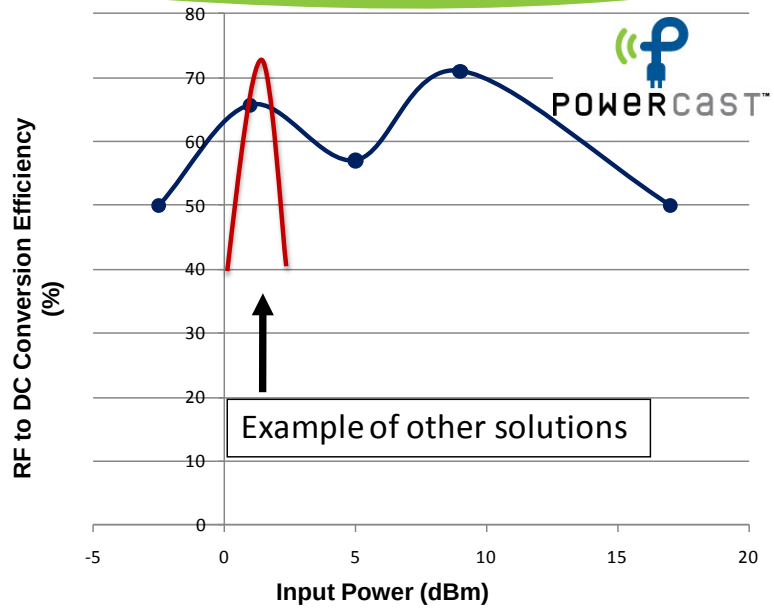
P2110

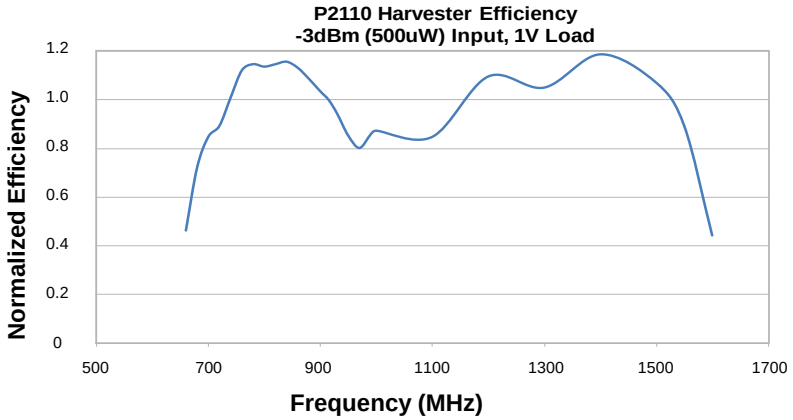
Pulsed Power Output

– RF range: -11.5dBm to 10dBm
– Output voltage: 1.8V to 5.25V (configurable and regulated)
– Range of at least 10 meters
– 14-pin configuration

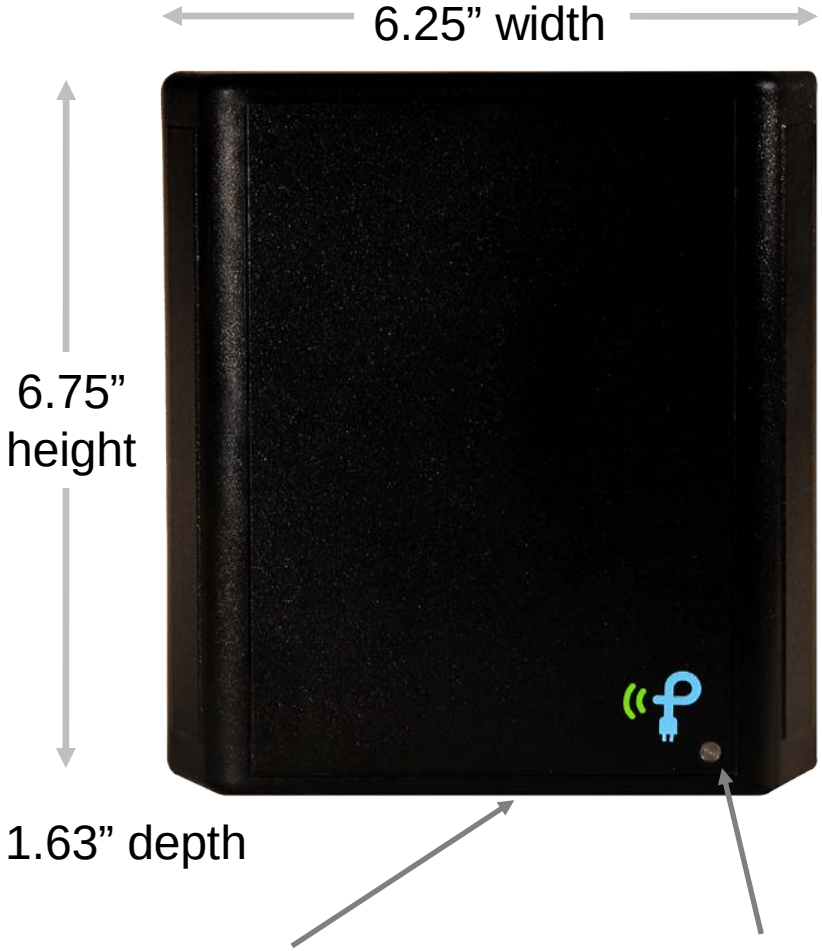
Powercast Differentiators

- **High efficiency over a broad range**
  - Load resistance
  - Input power
  - Recharging current
- **No Maximum Power Point Tracking (MPPT) required**
- **Over 850 MHz operating bandwidth**
  - Essential for ambient energy harvesting
  - Easy scalability for geographic regions using different frequencies
- **Result …**
  - Better performance
  - More power
  - Simplified design-in





TX91501 Powercaster® Transmitter



- 915 MHz center frequency
- FCC and IC certified
- RoHS compliant
- DSSS modulation (power)
- ASK modulation (data)
- 1W or 3W EIRP
  - TX91501-1W-ID
  - TX91501-3W-ID
- ~60 beam pattern
- Data broadcast (factory-set)
- Plug-and-play installation
- Powers virtually unlimited number of Powerharvesters

Lifetime Power® Development Kits

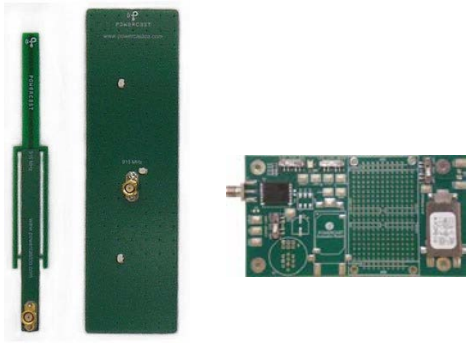
P2110-EVAL-01

- **Complete system for battery-free wireless applications**
  - Jointly developed with Microchip
  - Designed for wireless sensing applications using MiWi protocol
    - RF Transmitter (TX91501)
    - (2) P2110 Evaluation Boards (P2110-EVB)
    - (2) 6dBi Directional Antennas
    - (2) 1dBi Omni-directional Antennas
    - (2) Wireless Sensor Boards (WSN-EVAL-01)
    - Microchip 16-bit XLP Development Board
    - Microchip MRF24J40 PICtail/PICtail Plus daughter card
    - Microchip PIC-kit 3 programmer/debugger

P2110-EVAL-02

- **Complete system for wireless battery charging**
  - Developed in conjunction with Infinite Power Solutions
  - Features IPS THINERGY® Energy Cell
    - RF Transmitter (TX91501)
    - P2110 Evaluation Boards (P2110-EVB)
    - 6dBi Directional Antenna
    - 1dBi Omni-directional Antenna
    - Battery Charging Board (BAT-EVAL-01)
    - THINERGY® Micro-Energy Cell Evaluation Card
    - Cable for connecting to THINERGY® ADP
    - TI eZ430-RF2500 Wireless Development Tool

Battery Charging Kit Options



Item	P1110-EVB	P2110-EVAL-02
Charging Method	Continuous	Pulsed / Intermittent
Output Voltage Range	1.8V - 4.2V for P1110	1.8V - 5.25V for P2110
Output Voltage	Output voltage floats with the battery voltage until the configured maximum output voltage is reached	Fixed, regulated output voltage. Options for included charging board are: 2.8V, 3.3V, 4.1V, 4.2V, 4.95V
Usage	Direct power OR Battery-charging (direct connection to typical battery, additional circuitry for thin-film)	Pulsed power OR Battery-charging (additional circuitry typically required)
Operating / Charging Range (with identical antennas)	Moderate – 2 to 5 meters	Extended – 6 to 15 meters
Undervoltage cut-off	Not available – P1110 will draw 1.5uA of current when no RF energy present (An external diode can be used to reduce draw to 4nA)	Set to 2.1V (for THINERGY MEC)
Transmitter	Not included (sold separately)	3W transmitter included

Target Applications

Building Automation

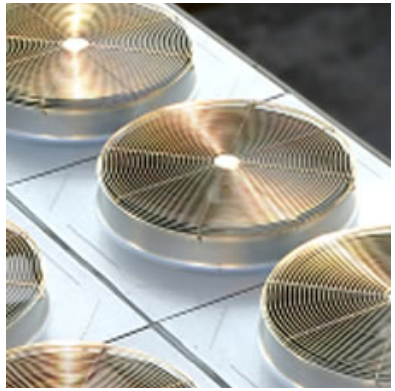
Structural Monitoring

Defense

Data Centers

Security

Industrial Monitoring

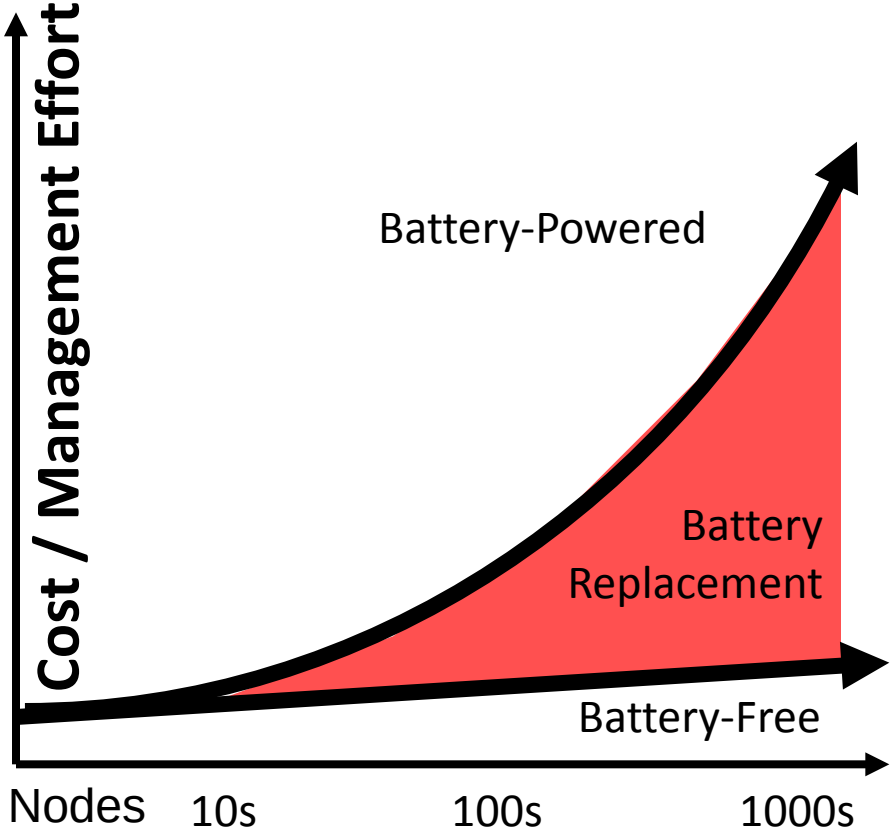


Energy Management

Smart Grid

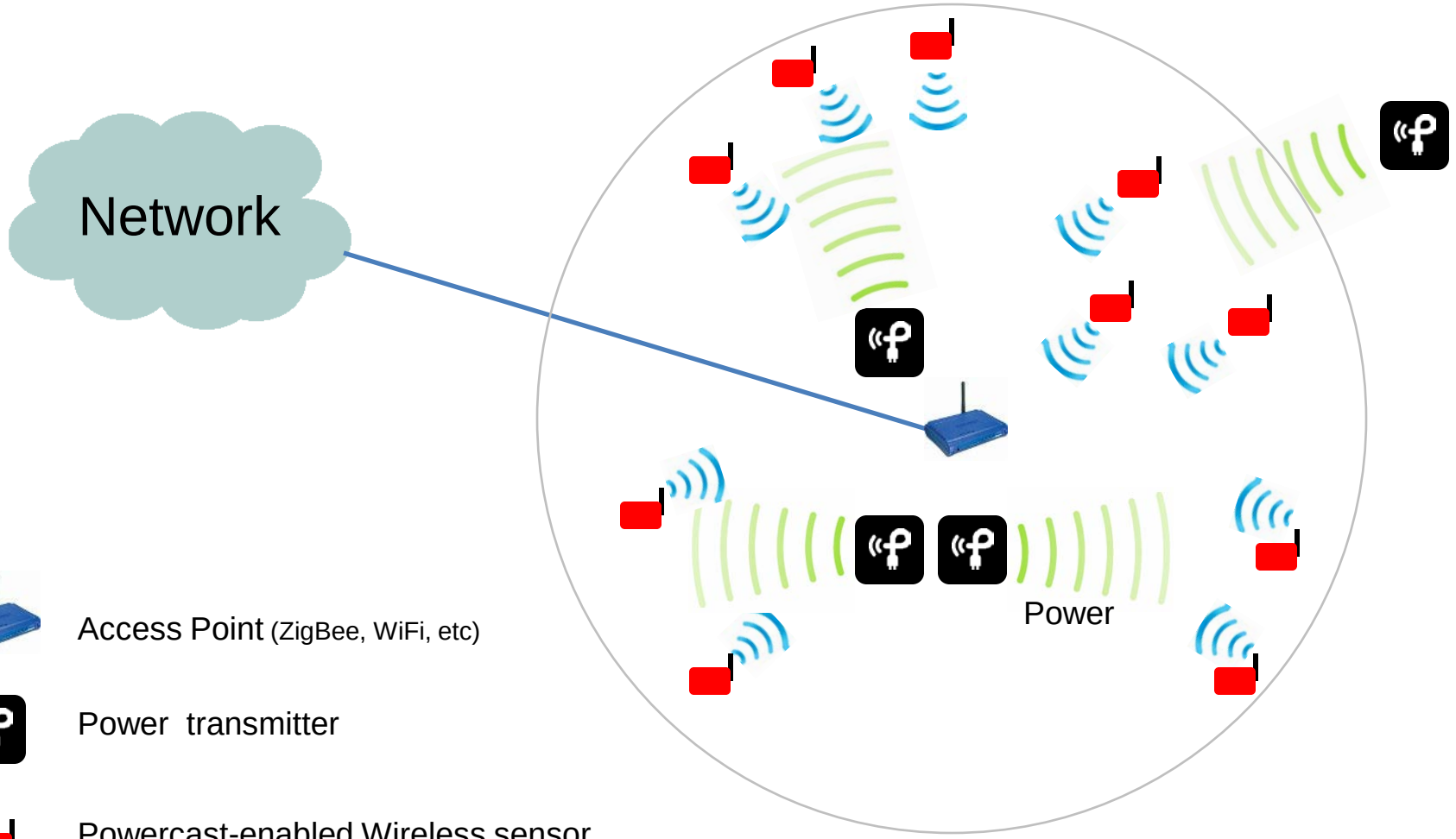
Sensor Networks Won't Scale Using Batteries

"The Internet of Things"



"Industry will need to manage wireless sensor networks involving tens of thousands of nodes with their own power. These cannot be visited without great expense and labor and some cannot be visited at all." Dr. Peter Harrop, Chairman, IDTechEx (UK)

Powercast enables a complete wireless infrastructure for micro-power and data



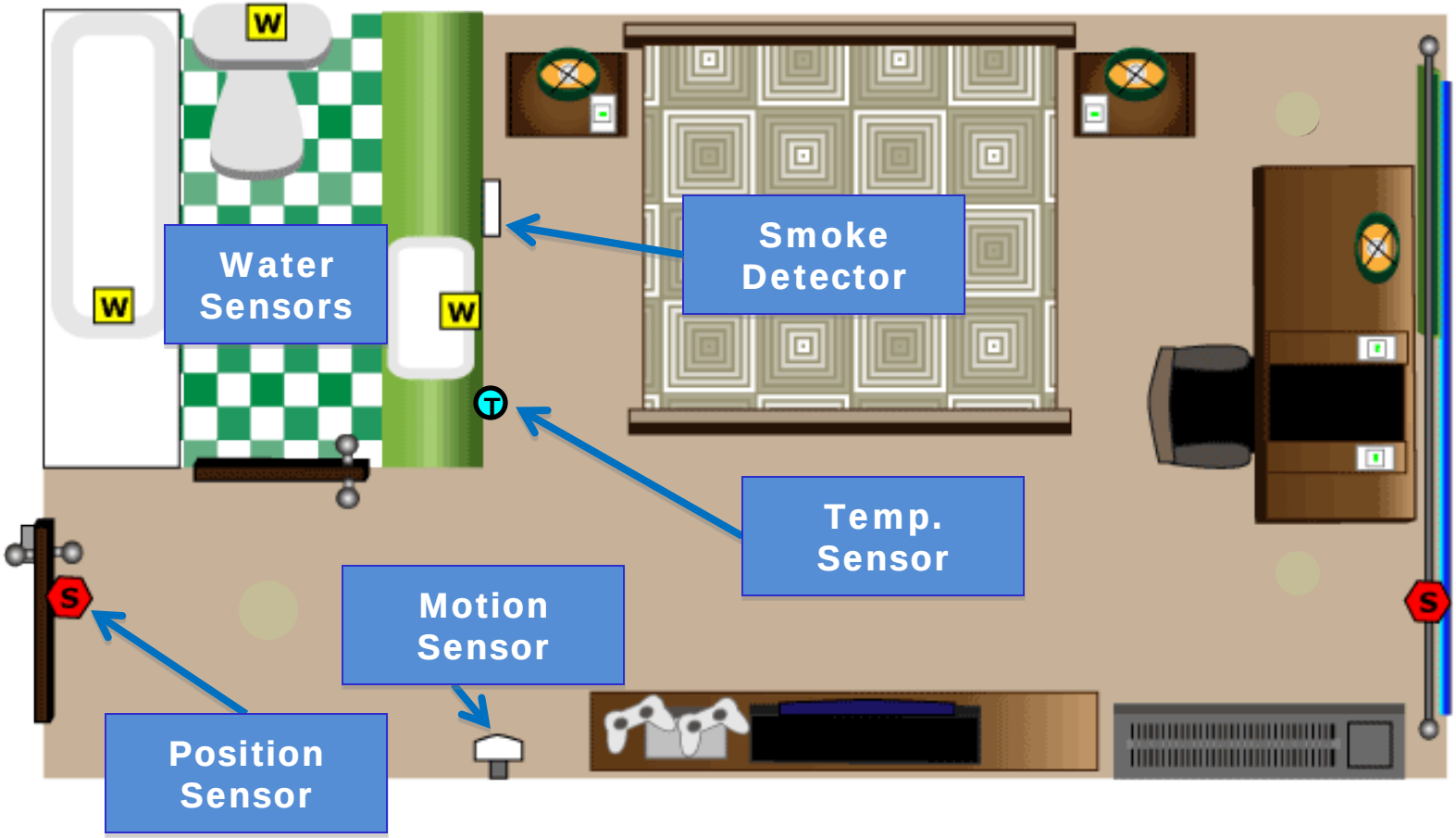
Access Point (ZigBee, WiFi, etc)

Power transmitter

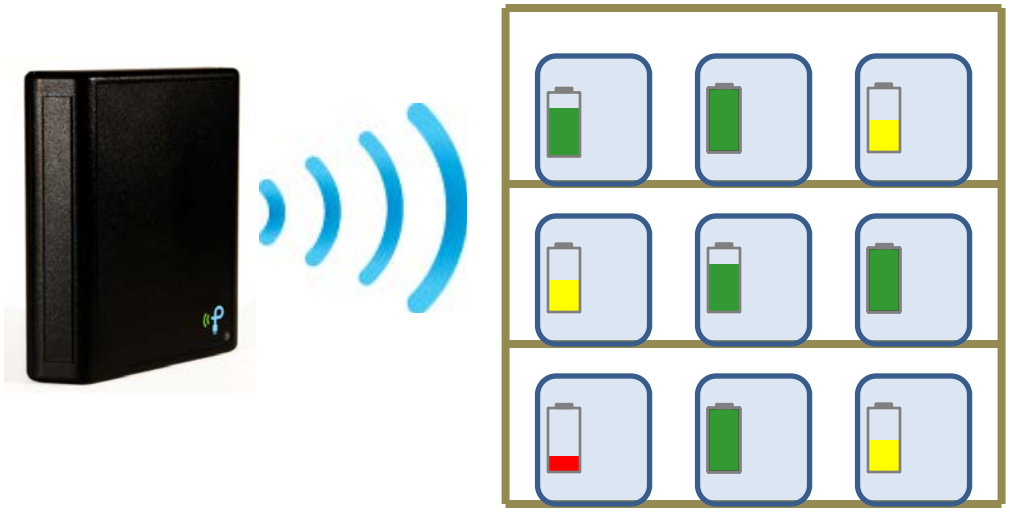
Powercast-enabled Wireless sensor
Temperature / Humidity / Motion / Light / etc

Automation Sensors - Hotel Example

Multiple devices charged/powered from a single, low-power transmitter



Wireless Trickle Charging



- Freedom of placement
- Eliminate wires and connectors
- Automatic/transparent charging
- Multiple battery types/chemistry

Desktop Trickle Charging

Suitable for low-usage items or longer charge times (+6 hours)

Consumer-oriented transmitter

Low transmit power, Low cost, USB powered

Product concept

Information Resources

Product Documentation

http://www.powercastco.com/resources/

Product Listings / Ordering

http://www.mouser.com/powercast/

Powercast Blog

http://www.RFWirelessSensors.com