

zigbee Green Power

White Paper

Author: Cam Williams, Strategy Committee Chair, Zigbee Alliance and Lead Architect of IoT Connectivity, Schneider Electric

The pain points of “wireless (not wireless)”

Almost all wireless products require wires for power – or they must rely on batteries to function. Both options are costly and limit the usefulness of these devices today. When we think of wireless technology, we often don't consider the amount of labor, energy, battery waste and other costs associated with small and large deployments. First, think of a smart home environment. If there are 60 wireless/IoT products in your home, and each device's battery lasts five years, that averages to one battery change a month. If you aren't home and can't change the battery, the device will fail. This makes your home automation system (and your life) more complicated.

On the commercial side, these pain points and costs can be significant depending on the type of deployment and scope of coverage. Commercial office space floor layouts change on average every five years, and having to rewire each time can be a huge cost and resource drain. Some venues – such as hotel room settings – might include 10+ potential sensors. Each component will require a battery change at some point.

Batteries constitute one of the most toxic waste streams on Earth. Ethical disposal and recycling of batteries is costly. Why purchase, transport, install, and dispose of a battery when the energy already exists where it is needed?

Simplifying power, streamlining design, saving the planet

Technology innovators from around the world have been working together for years through organizations like the Zigbee Alliance to solve the power obstacles that burden and hinder the potential around the Internet of Things. An open, standardized technology is

Zigbee Green Power | White Paper

available now to support smart devices that don't require battery changes. It's called 'Zigbee Green Power' and is already being built into millions of smart devices.

The benefits of this innovative wireless device platform go beyond installation, energy and cost savings: Zigbee Green Power products can be put anywhere, especially in places that are hard to wire. The more sensors you can put in a controlled space, the better the feedback and the better the control.

Zigbee Green Power devices are much simpler than full-fledged network devices. They usually have a lower cost of components, and a lower cost for development. With Zigbee Green Power devices, you set them and forget them. The network handles the complexity of routing messages and keeps the Zigbee Green Power devices connected.

The complete technology

The complete technology is actually a number of technologies combined into one global standard:

- Energy harvesting capabilities
- Ultra-low power RF silicon that uses many orders of magnitude less power than required for a sleepy or fully networked wireless connection
- An open global standard network technology that saves even more energy by reducing packet length, round-trips, connection rediscovery, and on-network time for devices that may be offline for extended periods of time
- An open global standard application layer protocol that supports compressed messages and limited transactions

Energy harvesting

The energy from dropping a needle to the ground, by cooling a drop of sweat, or a single LED flash is sufficient to transmit several radio messages. Likewise, a solar cell the size of your fingertip can provide enough energy to transmit a radio message every minute when exposed to indoor light – light you can't even read by. Harvesting energy from local sources like heat, kinetic or light allows the sensors and actuators for automation systems to go where they are needed without wires, batteries or costly installation.

Ultra-low-power silicon

Energy harvesting technologies are not new. What is new, and getting better every day, is highly power-optimized silicon – from a variety of vendors – designed to run on microamperes of energy. Most power savings come from the silicon's ability to shut off power to unused components and optimize power up from a cold start. Further savings comes from reducing the power for each message transaction.

These chips support IEEE 802.15.4, a mature protocol with a long list of suppliers and more than one billion units sold as of today. IEEE 802.15.4 was designed for ultra-low-power and constrained devices. Other technologies, like Wi-Fi and Bluetooth, were not designed for automation systems, nor low power.

Network integration

The Zigbee mesh network standard runs over IEEE 802.15.4, and green power has been part of Zigbee for more than 10 years. The Zigbee Green Power protocol defines compressed, secure, and highly optimized message traffic for ultra-low-power devices. It allows these devices to send messages, in a reliable way, to destinations in the mesh network that may be well beyond the range of these ultra-low power devices. The Zigbee network is always on, and can receive and forward Zigbee Green Power messages at any time.

Mains-powered devices like smart bulbs, smart power outlets, window shades, appliances, etc., serve a dual purpose. Besides their primary functionality of providing light or controlling power to attached devices, they also serve as routers – forwarding data packets on behalf of other devices in the network. This allows coverage of even large buildings with no significant limitations on the number of simultaneously active routers in a network. Local traffic does not affect the entire network. Instead of using excessive transmit power, devices that need to talk to each other but are out of direct communication range can rely on intermediary routers to forward their data.

The mesh structure has additional advantages beyond extending the nominal range determined by link budget alone. In contrast to simple star networks, which only provide point-to-point connectivity, mesh networks are resilient to indoor radio propagation effects

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– such as multipath fading and local interference – because there are always multiple redundant paths (routes) in the network should a specific link not (or no longer) be available.

A Zigbee network, including green power devices, is self-organizing and self-healing and quickly adapts to changes in network topology – effectively avoiding a single point of failure. Network topology can change as people walk by, furniture is relocated, and doors are opened or closed. Because Zigbee networks are self-organizing, there is no need to consider placement of devices, avoiding any planning overhead.

Once a Zigbee Green Power device is securely commissioned, any mesh device in the Zigbee network will forward a green power message to its destination. This amplifies the power and usefulness of these simple devices and provides a rock-solid reliable solution that is extremely robust against the hostile effects of indoor radio propagation, potential bottlenecks, or just some router simply being offline for a while (e.g., a smart bulb disconnected from mains using a conventional switch).

Zigbee devices do not rely on internet connections to function. Local control is always possible even if your internet connection is temporarily unavailable. At home, your Zigbee Green Power switches can still directly control your shades and lights, even if the internet is gone, or the gateway is offline for whatever reason.

Application layer

Zigbee Green Power uses **Dotdot**, the universal language for smart objects. This is the same application layer as Zigbee, but with a compressed and optimized message structure. Commissioning and pairing is the same as Zigbee. Simple push button commissioning, or automatic commissioning when a button is not available, makes it easy to connect lights to switches, or heaters to thermostats and temperature sensors. Advanced commissioning and pairing using a smart phone or a remote control is also supported.

Mature and sustainable

There are many proprietary solutions on the market with proprietary applications over IEEE 802.15.4 or even lower layers that are proprietary. These are single-company solutions, and

Zigbee Green Power | White Paper

usually only for a single market. What our industry needs today, to realize the full potential the IoT can offer to us all, is a universal standard for all global sensing and control markets that supports all kinds of self-powered products.

As an industry consortium of more than 400 member companies from all points on the globe, the Zigbee Alliance brings together innovative organizations to collaborate and create open wireless standards. Zigbee standards enjoy the largest market share of certified and deployed products in the IoT, numbering in the hundreds of millions. For 15 years, Zigbee Alliance members – product manufacturers and domain experts – have spent more than 100,000 hours participating in an ongoing rigorous standardization process to develop consensus, resolve conflicts and continue to evolve the network and application layer so that interoperability and backwards compatibility are enforced. Many of the device and object models have already gone through many iterations of updates and enhancements – and Zigbee Green Power is part of this investment, which includes test tools, certified test houses, and many silicon and stack providers. This broad and deep market of suppliers means there will always be silicon and stack vendors to upgrade your solutions.

The non-negotiable rule in the Zigbee Alliance is interoperability and backwards compatibility. This means that your deployed Zigbee Green Power products will still be interoperable in 20 years.

Simple and secure

Where wireless mesh nodes are typically equipped with at least 256K bytes of program and 16K bytes of data, a Zigbee Green Power device typically needs less than 32K for the program and 1K for data. Because Zigbee Green Power devices are not directly exposed to the wider internet, they are inherently protected against some of the more challenging internet security concerns, including Distributed Denial-of-Service (DDoS) attacks. Even one-way simplex devices are secure with a random factory security key. Bi-directional devices are able to store a generated key from the network, that is different from the network key, thus adding another layer of security for the application.

Details on power savings

The amount of energy required for message transmission is also a substantial part of the overall power consumption. This directly affects the lifetime of battery-powered devices and thereby the user experience.

A single Zigbee mesh network transmission takes as little as 500uJ of energy. Zigbee Green Power technology reduces this by factor 5 or more in many standard use cases. Transmission of a green power message, identifying the status of a light switch, can be accomplished using as little as 50uJ of energy. This outstanding level of efficiency enables using the kinetic energy of the button press itself to power Green Power radio transmissions. This makes it practical for energy harvesting wireless switch products. These are fully maintenance-free and can therefore be deployed into almost any environment.

A simplified wireless experience

Zigbee Green Power is a device platform for applications that monitor and control our home to make sure it is comfortable and safe for our loved ones. Advanced control and innovative application are only possible when there is a reliable and integrated sensing and control network in the home. Zigbee Green Power does this for a low cost, without any effect on your electric bill, except for the savings realized by running your home more efficiently. It also does this with the added benefit of being environmentally friendly and progressive as our connected culture evolves toward a battery-less, simplified wireless experience.



(SIDEBAR: Real use cases)

The following use cases and devices described below represent actual products being used by Zigbee Green Power customers today.

- **Leveraging Self Power:** Kinetically powered generic switch sensors can be integrated directly into products, like light switches, doors, desk drawers, windows and window handles. They generate energy solely from the user's normal, everyday hand movements of pressing a button, opening something, or rotating a handle – and they

work for the entire lifetime of the product. These sensors can automatically control lighting and ventilation, or alert the user about unexpected conditions such as the position of a window latch or intrusion. There is virtually no limit to the number of application use cases for user-operated mechanical products.

- **Smart Breakers:** Circuit breakers have a constrained and standard form factor. Making a smart breaker by converting and using the live mains AC power is not always possible because of limited space. By harvesting the energy flowing through the breaker, it isolates the breaker logic, takes less space, and is less costly to produce. Smart circuit breakers monitor energy use and can detect uncharacteristic consumption which can lead to equipment failure.
- **Industrial Connections:** In the industrial space, on assembly line fabrication machines, vibration, movement and other factors make wiring difficult and costly. Being able to place a wireless button in an effective location for the operator of the machine, is important, especially when safety is critical – thus, the case for a completely electro-kinetic industrial switch that you can place anywhere. It does not need a battery or wires of any kind.
- **Independent Living Support:** Peace of mind is a key promise of the smart home and is especially important for elderly people that might need assistance in their daily life. The above devices and specialized sensors can make life easier for seniors, and for those that care for them. Such specialized sensors can be installed in mattresses (detecting if a person leaves the bed), in floors (detecting movement and providing visual guidance), or as a wearable. These products may help people stay in their own home for 5 – 10 years longer than would be possible without them. Cloud connectivity and analytics can alert care givers of exceptional situations and patterns. Absolute reliability, without battery changes, is a key requirement for this application. The combination of the robust Zigbee mesh network with the ultra-low-power requirements of Zigbee Green Power provides the basis to meet these requirements.