

Taking Retail Digitalization Further with Light Harvesting Technologies



Over the past decades, retail digitalization has accelerated, transforming store operations with smart technologies that enhance the shopper experience and enable associates to use their time more effectively. However, powering these intelligent systems presents a dilemma for retailers.

The growing need for advanced functionalities is accompanied by an increased demand for power, challenged by intensifying emphasis on environmental sustainability, a priority underscored by the sector's significant carbon footprint.

Retailers today are setting ambitious sustainability goals and are eagerly seeking innovative solutions that allow them to balance these targets while improving operational efficiency and enhancing the customer and associates' experience. Meanwhile, every physical retail location has an untapped resource that could help solve this dilemma: light. Retailers spend a substantial portion of their electricity budget on lighting—24%, second only to refrigeration—so maximizing this investment is worthwhile.

Harnessing the light already present in stores to power the smart technologies retailers rely on is now closer to reality than many realize. This approach not only offers a more sustainable power source, it also aligns with the industry's environmental goals, paving the way for a greener and more efficient retail future.



Evolving Retail: From Digital Beginnings to Connected Stores

The world is digital, forming a hybrid model where online and physical retail operations work seamlessly together. This synchronization demands intelligence across the entire ecosystem, from distribution and online presence to physical stores and the applications used by consumers and store employees.

The introduction of Electronic Shelf Labels (ESLs) over 30 years ago laid the foundation for numerous benefits for retailers, including pricing automation, enhanced operational efficiency, optimized workforce allocation, and improved customer satisfaction and loyalty. By automating routine tasks and ensuring pricing accuracy, ESLs allow retailers to reallocate resources to value-added activities, driving productivity and profitability.

FIRST GEN ESL



- Black & White ESL
- On premise IoT management
- Paper Replacement
- Pricing Automation

CURRENT GEN ESL



- Multi-Color ESL
- Cloud-Based IoT Management
- Promotional Call Outs
- Operational Data At the Shelf
- Shopper Experience
- Inventory Management
- In-store fulfillment
- Analytics

DIGITAL SHELF SYSTEMS



- Battery-light Digital Shelf Systems
- Multi-Color Based displays
- Cloud-Based IoT Management
- Location-based Interactions (associates & shoppers)
- Promotional Call Outs
- Operational Data At the Shelf
- Tailored Shopper Experience
- Inventory Management
- In-store fulfillment
- Analytics
- Data Generation at the Shelf

However, digitalization in retail requires power, and with the expanded functionalities and increased smartness of IoT devices, the energy demand will only grow. Today's ESLs are typically battery-powered, with individual coin-cell batteries providing sufficient energy for use cases such as pricing automation and pick-to-light/stock-to-light systems. Despite their effectiveness, these batteries come with a pre-set amount of energy which could represent a latent constraint for some retailers willing to expand their business cases to the full potential of their in-store IoT.

Retailers have major problems to solve, day-in and day-out, such as On Shelf Availability or Waste Management. The latest innovations for in-store IoT, such as Digital Shelf Systems (DSS), integrate active sensors, cameras, and Bluetooth radios, providing a solution to address these challenges but in turn require greater energy sources. Simultaneously, sustainability initiatives are driving retailers to reduce their power consumption rather than increase it.

To bridge the gap between the increasing power demands and new capabilities brought by a digital transformation and the need to expand functionalities but not CO2 footprints, current solutions like light-harvesting technologies are arising as viable options. These innovative systems provide sustainable energy sources for retailers, supporting their advanced functionalities while aligning with environmental goals.

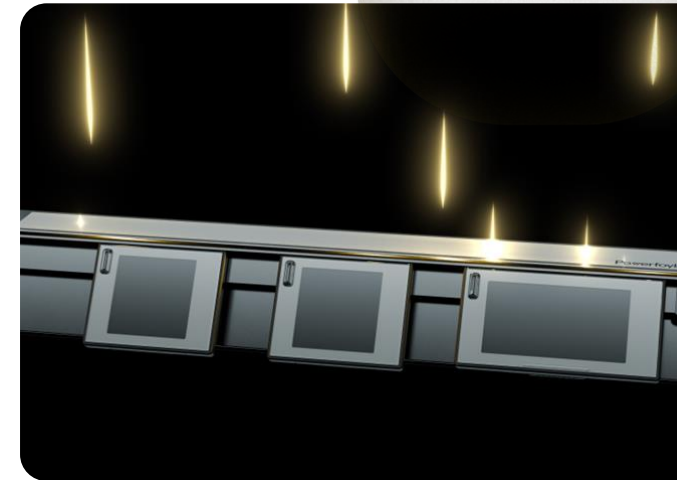
The Challenge: Rethinking Solar Cells for Indoor Use

Solar energy, heralded as the cleanest energy source, has been a cornerstone of sustainability since the 1950s. Originally designed for power production under direct sunlight, solar cells have been instrumental in large-scale applications like solar parks and rooftop installations, feeding power into the grid. Over a century of research has honed their efficiency for these purposes. However, integrating solar cells into retail environments presents unique challenges.

Retail settings differ significantly from the conditions solar cells were designed for. The light spectrum and intensity of in-store lighting vary greatly from natural sunlight, with in-store lighting ranging between 200 and 1500 lux compared to up to 120,000 lux in full sunlight. Additionally, technologies in retail must endure a demanding environment with frequent physical wear while any integration must not obstruct product displays, as preserving retail space is crucial.

Traditional small amorphous silicon (a-Si) solar cells, like those used in calculators, can theoretically generate enough power for indoor applications. However, in reality, these cells are fragile and need protective housings that block some light, especially from indirect angles, significantly reducing their power output. Additionally, the poor conductivity which requires these cells to be series connected renders them ineffective if any part is blocked from receiving light, posing challenges in real-world applications.

Despite these challenges, because of the promise of continuous and regenerative energy, solar cells have been tested for over a decade to power digital retail solutions, but no existing technology has fully met the stringent requirements. Innovations in light-harvesting technologies are crucial to bridging this gap, aiming to provide efficient sustainable energy solutions that align with the operational realities of modern retail.



Powerfoyle™: A light Harvesting Technology for Indoor Environments

Powerfoyle™, a newer technology that is invented, developed and manufactured by Exeger, overcomes all these limitations. Compared to a-Si cells, Powerfoyle is robust, generates more energy per surface area in indoor environments and can be seamlessly integrated. It has been invented and designed specifically to be durable and integrated into products for use in various environments, making it ideal for retail settings with indirect, diffuse light.

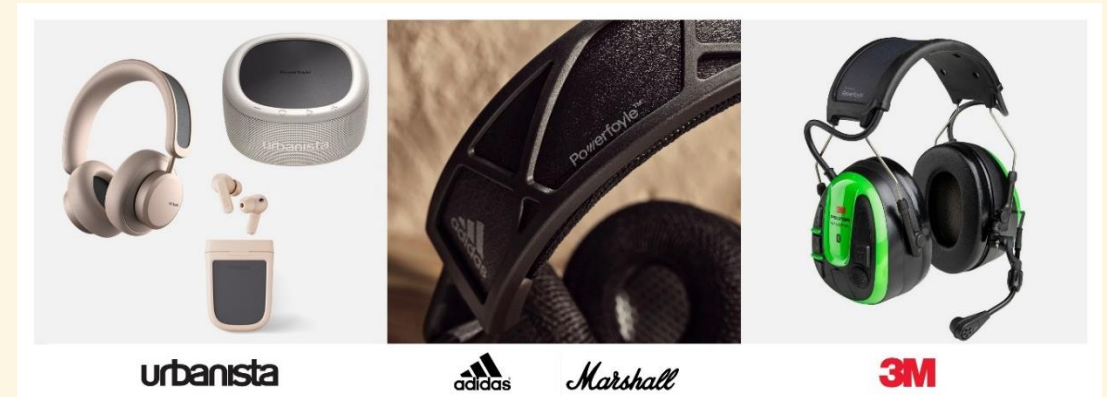
Powerfoyle is an advanced solar cell technology that builds on the principles of Dye-Sensitized Solar Cells (DSSCs), a breakthrough from the 1990s. DSSCs function like artificial photosynthesis, using a titanium dioxide layer covered with a light-absorbing dye. When light strikes the dye, it releases electrons into the titanium dioxide, generating an electric current. These electrons circulate through a circuit and return via an electrolyte solution, which refreshes the dye to sustain the process. DSSCs are particularly effective in low-light conditions, making them ideal for indoor applications.

Unlike conventional solar cells (including DSSC), which require silver lines to collect current which limit design flexibility, Powerfoyle uses a new electrode material with **1000 times better conductivity. This innovation allows for unprecedented design freedom in terms of size and shape.** Manufactured using screen printing, Powerfoyle can be tailored to various applications. In practice, this means that Powerfoyle is fully integrated, indistinguishable from the product itself.

The main components of Powerfoyle, including dyes and electrolytes, are developed in-house, ensuring optimal performance and quality.

The chemistry of Powerfoyle can be optimized to match different light spectra, with versions specifically designed for exceptional performance indoors and in mixed light environments. Issues that have plagued indoor solar cell technologies like deterioration from temperature and humidity variations as well as exposure to UV rays have been overcome with Powerfoyle. Raw materials are responsibly sourced and Powerfoyle is produced in Stockholm using 100% renewable energy with no toxic emissions.

Powerfoyle is already an established technology to power a range of use cases. The first product powered by Powerfoyle was launched in 2021 and there are currently 8 products available for sale globally with more announced.



Examples of products with Powerfoyle already on the market in other product categories

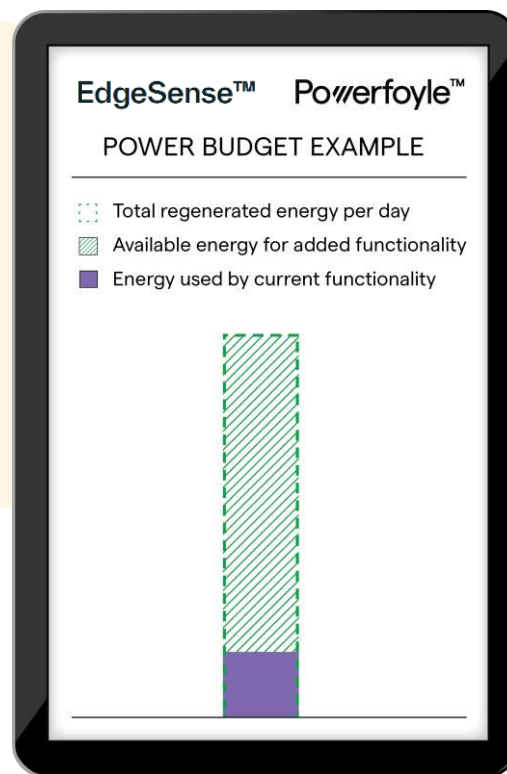
Enabling Virtually Unlimited Power: The Potential of Light Harvesting Technologies

What is a Power Budget?

The power budget refers to the total amount of electrical power available within a specific system and environment. It encompasses the energy allocated to power various devices and technologies, digital displays, sensors, and other IoT devices. Optimizing the power budget is essential for supporting necessary functionalities while minimizing energy consumption.

With an integrated power source, we can re-think how we approach energy usage. Instead of relying on stored, and gradually depleting, power in batteries, the continuous conversion of light into energy creates a regenerating power budget. The energy output of a solar cell is directly influenced by its size and the light intensity.

As functionalities are added, energy consumption increases. As long as energy generation exceeds consumption, battery life becomes perpetual—eliminating the need for conventional charging or battery replacements. In contrast, traditional batteries inevitably deplete their energy reserves over time, influenced by factors such as battery size and functionality demand.



Demonstration of available energy in a retail setting

Introducing EdgeSense™: A Giant Leap in Retail and Sustainability

EdgeSense™ is VusionGroup's latest innovation in retail, offering more than just the next generation of Electronic Shelf Labels (ESLs). It introduces the Digital Shelf System (DSS), a significant advancement for in-store IoT. At the shelf-edge, EdgeSense transforms physical stores by leveraging VusionOX—a Bluetooth-LE protocol—and proximity sensing to enhance automation and operational efficiency. Beyond dynamic pricing, EdgeSense serves as a fundamental element of a connected store, facilitating in-store fulfillment, and enabling new advanced use cases for retailers. With meticulous planogram adherence through precise product location data, combined with automated on-shelf monitoring, EdgeSense ensures consistent compliance. Moreover, it enhances the shopping experience with advanced geolocation and proximity sensing, offering personalized promotions and redefining the shopping journey through tailored device interactions.

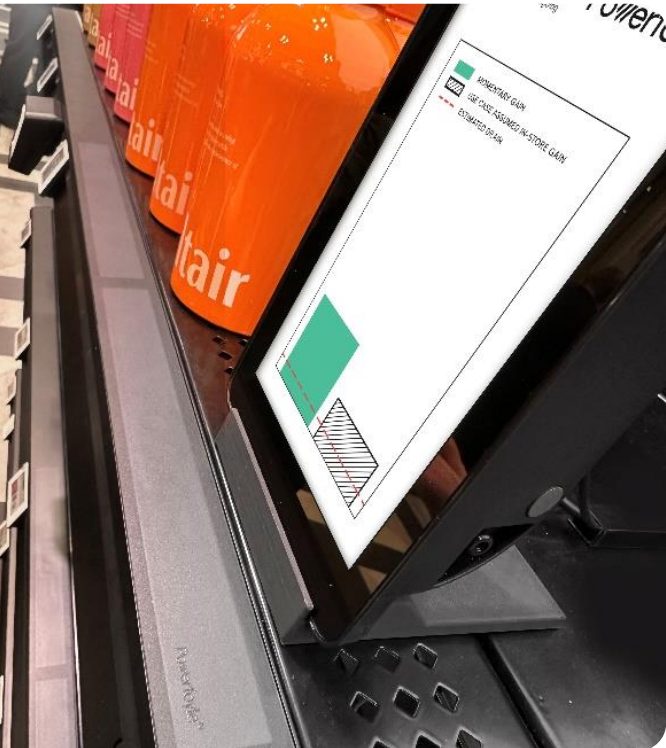
Sustainable by design, EdgeSense consolidates connectivity and power into a single rail, powering battery-less displays and eliminating the need for batteries for each individual label. A single EdgeSense rail can support up to 25 displays, reducing a retailer's digital system's carbon footprint by nearly 50% (based on the industry-average installation of seven displays per four-foot rail section), making a substantial impact, especially in large stores housing up to 120,000 items or entire retail chains.

In its standard form, EdgeSense enables retailers to benefit from a wide range of advanced use cases, suited for most store needs, from pricing automation to in-store fulfillment, all running on a single battery per rail. However, when more intensive use or additional sensing capabilities are required, enhancing the energy supply in EdgeSense rails can unlock additional business benefits.

Integrating Powerfoyle™ Unlocks Virtually Unlimited Power

By integrating the Powerfoyle technology, EdgeSense™ brings another giant leap in retail innovation and sustainability, combining the latest breakthrough for in-store IoT with a virtually endless source of energy. This joint solution embeds the Powerfoyle light harvesting technology, enabling retailers to envision more use cases for their Digital Shelf System investment, helping reduce the Total Cost of Ownership (TCO) while allowing them to pursue their sustainability targets.

Using the light already available in stores, Powerfoyle provides the EdgeSense platform with virtually endless energy, which in turn can power displays and other functionality with low-to-no battery maintenance.



It will save retailers money and time, and can help transform a store into a digitalized, connected market with a minimal carbon footprint. Initial assessments of an EdgeSense rail with Powerfoyle reveal that in 95% of store areas, the embedded light harvesting system could generate a similar amount of energy as 6 standard batteries during the rail lifetime. This allows for expanded use cases, as the increased power budget supports future-proof functionalities. Store staff also benefit from reduced maintenance requirements, as the light-powered system eliminates the need for battery replacements.

This continuous power generation enables retailers to reimagine smart shelving systems, adding functionalities up to the amount of energy generated. In typical installations, Powerfoyle generates up to six times more energy per rail than battery-powered systems, unlocking virtually endless energy.

EdgeSense with Powerfoyle showcased at NRF 2024

99

Light harvesting technologies are a game-changer for sustainable retail by utilizing existing in-store light to power digital tools, retailers can significantly reduce their environmental impact while reaping the huge benefits of a more connected and efficient store environment. I'm incredibly excited about the potential of light harvesting in retail which allows global retailers to achieve their sustainability goals without sacrificing operational excellence. It's a powerful testament to how innovation can drive sustainability whilst simultaneously creating a more connected and engaging retail experience".

Steve Lister, Founder, [SteveLister.com](https://www.stevelist.com)
Sustainability Consultant for Global Brands & Retailers

Exploiting such a power source from the Powerfoyle-equipped EdgeSense rails helps withstand a larger amount of smart shelf components, such as computer vision cameras for stock evaluation and sensors for air quality or inventory data collection. This reliable and always-available power source ensures that smart functionalities remain operational and adaptable to evolving market needs and innovations.

Picking the right hardware technology now, is paramount to prepare the next ten years of innovation in retail, and the collaboration between VusionGroup and Exeger has produced a solution that will pave the way for what's coming next.

EdgeSense™ x Powerfoyle™ benefits



Battery-less displays powered by single-battery rails



Long-lasting power with **Powerfoyle** indoor light harvesting



Low-to-no maintenance with rechargeable batteries

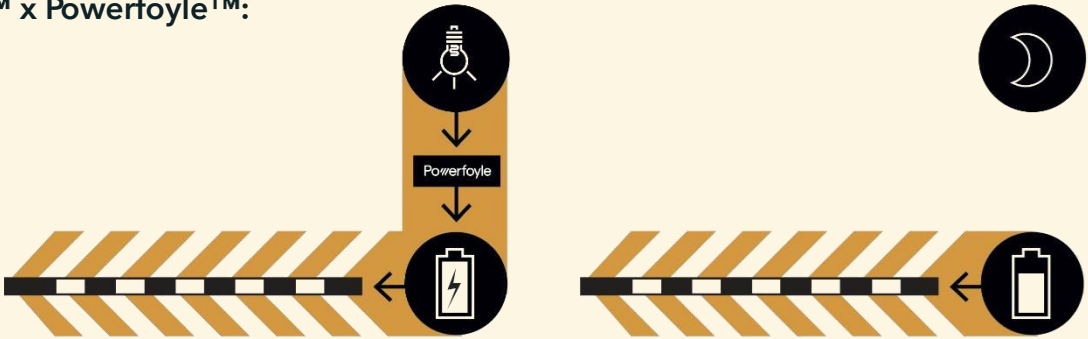


Reduced rail battery size and footprint



More functionalities with an increased power budget per shelf

EdgeSense™ x Powerfoyle™: how it works



Artificial light already present in stores reaches the Powerfoyle solar cell that is integrated into the EdgeSense rail. The solar cell converts that light into electricity for storage in the battery to power the rail. The battery is used as backup power during dark hours or when the solar cell is temporarily obstructed.

E-Commerce and Beyond: Harnessing Light Energy for Retail Advancements

The integration of light harvesting technologies such as Powerfoyle™ significantly enhances the power budget available to EdgeSense™, facilitating intensive use of advanced solutions like e-commerce fulfillment. Physical stores play a crucial role in achieving profitable and sustainable e-commerce operations by serving as efficient distribution hubs. By optimizing order fulfillment processes, reducing delivery times, and lowering carbon footprints, retailers can maximize the efficiency and sustainability of their e-commerce operations. Technologies like EdgeSense streamline in-store picking operations and enhance efficiency through automated pricing, precise product location, and seamless integration with existing ecosystems.

In the context of e-commerce fulfillment, the continuous energy generation provided by Powerfoyle allows EdgeSense to operate with virtually no battery maintenance. This increased power budget supports the intensive use of advanced functionalities such as improved inventory management, automated pick-to-light systems, and dynamic pricing updates, greatly benefiting associates by streamlining their daily routines. These capabilities are essential for efficient order fulfillment, ensuring that products are quickly and accurately picked and prepared for delivery, thus minimizing errors and reducing delivery times, ultimately enhancing the experience for consumers.

Moreover, the sustainable energy source aligns with the environmental goals of modern retail operations. The reduction in battery count and the reliance on renewable energy sources contribute to a lower overall carbon footprint, making the e-commerce fulfillment process not only more efficient but also more environmentally friendly.

By leveraging light harvesting technologies, retailers can unlock the full potential of their stores as e-commerce fulfillment centers. The enhanced power budget provided by Powerfoyle ensures that EdgeSense can support the intense and increasing demands for advanced e-commerce applications, facilitating a seamless, low-maintenance, and sustainable fulfillment process. This approach enables retailers to meet the growing demand for online shopping while maintaining operational efficiency and adhering to sustainability goals, thus driving both profitability and environmental responsibility.

Beyond e-commerce fulfillment, other advanced use cases for optimizing retail stores can benefit from a regenerating power budget, such as On-Shelf-Availability requiring computer vision cameras, weighing scales, or additional sensors. Integrating light harvesting technologies into in-store IoT devices ensures that retailers are not constrained by hardware design, allowing them to address both current and future challenges. By considering systems that eliminate power considerations, retailers can maximize the value of their investments and achieve significant business case wins, effectively tackling evolving operational demands.



Empowering a Decade of Retail Innovation and Sustainability

The former trade-off between the demand for advanced store functionalities and the need for environmental sustainability can now be addressed with new alternatives. VusionGroup and Exeger, have joined forces to create light-powered Digital Shelf Technologies. **EdgeSense™ with Powerfoyle™ makes store shelves smarter and greener.**

This ready-to-go solution supports the future of low-battery reliance, with sustainability at its core—from the Powerfoyle solar cell to efficient low-power components and recycled plastic. Beyond its eco-friendly design, EdgeSense with Powerfoyle unlocks enhanced functionality, enabling use cases such as improved inventory management, real-time pricing updates, food waste prevention and energy-efficient operations, with virtually no power constraints. Thanks to its capabilities and low carbon footprint, it is the responsible solution for today's needs and the flexible solution for tomorrow's environmentally conscious retail environment.

EdgeSense with Powerfoyle sets a new standard for retail digitalization, ensuring that stores are equipped with intelligent solutions sustainably powered for today's demands and the innovations of the next decade.





About VusionGroup

VusionGroup (ex- SES-imagotag) is the global leader in providing digitalization solutions for commerce, serving over 350 large retailer groups around the world in Europe, Asia and North America. The Group develops technologies that create a positive impact on society by enabling sustainable and human-centered commerce.

By leveraging its IoT & Data technologies, VusionGroup empowers retailers to re-imagine their physical stores into efficient, intelligent, connected, and data-driven assets. The Group unlocks higher economic performance, facilitates seamless collaboration across the value chain, enhances the shopping experience, creates better jobs, cultivates healthier communities, and significantly reduces waste and carbon emissions.

VusionGroup consist of six families of solutions which bring the full potential of IoT, Cloud, Data, and artificial intelligence (AI) technologies to the service of the modernization of commerce: SESimagotag (ESL & Digital Shelf Systems), VusionCloud, Captana (computer vision and artificial intelligence platform), Memory (data analytics), Engage (retail media and in-store advertising), and PDIdigital (logistics and industrial solutions).

VusionGroup supports the United Nations' Global Compact initiative and has received in 2023 the Platinum Sustainability Rating from EcoVadis, the world's reference of business sustainability ratings.

VusionGroup is listed in compartment A of Euronext™ Paris and is a member of the SBF120 Index. Ticker: VU – ISIN code: FR0010282822

www.vusion.com



About Exeger

Exeger is a Swedish company with a unique solar cell technology that converts all forms of light into electrical energy. This material, Powerfoyle, is the world's only fully customizable solar cell. With its superior design properties, it can be integrated seamlessly into any electronic device.

Powerfoyle enhances every product it is integrated into with extended or even unlimited battery life, putting the power of cutting-edge solar cell technology directly in the hands of people. Exeger is leading the way to energy independence through more sustainable and user-friendly products – with the vision to touch the lives of a billion people by 2030.

www.exeger.com