How Patient-Friendly Wireless Charging Drives Business Growth

A business case comparing the financial and market implications of patient-friendly wireless charging versus conventional solutions

Executive Summary

This business case compares the financial and market implications of designing implantable medical devices with patient-friendly wireless charging versus conventional wireless charging or non-rechargeable batteries. Key considerations include development costs, reimbursement strategies, total cost of ownership, patient and physician preferences, and market adoption potential. Evidence indicates that rechargeable devices with patient-friendly wireless charging offer substantially better return on investment from long-term cost savings, increased patient adoption, and higher revenue potential.

Types of Devices and Technologies Compared

This business case considers two types of battery-powered active implantable medical devices: primary cell and rechargeable. Primary cell implantable medical devices, such as traditional pacemakers, rely on non-rechargeable batteries to function and require surgical intervention to replace depleted batteries. Rechargeable implantable medical devices like many spinal cord stimulators, cochlear implants, and other types of devices, use wireless power transfer to recharge, avoiding additional surgeries for battery replacement. For these devices, patients use external chargers to recharge

devices inside their bodies. Different types of wireless charging affect device capabilities, cost, and appeal to patients and clinicians, which this business case also dives into. We'll outline the pros and cons of making devices rechargeable, as well as how the type of recharging technology used—next generation, patient-friendly recharging or conventional wireless recharging—affects patient adoption, outcomes, and overall device success.

Glossary

Term	Definition
Active implantable medical device	A medical device surgically placed within the body, powered electrically to perform therapeutic functions.
Non-rechargeable (primary cell) active implantable medical device	An implantable device powered by a battery that cannot be recharged and requires replacement after depletion.
Rechargeable active implantable medical device	An implantable medical device that includes a battery capable of repeated recharging without replacement.
Battery replacement surgery	A surgical procedure required to remove and replace depleted batteries in implantable medical devices.
Driveline	An external cable or wire penetrating the skin, connecting an internal medical device to external power or control systems.
Conventional wireless technology	Traditional wireless power systems with limited efficiency, typically requiring precise alignment and short range.
Advanced, patient-friendly wireless technology	Wireless power systems designed for ease of use, offering greater flexibility, comfort, and efficient energy transfer without precise alignment constraints.

Table of Contents

Executive Summary 1

Types of Devices and Technologies Compared 1

Glossary 2

Background 5

Medical Device Power Limitations 6

How Power Affects Device Capabilities, Selection, and Cost 7

- Enhanced Capabilities Recharging Enables 7
- Clinician and Patient Preference for Rechargeable Devices 8
  - Reasons for Patient Preference 9
  - Considerations for Specific Populations 10
  - Clinician Preferences for Rechargeable Devices 11
  - Reasons for Clinician Preference 12
  - Preferences for Advanced Implantable Technologies 14
- The Economic Advantages of Rechargeable Devices 15
  - How Rechargeable Devices Reduce Costs 15
  - Rechargeable Medical Device Impact on Margins 17

How Wireless Charging Increases Market Share 18

- Charging More for Rechargeable Devices 18
- New Devices and Treatments Wireless Charging Enables 19

Demand for Patient-Friendly Wireless Charging 21

- Traditional Wireless Charging vs. Advanced Wireless Charging 21
  - Advantages of Advanced Wireless Charging 22

Table of Contents Contd.

Impact of Wireless Charging on Outpatient Care and Patient Burden 23

Considerations for Life-Sustaining and Non-Life-Sustaining Devices 25

How Recharging Affects Hospital Costs and Reimbursement 28

Impact on Hospital Revenue and Reimbursement 28

Procedure-Specific Considerations 29

The Trend Toward Value-Based Care 30

Hospitals and Health Systems Implementing Value-Based Care 30

Value-Based Care Saves Hospitals Money 31

Conclusion: Unlock Your Device's Potential 32

Background

When looking at how advancements in medical device power can accelerate device adoption and advance new therapies, it's important to first understand current limitations with power and energy for medical devices. Active implantable medical devices are devices that go inside the body to monitor, diagnose, or treat health conditions and require reliable power to function. Today, most active implantable devices are limited by the size of the battery that goes inside them, or the power source needed to get power from outside of the body safely inside the body. Active implantable medical devices offer several benefits compared to other treatment options like pharmaceuticals, including more precise and effective treatment, fewer side effects, reduced medication dependency, remote monitoring capabilities, and improved quality of life for device users. But delivering on the promise of these benefits requires rethinking how implantable devices are powered.

As the need for more affordable and accessible healthcare grows, active implantable medical devices hold the promise of enabling better care in remote, in-home, and outpatient settings vs. inpatient settings like hospitals alone. However, active implantable devices are limited by the reliability and longevity of their power source. Implanted batteries and how they're replenished dictate how long devices can be used, for what purpose, and for whom. Patient and clinician preference, along with the availability of other treatment options, dictate whether the device's benefits are worth the tradeoffs of having to replenish device power, and affect how many people use a device. For medical device companies, striking the right balance of usability, accessibility, and effectiveness is imperative.

Implanted batteries — and how they're replenished — dictate how long devices can be used, for what purpose, and for whom.

Medical Device Power Has Limited Innovation and Adoption

Traditionally, there have been three ways to get power inside the body to replenish depleted batteries. Medical devices with non-rechargeable primary cell batteries necessitate surgical replacement upon depletion, typically every 3-5 years. Other devices requiring more power, like ventricular assist devices, are powered by cords called drivelines that connect to external battery packs through a hole in the abdomen. Drivelines are associated with dangerous and costly infections which can ultimately lead to death.

Rechargeable devices have batteries that users recharge wirelessly using an external charger; however, many of these devices have significant limitations too. Traditional wireless charging has precise alignment requirements so patients have to sit or lay still for hours at a time to charge. User frustration leads to non-compliance and limits the willingness of clinicians, patients, and device designers to opt for some rechargeable solutions.

Think of a cell phone placed on a wireless charging pad. If it's not placed in a specific spot, charging doesn't start, or is interrupted if the phone is moved, even slightly. The same issue exists with medical device charging. Difficulty aligning the external charger over the implanted device leads to user frustration and non-compliance, negating the benefits of using the device. Patient-friendly wireless charging solves this problem, ensuring people can rapidly recharge their implanted devices during regular activities without compromising quality of life. The challenge has been the availability and cost-effectiveness of patient-friendly wireless charging, which, until the last decade, was prohibitive.

Today, advancements in wireless power transfer and rechargeable battery technologies have enabled the development of patient-friendly rechargeable implantable devices, eliminating the need for frequent battery replacement surgeries, drivelines, and slow, cumbersome recharging. The choice between these technologies affects the revenue potential of active implantable devices. In the following sections, we'll compare the business value of different types of implantable power, looking at development and manufacturing costs, total cost of ownership, reimbursement strategies, and how power affects patient adoption and satisfaction.

How Power Affects Device Capabilities, Selection, and Cost

The first consideration in comparing the business value of different types of implantable device power is how power affects device capabilities, patient and clinician preference, and cost. We'll break down the differences in the following sections.

Recharging Enables More Capable Devices

Rechargeable implantable medical devices have additional capabilities that are not possible with non-rechargeable implantable devices. These include:

Smaller Device Size: Devices are more compact and comfortable due to smaller batteries and power system components. This reduces the size of the area that needs to be created to place the device, decreasing infection risk and device visibility.

Higher Power Delivery: Rechargeability enables advanced features in implantable devices without increasing their size or compromising safety. It allows devices to support enhanced data processing, personalized treatment algorithms, and detailed monitoring of patient health, providing clinicians deeper insights and improved treatment effectiveness. While non-rechargeable devices offer basic remote monitoring capabilities, their power limitations restrict the complexity and frequency of data collected. Rechargeable devices overcome these limitations, delivering the increased power necessary for the smarter, more sophisticated functionality that modern medical devices require.

Enhanced Patient Safety: Recharging minimizes surgical risk, infection potential, and mechanical wear through wireless charging technology which minimizes the need for frequent battery replacement or extraction surgeries.

Greater Device Longevity: Optimized power management and fewer battery cycles extend device lifespan significantly.

Scalable Technology: Recharging makes it possible to build in future upgrades and high-performance features for devices without compromising device design. Using wireless power and communications supports delivering long-term clinical and technological advancements without surgical interventions to upgrade devices.

Why Clinicians and Patients Prefer Rechargeable Devices

70.3%

of patients switching from non-rechargeable to rechargeable preferred the rechargeable option

87.3%

of DBS patients with rechargeable devices reported satisfaction with their devices

Studies indicate that many patients and clinicians prefer rechargeable implantable medical devices despite the need for regular recharging, valuing the long-term benefits over the convenience of non-rechargeable, "set-it-and-forget-it" devices. For example:

- In a study involving patients with deep brain stimulation (DBS) devices, 87.3% of those with rechargeable implantable pulse generators reported satisfaction with their devices. Notably, among patients who transitioned from non-rechargeable to rechargeable devices, 70.3% expressed a preference for the rechargeable option.

- Another study focusing on patients with hyperkinetic movement disorders found that 76% chose rechargeable devices, with 71.4% managing recharging independently. Only 11% experienced difficulties with the recharging process, suggesting that most patients adapt well to the routine.

- Research involving Parkinson's disease patients revealed that 71.4% of those with rechargeable devices were confident in managing recharging, with a mean recharge interval of 4.3 days. Most patients spent about an hour recharging and preferred to do so when the battery level was above 50%.

Reasons for Patient Preference

More Comfortable and Less Visible Devices: Rechargeable devices often have a smaller profile, which patients prefer for several reasons such as being able to hide device use when desired and reducing pain at the implant site, which a sacral neuromodulation study showed affected 5x more people for non-rechargeable implants vs. rechargeable.

Device Longevity and Avoidance of Replacement Surgeries: For life-sustaining devices like pacemakers and ICDs, a study showed the “vast majority of patients prefer a larger device to reduce the number of potential replacement operations...This preference crosses the spectrum of those with a previously implanted device, those undergoing initial implants, those returning for routine follow-up, and patients of various ages, gender, and habitus.”

Rechargeable devices have longer lifespans, reducing the need for surgical replacements and enabling smaller devices, so patients don’t have to choose. In this study, the benefit of longer lasting devices and fewer battery replacements was paramount for patients, more so even than device size.

Economic Considerations: While the initial cost of rechargeable devices may be higher due to higher rechargeable battery costs, the reduced need for both battery replacements and follow-up office visits can lead to cost savings over time, influencing patient choice.

Considerations for Specific Populations

Despite the general preference for rechargeable devices, certain patient groups may favor non-rechargeable options due to specific needs:

- **Elderly Patients:** Older individuals or those with cognitive impairments may find the recharging process challenging. This suggests there's value in offering rechargeable and non-rechargeable options for some devices, and that devices would benefit from more patient-friendly recharging that can be used by a more diverse patient population.

- **Patients with Limited Dexterity:** Individuals with physical limitations may struggle with the handling required for recharging.

- **Desire for Minimal Maintenance:** Some patients prioritize a device that requires the least amount of daily attention, even if it means more frequent surgical interventions. While daily intervention is undesirable, evidence supports weekly or monthly in-home recharging, or outpatient visits, as an ideal frequency and setting for recharging to maximize patient compliance while limiting maintenance needs.

While non-rechargeable devices offer the convenience of minimal maintenance between replacement surgeries, many patients prefer rechargeable implantable medical devices due to their longer lifespan, reduced need for surgical replacements, and overall satisfaction with device performance.

Additionally, many rechargeable devices can be adjusted remotely if needed, eliminating the need for follow-up visits, which is another key aspect of device maintenance.

This preference for rechargeable devices is even stronger when patient-friendly recharging technology is used, which we'll dive into later in this business case, because of people's ability to seamlessly integrate recharging into their daily life, as opposed to scheduling their lives around recharging needs. Clinicians, likewise, prefer rechargeable implants for similar reasons.

Clinician Preferences for Rechargeable Devices

Clinicians increasingly prefer rechargeable implantable medical devices, recognizing their long-term benefits despite the need for regular recharging. This preference is evident in various specialties, including neuromodulation therapies like spinal cord stimulation (SCS) and deep brain stimulation (DBS).

- **Spinal Cord Stimulation (SCS):** A survey involving nearly 200 practitioners revealed that 67.2% "often or always" use rechargeable systems. This trend is attributed to the compatibility of rechargeable devices with advanced stimulation modalities and their extended battery life, reducing the need for replacement surgeries.

- **Deep Brain Stimulation (DBS):** Clinicians have observed that rechargeable implantable pulse generators (IPGs) offer longer device longevity and reduce the frequency of surgical interventions. This not only benefits patients by minimizing surgical risks but also aligns with healthcare goals of reducing overall treatment costs.

- **Sacral Neuromodulation:** Clinicians in urology and pelvic floor disorders have also noted advantages of rechargeable devices in sacral neuromodulation therapies. Rechargeable systems are smaller, leading to better cosmetic outcomes and reduced pain at the implant site, which research shows is significantly greater for non-rechargeable implants. Additionally, the extended battery life reduces the need for replacement surgeries, which is a significant consideration for both patients and healthcare providers.

- **Cardiac Implantable Electronic Devices (CIEDs):** In cardiology, while rechargeable options are less common, there is a growing interest in developing rechargeable cardiac devices to minimize the risks and costs associated with battery replacement surgeries while also increasing device longevity. Clinicians recognize that longer-lasting devices can improve patient outcomes and reduce the burden on healthcare systems, and patients strongly prefer longer lasting devices.

Reasons for Clinician Preference

Enhanced Patient Satisfaction: Patients often report higher satisfaction with rechargeable devices due to fewer surgeries, cosmetic advantages of smaller implants, less pain from their device, and the autonomy provided by self-managed recharging routines.

Improved Patient Outcomes: Studies indicate that rechargeable implantable medical devices can deliver more effective treatment outcomes compared to non-rechargeable counterparts in certain applications. For example, research on rechargeable SCS devices suggests improved long-term treatment effectiveness compared to non-rechargeable systems through reductions in pain diagnoses, hospitalizations, physician visits, and pain medication usage over time. A study of DBS for Parkinson's disease reported that 87.7% of patients with rechargeable implantable pulse generators were satisfied with the stimulation effects.

Cost-Effectiveness: Over time, rechargeable devices can be more economical by reducing the cumulative costs of multiple surgeries, hospital stays, and follow-up doctor’s office visits. While some reimbursement models favor these repeated surgeries and follow-up visits, clinicians’ preferences have increasingly shifted toward rechargeable devices that don’t require as much intervention. For example, a study analyzing sacral neuromodulation devices found that over a 15-year period, rechargeable systems were associated with a cost savings of $27,121 per patient compared to non-rechargeable systems. With the growth of

value-based care reimbursement, the shift to recommending rechargeable devices is likely only going to continue.

Reduced Surgical Interventions: Rechargeable devices typically have longer battery life, decreasing the need for replacement surgeries and associated risks. Battery replacement surgeries, though generally considered minor, carry risks such as infection and wound healing issues that clinicians seek to avoid. A study on deep brain stimulation (DBS) highlighted that multiple implantable pulse generator (IPG) replacements over a patient's treatment course can increase health risks, including elevated post-implantation infection rates and wound healing problems. This has led more clinicians to favor rechargeable options.

Across various medical fields, clinicians are increasingly valuing the benefits of rechargeable implantable devices, such as reduced surgical interventions, improved patient satisfaction, better patient outcomes, and long-term cost-effectiveness. While the need for regular recharging is a consideration, the overall advantages make rechargeable devices a preferred choice in many clinical scenarios.

Preferences for Advanced Implantable Technologies

In addition to the above, rechargeable devices allow for the latest in advanced implantable technologies, not just at the time of implantation, but also through remote upgrades. This aligns with clinician and patient preferences for:

- **Prioritization of Safety and Effectiveness:** A study involving patients, physicians, and hospital administrators found that “respondents were willing to pay the highest for medical devices that provided improvements in clinical safety, followed by increased clinical effectiveness, technology for treating severe diseases, improved implement capacity, and innovative technology (without substitutes).”

- **Demand for Post-Procedural Information:** Research shows that both clinicians and patients want comprehensive post-procedural information about their implanted devices, including long-term tracking and the ability to be notified of potential device issues. The remote monitoring and accessibility of rechargeable devices is advantageous and tends to require more power and advanced technological capabilities than most primary cell devices have, although some smarter primary cell devices do exist.

In summary, clinicians and patients are inclined toward implantable medical devices that incorporate the latest technological advancements, especially when such features contribute to improved safety, effectiveness, and user convenience. That means rechargeable devices that don’t require replacements to be upgraded are ideal. Designing devices that align with these preferences can enhance patient satisfaction and adherence to treatment regimens.

The Economic Advantages of Rechargeable Devices

Rechargeable implantable devices have a lower total cost of ownership than non-rechargeable implantable devices because they eliminate or reduce both battery replacement surgeries and clinical visits to monitor battery health, patient outcomes, and device performance. This significantly reduces ongoing healthcare costs for hospitals and patient support costs for medical device manufacturers.

Although initial design and development expenses for rechargeable devices might be slightly higher, these upfront costs are quickly offset by savings in patient care, device support, and device maintenance over the device's lifetime. Additionally, the growth of value-based care reimbursement models favors rechargeable devices because of their reduced patient and healthcare system burden. Consequently, rechargeable devices deliver substantial long-term economic benefits to patients, device manufacturers, providers, and healthcare systems.

How Rechargeable Devices Reduce Costs

Increased Device Longevity: Rechargeable spinal cord stimulators, as one example of an implantable device with both non-rechargeable and rechargeable options, have demonstrated 2x longer lifespans than non-rechargeable stimulators.

Lower Total Cost of Ownership: Studies have shown that rechargeable systems can result in an average savings of almost $64,000 per patient over their lifetime by minimizing replacement surgeries, patient support, and clinical follow-ups. This is a 43% reduction in costs compared to non-rechargeable systems and when paired with higher initial sales prices, means rechargeable devices command higher margins than non-rechargeable devices.

Better Utilization of Hospital Resources to Increase Profits: Rechargeable devices can significantly decrease the number of surgeries required for battery replacements, leading to potential savings of $14,275 per patient. While these surgeries also generate revenue for hospitals, medical device manufacturers and hospitals often experience lower revenue from sales of replacement devices, so hospitals can be incentivized to perform fewer replacement surgeries in favor of procedures that generate higher revenue. Additionally, fewer instances of surgical complications from fewer overall surgeries leads to reduced unplanned healthcare expenses, like hospital readmissions or emergency care, which typically aren't significant revenue generators.

Remote Management and Reduced Clinical Support: Rechargeable implantable devices can reduce patient maintenance and healthcare interactions, creating opportunities to allocate resources to new patients, because devices can be easily recharged in outpatient or home settings and clinicians can get access to more system data remotely. This reduces the need for frequent clinical visits to monitor battery health and device performance.

In contrast, depending on their capabilities, non-rechargeable devices can require more frequent check-ups and clinical monitoring to validate device effectiveness, fine-tune treatment parameters, and accurately predict end-of-life battery depletion, ensuring patient safety and device reliability. Thus, rechargeable technology can simplify device management, reduce patient burden, and decrease routine medical care, which

typically commands less revenue and incurs higher costs when compared to other sources of revenue, such as new patient visits.

Less Waste and Improved Sustainability: Rechargeable medical devices reduce battery waste, aligning with global sustainability goals and influencing device preferences among hospitals, clinicians, and patients. Growing awareness of medical waste impacts, combined with advocacy from healthcare institutions and professional societies, is increasing clinician support for more sustainable care. Although patient safety and clinical outcomes remain paramount, clinicians increasingly see sustainability as essential to responsible healthcare.

Rechargeable Medical Devices Command Higher Margins

Medical device manufacturers incur additional indirect costs from medical device support. Support costs vary widely; however, rechargeable medical devices often have the advantage of requiring far less ongoing patient support which, when paired with the higher sales prices rechargeable devices command, means rechargeable medical devices can be more profitable for medical device companies.

These additional costs typically include clinical support and staffing costs, administrative costs to coordinate and manage patient follow ups, additional device monitoring and diagnostic equipment costs, particularly when those capabilities aren't built into the device itself, and technical support costs such as call centers and/or remote patient monitoring support. Some of this post-implantation support is still needed for rechargeable devices, however, the overall burden of support for medical device manufacturers is much lower for rechargeable implantable devices vs. non-rechargeable devices.

While they do not eliminate all of these costs, rechargeable medical devices reduce these costs significantly by minimizing clinical interactions, enhancing operational efficiency (via enhanced remote capabilities, as one example), and supporting a more sustainable business model.

How Wireless Charging Increases Market Share

Rechargeable implantable devices offer a competitive advantage by increasing clinician preference and patient adoption, and reducing costs. To look holistically at how rechargeable implantables affect medical device manufacturers' business, however, their impact on device sales and overall market share must also be considered.

Because more clinicians and patients prefer rechargeable devices, medical device manufacturers can charge more for rechargeable implantables than non-rechargeable implantables. Health insurers also increasingly favor rechargeable devices due to long-term cost reductions and improved patient outcomes, which means medical device manufacturers can expect similar or greater reimbursement, and hospital and clinician preference for rechargeables to continue.

In addition, companies adopting advanced, patient-friendly wireless charging technology can further differentiate themselves, capturing increased market share and higher revenue through new patient segments, increased hospital network penetration, and enhanced brand reputation.

When looking at how wireless charging drives business growth, there are three situations to consider: 1) devices that could be primary cell or rechargeable, 2) devices and their corresponding treatments that would not be possible without wireless charging, and 3) devices that are currently rechargeable but are limited in patient usability and effectiveness, slowing adoption.

Device Makers Can Charge More for Rechargeables

Rechargeable implantable medical devices often have a significantly higher average sales price when compared to their non-rechargeable counterparts. For example, the average sales price for rechargeable SCS devices is approximately $36,300, whereas non-rechargeable devices average $18,700. This represents a price difference of about 94%.

Advanced Wireless Charging Makes New Devices and Treatments Possible

Wireless charging drives business growth by making new devices possible that wouldn't be otherwise, due to the limitations of primary cell batteries such as their large size and limited power delivery. Below are examples of implantable medical devices whose functionality would be impractical or impossible without wireless charging, due to size constraints, power needs, sensitive implantation sites, and more.

1. **Abbott Eterna™ Spinal Cord Stimulation (SCS) System:** This small rechargeable device provides long-term pain relief without the need for multiple surgeries for battery replacement. Without wireless charging, the device's market share would likely be lower due to patient preference for recharging and the heavy marketing emphasis on the device's small size as an advantage for both clinicians performing the implantation procedure and patients using the device. Abbott introduced the Eterna SCS system in 2023, highlighting it as the smallest implantable, rechargeable SCS system on the market, featuring their proprietary BurstDR stimulation technology. Abbott's neuromodulation segment, which includes SCS devices, experienced almost 19% year over year growth in 2023, attributed largely to innovative technologies like Eterna™.

2. **Nevro's Senza Spinal Cord Stimulator:** As a rechargeable device, Senza enables high-frequency, adaptive therapy that responds to an individual's pain needs and would not be feasible with a primary cell device due to rapid battery depletion. Nevro started selling their Senza SCS system commercially in Europe in 2010, followed by Australia in 2011, and the United States in 2015. In the less than ten years since launching in the U.S., Nevro grew its market share to 16.4% of the total spinal cord stimulator market, the largest of all neuromodulation therapies comprising $6 billion in total. This rapid growth contributed to the company's competitive position in the market and led Globus Medical to acquire Nevro in early 2025, stating its intent to

“accelerate Nevro's technology adoption, allowing for faster market penetration”. This growth wouldn’t be possible without wireless charging and to see continued growth, Nevro has shared that clinicians and patients want wireless charging that’s easier to use, to ensure compliance and that patients get the benefit of pain relief.

3. **Cochlear Implants:** Cochlear implant (CI) manufacturers embraced recharging early on with Advanced Bionics introducing the first rechargeable CI in 2007 and Cochlear Limited following soon after. For fully implanted cochlear implants, rechargeability allows users to maintain auditory function without repeated surgeries to replace batteries, making these devices particularly appealing to younger and active patients. For wearable cochlear implants, rechargeable batteries remove the need for disposable batteries, easing maintenance for users with limited dexterity and reducing both total cost of ownership and environmental waste.

   Cochlear Limited, as the market leader, has leveraged its rechargeable solutions to increase market penetration. Despite these advances, the effectiveness of cochlear implants currently lags behind other implantable devices like brain-computer interfaces, which use thousands of electrodes capable of both recording and stimulation, secure wireless communication, and batteries lasting up to 20 years to ensure they’re both highly effective and usable (De Wachter et al., 2020; Luan et al., 2020). As cochlear implants have reached a performance plateau, continued advancement in wireless power and communications technologies is essential for improving their effectiveness in restoring hearing loss.

4. **Brain-Computer Interfaces and Neural Implants:** Paradromics’ Brain-Computer Interface (BCI) is an example of an implantable medical device that depends on wireless power. The BCI was developed to facilitate high-bandwidth communication between the brain and external devices, aiding individuals with neurological conditions. It wouldn’t be possible with a primary cell battery because of the high power demands from continuous, 24/7 use of the device and the high data processing capabilities needed. For other

Brain-Computer Interfaces and neural implants, wireless power is essential to enable device miniaturization and ensure safety. Cranial and neural implants must be tiny to fit into the skull or be implanted in the brain and brain tissue is highly sensitive to temperature rise. Therefore, for increased power needs, to enable tiny implants, and to ensure patient safety, wireless power is essential.

Demand is High for Patient-Friendly Wireless Charging

Beyond the ability for medical device companies to make and commercialize new devices that weren't previously possible without wireless charging, advancements in wireless power technology are enabling medical device companies to develop more capable and patient-friendly devices. Given the high demand for easy-to-use and effective devices, integrating advanced wireless charging capabilities into their device strengthens a company's advantages over other similar devices and can accelerate patient adoption even more.

Traditional Wireless Charging vs. Advanced Wireless Charging

We already looked at the reasons many clinicians and patients prefer rechargeable implantable medical devices. Now, we'll dive into what type of recharging they want. Evidence suggests that a weekly recharge frequency for in-home managed implantable medical devices or a quarterly recharge frequency for implantables recharged in outpatient settings strikes an effective balance between minimizing maintenance needs and promoting user compliance and safety. In addition, we know that strong preferences exist for smaller, less visible, and more comfortable rechargeable medical devices. More efficient wireless charging enables this by safely delivering the same power as traditional wireless charging in a significantly smaller implant.

Advantages of Advanced Wireless Charging

Traditional wireless charging methods for implantable devices often face limitations such as slow charging speeds, more frequent recharging requirements, and limited alignment tolerance, which can affect patient compliance and device performance. In addition, limited charge range affects where in the body and into which body types rechargeable devices can be implanted, meaning not everyone who meets all other eligibility requirements is eligible for each device.

The solution is advanced, patient-friendly wireless charging with capabilities including:

- **Rapid Charging:** The best wireless charging is so fast and seamless that it fits into people's lives without requiring lifestyle changes.
- **Reliable, Uninterrupted Charging Over a Large Range:** As opposed to conventional wireless charging, which requires precise alignment of external chargers over implants, patient friendly wireless charging involves seamless and reliable power transfer as patients go through their regular activities. When charging systems can quickly adapt to user movement and offer a larger charge range, it means people don't have to sit or lie still for hours to recharge implants, a significant source of frustration and non-compliance today.
- **Power That Enables More Capable Implants:** Patient-friendly wireless charging means power that enhances, rather than restricts, implantable device capabilities. For example, focal treatment necessitates miniaturized implants, which depend on compact, high-power-density systems.
- **Higher Efficiency and Safety:** Increased power transfer efficiency minimizes heat generation and energy loss, enhancing device safety and longevity. This means rechargeable implants can be located in higher sensitivity areas of the body, can be more powerful, and last longer.

- **Scalability Across Active Implantables:** Patient-friendly wireless charging enables scalable devices that are able to be upgraded without surgical intervention, and gives medical device companies one universal power platform for their portfolio of devices that clinicians and patients can use across applications. This reduces the complexity of device design, development, and commercialization, as well as simplifies clinician and patient education, while meeting clinician and patient needs for scalability and compatibility.

By addressing the shortcomings of traditional wireless charging, advanced patient-friendly wireless charging technology ensures that the benefits of rechargeable implantable medical devices are fully realized, thereby supporting greater market adoption.

Advanced Wireless Charging Enables More Outpatient Care, Increasing Medical Device Company and Hospital Margins while Reducing Patient Burden

The adoption of rechargeable implantable medical devices (AIMDs) is transforming patient care by offering flexible recharging options that align with diverse lifestyles and clinical needs. Patients can recharge these devices at home on a weekly or monthly basis or at an outpatient center as infrequently as quarterly, reducing the need for hospital stays traditionally associated with battery replacements. Advanced, patient-friendly wireless charging is crucial to accelerating the shift to outpatient care, enhancing medical device manufacturers' and hospitals' profitability, and reducing patient burden due to several key factors:

1. Improved Patient Compliance and Independence

- **Ease of Use:** Advanced, patient-friendly wireless charging eliminates complex alignment and positioning requirements, enabling patients to easily recharge at home or in outpatient facilities.

- **Reduced Anxiety:** Patient-friendly charging minimizes user error, reducing anxiety and boosting compliance, which encourages clinicians to confidently recommend outpatient recharging strategies.

2. Enhanced Clinical Confidence and Safety

- **Reliable Recharging:** Advanced wireless power systems offer consistent power delivery with real-time monitoring, enabling clinicians to safely transition traditionally inpatient recharging tasks to outpatient settings.

- **Tailored Clinical Oversight:** For life-critical implants (e.g., pacemakers, ventricular assist devices), clinicians can confidently offer supervised outpatient recharging sessions, ensuring safety without lengthy inpatient stays.

3. Increased Revenue and Margins

- **Patient Population Growth:** Shifting to recharging at home or in outpatient settings frees up inpatient resources to perform more implantation procedures, growing the number of people benefiting from treatments and attracting new patients to hospitals.

- **Improved Efficiency:** Shifting to outpatient procedures reduces hospital resource demands, overhead, and length-of-stay expenses, improving profitability margins.

- **Scalable Care Models:** Outpatient models are scalable, allowing providers to

serve more patients efficiently, optimizing facility utilization, and expanding high-value procedures.

4. Enhanced Patient Outcomes and Quality of Life

- **Broader Access to Care:** Outpatient and in-home care, like recharging in this case, is often more accessible to many who don't live near inpatient facilities. Advanced wireless charging provides patients options to recharge at convenient intervals, integrating easily into daily routines or brief clinic visits near where they live or can be.

- **Reduced Complications:** Outpatient care limits hospital-acquired infections, decreasing clinical complications and the associated costs.

Advanced, patient-friendly wireless charging empowers clinicians and healthcare providers to safely and effectively move recharging processes from hospital-centric care toward flexible outpatient or at-home models. By combining reliability, safety, and ease of use, these technologies enable profitable outpatient procedures, optimize healthcare resources, and substantially elevate patient experience and clinical outcomes.

Considerations for Life-Sustaining and Non-Life-Sustaining Devices

For life-sustaining devices like pacemakers, clinicians often prefer controlled recharging processes to ensure patient safety. While inpatient battery replacement procedures are effective, they involve higher risks, increased costs, and greater resource utilization. Transitioning recharging sessions to outpatient settings offers substantial benefits, including reduced patient stress, lower infection risks, shorter recovery times, and significant cost savings for healthcare systems.

Advanced, patient-friendly wireless charging technologies further enhance these benefits by providing healthcare providers with greater flexibility. Clinicians can supervise recharging sessions at outpatient clinics, maintaining necessary oversight for critical implants, while patients with less critical devices can manage recharging at home, integrating seamlessly into their daily routines.

Real-World Examples:

- **BIOTRONIK's Implantable Cardioverter-Defibrillator (ICD):** A study of patients with a BIOTRONIK ICD showed that "as many as half of the regular scheduled visits may have been skipped, without impairing patient safety" due to advancements in wireless and remote monitoring capabilities, which have only improved even more since the study was conducted.

- **ReliantHeart's HeartAssist5:** This ventricular assist device (VAD) incorporates remote monitoring capabilities, enabling clinicians to oversee device performance without requiring patients to be hospitalized. Such innovations support the shift toward outpatient care and continuous patient monitoring.

- **Impulse Dynamics' Optimizer Integra CCM-D:** The integration of rechargeable technology in life-sustaining devices like the Optimizer Integra CCM-D suggests a move towards more patient-friendly solutions that could facilitate outpatient or in-home care management and reduce hospital visits. The Optimizer Integra CCM-D is a rechargeable device designed to treat the 85% of people with heart failure who are not candidates for cardiac resynchronization therapy (CRT) without the complications of frequent battery replacement surgeries. As Cleveland Clinic Dr. Niraj Varma says "The idea is...that battery life can be extended significantly. This saves battery changes, which is costly not only from a health care resource point of view, but also patient risk since surgeries for battery changes are associated with infection, extraction and all kinds of problems. So the fewer battery changes a patient receives the better."

Real-World Examples:

- **Inspire Medical Systems:** The implantation of the Inspire Hypoglossal Nerve Stimulator, a device for obstructive sleep apnea, is typically performed as an outpatient procedure lasting about three hours. This approach minimizes hospital stays and aligns with patient preferences for less invasive care.

- **Johns Hopkins Medicine:** Spinal cord stimulators, used to treat chronic pain, are implanted through procedures that often allow patients to return home the same day. This outpatient model reduces hospital resource utilization and enhances patient comfort.

- **Axonics' Sacral Neuromodulation System:** Furthermore, clinical evidence supports patient compliance with in-home charging. A prospective study on the Axonics rechargeable sacral neuromodulation system found that nearly all participants (98%) had an estimated recharge interval of at least 7 days, with 69% exceeding 14 days. At the 3-month follow-up, 98% of patients were able to charge their devices without issues, indicating high compliance with the recommended weekly charging schedule.

These examples illustrate how healthcare providers are successfully implementing outpatient and in-home care strategies for implantable devices, leading to improved patient outcomes and more efficient and profitable use of hospital and health network resources.

By embracing advanced wireless charging technologies and outpatient care models, health networks can tailor recharging schedules and settings to balance clinical oversight with patient convenience. This approach not only reduces hospital admissions and healthcare costs but also enhances the quality of life for patients relying on implantable medical devices.

Impact of Recharging on Hospital Costs and Reimbursement

The Affordable Care Act (ACA) introduced several payment reforms aimed at enhancing healthcare quality and reducing costs, notably through value-based purchasing initiatives. These reforms have influenced hospital reimbursement structures, particularly concerning surgical interventions and follow up care requirements. The impact of these changes varies among hospitals, depending on their financial models and patient demographics.

Impact on Hospital Revenue and Reimbursement

The adoption of rechargeable implantable medical devices can influence hospital finances in several ways:

- **Revenue Generation:** Traditionally, hospitals have viewed surgical procedures as significant revenue sources. Each surgery, including those for battery replacements in implantable medical devices, generates income through procedure fees, facility charges, and associated services. However, treatments are underutilized currently, creating demand for more initial implantation surgeries. The more replacement surgeries there are, the fewer operating resources are able to be allocated to new patient implantations. Furthermore, frequent surgeries increase the risk of complications, potentially leading to additional costs of readmissions without significant new revenue or new patients getting access to treatments. Lastly, hospitals can incur penalties from readmissions under value-based reimbursement models that focus on patient outcomes and cost efficiency. Therefore, rechargeable medical devices offer a more effective and sustainable source of revenue growth than repeated battery replacement surgeries for non-rechargeable implantable devices.

- **Cost Reduction Initiatives:** The ACA's emphasis on cost containment has led to programs that penalize hospitals for excessive readmissions and hospital-acquired conditions. For instance, the Hospital Readmissions Reduction Program (HRRP) reduces Medicare payments to hospitals with

higher-than-expected readmission rates.

- **Enhanced Value-Based Performance:** Hospitals engaged in value-based care models could benefit from reduced complication rates and improved patient outcomes associated with fewer surgeries, potentially leading to financial incentives and higher overall reimbursement.

- **Resource Allocation:** Decreasing the number of elective surgeries allows hospitals to allocate resources more efficiently, potentially improving care in other areas and enhancing overall operational efficiency.

The shift towards rechargeable implantable medical devices presents both challenges and opportunities for hospitals. The financial impact largely depends on individual hospital reimbursement structures, state policies, and the extent to which they have embraced value-based care models. By eliminating the need for routine battery replacement surgeries, rechargeable devices align with the ACA's goals of reducing unnecessary procedures and associated costs. Hospitals focusing on value-based care may benefit financially from reduced complication rates and improved patient satisfaction, leading to better performance metrics and avoidance of penalties.

Procedure-Specific Considerations

The impact of these reimbursement models can vary by location and procedure type:

- **Medicaid Expansion:** States that expanded Medicaid under the ACA have seen changes in reimbursement dynamics. For example, Kentucky experienced a significant increase in insured patients, leading to higher reimbursement rates for surgical procedures post-expansion.

- **Targeted Procedures:** Certain procedures, especially those with high readmission rates, are under increased scrutiny. Hospitals performing these surgeries may face greater financial incentives to reduce unnecessary interventions to avoid penalties.

The Trend Toward Value-Based Care

Several states and hospitals have embraced value-based care models, aiming to improve patient outcomes while reducing unnecessary medical interventions, such as battery replacement surgeries. These models incentivize healthcare providers to focus on quality rather than quantity of care.

Examples of Hospitals and Health Systems Implementing Value-Based Care

- **Cleveland Clinic:** This renowned health system has employed value-based care strategies to reduce medical costs and improve population health. Their approach includes developing financing arrangements and care-delivery strategies aimed at reducing the financial burden and enhancing patient outcomes, two goals that rechargeable implantable devices support.

- **Kaiser Permanente:** As a leader in integrated care, Kaiser Permanente emphasizes value-based care by focusing on preventive measures, chronic disease management, and coordinated care efforts to enhance patient outcomes and reduce unnecessary interventions. Kaiser Permanente's transition to a value-based care model has yielded significant cost savings and improved patient outcomes. For instance, their chronic condition management program emphasizes proactive outreach and telehealth options, enabling patients to manage conditions such as diabetes and hypertension from home. This approach has led to enhanced care quality and cost reductions.

These states and health systems exemplify the shift towards value-based care, prioritizing patient outcomes and cost-effective treatments. They are likely to support the continued adoption of rechargeable implantable medical devices, which reduce the need for additional surgeries and align with their goals of improving care quality and reducing unnecessary medical interventions.

Value-Based Care Saves Hospitals Money

As noted above, several leading healthcare organizations have reported cost savings and improved efficiencies after transitioning to value-based care models. Examples of cost savings include:

- The Cleveland Clinic's Value-Based Care initiative drove a 7.5% reduction in direct costs per patient encounter within a year, and a 16.4% increase in patient encounters per day.

- Though they don’t provide specific numbers, Kaiser Permanente says its value-based approach to chronic disease management drives significant cost reductions and enhanced patient outcomes.

- Collaborations like the one between Carrum Health and Cleveland Clinic have resulted in up to 45% savings per episode of care and a 30% reduction in unnecessary procedures.

Because of the trend toward value-based care, medical device companies looking to grow device adoption would benefit from offering hospitals rechargeable options. As healthcare systems prioritize cost efficiency, shifting reimbursement strategies, and improving patient outcomes, companies that are offering rechargeable implantable medical devices with patient-friendly wireless charging stand to gain a competitive advantage. Leveraging an expert like Resonant Link Medical for wireless power and data transfer further enhances device capabilities, provides cost efficiency, and accelerates product commercialization.

Conclusion: Unlock Your Device's Potential

By integrating patient-friendly wireless charging into implantable devices, medical device companies can achieve superior market positioning, higher average selling prices, faster commercialization timelines, and significantly improved long-term revenue potential—key for sustained business growth.

Patient-friendly wireless charging technology significantly accelerates business growth for implantable medical devices by improving patient experience, clinical outcomes, and market differentiation. Devices equipped with intuitive, easy-to-use wireless charging systems reduce patient burden, increase compliance, and significantly minimize maintenance and associated healthcare costs.

These improvements translate into higher patient satisfaction, increased adoption rates, and greater clinician preference—critical drivers for accelerated market growth and increased sales. Additionally, rechargeable systems that leverage advanced wireless charging technology extend device longevity, reduce surgical interventions, and decrease healthcare resource utilization, making them highly attractive under value-based reimbursement models.

To learn more about what's possible with advanced wireless power and data transfer technology for your medical device, contact Resonant Link Medical at **info@rlmedical.com**.