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Controlled Growth

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Controlled environment agriculture (CEA) is increasingly turning to automation as growers face mounting pressure to improve efficiency, reduce resource consumption and maintain consistent crop quality to remain competitive. Although CEA is often discussed as a single industry, it's developing on two tracks: The first is vertical farming, with artificial lighting in a highly controlled environment; while another cohort

of growers is taking a smart greenhouse approach by combining automation with natural resources like sunlight and rainfall. While their methods are different, they share a common need for smarter, more connected operations.

In both greenhouse and indoor farming environments, production relies on a complex network of systems—including lighting, HVAC, irrigation and environmental controls—that must work together to create optimal growing conditions. While there are a number of technology companies focused on helping growers manage resources more efficiently, a broader challenge remains: How best to support the industry's growing focus on digitalization, energy control, data collection and scalability. Just as importantly, they need practical, cost-effective tools to turn operational data into actionable insights.

As automation becomes more prominent in CEA, growers need a trusted partner to streamline systems and keep pace in the market. Originally developed for smart buildings and industrial facilities, Bosch Rexroth's ctrlX AUTOMATION platform offers capabilities that are well-suited to the challenges growers face today. The following sections will cover how growers can use Bosch's connected automation technology to gain greater control over critical resources, improve operational efficiency and build a scalable foundation for future growth.



Bringing proven automation technology into CEA

For decades, Bosch Rexroth has helped manufacturers, building operators and other industries expand their operations through automation. Today, that same expertise is reflected in the award-winning ctrlX AUTOMATION platform, an open ecosystem that combines hardware, software and app-based functionality to help organizations connect systems, collect data and make more informed

decisions.

At the center of the platform is ctrlX CORE, a compact controller that serves as the foundation for a wide range of automation applications. As referenced above, although this technology was originally developed for industrial automation, ctrlX AUTOMATION has evolved beyond traditional motion control to support IoT connectivity, environmental monitoring and building automation. Those capabilities are increasingly relevant to CEA. In many ways, modern greenhouse operations are beginning to resemble smart buildings, with interconnected systems continuously managing lighting, climate, irrigation and nutrient delivery. Those are precisely the types of connected environments ctrlX AUTOMATION was designed to support.

What makes ctrlX AUTOMATION particularly suitable for growers is its open architecture, which allows growers to connect systems that have traditionally operated independently and collect data on critical resources. This allows growers to answer some of the most important questions facing modern operations: Is water being used efficiently? Is the operation consuming more electricity than necessary? Are crops growing at the rate required to harvest on time? And perhaps most importantly, how can the collected data be used to make better decisions for future operations? This last question is vital for many growers.

Collecting data is important, but the real value lies in understanding what that information is revealing about an operation and using those insights to guide decision-making. When operational data is brought together in a single platform, growers can begin identifying trends, uncovering inefficiencies and gaining a clearer understanding of what's driving performance across their operations. Those insights can then be used in determining resource management, production strategies and future growth.

Maintaining independence in a connected operation

As automation becomes more common in CEA, many growers face an important decision: Should they commit to a single technology provider or maintain flexibility to adapt as their operations evolve? The former often requires a significant upfront investment and can leave growers dependent on a single vendor for future upgrades, support and expansion. For operations focused on growth and innovation, the latter can be a more practical long-term strategy.

ctrlX AUTOMATION is designed to provide choice: Growers can continue using existing equipment, incorporate third-party sensors and software and adopt new technologies as they become available without having to replace an entire system. This level of autonomy allows operations to evolve at their own pace while avoiding the vendor lock-in that often accompanies traditional automation platforms.

That same philosophy extends to the platform itself—growers can explore the technology before committing. Bosch Rexroth offers virtual controller environments and trial versions of select applications so users can test functionality, experiment with different use cases and determine how the platform fits their operations. Rather than requiring growers to jump in with both feet, ctrlX AUTOMATION provides a practical way to start small, learn the technology and make informed decisions about future adoption.

That ability to start small extends beyond a trial run. Many growers begin automation by addressing a specific operational challenge, such as nutrient dosing or irrigation management. Because ctrlX AUTOMATION is designed to scale, growers can start with a targeted application and opt to expand functionality over time.

For growing operations, scalability and cost often go hand in hand. While connected technologies can

provide significant operational benefits, concerns about recurring fees, proprietary systems and future upgrade costs create barriers to growth. Growers who choose ctrlX AUTOMATION are not required to commit to a subscription-based software model. The solution gives growers freedom to select the applications and functionality that best fit their needs without burdening users with recurring fees or proprietary solutions. As operations expand and new challenges emerge, they can add capabilities without being tied to a single provider's roadmap, giving growers the ability to control costs and build a technology ecosystem that best supports their goals.



Making automation more accessible

Not long ago, implementing these types of systems often meant writing custom programs or relying heavily on specialized engineering support. Thanks to advances in AI tools and low-code/no-code platforms, ctrlX AUTOMATION doesn't require growers to become controls experts or coders. That shift is helping make automation more accessible for growers who want to improve operations without adding

unnecessary complexity.

Accessibility also extends beyond implementation. Through remote access and screen-sharing tools, Bosch Rexroth can provide support and troubleshooting assistance without requiring an on-site visit. As a CEA operation expands, the ability to receive technical support remotely can help minimize downtime and keep operations running smoothly.

Finally, as growing operations become more connected, cybersecurity is paramount. The ctrlX CORE controller runs an operating system compliant with the Cyber Resilience Act, a cybersecurity framework designed to strengthen the security of connected products and digital systems. This helps provide an additional layer of protection for connected devices and operational data.

ctrlX AUTOMATION grows with the grower

With ctrlX AUTOMATION, growers have access to a single platform to manage resources, control the environment and collect meaningful data without compromising established technologies, partnerships and processes that already support operations. Just as importantly, it gives growers the flexibility to start with targeted applications and expand capabilities as operations grow.

There's no denying that data is becoming central to modern growing operations and the volume of data being generated is expanding rapidly. The real opportunity lies in how the data is used. Growers who can turn operational data into action will be better positioned to improve efficiency, make the most of available resources and adapt to future challenges. Our goal is to provide the CEA industry with a foundation that can grow with the growers, helping them take advantage of new opportunities while maintaining the freedom to innovate on their own terms. **IG**

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