

Advanced Architectures and Analytics Lower the Cost of Energy for Indoor Growers

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Introduction

Studies [1, 2] of indoor farming production show that the cost of energy is frequently second only to the cost of labor. Controlling and reducing the cost of energy over time is therefore critical to the current and future competitiveness of produce grown in Controlled Environment Agriculture (CEA) facilities.

At Advanced Energy (AE), we create advanced architectures for powering LED-based horticulture lighting solutions that lower the total cost of energy for indoor farming applications by:

- Reducing overall energy usage
- Optimizing metrics that contribute to higher energy rates
- Lowering installation and operating cost of power infrastructure

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Bending the Curve in Other Industries

While CEA is still in its infancy and continues to grow and mature, AE draws on our many years of experience helping other industries to optimize their energy usage footprint.

For example, the rapid proliferation of the internet was accompanied by concerns about associated energy usage. AE and its Artesyn product group collaborated with customers, industry groups, and regulating agencies to bend the energy usage curve downwards [3]. We have tens of gigawatts of high efficiency power supplies installed in enterprise and cloud servers. Over the last 25 years, our innovations have increased the efficiency of our power supplies from 75% to approximately 98%. This is an order of magnitude reduction in wasted power – 2% today compared to 25% in the past – and resulted in greater energy cost savings for our customers. Today, the horticulture industry faces many of the same challenges, and we are applying our expertise to help “bend the curve.”

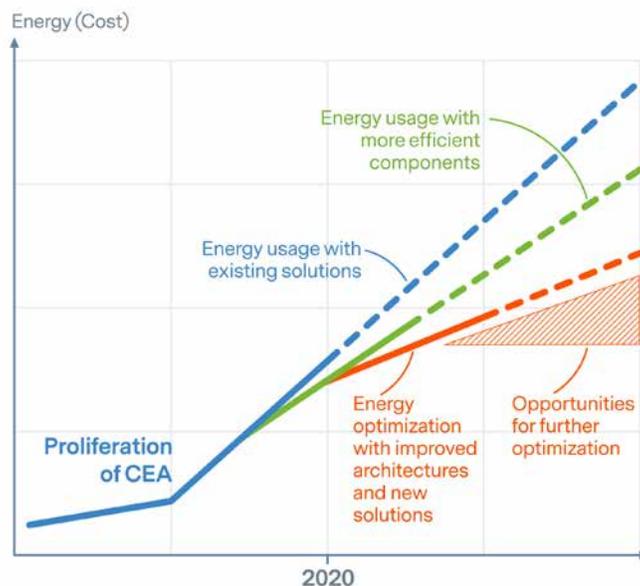


Figure 1. Bending the energy cost curve.

AE has been a leader in the semiconductor fabrication industry for over three decades. Like CEA, downtime in fab operations can lead to significant losses. While designing and manufacturing reliable systems is key to reducing downtime, we are also now augmenting those systems with data analysis tools. Our [PowerInsight by Advanced Energy™](#) data analytics platform provides actionable intelligence that allows customers to monitor the health and utilization of their equipment and power infrastructure. In addition, predictive maintenance analytics helps users optimize scheduled downtime to minimize negative cost impact.

With extensive expertise in reducing overall energy costs across a wide range of industries,

we can now leverage our experience in the horticulture industry. We currently have tens of megawatts of power conversion equipment installed and in the pipeline.

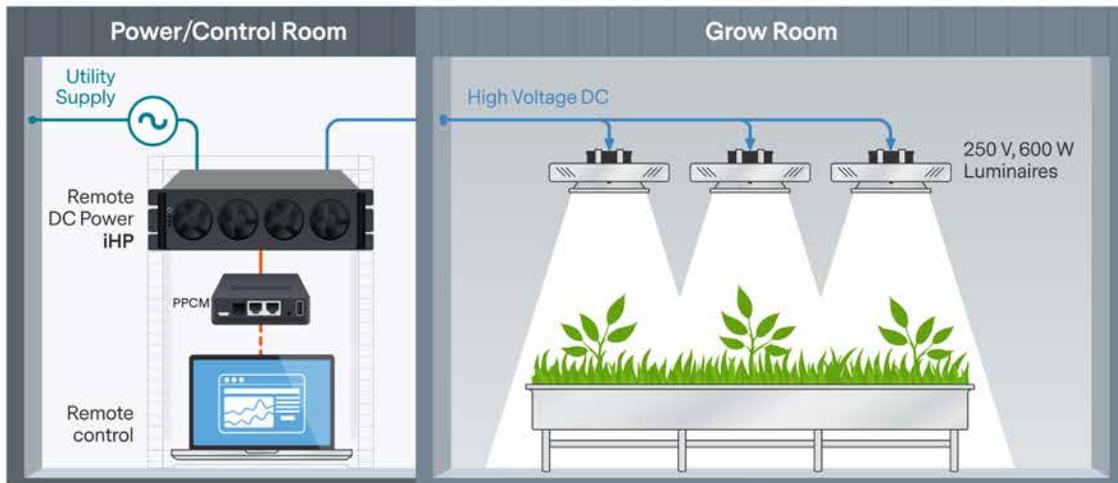


Figure 2. Improved Lighting Approach

1. Power has been removed to separate control room
2. High voltage DC is distributed to the lamps instead of AC
3. Direct connection to three-phase utility
4. Remote control possible through PPCM module

Solutions

Let's take a look at some of the approaches that we are using to help our customers manage their energy costs.

Power Architecture

With traditional LED luminaires and fixtures, the power conversion circuitry creates inefficiencies that can increase the energy cost for the indoor farmer in several ways. While LED drivers may achieve high levels of power conversion efficiency, converting the power in these smaller increments often means a lower power factor (PF) and a higher total harmonic distortion (THD). These fixtures also operate from single-phases and without careful planning, imbalances can occur on the three-phase systems that feed the grow facilities. For large-scale farming, these factors add up and can cause poor power quality on the utility feeds. This affects not only the farmer but also the farmer's neighbors who are tied to these same feeds. This can result in difficult conversations with the utility company and can often lead to increased energy costs through penalties, levies, or higher rates. In addition, with the proliferation of smart meters with more advanced measuring capabilities, the lower PF, higher THD, and resulting higher current draw can directly translate into higher energy bills.

Our [remote DC power solution](#), utilizing our scalable iHP platform, is a true three-phase power conversion subsystem that is connected directly to the three-phase facility power. This solution eliminates any phase imbalance issues with a very low THD signature that is friendly to the power grid and reduces the power grid inefficiencies that can lower energy costs and provide local utility rebates (DLC tests pending).

This centralized power architecture has a few other benefits for CEA:

- Heat, due to the remaining inefficiencies in power conversion, is moved to a control room reducing the amount of air conditioning required within the indoor grow area
- Higher voltage DC distribution that does not result in the need for heavier or additional wiring
- Support for many communication interfaces which simplifies the networking of the power conversion equipment with other networked elements in the grow facility

Centralizing the power conversion also allows us to innovate further and reduce the total cost of ownership of power infrastructure for our customers. We have enhanced our power system architecture with a new patented technology that pairs our iHP-based DC remote power system with an intelligent transfer switch (iTS). The iTS can switch one power source between two different loads, taking advantage of the lighting day and night (on/off) grow cycles of the plants. This further lowers the CapEx and OpEx energy costs per installation.

Connectivity

The success of controlling costs, including that of energy, in CEA is heavily dependent on industrial IoT (IIoT). To support this, our remote DC power solution supports multiple physical interfaces and communication protocols. This allows ease of installation in facilities with existing control systems. We also offer a solution that minimizes CapEx costs when compared to often-costly PLC controllers. Our solution incorporates digital control to replace the traditional 0 to 10 V PLC dimming control. Control and monitoring are enabled by pairing the DC power solution with an Artesyn PowerPro Connect Module (PPCM). The PPCM is a low-cost microcomputer with custom software for creating complex lighting schedules. The PPCM enables real-time monitoring with a cloud-based option.

Analytics and Insights

In addition to the communications interfaces required to support IIoT, our PowerInsight by Advanced Energy solution, deployed at several semiconductor fabs, can be adapted to bring value to CEA. This platform arms our customers with actionable insights by leveraging and combining our power delivery expertise and domain knowledge with modern data science. The foundational building blocks built into the platform enables us to quickly develop other data analysis applications for various industries.

In both the CEA and semiconductor industries, two key drivers are (1) improving production yield and (2) reducing the total cost of ownership (TCO). As a supplier of critical components to both these industries, many of our power supplies include sensors capable of real-time process measurements and millisecond system response times. Data on energy and power usage from these sensors can be used in real time or analyzed offline. Yield and energy profiles for different applications (wafers or crops) can be optimized through such analysis. Operational data is also used for system health diagnostics and TCO can be reduced through the minimization and predictive scheduling of equipment maintenance.

As an example, in a semiconductor processing application, PowerInsight is implemented in predictive chamber cleaning cycle. The predictive chamber clean algorithm provides a figure of merit in the form of numbers of hours left of operation before cleaning is required. This approach reduces unplanned down time and maximizes the utilization between cleaning cycles, thus saving the factory cost of maintenance.

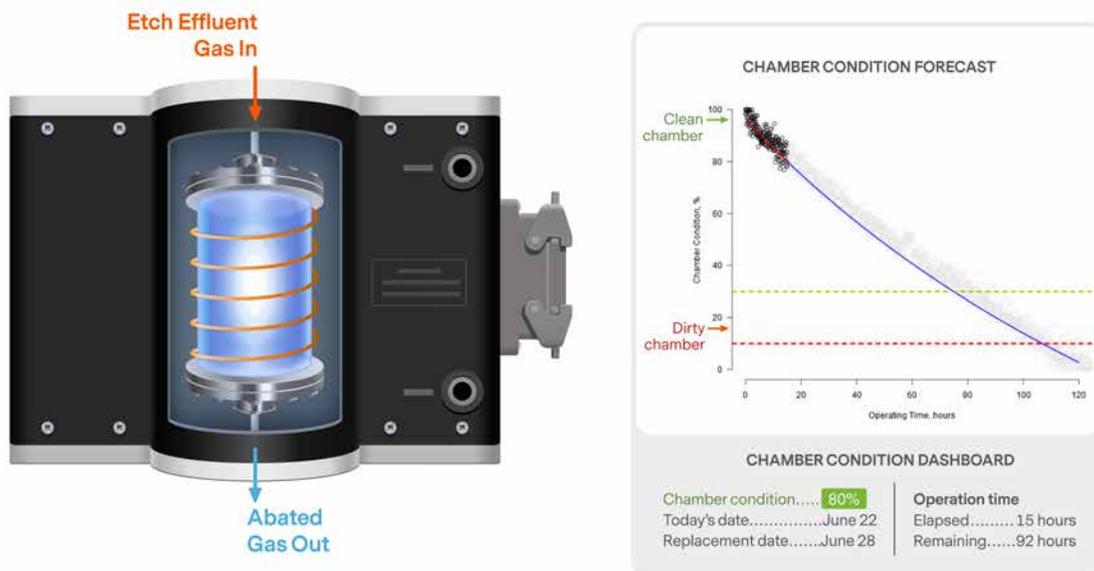


Figure 3. Health Diagnostics and Predictive Maintenance from PowerInsight by Advanced Energy

Economic Benefits of Remote DC Power Architecture

The remote DC power architecture offers many economic benefits in CEA installations:

	OpEx	CapEx
Centralized Power	Reduced utility bills through optimization of efficiency, PF, and THD	Less power supplies required and still scalable solution
Installation Costs		All power equipment in same location and easily accessible Low current wiring
Architectural Enhancements	Reduced cooling costs in grow rooms	Leverage existing installed infrastructure Reduce underutilized capacity
Networking	Supports multiple interfaces and protocols for optimization	Choose Advanced Energy or third-party hardware for control and monitoring
Maintenance	All power in same location for ease of accessibility	Potential to extend life of infrastructure through predictive maintenance
Analytics and Insight	Performance visualization Performance optimization Predictive maintenance	Potential for optimization of infrastructure spend through data analytics

Looking to the Future

We believe the future is full of opportunities for energy management and cost optimization to reduce the total cost of ownership for both CapEx and OpEx.

Improvements in Power Conversion Efficiency

As mentioned previously, the efficiency of power conversion stages continues to improve. Combining emerging device technologies, e.g. WBG transistors based on GaN and SiC, with advanced control techniques, proprietary magnetics and packaging technologies, we will continue to offer higher efficiency and more dense platforms for the horticulture space.

Architectural Improvements

AE is committed to innovation, not only in product development, but also in architectural enhancements. We have already enhanced our power system architecture to include a new intelligent transfer switch (iTS) that impacts both CapEx and OpEx. Additionally, further enhancements are underway that will both improve and better utilize the available infrastructure.

Microgrids and Energy Sources

Our customers in many sectors are looking beyond the existing AC grid for operation improvements. Both long and short duration alternate energy sources are under consideration. This leads to the adoption of microgrids outside facilities and energy storage solutions within facilities. The implementation and the management of these resources will have significant future impact on energy and cost management.

Insight and Analytics

As IIoT takes hold of every facet of manufacturing, the transition from distributed control systems to edge computing for real-time systems controls and cloud-based big data analytics

is gaining momentum. With respect to horticulture, the equivalent of edge computing may be the single grow house. The central command in the cloud is where data from multiple disparate grow houses would be used to build predictive analytic models that would provide optimized conditions for growth.

One such example could be a model that considers the wavelengths and amount of power needed for optimum growth for specific types of produce (e.g. tomatoes or lettuce). To build such analytics models requires data from the field and an easily configurable analytics platform. PowerInsight was developed using a containerized architecture built on embedded Linux with flexible analytic building blocks to enable shortest time-to-value. The platform offers an easily configurable visualization dashboard. The edge analytics engine can be self-learning, with initial training in the cloud, and adjusts the predictive outcome based on newly ingested data in the field. Multiple sources of data can be input into the platform for cross correlation and optimization. PowerInsight is AE's big data analytics platform that combines our core expertise in power conversion with modern data science.

Conclusion

Advanced Energy brings its decades of power conversion and energy management experience to improve the horticulture industry. As a pure-play power and energy leader, we understand the challenges and opportunities in managing energy usage and its associated costs. Through product, architectural, and analytics innovations, we will continue to expand our offering of industry-leading solutions enabling the CEA industry to achieve its goals of supplying the world with high-quality food in a cost-effective and environmentally friendly manner.

References

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ABOUT ADVANCED ENERGY

Advanced Energy (AE) has devoted more than three decades to perfecting power for its global customers. We design and manufacture highly engineered, precision power conversion, measurement and control solutions for mission-critical applications and processes.

Our products enable customer innovation in complex applications for a wide range of industries including semiconductor equipment, industrial, manufacturing, telecommunications, data center computing, and medical. With deep applications know-how and responsive service and support across the globe, we build collaborative partnerships to meet rapid technological developments, propel growth for our customers, and innovate the future of power.

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