



WHITE PAPER

Dynamic Lighting for business adaptation, growth, and long-term success

Applications of dynamic LED lighting solutions for adaptable
greenhouse business models

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Preface

In our white paper series, we have covered the definition of truly dynamic lighting and explored how implementing dynamic LED lighting can reduce greenhouse energy consumption, increase crop yield, and improve crop quality. To refresh, a truly dynamic lighting solution must meet the following four criteria:

1. Output intensity can be changed effortlessly;
2. Light spectrum can be modified at any point;
3. Lighting scenarios are programmable and reprogrammable;
4. The solution is responsive to ambient light conditions.

In this white paper, we explore how dynamic lighting enables a greenhouse operation to grow and adapt through its modularity and flexibility.

Introduction

Although greenhouses operate by precisely controlling the growing environment, there are multiple external factors that cannot be controlled and require adaptation. Generally speaking, businesses with the ability to adapt have an advantage over competitors as they can maintain product quality and quantity over time, or completely pivot to produce commodities that are in higher demand. For the greenhouse sector, adaptation looks like the ability to implement new technologies to improve operational efficiencies, to change crops in response to consumer demands, etc. Greenhouse growers have had to adapt to the increased demand for local food, the restricted availability of labour and the increased cost

of inputs such as natural gas and fertilizers, all of which were heightened by the COVID-19 pandemic and are expected to continue intensifying in the long term. Beyond that, climate change presents multiple challenges through unpredictable weather, heat waves, increasingly hot summers, high pest and disease pressure and the limited availability of high-quality water.^{i,ii}



Source: National Cooperative Grocers

Greenhouse technology has rapidly advanced to address these concerns through advanced environmental controls, energy screens, co-generation, sensors and imaging technologies to name a few. However, horticultural lighting has lagged behind. The dominant lighting systems provide growers with little flexibility once installed, thus a limited capacity to adapt over time.

Sollum Technologies is challenging this paradigm by providing an intelligent LED horticultural lighting solution that is modular and flexible on multiple levels, making it resilient and future-proof. It allows growers to adapt to evolving conditions such as the introduction of new crops, changing environmental conditions, resource constraints and business development objectives.

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were heightened by the COVID-19 pandemic and are expected to continue intensifying in the long term."

Modularity: for greenhouses small and large

A key component of building a dynamic system is modularity, an increasingly popular feature in many systems which allows a technology to be implemented at various scales. Modular systems are made of independent, repeated entities that are combined to form a larger unit. These repeated entities can be added, removed, or changed without affecting the whole. An example of this is a solar power system, which is composed of multiple panels that are each a functional unit linked to a power grid that can consequently be scaled up or down. Similarly, light fixtures themselves are modular in that a system can be scaled up or down by adding or removing fixtures. Modular systems are designed for expansion, use at multiple scales and independent control of units within the larger system.



Source: Sollum Technologies

With legacy lighting, which is predominantly high-pressure sodium (SON-T) and other HID fixtures, the system is only modular in that additional light fixtures can

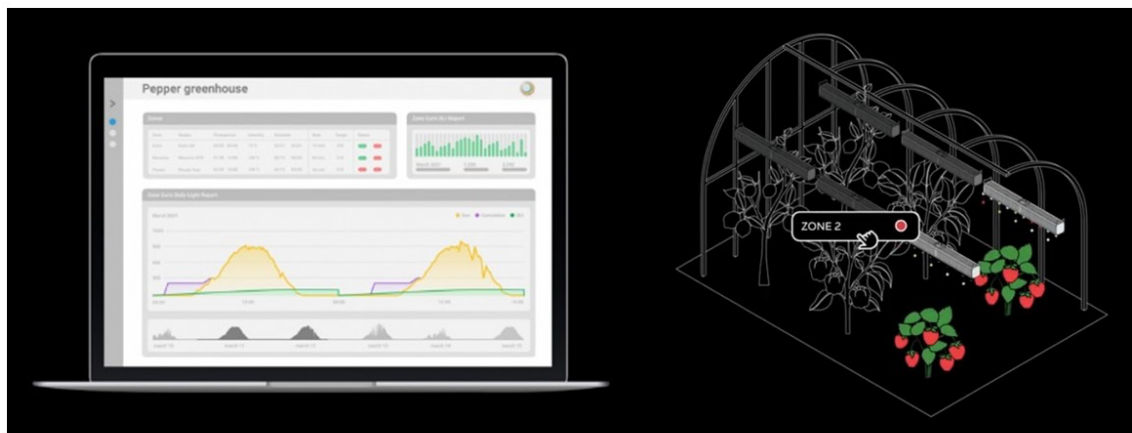
be added to the system. Once zones have been defined by their electrical installations, control is limited to the scale of the entire zone. Modularity is thus severely limited.

Dynamic lighting solutions such as Sollum Technologies' are modular both at the level of the fixture and the system. As with legacy systems, fixtures can be added and removed from the overall system. However, Sollum Technologies' SUN as a Service® (SUNaaS) distributed platform then allows the grower to group the lamps into zones which can be easily reconfigured without any physical modifications or additional hardware. Modularity is completely preserved.

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Flexibility: helping greenhouses grow any crop, any time

Once light fixtures are grouped into grower-defined zones, the greenhouse light environment is perfectly flexible and can be modified with the click of a mouse. The grower can develop zone-specific light scenarios by selecting a specific photoperiod, light intensity and spectrum. For example, a grower can begin the photoperiod with Spectrum #1 at a given intensity, then transition to Spectrum #2 midday and an end-of-day treatment with Spectrum #3. To reiterate, each light zone can have its own lighting scenario that can be modified at any point, whether throughout the day or between production cycles.



The modularity and flexibility of truly dynamic light provides greenhouse growers with unparalleled means of adapting their lighting strategy according to the external fluctuations previously mentioned, namely the adaptation to shifting market demands, pest and disease pressure, climate variations and greenhouse expansion.

"Each light zone can have its own lighting scenario that can be modified at any point, whether throughout the day or between production cycles."

Applications

Previous white papers have elaborated on the use of dynamic lighting to impact crop growth (e.g., use of far-red light for internode elongation and flowering response). Given the current white paper's focus on adaptation to a changing world, this section elaborates on the ways in which dynamic lighting can help growers navigate environmental and market-related challenges.

Pest and disease management

A major challenge in greenhouse production is pest and disease pressure, which are bound to fluctuate in response to climate and environmental changes.



Greenhouse pests are typically managed through integrated pest management (IPM), which encompasses the combination of proper hygiene and sanitation, consistent pest scouting, biological control and the occasional use of chemicals in dire cases. With dynamic lighting, an additional strategy becomes available. Through strategic partnerships with Canadian universities and industry, Sollum Technologies is working to develop light-assisted pest management by studying the behavior of pests and biologicals in response to different light

conditions. Further, dynamic lighting allows growers to easily change crops between seasons, which can help break the reproductive cycle of crop-specific pests. When changing crops, growers can adapt their lighting strategy accordingly- something which is not possible with fixed spectrum LED or HPS lighting.

Dynamic lighting also has applications for the management of greenhouse pathogens, both directly by modifying the development of pathogens and indirectly by allowing growers to change crops as needed.

"Dynamic lighting allows growers to easily change crops between seasons, which can help break the reproductive cycle of crop-specific pests."

Weather

In recent years, greenhouse operations have faced an increasing number of extreme weather events such as heat waves or harsh winters. Pollution, resulting

in smog can also have a large impact on light availability. Even more common weather events such as dark and cloudy days are not adequately compensated for by traditional lighting systems. With dynamic LED lighting, all weather events are accounted for thanks to flexible spectral and intensity output that adapts in real time to changing light conditions. For example, this technology allows a cloudy day to be converted to a clear day as far as the crops are concerned. Furthermore, this adaptability enables growers to shift their growing timelines because they are no longer as limited by seasonal barriers - for instance, greenhouses can shift towards winter production thereby avoiding the hottest, most difficult months of production. Consider an unlit pepper crop which is typically transplanted in December and carried through until the following November. As a result, summer heat waves land in the middle of the crop cycle and can severely damage the plants, making them less productive for the remainder of the season. With dynamic lighting, growers can instead begin in the late summer and face these extreme summertime conditions towards the end of the crop cycle, thus restricting yield losses.



Source: Tyson Koschik, CBC news

"With dynamic LED lighting, greenhouses can shift towards winter production thereby avoiding the hottest, most difficult months of production."

Crop diversification

As mentioned in relation to pest and disease pressure, dynamic lighting allows greenhouse growers to change crops and tailor their lighting strategy to this new crop rather than applying the same fixed spectrum, light intensity and zoning. In this way, dynamic lighting makes greenhouses more resilient to market changes as they can easily change crops in response to market conditions and consumers' demand for diverse products. During the early days of the COVID-19 pandemic, many producers in Canada were overwhelmed by the sudden demand for locally grown food beyond the typical greenhouse crops (i.e., tomatoes, cucumbers and peppers). There has been an increasing demand for greenhouse-grown berries, melons, leafy greens and herbs, pharmaceutical crops and flowers, all of which have unique lighting needs for optimal growth. With a dynamic lighting solution, the same fixtures can be used to provide light recipes varying in spectrum, intensity and photoperiod to meet the needs of specific crops.

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Greenhouse expansion

As the global population increases and the amount of arable land decreases, controlled environment agriculture will become increasingly important and greenhouse acreage will continue to grow. The modularity of Sollum Technologies' dynamic lighting solution is well adapted to this trend, as modular systems are designed for growth and for use at multiple scales. This means that dynamic lighting will be useful for small and large greenhouses alike, whether a single-bay greenhouse or greenhouse complex. For greenhouse expansions, the installation of additional light fixtures is simple and does not interfere with the functionality of the system as a whole. Rather, SUNaaS allows growers to easily add light fixtures to their system and integrate the fixtures into new or pre-existing lighting zones.



Source: Sollum Technologies / Allegro Acres

"SUNaaS allows growers to easily add light fixtures to their system and integrate the fixtures into new or pre-existing lighting zones."

Conclusion

Through our white paper series on dynamic lighting, we have explored the concept of flexibility in horticultural lighting to eventually develop a definition of dynamic lighting and identify its key benefits. In summary, dynamic lighting as exemplified by Sollum Technologies' smart LED solution provides greenhouse operations with the modularity and flexibility to adapt to changing environmental, social and economic challenges.

About Sollum Technologies

Inspired by nature, Sollum Technologies was founded in 2015 to offer greenhouse growers the only smart LED lighting solution which dynamically recreates, perfects, and modulates

the full spectrum of the Sun's natural light. The company is based in Montréal (Québec, Canada), where its design, development, and manufacturing activities are located. Sollum™ works closely with its clients and research partners – namely, Agriculture and Agri-Food Canada's Harrow Research and Development Center, to create recipes that are adapted to the growth cycle of each crop, regardless of its native climate or the location of the greenhouse. Its SUN as a Service® cloud platform enables multi-zone light management so growers can implement several different recipes simultaneously in the same greenhouse. The platform also automatically adapts the lighting of each zone to the ambient light to match recipe targets. Sollum's award-winning lighting solution thereby provides unparalleled value in terms of energy savings, productivity, and superior produce quality through a flexible, adaptive, and easy-to-use application, with great respect for the environment. For more information, visit sollum.tech or our [LinkedIn](#) page.

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