Saxon Capital Group, Inc. - Energy Glass Solar™'s Innovative Approach to Greenhouse Sustainability:

The Energy Glass Solar™ System Field Test

(OTC-SCGX)

Objective and Methodology

Saxon Capital embarked on a four-month field test in Almeria, Spain, with a clear goal: to assess the agronomic impacts of photovoltaic panels on a tomato crop in a commercial greenhouse. This endeavor aimed to minimize the surface area covered by the panels, integrate them seamlessly with the greenhouse structure to avoid stress and reduce the electromagnetic fields (EMF) generated by the panels to safeguard the natural bumblebee pollination process while generating the necessary power to run all climate control and production systems in a greenhouse. Conducted at the TECNOVA Foundation's Experimental Centre, this trial was meticulously designed and executed by the foundation's technical staff, Energy Glass Solar™ Engineering, and Proconsult Team.

The Broader Context

This research is part of Saxon Capital's belief that agricultural greenhouses are crucial for enhancing food system resilience amidst challenges like climate change, farmland degradation, and population growth, offer significant improvements in water and land use efficiency, protecting crops from adverse weather and pests and enabling precise control of environmental conditions to maximize productivity. Furthermore, it ensures the food supply to local communities, promoting local production (reducing the agricultural industry's carbon footprint) and using non-productive land.

Agriculture: A Strategic Sector for Global Development and Security

The Agricultural Industry is a strategic sector for every nation´s development and security. Several vital factors propel the industry's growth, including the rising global population and the corresponding increase in food demand. **Each second, the world's population grows by nearly three more people, 240,000 people daily**. By 2025, the global population will reach 8 billion and 9.6 billion by 2050. On the other hand, there is also a growing demand for fresh food to cover the essential feeding nutritional needs in underdeveloped countries and an increasing awareness of healthier lifestyles in developed countries.

However, these growth factors face serious challenges that require a strategic approach to solve them, combining traditional agricultural practices with new technologies. and production methods. Among the multiple challenges that must be taken into consideration, we should consider:

- The disruption caused to the world's food supply by the COVID-19 pandemic and the global international conflicts. Many countries have taken these situations as a warning to avoid dependency on third countries **to guarantee the food supply** in their territories. In contrast, others imposed restrictions on exporting agricultural produce to protect their local supply, creating a perfect storm in the availability of food and its prices.
- With many resources needed for sustainable food security already stretched, the challenges are enormous. **Climate change** is already negatively affecting agricultural production globally. Farms must increase food production while preserving the environment, but they can't do it alone or use only today's traditional farming practices.
- **Subsistence farming in poorer countries is still a labor-intensive, low-reward industry**, at the mercy of unexpected environmental changes, economic downturns, and many other risk factors. And while mechanized agriculture in the developed world has considerably increased output per unit of land, more is required to meet tomorrow's food demands sustainably.

The expansion of the greenhouse horticulture market is also linked to the rising food consumption worldwide, driven by the ever-growing global population. Climate change's impact on crop yields is also a pivotal factor influencing this sector. As awareness and understanding of greenhouse technology's potential to enhance crop yields grow, the market is poised to meet diverse growth opportunities in the coming years. These developments signal a transformative phase in the industry, where traditional methods are being supplemented and sometimes replaced by technologically advanced, sustainable practices to meet the changing demands of a growing world.

Rapid Growth in Greenhouse Cultivation

According to a report by Allied Market Research, the rapidly expanding global greenhouse horticulture market is forecasted to reach $65.0 billion by 2030. This significant growth, from $32.3 billion in 2021, represents a compound annual growth rate (CAGR) of 7.8% from 2022 to 2030.

In commercial greenhouses, glass roofs and plastic walls are common materials used to cover and create optimal environments for plant growth. In terms of greenhouse types, plastic greenhouses were predominant in 2021, making up nearly three-fourths of the market, and are expected to grow at a CAGR of 8.2% through 2030.

In 2021, the fruits and vegetables segment dominated the market, making up more than half the market share. This segment is projected to grow at the highest CAGR of 8.3% from 2022 to 2030.

Geographically, Europe held the largest market share in 2021, accounting for over two-fifths of the global market. However, the greenhouse horticulture market in North America is expected to experience the fastest growth, with a projected CAGR of 8.4% from 2022 to 2030. While in the U.S, floriculture maintains a dominant portion of the greenhouse industry (28,400 acres approx), greenhouse cultivation for food production is growing across the nation (3,600 acres approx), but still far away compared to countries such as Spain, with over 148,000 acres (the province of Almeria in the south of Spain, concentrates 86,500 acres of food production greenhouses).

This growth trajectory highlights the dynamic nature of the global greenhouse horticulture market, driven by evolving market trends, diverse crop types, and regional variations in adoption and technological advancements.

The integration of advanced technologies such as ventilation systems, LED grow lights, heating and cooling systems, communication technologies, irrigation, and control systems has revolutionized these spaces. Notably, heating and cooling systems are the most significant equipment investments in the commercial greenhouse industry.

Energy Challenges in Greenhouses

To keep pace with this growth and realize the potential benefits of Controlled-environment agriculture (CEA)/Protected Agriculture (PA), **solutions are needed to meet each farm's unique energy challenges and demands, as a solution-fits-all concept won´t work with sustainable and cost-effective strategies and technologies.** Greenhouses are significantly more energy-intensive than traditional open-air agricultural systems and often rely on fossil fuels, raising sustainability concerns and economic costs associated with such energy use. This is particularly problematic in remote areas with unreliable grid power or in extreme environments like arid, Arctic, and urban areas. The industry needs sustainable and cost-effective energy solutions to continue its growth trajectory, especially in the United States, where the demand for greenhouse cultivation is rapidly increasing.

Sustainability Concerns and Growing Demands

The reliance on fossil fuels in greenhouse cultivation is becoming increasingly unsustainable. Energy access and reliability also pose significant challenges, particularly in rural areas where grid power may be unavailable or unreliable. This is crucial as many greenhouse crops are sensitive to environmental changes, requiring stable and resilient energy sources to prevent crop failure.

The Need for Sustainable Energy Solutions

To support this growth and realize the benefits of CEA/PA, it is essential to address the unique energy challenges with sustainable, cost-effective strategies and technologies. Factors like greenhouse location, shape, size, building materials, technology use, crop selection, and cultivation methods significantly impact energy requirements.

Optimizing Greenhouse Productivity and Efficiency

Sustainable greenhouse design is critical to optimizing productivity and energy efficiency. This involves a combination of strategies, technologies, and systems tailored to the location's specific energy and environmental needs. Managing internal microclimatic conditions, which include regulating temperature, humidity, CO2 levels, and lighting, is vital for plant growth and productivity.

Innovative Solar Technologies for Energy Demands

Solar energy technologies, both passive and active, present a solution to the energy demands of agricultural greenhouses. Passive solar greenhouses use design strategies to maximize solar energy capture and storage. Active solar systems, like photovoltaic (PV) panels and solar thermal collectors, generate electricity and improve thermal performance. These systems, especially when combined in hybrid PV-thermal systems, can significantly enhance the energy efficiency and sustainability of greenhouse operations.

Optimizing Greenhouse Energy and Crop Yield with Photovoltaic Panels (PV) Technology

Use of Wall- and Roof-Mounted PV Modules Greenhouses are increasingly adopting wall- and roof-mounted photovoltaic (PV) modules to produce energy and cultivate crops simultaneously. This approach avoids large-scale, ground-based solar farms' ecological and land development issues.

Incorporating photovoltaic (PV) modules into greenhouse designs needs a strategic balance between energy generation and crop yield. Research conducted by Cossu et al. (2020) has highlighted a key consideration in this integration process: the impact of PV coverage on sunlight penetration. The study reveals that with **each 1% increase in the PV coverage ratio, there's a corresponding 0.8% decrease in the cumulative global radiation inside the greenhouse**, which could negatively affect plant growth.

Based on the experience of the Tecnova Foundation experts, limiting the PV panel coverage to **no more than 20%** of the total greenhouse roof area is recommended. This recommendation aims to mitigate the risk of substantial natural light reduction, which could lead to detrimental effects on crop development. By adhering to this guideline, greenhouse operators can effectively balance harnessing solar energy and ensuring optimal crop growth conditions.

Saxon Capital's Energy Glass Solar™ Solution is positioned as a sustainable energy solution for greenhouses. The trial's results were promising, proving that the Energy Glass Solar™ panels, covering **less than 5%** of the greenhouse roof, effectively minimized shadow zones and allowed optimal light penetration without negatively affecting the natural bumblebee pollination process.

Considerations for PV Cell Type and Design

Choosing PV cell type, module design, and installation patterns is crucial in balancing energy productivity with crop needs. Options include opaque and semi-transparent PV cells. While opaque cells are standard and provide more shading, they may require additional strategies to mitigate their impact on crops. On the other hand, semi-transparent PV cells can optimize light transmittance and enhance crop growth and energy production by harnessing incident and reflected solar radiation.

Photovoltaic Panels (PV) System Configurations Greenhouses predominantly use grid-connected Photovoltaic Panels (PV) systems. This setup allows excess energy generated by the PV modules to be fed back into the power grid, providing a potential revenue source and reducing the need for backup power sources. However, it requires a reliable utility connection and appropriate policies like net metering. Semi-transparent and bifacial panels are also used to balance energy generation with light requirements for crops, though they entail higher initial costs and maintenance.

Conclusion

The integration of solar technologies in greenhouses represents a promising avenue for reducing reliance on fossil fuels, improving sustainability, and supporting the continued growth of the greenhouse industry. This approach aligns with the increasing need for environmentally friendly and cost-effective energy solutions in agriculture, ensuring the resilience and productivity of greenhouses in various climatic and geographical conditions.

The Energy Glass Solar™ Solution panels by Saxon Capital **have shown efficacy in keeping optimal greenhouse conditions off-grid without compromising plant growth and development.** The encouraging results achieved during the field test at TECNOVA in Almeria, Spain, are a validation of the Energy Glass Solar™ Solution for Greenhouses:

Key Field Test Results:

1. ***The photovoltaic panels did not negatively impact Plant Growth Metrics, such as plant height and flowering patterns.***
2. ***The panels covered the energy required to support the correct climate control conditions.***
3. ***Pollination Efficiency by bumble bees was consistent, and their activity was never disrupted.***
4. ***The yield and quality of the tomatoes (crop productivity) were comparable between the test and control groups.***
5. ***The panels generated lower EMF than traditional electric panels, alleviating concerns about their effect on plant growth and pollinator activity.***
6. ***Transmissivity Coefficients remained consistent, validating the panels' efficiency in light transmission.***

7. ***Photosynthetically Active Radiation (PAR) levels remained within standard values, indicating no hindrance to light availability essential for plant growth.***
8. ***The panels proved resilient despite extreme weather, ensuring a continuous energy supply.***

This innovative approach aligns renewable energy technology with agricultural best practices, paving the way for more sustainable and efficient farming practices. The success of this trial highlights the potential of such technologies in addressing the unique energy challenges of the greenhouse industry, contributing significantly to its sustainable growth and alignment with global sustainable development goals.

The Energy Glass Solar™ System presents an opportunity to enhance greenhouse productivity while also addressing energy efficiency and environmental impact. This cutting-edge technology can use translucent materials such as glass or polycarbonate in varying colors to optimize plant growth and increase yields.

For example, utilizing a specific combination of blue and red light is particularly noteworthy. This combination maximizes the photosynthetic rate, leading to healthier and more robust plant growth. In horticulture, blue light (around 450 nm wavelength) is essential as it is readily absorbed by chlorophyll, aiding in efficient energy conversion. Meanwhile, red light (near 650 nm wavelength) is crucial for both growth and flowering, enhancing the overall development of the plants.

Moreover, the Energy Glass Solar™ System's capability **to supply power for all operational needs** within a greenhouse is a game-changer. It ensures that greenhouses can maintain their energy requirements sustainably. This is especially vital when energy efficiency and renewable energy sources are increasingly prioritized.

Additionally, the system's design **minimizes electromagnetic field (EMF) emissions**. This aspect is crucial for protecting the natural processes within the greenhouse, such as bumblebee pollination, which can be sensitive to EMF disturbances.

In conclusion, the Energy Glass Solar™ System stands out as a multifaceted solution for modern greenhouses. It offers enhanced plant growth through optimal light conditions and contributes to energy sustainability and environmental protection. This system opens new avenues for greenhouse technology, potentially revolutionizing agricultural operations in controlled environments.

Authors:

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References (10)

1. Nägeli Juan, L., Murray, U., McKeown, P. C., Styles, D., Spillane, C., Bonilla Findji, O., & Martínez Barón, D. (2019). Implementation of the Climate-Smart village approach. https://core.ac.uk/download/195715720.pdf.
2. The future of farming. Elizabeth Gasiorowski Denis https://www.iso.org/news/Ref2183.htm
3. Revolutionize Your Energy Usage: The Power of Advanced Building Automation. https://energy5.com/revolutionize-your-energy-usage-the-power-of-advanced-building-automation
4. Assessment and comparison of the solar radiation distribution inside the main commercial photovoltaic greenhouse types in Europe. By Marco Cossu, Andrea Cossu, Paola A. Deligios, Luigi Ledda,Zhi Li, Hicham Fatnassi, Christine Poncet, Akira Yano
5. Bumblebee pollination activity in a commercial tomato greenhouse during the winter season. By Niks Ozols, Jānis Gailis, Inta Jakobija, Jānis Jaško, Viktorija Zagorska. RURAL SUSTAINABILITY RESEARCH 48(343), 2022 ISSN – 2256-0939
6. Renewable Energy for Heat & Power Generation and Energy Storage in Greenhouses Joint Institute for Strategic Energy Analysis National Renewable Energy Laboratory Gail Mosey, Laura Supple
7. ENERGY USE IN U.S. AGRICULTURE: AN OVERVIEW Greta Raser and Madeline Silecchia* https://farmandenergyinitiative.org/wp-content/uploads/2020/08/Energy-Use-in-Agriculture.pdf
8. LED Illumination for High-Quality High-Yield Crop Growth in Protected Cropping Environments. Md Momtazur Rahman,* David Luke Field, Soyed Mohiuddin Ahmed, Md Tanvir Hasan,3 Mohammad Khairul Basher, and Kamal Alameh. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8621602
9. Uchanski, M., Uchanski, M., Hickey, T., Bousselot, J., Barth, K., & Barth, K. (2023). Characterization of Agrivoltaic Crop Environment Conditions Using Opaque and Thin-Film Semi-Transparent Modules. Energies, 16(7), 3012.
10. P096_2022 Evaluation of the agronomic effects produced by photovoltaic panels during a Tomato crop developed in a Greenhouse. Saxon Capital Group & Fundación Tecnova Research Paper, by Sandra López Salvador, Laura Rodriguez Chikri.