

Nominating Region: North-Central Region

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Project or Committee Number and Title: NCERA-101 Committee on Controlled Environment Technology and Use; <https://www.controlledenvironments.org/>

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PROJECT SUMMARY

Issue, problem or situation addressed: The NCERA-101 Committee, or "the Committee," plays a key role in addressing two Grand Challenges for food and agricultural research: 1) enhancing sustainability, competitiveness, and profitability in food and agriculture by leveraging technological advances that enable competitive specialty-crop production in controlled environment (CE) facilities; and 2) contributing to the mitigation of climate change impacts on food, feed, fiber, and plant-based energy systems by providing technical guidelines for the sustainable operation of CE facilities. The Committee has been instrumental in educating the national and international CE user community by providing a platform for information exchange among researchers, students, CE facility managers, and industry representatives, and by promoting the sustainable use of new and existing technologies.

Selected objectives:

1. Technology advancement and transfer: Advance the use of high-tech CE facilities (i.e., growth chambers, greenhouses, indoor vertical farms) used for research and commercial production.
2. Standards and guidelines: Develop measurement protocols and best practices for environmental control and data acquisition in CE facilities to improve reproducibility of crop responses.
3. Environmental: Promote sustainable operating practices, including responsible resource consumption (energy, water, nutrients) for CE facilities.
4. Education and training: Support the participation of graduate students during annual meetings to benefit career development of future researchers and academics, and to expand the human-resource capacity for CE research and industry.

Accomplishments:

Selected outputs: Since 1975, members have developed numerous professional collaborations that were facilitated because of interactions during annual meetings. Collaborations have resulted in successful grant proposals, publications, and professional standards. Notably, the Committee has published the *Plant Growth Chamber Handbook* and *International Guidelines for Measuring and Reporting Environmental Parameters for Experiments on Plants in Greenhouses, Growth Rooms and Chambers*, and *Tissue Culture Facilities*. Collectively, these guidelines have been viewed over 8,600 in the last year, demonstrating significant stakeholder interest. Committee members have also contributed to the development of industry standards and guidelines (e.g., [ANSI/ASABE EP411.4](#), [ANSI/ASABE/ASHRAE EP 653](#), [ANSI/ASABE S640](#) and [S642](#)), with over 2,000 views since 2017. In 2017, Committee members published a [book](#) used by most academics teaching CE related courses, with over 1,000 copies sold as of today. Furthermore, Committee members have played a major role in developing guidelines for space-based life-support systems led by NASA. Currently, the Committee is working with the [Design Lights Consortium](#) (DLC) to update guidelines for reporting light use by plants based on a recent [discovery](#) made by Committee members, who showed that photons between 700 and 750 nm contribute to photosynthesis. These

are all examples of major outputs that have only been possible due to collaborative efforts of multiple Committee members.

Short-term outcomes: Outreach efforts that are part of several projects led by Committee members create awareness about collaborative projects. For example, the [Indoor Ag Science Café](#), initially funded through a USDA-SCRI grant led by members of the Committee, has become a popular platform for sharing research updates from the CE community with the general public. Since 2018, enrollment in the 60 webinars presented has increased from 138 to 1,607 (as of February 2024), including participants from multiple countries.

Medium-term outcomes: The CE industry (including academia and commercial operations) has experienced exponential growth over the last decade, which is reflected in membership growth. Since 2010, the number of institutions represented at annual meetings has increased 125%. Membership has substantially expanded beyond university faculty and institutional researchers, and now includes a sizeable number of industry members (66), some of whom are direct competitors with each other. This highlights the Committee's collaborative approach, fostering idea-sharing and discussions about opportunities and challenges in the CE industry. Student attendance at annual meetings has surged, partly attributed to \$10,000 travel awards supporting around 20 students yearly. Industry donations primarily fund this award.

Long-term outcomes: Throughout the years, the Committee has positively impacted the expansion of CE programs at multiple institutions. Approximately 15 years ago, only a handful of states, including AZ, UT, NY, MI, and IN, offered research and teaching programs in CE agriculture. As of today, established CE programs exist in at least 30 U.S. states, some with multiple experts. Various members of the Committee started as student-attendees during annual meetings and are now leaders in the field. In addition, the Committee has supported expansion of the CE industry, leading to increased demand for equipment, production, and retail. CE-related industries collectively contributed \$77 billion to the U.S. economy in 2024, reflecting an average 6% revenue increase across industries over the past 5 years (ranging from ~2% to 20%) ([1,2,3,4,5](#)). The Committee significantly contributes to NASA-sponsored space biology and life-support programs. Members address challenges in growing plants in space, with findings applicable to earth-based systems. They actively participate in NASA's ground and space-based plant experiments.

Positive impacts: CEs promote local and regional food security by enabling year-round crop production close to target markets at competitive prices. Knowledge generated and transferred by Committee members through various publications and [workshops](#) has enabled growers to optimize yields while making operations more efficient, thus enhancing profitability while minimizing environmental impacts. The Committee will continue to support such efforts through the development of Design Standards ([CEADS](#)) that are helping define goals for the rapidly growing CE industry, considering social, economic, and environmental advances focused on sustainability.

Added-value and synergistic activities:

Multi-disciplinary activities: The Committee facilitates collaborations among members with diverse technical backgrounds including engineers, plant scientists, sensor experts, lighting specialists, business professionals, computer scientists, and economists. Furthermore, active participation by industry members is vital, as it advances development and implementation of new technologies and control strategies. Collectively, members have published approximately 820 peer-reviewed publications or technical reports during the last 5 years, several co-authored by at least two members of the Committee. In addition, standards and guidelines described in the 'Outputs' section highlight the multidisciplinary and international nature of Committee

collaborations. During workshops, grower meetings, and other events hosted by various Committee members, thousands of stakeholders have improved their knowledge about plant- and engineering aspects of CEA.

Multi-functional integrated activities: Committee collaborations have resulted in various multi-disciplinary and multi-institutional research and outreach projects. Recent examples include Greenhouse Lighting And Systems Engineering ([GLASE](#)), Lighting Approaches to Maximize Profits ([LAMP](#)), Optimizing Indoor Agriculture ([OptimIA](#)), Next-Generation Propagation Strategies for the US Strawberry Supply Chain ([PIP-CAP](#)), Controlled Environment Agriculture Herb Extension and Research Base ([CEA HERB](#)), Advancing Controlled Environment agriculture through data-driven decision making and workforce development ([ADVANCEA](#)), in addition to various NASA-funded projects involving multi-institutional research organizations and commercial companies who all have representatives that are members of the Committee.

Additional partnerships, associations, or collaborations: The Committee maintains international collaborations with both the UK Controlled Environment User Group (CEUG) and the Australasian CE Working Group (ACEWG) and has met with these organizations during several international meetings. The Committee (in 2015) also co-organized an annual meeting with the Association of Education and Research Greenhouse Curators (AERGC), and in 2019 with the NE-1835 Committee (Resource Optimization in Controlled Environment Agriculture). Members of the Committee also are active participants in professional horticultural and agricultural engineering societies, and serve in leadership roles as executive committee members, division chairs, and/or working group chairs of these societies.

Project goals that would not have happened without the collaboration of committee members: None of the outcomes and impacts previously mentioned would have occurred without Committee collaborations. Broad industry participation, adoption of new standards and guidelines, and expansion of CE-related academic programs can all be attributed to the concerted collaborative efforts led by Committee members.

Evidence of multi-institutional and leveraged funding: In the last 6 years, collaborative projects have received funding totaling over \$28M. Examples of currently-funded projects with multiple Committee members include: Cornell U and Ohio State U (2020-2024) Accelerating workforce development for the controlled environment agriculture (USDA-NIFA); U of Georgia, Colorado State U, Cornell U, Rutgers U, Texas A&M U, Utah State U, and USDA-ARS, (2018-2022) LAMP (USDA-SCRI); Michigan State U, Purdue U, Ohio State U, U of Arizona (2019-2024) OptimIA: Improving the profitability and sustainability of indoor leafy greens production (USDA-SCRI); North Carolina State U, Ohio State U, USDA-ARS, Rutgers U, Virginia Tech U, U of Florida, UC-Davis, CalPoly, U of Maryland, and Purdue U (2021-2025) PIP-CAP: Next-generation propagation strategies to increase the resilience of the US strawberry supply chain (USDA-SCRI); Ohio State U, Rutgers U, U of Arizona, Cornell U (2022-2026) ADVANCEA (USDA-SCRI); Michigan State U, Iowa State U, North Carolina State U, Texas Tech U, the U of Tennessee, and USDA-ARS (2022-2025) CEA HERB (USDA-SCRI); U Delaware, Colorado State U, and Arizona State U (2023-2026) Tailoring hydroponic factors to controlled-environment production of emerging food crops (USDA-NIFA); McGill U and U Guelph (2024) CSA/DLR Ground Test Demonstrator (GTD) subsystems conceptual design study (CA Space Agency); Cornell U, Rensselaer Polytechnic Institute, Rutgers U (2017-2024) Greenhouse Lighting and Systems Engineering (GLASE) (NYS Energy Research and Development Authority); Sierra Space and NASA (2024-2026) Hydroponic/Aeroponic Nutrient Delivery In Volumetrically Efficient Garden (HANDIVEG) (NASA).

Participating institutions and units:

Since the first meeting of the Committee in 1976, membership has steadily increased from 12 to 176. The Committee is comprised of members from 142 different institutions representing 35 U.S. states and nine countries. Currently, Land Grant Universities, NASA research centers, and USDA research labs with Committee members include:

Brigham Young University	University of Arizona
Clemson University	University of California
Cornell University	University of Connecticut
Duke University	University of Delaware
Iowa State University	University of Florida
Kansas State University	University of Georgia
McGill University	University of Guelph
Michigan State University	University of Hawaii
NASA - Ames Research Center	University of Illinois
NASA - Kennedy Space Center	University of Maryland
North Carolina State University	University of Minnesota
Ohio State University	University of Tennessee
Penn State University	University of Wisconsin
Purdue University	USDA-ARS
Rutgers University	Utah State University
Texas A&M University	West Virginia University
University of Alaska	University of Wyoming

A detailed list of all members (including members representing commercial companies and international members) can be found at: <https://www.controlledenvironments.org/members/>