# NCERA-101 Wisconsin Report

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## 1. New Facilities/Equipment.

Biotron is entering the final phase of a $7,000,000 renovation. The major portion of the renovation has been driven by energy conservation opportunities (ECO). The major ECO's and associated energy savings are listed below.
ECO-1. Install variable frequency drive for AC-1, which provides make up air for the research rooms, annual energy savings(AES), $4542.
ECO-2. Install T8 light fixtures in plant and animal rooms, AES $113,856.
ECO-3. Convert AC2 & 3 to DDC control and constant volume duct boxes, AES $90,345.
ECO-4. Convert AC 1, 2, 3 to campus chilled water, AES $13,219.
ECO-5. Replace 250 ton chiller, install return loop, eliminate 108 motors/pumps, AES $63,484.
ECO-5A. Replace backup 250 ton chiller, AES $292
ECO-6. Convert 6 super-cold-rooms to DX refrigeration, AES $143,485.
ECO-7. Replace cooling towers, AES $868.

Other equipment being replaced; R/O building water system, clean steam relative humidity system for research rooms, epoxy flooring for research rooms, greenhouse roof extension, emergency shut down computers for research rooms, sheave/pulley assemblies for research room air handling units, research room light plenums, rodent caging, biological safety cabinets and extending Andover access control security system.

Common areas of the Biotron, including locker rooms, conference rooms, office rooms and hallways will be renovated.

Control System:

The Biotron is moving into phase 2 of a 3 phase environmental control system upgrade. Phase 1 was the replacement of the in-house custom control system with an off-the shelf control system from Johnson Controls(JC). The new system makes use of Field Equipment Controls (FEC) and the Mitosis Extended Architecture human machine interface (HMI). The primary motivations for Phase 1 were reduced cost and increase support of control equipment. Phase 2 has just started and will take approximately one year. It is part of the ECO project. One noteworthy part of Phase 2 is the replacing of all the pneumatic temperature control values with new digital valves and the complete redesign of the hot and cold glycol loops. The primary motivation for these changes is increased energy efficiency and precision control of valve position. Phase 3 of the upgrade involves replacing all greenhouse JC Unitary Controllers (UNT) with JC FECs. Phase 3 will be starting shortly and is expected to finish in 8 months. UNTs are obsolete controllers and the primary motivations for replacing them include using supported hardware and closer integration with FEC equipment installed in phase 1.

Controlled Environment Greenhouse Supplemental Lighting:

LED light fixtures ( six 325 watt Lumigrow Pro 325) and induction light fixtures (six 400 watt iGrow IGF-400-VG-CM ) have been installed in two 180 sq ft climate controlled greenhouses to replace eight 600 watt high pressure sodium lights. A pilot study has been initiated to test the effect on plant growth under supplemental LED and induction lighting in the Biotron Greenhouses to reduce lighting electricity costs, to reduce cost to remove excess heat generated by less efficient supplemental lighting sources and to allow researchers the flexibility of controlling red and blue supplemental light (using LED fixtures). This pilot study will allow researchers to compare the response of several species under our standard high pressure sodium lights to more efficient light sources.

**2. Unique Plant Responses:** None to report

**3. Accomplishment Summaries:**

Biotron Project on growth of microalgae in treated secondary effluents.

A private company funding UW department of Botany research housed in the Biotron has developed an algal growth system based on the use of wastewater treatment plant effluent as growth medium and nutrient source to produce biomass for biofuel production. Among the many proposed sources for organic material for biofuels, algae have the highest potential production rates and can be produced on the least land area. Algae furthermore lack many of the degradation resistant organics such as lignins, found in higher plant sources such as wood pulp and corn stover. Problems with algae include water availability, nutrient sources for growth, and harvest processes.

The work currently performed in the Biotron includes two areas of algal growth. 1) Examine the effects of augmenting the levels of nutrients such as magnesium (needed for chlorophyll synthesis) and a mix of trace elements that includes iron, boron, manganese and zinc. 2) Determine the effects of elevated levels of carbon dioxide on the growth rate of the selected algal strains. The Biotron was uniquely equipped to investigate the latter aspect of growth because of the availability of rooms with controlled carbon dioxide levels. Using existing Biotron facilities, $CO_2$ gas was administered at levels up to 20,000 ppm to reactor vessels with minor variation (+/- 50 ppm). This was accomplished by directly injecting the into a mixing chamber within the greenhouse room and utilizing a P&P systems WMA-4 $CO_2$ controller.

The investigators work with magnesium and trace elements showed that the addition of these mineral nutrients increased the rate at which algal biomass was produced by more than a factor of two and the level of algal density produced (as gm/L) by a similar margin over control algal cultures that received only additions of nitrogen and phosphorus. This difference may arise from our use of secondary effluent from the Madison Metropolitan Wastewater Treatment Plant. Since this plant processes mainly domestic wastewaters and not much industrial wastewater that might contain metals, dense algal growth can deplete the levels of mineral nutrients with a resulting reduction in growth rate. Cultures not receiving supplements of magnesium and trace minerals were noticeably a paler green than those with the supplements, presumably due to less chlorophyll.

Elevation of the levels of carbon dioxide in the ambient air within the growth chamber had a dramatic effect on the rate at which algal biomass was produced. At normal ambient $CO_2$ (about 400 ppm), the rate of biomass increase was only 0.15 gm/L day, but at 1200 the rate of increase in biomass was 0.205 gm/L day. At 1700 ppm the rate of biomass production hit 0.27 gm/L day. The increase in $CO_2$ resulted in a rough tripling of the production of biomass at the end of the growth cycle.

Turning a deficit into a resource for plant heat stress studies in the Biotron Greenhouses:

Heat stress studies were conducted in two of four 525 sq ft evaporatively cooled greenhouse rooms, ordinarily sidelined during summer months due to extreme temperature spikes. The rooms, prone to overheating from mid May to September, were offered to researchers on a trial basis for the study of potato response to heat stress under 35 $^{o}$C days and 25 $^{o}$C nights. This successful use of the Biotron's largest greenhouse rooms lead to heat stress experiments continuing into late fall.

**4. Impact Statements: None**

**5. Published Written Works**: None

**6. Other relevant activities or information**:

Biotron Greenhouse Research Manager, Bjorn Karlsson, presented the following outreach presentations:

November 29, 2012: Presentation of Biotron history, current research and supplemental lighting sources to UW Madison horticulture class Environmental Horticulture, Hort 320.

January 18, 2013: Presentation on light and temperature control at the Research Plant Care Workshop: Best Practices in Controlled Environment Research Plant Care. UW Madison D.C. Smith Instructional Greenhouse.