SYLLABUS: CEA100 Introduction to Controlled Environment Agriculture

Whether you are an aspiring entrepreneur that wants to own your own CEA production facility, a STEM graduate exploring CEA as a professional choice, or a consumer interested in learning more about soilless food production, this course is designed to give a comprehensive overview of the different types of CEA production systems, how the industry intersects with the need to reduce the use of scarce resources to produce more food, and CEA's role in providing fresh, fastest growing forms in agriculture in the 21st century.

This course was designed to provide a curated, research-based overview. Unlike random information and sources on the Internet – the course is to help those interested in pursuing a career in the CEA industry a starting point. There is no other course like this on the Internet. The research and documentation provided in this course are the results of extensive due diligence conducted by the author, Sue Raftery PhD, in building and successfully launching AGROWN and AgTech Innovation Center. Sue wants to enable others interested in pursuing their dreams in the CEA industry a “faster path” – that is what the AgTech Innovation Center is all about – supporting the industry in the US, North America, and globally.

The following modules make up the course, each module has an Assessment that will allow you to know your mastery level of the course. If you choose to pursue an AIC CEA Certification program, this course is part of that "path to career" process.

Course Modules

CEA and Food-Energy-Water Nexus

- **Why is food-energy-water nexus important in agriculture**
  The intersection of water, food and energy are often invisible and or unknown to most who expect the light to go on when the switch if flipped, the water to run when you turn on the spigot, or to find food at a restaurant, home, or the grocery when you are hungry. Perhaps the expectation of these "invisible" in plain sight commodities to "just be there" need to be reset.
- **Food production and food systems**
  While U.S. consumers, through current policy, would appear to have a "cheap food" advantage in the global community – it seems that we are not accounting for the hidden costs of how food is grown, processed, transported; nor the costs for the adverse effects of the types of food the majority of the U.S. populations consumes
- **CEA and the food-energy-water nexus**

  What if we had the opportunity to grow food using?

  90% less water

  80-90% less land

  60-70% less fertilizers

  Locations closer to the consumer to reduce transportation costs

  Renewable fuels, and/or integrated with local utilities

  The good news, this system already exists – and in the case of hydroponics

Creating Sustainable Food Systems

- **Current food systems**
  One of the largest obstacles to local/regional food production is the prevailing food system itself (cheap energy, surplus fresh water, and plentiful land). The current food industry and the global shipping (logistics) industries prefer the status quo (Tumber, 2012). Changing this will require a fundamental shift in where and how food is grown in the twenty-first century.
- **Rural-Urban Convergence of food production**
  Until consumers understand where their food comes from, we will continue to live in a world in which the landscape that produces our food is invisible, and disconnected from our consumers in our supermarkets (Burke, 2011). This disconnect is a human construct, one which can be reversed.
- **Building new resilient food systems**
  Rather than replicate rural-based agriculture, cities must begin to design an urban model. This new urban model requires the integration of growing food into the urban economic and ecological systems (Mougeot, 2008). This new model must be created from a technological viewpoint that mimics high tech start-ups, not based on a nostalgic agrarian mindset.

Reducing Food Waste & Increasing Food Resilience

- **Food waste in the current food system**
  For many American consumers, food comes from the supermarket. With less than two percent of the population currently engaged in the growing and harvesting of food, is it any wonder that food knowledge has declined as the crop yields have increased. Long before the food arrives at the supermarket, the process of food waste has already begun. Yet, for the average consumer convenience trumps homemade, and appearance trumps taste when it comes to the selection of food for daily sustenance. These food choices, made by consumer's every time they visit their local supermarket, affect the entire food chain in our current food system.
- **Food waste to grow food: Opportunities & Challenges**
  Given all of the waste in the current food chain, there appears to be a steady stream of readily available biomass to convert to energy to contribute to the growing of food, be it to run the machinery or other growing technologies, deliver locally-grown food, or using the compost residuals to replenish the soil. Considering that little food waste is currently even being diverted to composting facilities, there are ways for sustainable agriculture to play a role in transforming the current food system. It is time for sustainable agriculture to stake a claim on the opportunities that can come from finding solutions through the linking of "food waste" as an integral part of food growing.
- **The power of regional solutions to waste**
  With transparency locally/regionally, what if the local supermarkets were scored on the level of food recycled, composted, or digested? Would this make a difference to the shoppers? Until real numbers are associated with waste where individuals shop, eat out, and cook at home, it will, given the current American culture, remain someone else's problem. Bloom calls for landfill taxes, and recycling bins just for food waste. While there will be pushback from the consumers, in the long run, it will be part of everyday life in the not too distant future.

Food Safety

- **Current food safety standards**
  Before the Food Modernization Safety Act (FMSA) was passed and signed into law in 2011, the Federal Government did not regulate food safety of fresh produce that is grown on 8.4 percent of U.S. farmlands. Until FSMA, food safety in the produce industry were either voluntary, imposed by consumers, or industry-led commodity groups such as the California Leafy Green Association.
- **The Food Safety Modernization Act**
  While the FSMA is now in place and required for those producing and processing food in the US, foodborne recalls and incidents continue to occur. The Center for Disease Control 2015 report shows that over 48 million (1 in 6) Americans get sick each year, with over 128,000 hospitalized, and over 3,000 deaths. The FSMA moves the focus from "reaction-recall" mode to that of "prevention – and proactive steps" to reduce the number of foodborne illnesses.
- **Economic impact of food safety on food businesses**
  Economic analysis of food safety related costs show that it is much cheaper for producer/grower to invest in preventing events of foodborne outbreaks than costs after

events (Ribera et al., 2012). The FSMA will move food growers and processors (local or global in nature) to provide proactive measures and standards to reduce the ever increasing number of food recalls to retailers and consumers.

Hydroponics

- **Types of CEA hydroponic growing systems**
  Controlled hydroponics is a technology for growing plants in nutrient solutions, which are water containing fertilizers with or without the use of artificial medium such as sand, grave, vermiculite, rockwool, perlite, peat moss, coir, or sawdust to provide mechanical support in a technically controlled environment (Komai & Bhardwaj, 2014). The computer controls not only regulate watering and fertilizing (fertigation), but also likewise controls the airflow, humidity, root circulation, lighting, and CO2.
- **Hydroponics and NASA Space Habitats**
  For the past 30+ years, NASA has been deeply involved with creating sustainable, self-sufficient ecosystems to support human life. These technologies, on display at EPCOT at Disney World, have many “terrestrial” applications and will advance the progress and innovation in CEA growing in the coming decades.
- **Siting your CEA greenhouse, selection of inputs, and resource identification**
  Where and how you build a CEA greenhouse, if you are to maximize for success, is quite involved and require attention to detail. How to correctly site and select materials for a CEA greenhouse are covered. Hydroponics, and CEA high tech growing, bear little resemblance to traditional agriculture in systems, processes, or technology – and is by no means a “magic bullet” for the stresses on our current agriculture/growing systems. It is another “option” that will be used, along with advances in other areas of traditional growing to feed an ever-expanding population.

Aeroponics

- **Aeroponics vs Hydroponics**
  Aeroponics is in the suspension of the roots without any anchor medium (like hydroponics), with the further exposure to oxygen that dramatically increases crop yields (Long, 2012). NASA has worked with aeroponic growing systems for the International space station and their Deep Space Mars Research and Development. With only mist, the amount of water is further dramatically reduced from the hydroponic systems
- **How aeroponics is supported through NASA/Space applications of Aeroponics**
  Aeroponics, requiring significantly less water, is the ideal solution to feeding space travelers and has been used on the International Space Station. Plants are integral to life in space in producing oxygen and cleaning CO2, plus providing a way to reclaim water used in the living environment.
- **Aeroponic vertical and table growing systems**
  Most vertical systems of aeroponics are shaped both vertical (towers) and horizontal (growing tables, that can often be stacked for vertical growing of crops suited to this type of configuration, such as leafy greens and herbs). Given exposure to oxygen and room for maximum root expansion (100% suspended in air). Crops grow so fast (if the growing system is working properly) that disease and any harmful pathogens have little/no time to form on the plants.

Aquaponics

- **How does aquaponics work?**
  When you combine hydroponics and aquaculture the grower is able to stabilize the water quality in the water by converting the ammonia from the fish waste to become beneficial bacteria that can be converted to nitrates – thus becoming nutrients needed by the plants. Thus, the plants filter the water to create a safe environment for the fish.
- **Benefits and limitations of aquaponics**
  List of benefits of aquaponics:
  Adaptable to hobby or commercial growers
  No artificial chemicals/fertilizers, all organic
  No soil-borne diseases
  Suited for year-round production
- **Commercial aquaponics production and profitability**
  Like hydroponics, aquaponics is also much more efficient than traditional field-grown vegetables, and will produce much higher yields at lower costs. While most people will think of tilapia as the fish most often grown in an aquaponics system, it is not limited to just that species of fish. Non-edible fish (Koi or goldfish) can also be part of an integrated system. Others grow trout, shrimp, or other species of fish that are grown to meet local demand for the growers.

Aquaculture

- **The demand for seafood and opportunities for aquaculture**
  It is estimated that about 1 billion people rely on fish (defined here as fish, mollusks, and crustaceans consumed by humans) as their primary source of animal protein (FAO, 2001) and it provides more than 3 billion people with at least 15 percent of their average per capita animal protein intake (FAO, 2009). While fish makes up 19 percent in Africa and 21 percent in Asia, in the U.S. and Europe fish protein is only 10 percent and 7.6 percent of their daily diets.
- **History and varying types of aquaculture**
  For those of you interested in the history of aquaculture, scholars agree that it began in China and can be traced back to 3,500-4,000 years Before Present Era (BPE). It was with the first of China’s Emperors in the period of 2852-2737 BPE that there was evidence of growing grey mullet in pond culture. It is also believed that the Egyptians may have also developed some form of aquaculture about the same time as the Chinese. The first published work on aquaculture was a small volume by Fran Li that appeared in 475 BPE
- **Recirculating aquaculture systems (RAS)**
  Recirculation aquaculture systems (RAS) represent a new and unique way to farm fish. Instead of the traditional method of growing fish outdoors in open ponds and raceways, this system rears fish at high densities, in indoor tanks with a "controlled" environment. Recirculating systems filter and clean the water for recycling back through fish culture tanks.

Current Trends in CEA and Fresh Food Production

- **Current trends in local/regional food systems**
  For those interested in controlled environment agriculture (CEA) as either a career choice, owner, or investor it is important to understand that commercial scale CEA is complex, and the marketing channels may pose current challenges to selling the products grown in the greenhouse.
- **Vertical Farming**
  The modern idea of vertical farming uses techniques similar to glass houses, where natural sunlight can be augmented with artificial lighting. This is one of the fastest growing areas of CEA growing with many pioneers and innovators involved in establishing the data to show viability with other types of “ponics” growing.
- **Diversifying the definition of agriculture (think distributed agriculture)**
  The U.S. has long separated the growing of food (rural communities) at a distance from consumers (urban/suburban communities). With the convergence of the dwindling availability of natural resources (energy, land, fresh water), along with extreme weather occurrences and an ever growing global population, there is a need to create a new food system that includes urban agriculture (Raftery & Miner, 2012). Controlled environment agriculture (CEA) is well suited to be built closer to the consumer in urban and peri-urban (area immediately surrounding a city or town).

Controlled Environment Agriculture as a Career

- **Emerging CEA industry in the US and globally**
  The growth of CEA here in the US and around the world is expected to hit an all-time high in the next decade. Three overriding concerns remain as “bottlenecks” and all three are inter-related: capital intensive nature of building; the operational complexity; and the lack of skilled workers.
- **Career Paths in CEA**
  Unlike traditional agriculture skills that have been handed down from generations, controlled environment growing (CEA) requires technical proficiency and skills building currently unavailable in the U.S. for workers, or potential owners. Controlled environment growing (CEA) requires technical (STEM related) proficiencies and skills building currently unavailable in the U.S. for workers, or potential owners.
- **Grower/owner, owner, investor, supply chain, sales channels, business, scientist**
  Focus is given to the differing training tracks that are needed to follow different career paths as grower, greenhouse technician, quality control; or for those interested in business careers in the industry.

Contact Phone: 804-464-8040 | Email: info@agtechtraining.com