GROWERTALKS

Cover Story

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Smart Technology in the Greenhouse

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In today's world everything is "smart." But what does that really mean?

In simplest terms, it means that through various technologies, it makes what used to be an inanimate thing appear to have cognitive awareness or a very rudimentary kind of "thinking." This word is now applied to virtually everything, from your wristwatch to the thermostat in your home. Your doorbell camera may be able to use facial recognition to tell you who's at your front door. Your personal assistant can recognize your voice and turn your words into positive actions.

These things are amazing to be sure, but in the end, all this technology is supposed to do several things: keep us better informed, make our lives easier or more convenient, utilize energy in a better way, protect people and our loved ones, safeguard our belongings and equipment, and keep a record we can refer to when needed (history). All of these advancements in technologies have given rise to many smarter systems for greenhouses.

Smart technologies for the greenhouse

Generally, smart technologies used in modern greenhouse operations fall into these broad categories:

- Environmental management
- Cooling
- Heating
- Irrigation and fertigation
- Humidity control (humidification, dehumidification)
- CO_2 production and/or injection
- Light management (shading, blackout, supplemental, photoperiodic)
- Environmental data archiving, display and analytics
- Production management
- Production robots (sticking, transplanting, spacing)
- Bar code scanners (seed, tray and cart inventory)
- Inventory management (databases, reports, searches and predictive analytics)
- Shipping management (databases, reports, searches and predictive analytics)

As you look at even this partial list, it soon becomes obvious that they all have a few things in common. They all require:

1. Accurate, reliable data—In non-computer terms, data is information. Just as with ourselves, smart decisions cannot be made with inaccurate or false information. Our decisions will be misguided. What this means in the real world is well-calibrated, reliable sensors of various kinds. In the control world, these are called inputs.

2. Integration—To make smart decisions, systems need to know more than what's happening in one place. These systems need information about all factors that can affect the decision-making process. For example, would a smart irrigation program make the same decision on a cold, cloudy day as it would in hot, sunny weather? Probably not. So you can see how the integration of light level and ambient temperature can make a much smarter decision than one based simply on clock time.

3. Smart algorithms—Put very simply, an algorithm is just a step-by-step decision-making formula that leads to an output. You can call this output a decision. For example, if you're heating, you might ask, what is the heating setpoint? How cold is it outdoors? What's the difference between the indoor and outdoor temperatures? What's the design of this zone's heating system? That is, its ability to maintain a higher temperature indoors in relation to outdoor temperature. Based on this information, you can make a particularly good guess of what the heating system's hot water target should be or the pulse-width-modulation of unit heaters. This smart decision can produce the best quality crop with the least energy possible.

4. The ability to collect, organize, display and analyze data—For predictive analysis and troubleshooting, a record of key sensor levels and equipment responses must be kept and organized for the end user's benefit. Typically, the information is shown on graphs, in tables or on dashboards to give the end user a quick visual impression of current status or past events. Analytics programs can make predictions based on past events against current conditions.

How do systems get "smart"?

As you look at various systems, you'll start to hear certain buzzwords tossed around. However, don't allow the "flash" to obscure your need for real results. On the other hand, used effectively, these smart features can be unbelievably valuable and have a real impact on the bottom line.

To help you make better decisions in selecting the best system for your needs, let's define some of these catchphrases. We'll go from the simplest to the most sophisticated technologies that you're likely to encounter.

• **Wireless.** Wireless communication is nothing new. It's been around in various forms, like radio and TV, for over 100 years. You've probably used it for years in your business networks (WiFi and Bluetooth). In greenhouse structures, with all of their metal poles and trusses that tend to absorb or reflect radio waves, there have been issues with network reliability over the years. However, due to recent improvements, these technologies are becoming more practical in the greenhouse. If communication reliability is crucial, you may want to do some testing before going fully wireless on any portion of a network. If the system or device in question has local smart controls, and the wireless connection is simply for remote access, the reliability of the WiFi network may not be as crucial.

• **Remote access or management.** This is something we've all come to expect. It means we don't have to walk up and touch the device or system any longer; we can access it remotely from virtually anywhere we have access to the Internet. You'll most likely find that most systems you look at will have some remote access, although the exact nature of the interface may vary.

• **Data acquisition.** Again, this is something we've all come to expect and it's extremely valuable. For this reason, loss of data is something you'll want to avoid. Many systems have process computers or other smart controllers distributed around the greenhouse and are networked back to a central server for data archiving. Your IT consultant will be able to assist you with data loss at the server. However, you should investigate how data is collected and stored at the distributed controller. Many have an SD card or other storage device on board to prevent data loss in the event of a network failure. When the network is restored, the data is then sent to the server for permanent storage.

• **Data analytics.** Once the data is collected and archived, it can be analyzed to make predictions or provide the end user with critical information, such as average daily temperature (ADT) for quality control purposes.

• **Machine learning.** Many smart systems run problem-solving programs called algorithms. In the early days of computing, these algorithms were static; they stayed the same unless rewritten by a programmer. It soon became apparent that these programs could "learn" from experience. The algorithms could automatically change based on this experience and make an even smarter decision next time. In some systems, this technology is in its infancy, so be sure to investigate its performance with existing users. Not all machine-learning programs are created equal.

• **Artificial intelligence (AI).** AI is the most advanced form of machine learning. Many mathematicians, scientists, engineers and computer programmers have contributed to the field over the last century. Gradually, it's become more practical due to improvements in data storage and processing speed capabilities. With the ability to remember more (data storage) and think more quickly (processing speed), along with anthropomorphisms (humanlike qualities) like speech and facial recognition, machines appear more intelligent. Just as with machine learning, you must decide if AI will accomplish what you need. The amazing feats one sees with AI can blind us to underlying weaknesses in its ability to get the job done.

What hardware do you need to create a smart system?

The exact details of what you'll need depends on which system you select, but in general, you'll need certain things with any smart system. As we've discussed, information (data) is extremely important to any smart system, so you'll need a reliable network of some kind. Many networks use Ethernet. Ethernet has become a quite common method for sharing data between devices. You probably use this protocol extensively in your greenhouse and maybe even at home.

Related to Ethernet, there are numerous wireless products available that can be used to move data between devices. Your IT consultant can help you if your smart system's supplier has questions in this area.

Other unfamiliar names that might come up as you look at smart systems are Modbus (the most common), BACnet or Can Bus. What are these strange-sounding things? These are protocols for machines to exchange information with one another. They can be extremely helpful when large amounts of information need to move from one device to another. And the information can flow both ways—data from the machine and commands to the machine. The good news for you is that the manufacturer will usually build this capability into the smart system, so it's not something your people will have to handle.

As we mentioned earlier, good information is your most important asset when it comes to making a system "smart." For this reason, sensor selection is especially important. There are sensors available now to accurately measure virtually anything and at reasonable cost. In many cases, the system's manufacturer has already selected sensors that work well with their process. If, however, you need to select a sensor yourself, care should be taken.

Some of the biggest mistakes that are made with sensors are poor resolution, slow reaction time and bad calibration. Since these mistakes can affect the performance of your smart system, let us discuss these in more detail:

• **Resolution.** All sensors, no matter what they're designed to measure, have a definite range. If you select the wrong range, the accuracy of your system will suffer. For example, say you want to measure the climate temperature of an indoor zone that typically is about 60 to 100F. If someone selects a temperature sensor with a range of -40 to 1472F (a Type-E thermocouple in this case), you'll typically be using less than 3% of this sensor's range. This can result in poor quality temperature data with inaccurate control as a result.

• **Reaction time.** In addition, the mass or other qualities of the sensor can affect its reaction time, leading to a slow response to changes in the controlled process. The sensor's manufacturer should be able to give you specifications for reaction time.

• **Calibration.** A common mistake in calibration is to attempt this operation, but not in real time. For example, say the scaling of the sensor is done via a computer a long distance away from the sensor itself. This arrangement will only work well if there are two people using cell phones or walkie-talkies relaying calibration information in real time. A more practical approach would be to do the calibration via your smartphone while standing at the sensor location. Also, your calibration is only as good as your reference, so make sure it's calibrated properly.

What's next?

As you read this article, hundreds of people at many companies around the world are working to make systems that are smarter and more predictive. As with all emerging technologies, over time, certain approaches will rise to the top as others will fall by the wayside. Here's a list of some of the promising technologies:

• **LIDAR**—An acronym for "Light Detection and Ranging" uses a pulsed laser to build a 3D image. This technology holds great promise in many areas, but in greenhouses it could be used to accurately judge crop quality and maturation. LIDAR is just another sensor input, but it creates a mountain of data that can be used to improve overall quality and make predictions for environmental control and shipping.

• **AI**—Continuing advancements in AI and computer processing will lead to smarter systems over time.

• **Crop modeling**—This concept is a natural extension to machine learning. Its goal is to incorporate all growth factors into a common model to produce the best quality crop in the shortest time with the least resources. So instead of just temperature and humidity, fertigation, light energy and other known factors are all inputs added to an advanced crop modeling algorithm. In addition, it can automatically improve its decisions over time as growth data comes in from the crop.

What's the takeaway?

We've all learned that an emerging technology that initially looks promising doesn't always pan out. This is the main danger that promising or "cutting-edge" technologies pose. Therefore, as history has shown, the main takeaway is to do your homework. If in doubt, purchase the proven technology. You'll never be sorry.

And remember: all current technology has a shelf life of perhaps 20 years or less, so upgrades are inevitable. In the IT world, five or six years is a more practical lifespan. These upgrades will give you an opportunity to advance to newer proven technologies in the future. **GT**

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industry.