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Greener greenhouses promise more energy-efficient growing power

Commercial greenhouses in Europe are testing new energy and water efficiency technologies in support of the green transition.

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In the province of Almería in southeastern Spain, farmers grow an estimated 2.5 to 3.5 million tonnes of fruit and vegetables every year in what has become known as Almeria's sea of greenhouses. In this region, greenhouses stretch as far as the eye can see, covering an area of over 40 000 hectares (400 square kilometres).

It's partly thanks to this production that consumers across the continent can enjoy foods such as cucumbers, tomatoes and melons throughout the year. But there's a catch, these greenhouses aren't always very sustainable in terms or energy or water use.

Serena Danesi is a research associate at the Institute of Energy Systems and Fluid Engineering (IEFE) in Zurich, Switzerland. She specialises in thermal engineering and heat recovery and, over the past four years, has been leading the TheGreefa project that received funding from the EU to develop a new, more energy-efficient and environment-friendly system for controlling both temperature and humidity in greenhouses.

If Europe wants to meet its climate targets, and set the standard for sustainable food production – a goal set out in the EU's Farm to Fork strategy adopted in 2020 – then improving the sustainability of greenhouse farming will be a key concern.

'If we want to eat cucumbers, tomatoes and watermelons all year round, we need to be aware that their cultivation consumes a lot of energy and water,' said Danesi.

Climate control

Changes in climate conditions and a need to have more control over the growing environment of crops have led to a rapid expansion of commercial greenhouse cultivation across Europe.

It was estimated, in 2018, that Europe had some 210 000 hectares (2 100 square kilometres) of greenhouses, with particularly high concentrations in Spain (70 000 ha), Italy (42 800 ha), France, the Netherlands, and in

Central and Eastern Europe.

The energy needs of greenhouses differ, however, depending on their location. TheGreefa brings together researchers from Italy, France, Germany, Spain, Switzerland, Poland and Tunisia to investigate how their proposed system performs in different climate zones.

‘Greenhouses in Central Europe need heat because it is cold there. On the other hand, in Spain, they need cooling in the summer,’ said Danesi. ‘So there are different problems for different parts of Europe.’

In addition to temperature, humidity control is also an issue. As water evaporates from plants in a process known as “transpiration”, humidity levels rise and can become dangerously high. High humidity can cause fungal diseases, which can easily spread and destroy a crop. Moreover, if the humidity is too high, the plant will not be able to transpire normally and will die.

Heat from humidity

The ingenious solution proposed by the TheGreefa researchers allows greenhouse owners to use the moisture released naturally by the plants to generate heat. It also makes it possible to recuperate pure water from the excess humidity, thus saving on both water and energy.

A salt solution absorbs any increased moisture in the greenhouse, releasing heat in the process through a thermo-chemical reaction.

‘We can dehumidify the air and create heat all at the same time,’ said Danesi.

An added benefit is that this absorption process eliminates the need for ventilation, drastically reducing the amount of heat lost when windows need to be opened to get rid of excess moisture.

Once the salt solution has absorbed as much water as it can, it can then be regenerated using low level heat produced by surplus solar power. This separates the salt and the water, leaving the salt solution ready to be stored and reused when needed.

The dehydrating effect created by the salt solution can also be used for drying fresh produce like herbs and fruits to extend their shelf life. Because it works at low temperatures, qualities like smell and taste remain intact.

The technology was tested in greenhouses in Switzerland and Tunisia. In Switzerland the focus was on heating and seasonal storage, while in the southern countries the focus was on energy efficiency and water recovery.

‘We are now evaluating the results and we have seen some energy savings,’ said Danesi. ‘In the Swiss greenhouse, our system reduced thermal energy requirements by 50%.’

Although promising, widespread application of this technology in commercial greenhouses is still some way off. Pilot testing will, for the time being, continue in smaller-scale environments before moving on to a larger scale.

Farming goes solar

Another way in which greenhouses could become more sustainable would be to take advantage of the fact that these structures occupy large areas bathed in sunlight. That puts greenhouses in a unique position to use sunlight to generate clean electricity.

One challenge, however, is that solar panels tend to be opaque, so they can’t be placed over crops, otherwise these won’t grow. This was the challenge that electrical engineer Nick Kanopoulos decided to take on in a three-year EU-funded project called PanePowerSW that ended in 2021.

Kanopoulos is CEO of the start-up company Brite Solar based in Thessaloniki, Greece, that specialises in next-generation solar technology.

‘We wanted to build a solar panel suitable for agriculture so that, on the same land, we can produce both crops and energy without one impeding the other,’ he said.

Kanopoulos and his team developed a solar panel coated with nanomaterials that absorb light particles in the UV range of sunlight, which are not useful for either photovoltaic panels or growing plants. It then re-transmits them in the red and blue ranges of the visible spectrum, which are useful for both.

Visible light is thus able to pass through the panels while boosting both electricity production and photosynthesis, making the technology ideal for use in greenhouses.

Clean energy benefits

The team tested the panels in greenhouses in Greece, Spain, the US and Singapore, and in open field cultivation in Germany, France, the Netherlands and Romania. Tests were run on different crops, including tomatoes, blueberries, ornamental flowers and pear trees. Their results showed that farmers can significantly reduce their carbon dioxide footprint by generating clean energy while growing crops.

Besides farmers being able to produce their own energy, the innovative greenhouse structure offers further advantages. It collects rainwater for use on the crops and provides protection against adverse weather. It also reduces water evaporation, resulting in a significant drop – about 20-40% – in the water needed for irrigation.

Kanopoulos’ team is now expanding and building a factory in Greece to automate and speed up the production of solar glass. He said that with this factory, the company will be able to combine nano-coating application with solar panel assembly, all in one production line.

This will help them reach more customers, both small and large farmers, in an effort to make the agricultural sector more sustainable.

‘We think the wide use of this technology will decarbonise agriculture to a great extent and contribute to sustainable food production,’ said Kanopoulos.

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