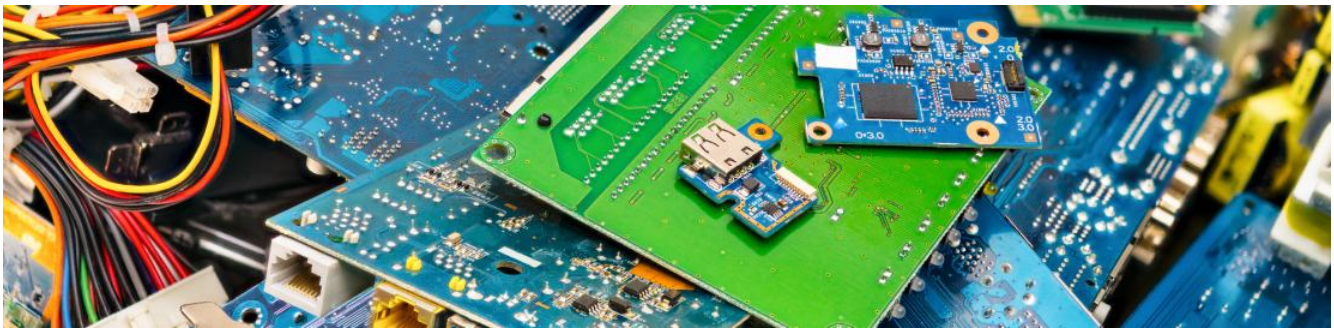
Horizon
The EU Research & Innovation Magazine

European Commission



Electronics made of wood and paper

Greener sensors, circuit boards and other electronic devices are being developed by EU researchers to reduce unsustainably high levels of e-waste.

13 June 2024 - By MICHAEL ALLEN

To develop eco-friendly electronics such as sensors and circuit boards, Dr Valerio Beni is following the paper trail – literally.

An expert in green chemistry at Swedish research institute RISE, Beni has switched his focus to wood from pulp in a bid to make consumer electronic devices that have no carbon footprint and are easier to recycle.

In the woodwork

He and his colleagues discovered that producing pulp and turning it into paper for a new generation of electronics required burning too much energy for the effort to be as environmentally friendly as they had hoped.

‘So we thought, why don’t we take a step back and go to the initial material for making paper?’ said Beni. ‘That is wood.’

He leads a research project that received EU funding to explore ways to make consumer electronics with wood-based materials.

Called HyPELignum, the project runs for four years through September 2026 and brings together research institutes, a university and industry representatives from Austria, the Netherlands, Slovenia and Spain.

The life cycles of current electronics are unsustainable. In addition to the energy and raw materials needed for production, the gadgets result in mountains of waste once they get discarded.

In 2022, the world generated a record 62 billion tonnes of e-waste – or 7.8 kilogrammes per person – with Europe producing 17.6 billion tonnes, more than any other region, according to United Nations data.

That worldwide mountain has almost doubled from 34 billion tonnes in 2010 and is projected to increase to 82 billion tonnes by 2030.

In addition to growing fast, e-waste is complex to manage, according to the UN. In 2022, only about a fifth of global e-waste was recycled – although Europe fared better by recycling around 43%.

Better boards

Circuit boards are the main component of e-waste.

As much as 60% of the environmental impact of electronics is caused by a device's circuit board, according to Beni.

The boards are a layered matrix of materials – usually resins, plastics and copper, which are hard to recycle. They're etched to imprint metal circuits, onto which electronic components can be soldered.

As an alternative, the HyPELignum team is developing two types of wooden circuit board.

One is made of thin layers of wood, a bit like plywood. The other is constructed from cellulose fibres extracted from wood and wood waste.

'The idea is to try and replace some of the high carbon-intensive materials in electronics with low carbon-intensive material,' Beni said.

The circuits are printed – rather than etched – onto the wooden boards using conductive metal inks developed by the project. These inks also contain cellulose and bio-based plastics produced from wood.

At the end of their life, the wooden boards should be easier to recycle than traditional circuit boards. It might even be possible to compost them.

New layers

A key challenge with recycling electronics is separating the components from the circuit boards.

To tackle this, the HyPELignum researchers are developing thermally and chemically degradable layers that can be placed between the wood and the printed circuits.

When these are destroyed at the end of a product's life, the circuits and electrical components fall off the wood. The wooden board and the mainly metal circuit and components can then be sent to different recycling streams.

Furthermore, the degradable layers are also derived from wood. The project has been producing them from lignin extracted from wood waste.

Such "green chemistry" emits much less carbon dioxide (CO_2) by featuring biogenic materials that can be renewed rather than fossil oil, according to Beni.

'Wood and biogenic materials are more or less zero in terms of CO_2 impact,' he said. 'They absorb CO_2 to grow and then they release the same CO_2 when used.'

More and more

The global population's ever-increasing appetite for digital devices is driving the need for greener versions, according to Dr Corne Rentrop, an expert in electronics and sustainable production at Dutch research organisation TNO.

'We want more data, we want more connectivity, we want to have internet everywhere, so the amount of electronics needed to equip that is growing constantly,' Rentrop said.

At the same time, the lifetime of electronics is decreasing.

'If you look at your electronic devices, they last for four to five years,' Rentrop said. 'That is basically it.'

He leads a separate EU-funded project to reduce the carbon footprint of electronic-device production and improve recycling.

Called ECOTRON, it runs for four years through August 2026 and has a range of participants from Belgium, the Czech Republic, Finland, France, Italy, the Netherlands and Spain.

Flexible films

Like its HyPELignum counterpart, the ECOTRON team is seeking to replace traditional circuit boards with ones made from renewable materials.

‘We can be more sustainable because the process requires less energy than producing standard circuit boards,’ Rentrop said.

But instead of wood, he and his colleagues are creating flexible films from materials like bio-based plastics and paper.

At the end of their life, bioplastic boards could be melted and recycled – and maybe even composted.

‘Compostable electronics would be fantastic,’ Rentrop said. ‘Paper is of course a compostable material, but the inks and the electrical components are not.’

To overcome this hurdle, the project is developing reversible interconnects that can be triggered to release the electrical components.

Company cases

The ECOTRON researchers are taking existing products and working to replace them with more sustainable electronics.

A Finnish company named Polar Electro, which makes devices that monitor fitness and athletic training, is participating in an effort to produce a wearable chest strap that measures a person’s heart rate.

The project has replaced an existing Polar Electro chest strap with a bio-based version whose performance is comparable, according to Rentrop.

Working with pharmaceutical company Johnson & Johnson, the team is developing smart stickers that contain temperature loggers for vaccine packages.

Healthcare professionals administering vaccines can access this temperature data using a handheld device such as a smartphone to check that each dose has been stored properly.

In this case, the researchers are working with paper, producing devices that can be recycled.

‘We are making an electronic device which is regarded as paper,’ Rentrop said. ‘This is recycling by design.’

Research in this article was funded by the EU’s Horizon Programme. The views of the interviewees don’t necessarily reflect those of the European Commission. If you liked this article, please consider sharing it on social media.

More info

- HyPELignum
- ECOTRON
- EU circular economy research