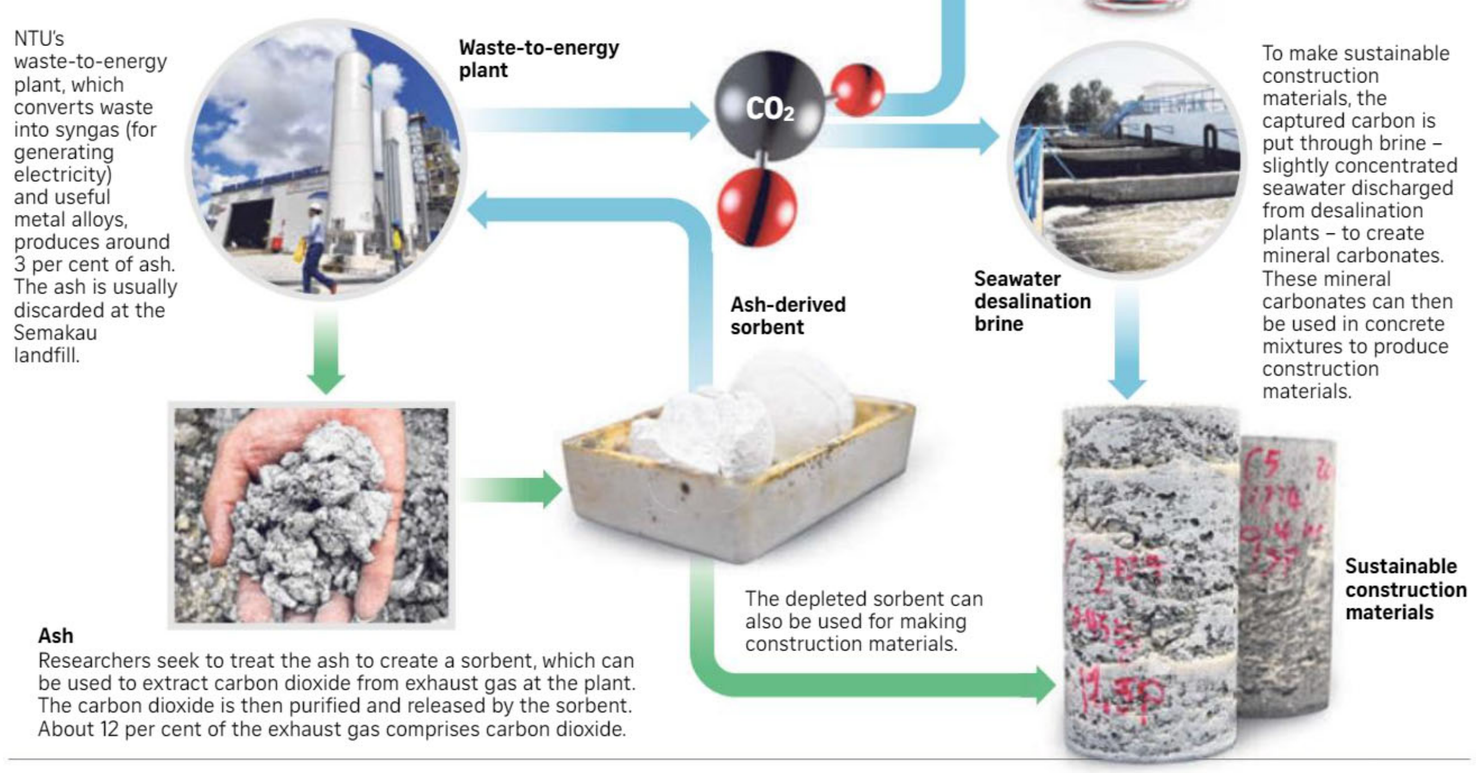
## Turning trash into resources

To make Nanyang Technological University's waste-to-energy facility even greener, researchers are looking to use the ash generated to capture carbon emissions from the plant and convert these into sustainable construction materials. **Cheryl Tan** looks at how this is done.




Source: ASSISTANT PROFESSOR PAUL LIU, SCHOOL OF CHEMICAL AND BIOMEDICAL ENGINEERING PHOTOS: NG SOR LUAN, ST FILE STRAITS TIMES GRAPHICS

### About the waste-to-energy plant

Nanyang Technological University's (NTU) waste-to-energy facility in Tuas South aims to convert the varsity's waste into valuable resources such as electricity, construction materials and useful metal alloys.

The $40 million facility, set up in May 2019, has processed 4,500 tonnes of rubbish so far.

The facility, which is capable of treating 11.5 tonnes of waste daily, takes in municipal waste from the NTU campus and other locations.

Unlike conventional mass burn incinerators, which operate at around 850 deg C, the NTU plant is able to heat up to 1,600 deg C. Its high temperature means it is able to turn rubbish into syngas – composed of mostly carbon monoxide and hydrogen – which is used to generate electricity.

The rubbish is also turned into recyclable metal alloys and slag – a glass-like material that can be used as a replacement for sand in concrete.

Some 85 per cent of the waste is converted into syngas, 12 per cent to slag and metal alloys, and the remaining 3 per cent into fly ash.

The slag is turned into NEWSand, a material that can be used in construction.

NEWSand can partially replace fine particles in concrete, and has been used in constructing a temporary concrete footpath at Our Tampines Hub and the new plaza in front of the Environment Building in Scotts Road.

Assistant Professor Grzegorz Lisak, director of the Residues, Resource and Reclamation Centre at NTU's Nanyang Environmental and Water Research Institute, told The Straits Times that the facility's exhaust flue gas, which contains carbon dioxide, is treated before being discharged as clean gas – containing mainly nitrogen – into the atmosphere.

But about 12 per cent of carbon dioxide is still leaked into the atmosphere.

Therefore, Prof Lisak's team is using ash to trap carbon dioxide in order to decarbonise the operations and get the facility to net-zero emissions.

"We are providing a testbed for this carbon capture technology, which can be applicable to other incineration plants," said Prof Lisak.

**Cheryl Tan**

# NTU team finds way to turn waste residue into building materials

**Ash generated from waste treatment facility is used to capture carbon emissions and turn these into resources**

**Cheryl Tan**

Researchers from Nanyang Technological University (NTU) have found a way to turn trash into resources – using ash generated from its waste treatment facility to capture carbon emissions and convert them into, for example, construction materials.

The project was one of 12 awarded a combined $55 million in grants under the national Low-Carbon Energy Research Funding Initiative, which seeks to reduce carbon dioxide emissions. One way is to capture carbon – for storage underground or to convert it into useful products.

NTU's waste-to-energy facility in Tuas South converts the university's trash into resources such as syngas (for generating electricity), metal alloys and construction materials.

Assistant Professor Grzegorz Lisak, director of the Residues, Resource and Reclamation Centre at NTU's Nanyang Environmental and Water Research Institute, said the facility can process up to 11.5 tonnes of waste each day, of which around 3 per cent ends up as ash, a by-product from the process of turning the waste into gas for generating electricity.

In comparison, about 18 per cent to 20 per cent of the waste processed in conventional waste-to-energy plants ends up as ash.

There are four such incineration plants in Singapore, and the ash usually ends up at the country's only landfill, on Pulau Semakau, which could be filled by 2035.

"While flue gas from the incineration and gasification plants is treated and filtered before being discharged as clean gas into the atmosphere, about 12 per cent of carbon dioxide ($CO_2$) is still released in the process," said Prof Lisak.

The plant has produced about 7,200 tonnes of $CO_2$ since it began operations in 2019. This is less than 1 per cent of the carbon emissions produced at the other waste-to-energy incineration plants in the last financial year – around 791,000 tonnes.

In a bid to help Singapore get to net-zero emissions and to reduce the amount of waste channelled to Pulau Semakau, the researchers came up with a solution to meet both needs.

Assistant Professor Paul Liu of NTU's School of Chemical and Biomedical Engineering, principal investigator of the study, said that as Singapore does not have many natural resources to be utilised for capturing carbon – one way is to turn to waste residues such as ash.

"We found that by selecting the right type of ash and performing the right treatment, we were able to develop very a high-performance $CO_2$ capture material at relatively low cost."

The ash generated from NTU's facility contains up to 80 per cent calcium, making it an effective material for absorbing carbon from the flue gas generated by the gasification, said Prof Liu.

Professor Simon Redfern, dean of NTU's College of Science, said calcium is a natural absorbent of carbon, though the process occurs over a much longer timescale. Calcium reacts with carbon, forming a solid, stable compound known as calcium carbonate.

Organisms in the ocean, such as oysters and mussels, use the calcium carbonate found in seawater to form their shells, said Prof Redfern. When these organisms die, they decompose on the ocean floor, and the sediments eventually become limestone.

While nature plays an important role in removing $CO_2$ from the atmosphere, the high concentration of $CO_2$ in flue gas contributes heavily to global warming, underlining the need for carbon capture solutions to remove it from the atmosphere, said Prof Redfern.

This is where materials like ash from NTU's waste-to-energy plant can come into play to speed up the carbon capture process.

The ash is first treated chemically to form a sorbent, which can extract high concentrations of carbon dioxide from the flue gas.

The process happens at a high temperature of 600 deg C, which accelerates it and prevents any carbon dioxide from escaping during the capture process, said Prof Liu.

The sorbent then releases the captured carbon dioxide in a purified form, which can be bottled and used in the manufacturing of carbonated drinks or as dry ice, or in welding in construction.

Alternatively, the $CO_2$ can also be put through brine – slightly concentrated seawater discharged from desalination plants – to make mineral carbonates. These can then be used in concrete mixtures for construction materials, said Prof Liu.

The spent sorbent can also be added into the mix for sustainable construction materials, he added.

The pilot facility to capture carbon emissions from NTU's waste-to-energy plant will soon be constructed and will be ready by late next year.

Prof Liu said that as the waste-to-energy plant produces flue gas, which has a higher concentration of carbon dioxide, it is a good way to test the effectiveness of the carbon capture technique.

"Ultimately, we want to capture $CO_2$ from fuel imports and natural gas power plants – which supply more than 90 per cent of our electricity, as these sources have more diluted $CO_2$," he added.

Emissions from natural gas power plants contain between 3 per cent and 5 per cent of $CO_2$, noted Prof Liu.

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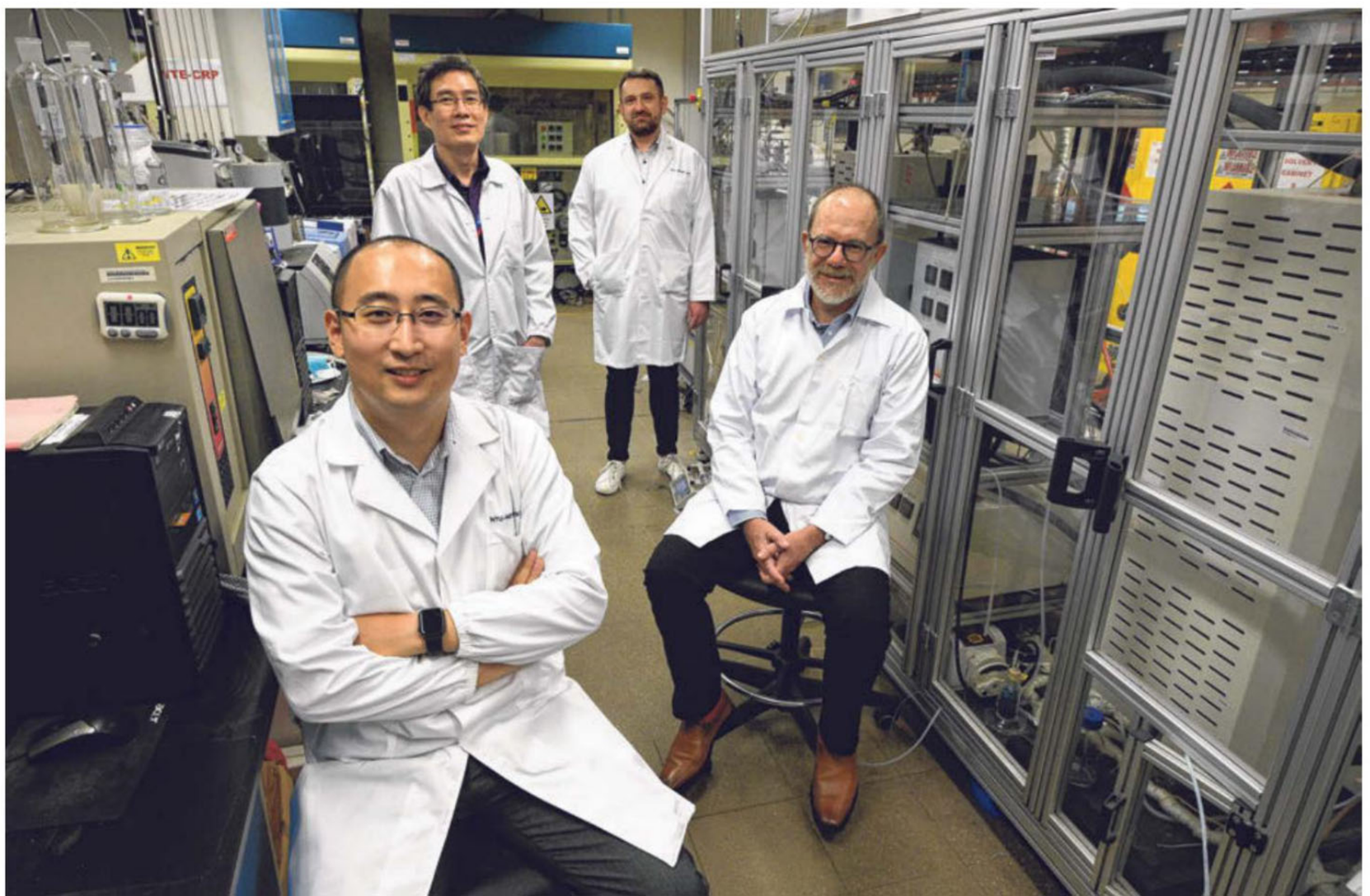

Samples of sustainable construction materials made from waste residue. Nanyang Technological University's project was one of 12 awarded a combined $55 million in grants under the national Low-Carbon Energy Research Funding Initiative, which seeks to reduce carbon dioxide emissions.

Left: The NTU team includes (clockwise from lower left) Assistant Professor Paul Liu from the School of Chemical and Biomedical Engineering; Professor Lim Teik Thye from the School of Civil and Environmental Engineering; Assistant Professor Grzegorz Lisak, director of the Residues, Resource and Reclamation Centre at the Nanyang Environmental and Water Research Institute; and Professor Simon Redfern, dean of the College of Science. ST PHOTOS: NG SOR LUAN