NEW TECHNOLOGIES FOR A CHANGING CLIMATE

MORE FROM LESS

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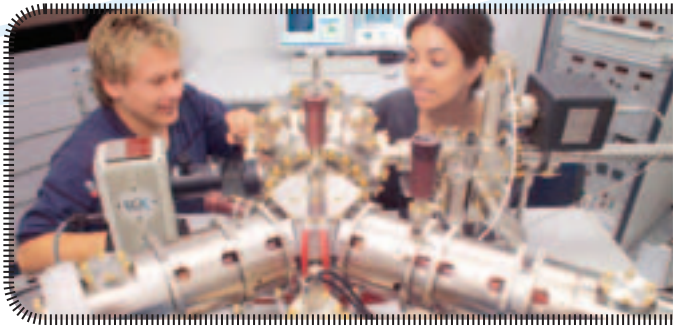
We are supporting a growing population on a finite planet and so must be smarter and more efficient than ever before. We need ongoing innovation and new ways of getting more from less.

This challenge has produced a changed climate for the development of new technologies: innovations that can reduce environmental impact, and change the way we live.

Whether we're sourcing, converting, distributing, storing or using energy, there are many revolutionary technologies in the pipeline. This booklet is your guide to what is likely to be in store. Some of these products are already available; others may be many decades from becoming an everyday reality. But each offers a new way of looking at our world, and new possibilities for our future.

Technologies such as biotechnology and nanotechnology are opening the door to improved efficiency and cleaner, greener lifestyles.



Monash University's School of Physics has recently installed a Low Energy Electron Microscope (LEEM), capable of imaging at super-high resolutions of several nanometers. The LEEM is the first instrument of its type in the Southern Hemisphere. [Steve Morton, Monash University]

Biotechnology is the science of living things, like bacteria and plants, and of biological processes, such as growth (e.g. in seed germination) and fermentation (e.g. when brewing beer or making yoghurt). Biotechnology can also be used to produce cleaner industrial processes, or to help clean the environment. A new and powerful tool in the biotechnology toolbox is gene technology, which allows us to transfer genes – and the traits they encode – from one organism to another.

Nanotechnology is the science of the very small, dealing with particles only several nanometres wide. A nanometer (nm) is one millionth of a millimetre, and a nanoparticle may contain only several hundred atoms. By comparison, a human hair is around 80,000 nanometres in diametre. At this tiny scale, the properties of ordinary materials such as gold and silicon change, allowing us to make all-new materials and devices.

Around the house

Lighting the way

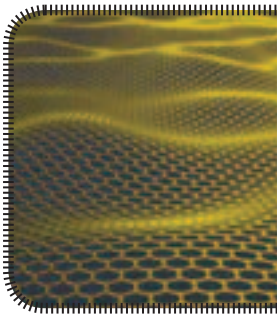
Cheap and highly efficient white Organic Light Emitting Diodes (OLEDs) pass an electrical current through inexpensive dyes to create white light many times brighter than that produced by incandescent globes. Using nanoparticles OLEDs can be coated onto plastic sheets or metal foils, creating energy-efficient light-emitting films no thicker than a sheet of paper. Researchers predict that increases in the efficiency and economy of OLEDs will see them replace fluorescent tube lights by 2023.

[Tich-Lam Nguyen, University of Melbourne Nanoscience Laboratory]

OLED displays are far superior to flat-panel plasma and liquid crystal displays, offering better image quality, wider viewing angles, and drastically reducing power consumption.

Greener computing

Sheets of carbon just one atom thick – called graphene – are being used to develop electronic devices that run cooler, faster, more reliably and more efficiently. Graphene nanotubes rolled into high-strength fins can be used to cool computer chips more efficiently than conventional copper, but are ten times lighter. Another innovation is the memristor, a new electronic circuit which is tipped to replace traditional transistors and be used to develop nano-scale logic gates and super-dense high-speed memory chips.



Jannick Meyer

Graphene is the ultimate building block: just one atom thick, it can be rolled into tubes, wrapped into balls or stacked into blocks.

TECHNOLOGIES

Paint-on energy savings

You can now drastically reduce the cost of heating and cooling your home using a coat of insulating nano-paint. One such paint already available in Australia contains nano-scopic balls of glass that reflect sunlight and reduce heat transfer, cutting your energy bills and reducing damage from mould, corrosion and UV light. Cavity insulation, used in ceilings and walls, is also getting thinner, making it more useful in smaller spaces. Insulating foam, comprising huge numbers of microscopic pores that minimise heat transfer, can be formed into sheets that fit places other insulation won't go. Researchers are also investigating how to generate an electrical current by using insulation to create differences in temperature .

Powering your lifestyle

Infra-red thermovoltaics

Nanoscale crystals called quantum dots can be used to harvest power from invisible infra-red light, the warm part of sunlight. The quantum crystals can be grown to specific sizes, and each size absorbs a specific frequency of light. By including crystals in a chosen range of sizes, scientists can tune a solar cell to efficiently absorb energy from visible and invisible light frequencies. Solar cells tuned to harvest thermal energy **could also work at night**, absorbing energy released from surfaces warmed by the previous day's sunlight, such as buildings and roads. Cells using this technology could also harvest waste heat to generate clean electricity.

Solar options

Solar energy is fast becoming cheaper, more efficient and more effective. Next generation solar cells will be flexible, thin and virtually transparent, suitable for lining windows or walls of buildings. Solar power plants are being built all over the world with new research and technologies for energy generation and storage in development to ensure a reliable power source. New anti-reflective technology means stationary solar panels will be able to absorb sunlight regardless of the sun's position.

[Chris Morgan/Idaho National Laboratory]

By depositing nanoparticles of silver on the surface of thin-film solar cells, Australian National University researchers can trap light energy, boosting efficiency and making solar power more competitive with fossil fuels.

KYLIE CATCHPOLE [Meghan Petersen]

Red dye made from common berries can improve the efficiency of fiber-based solar cells, already twice as efficient as traditional flat cells.

The plastic fibers are stamped onto plastic sheets using the same technology that attaches the tops of soft-drink cans; the dye helps each fibre to absorb more sunlight. CSIRO is currently researching more cost-effective, reliable and efficient dyes for this type of cell.

CSIRO's Universal Energy Platform will use broadband Internet connections to allow consumers to remotely or locally manage their energy use, giving individuals the same opportunity as large energy consumers to reduce their electricity bills – and their environmental footprint.

CSIRO is also working on technology that will bring high performance wireless broadband to regional and remote homes, enabling the delivery of new health, government and education services over the Internet.

In your kitchen

Fresh water from the sun

IBM are working with Saudi Arabia's national research organisation to build a solar-powered desalination plant, combining two technologies in a bid to radically change the way fresh water is supplied. The team will use nanoparticles to filter salts and toxins from seawater, powering the process using high density solar cells. They aim to produce all of Saudi Arabia's drinking water using solar technology.

Smart agriculture

Our understanding of plant genetics has introduced a host of farming innovations, including crops that grow in salty conditions, require less water and are less dependant on chemical pesticides. Growing crops that need fewer chemical fertilizers and pesticides reduces environmental run-off and pollution, and also conserves fuel that would otherwise be used for chemical transport and delivery. More greenhouse gas savings come from crops that thrive in a 'no-till' environment. Reducing soil tillage keeps more organic matter in the soil, thus trapping more carbon dioxide gas, as well as reducing evaporative water loss, and cutting erosion.

Clean drinking water saves lives. The University of South Australia is developing energy-efficient water filters that use ordinary sand coated with a nanomaterial as a filter to remove pollutants and bacteria like cholera from drinking water.

Many consumers are opting for a low-carbon diet, using carbon calculators to reduce the environmental impact of the foods they choose to buy. Consumers can select meat or dairy produced from livestock that generate less methane, eat vegetables with fewer 'food miles' or reduced need for pesticides, or opt for eco-friendly packaging.

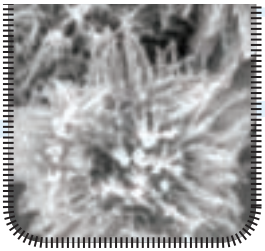
Flying fuels

Aviation is important to the Australian economy and way of life, but it also accounts for two per cent of global greenhouse gas emissions. Cleaner jet fuels derived from plant matter (known as bio-oil) offer the largest single opportunity to reduce emissions. CSIRO and the Australasian aviation industry are working together to investigate cost-effective plant-derived jet fuel.

Hybrid plastics

Traditional plastics are produced using fossil fuel-based hydrocarbons, but are starting to be directly replaced with silicon-derived Polyhedral Oligomeric Silsesquioxanes, or POSS technology. POSS materials are recyclable, non-flammable, and don't produce the volatile organic compounds associated with sick building syndrome.

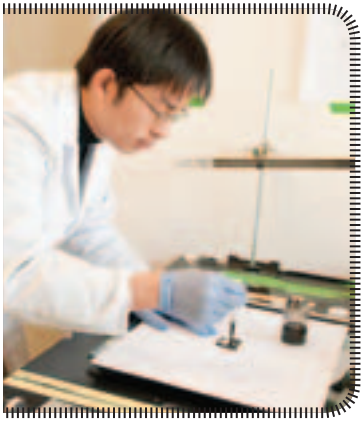
Getting around



Tomorrow's cars

Hybrid cars combine petrol with electric batteries to use 30 to 50 per cent less fossil fuel than conventional vehicles, and CSIRO's UltraBattery promises to take these savings even further. Compared to existing hybrid electric batteries, the UltraBattery lasts four times longer, costs 70 per cent less and provides 50 per cent more power.

CSIRO are also researching the use of waste engine heat to power your car's air conditioning, the development of carbon coatings to reduce engine friction, the integration of plug-in electric vehicles into our homes and the electricity grid, and increasing the use of light metals such as magnesium in car bodies and parts, because lighter cars use less fuel.



[Linda A. Cicero/Stanford News Service]

Paper batteries

Yi Cui's team at Stanford University has produced ultra-lightweight batteries by printing paper with ink made of carbon nanotubes and silver nanowires. The batteries last 40,000 charge-discharge cycle s, survive soaking and bending, and can be used to store energy produced by wind farms and solar energy systems.

Cheap fuel cells

Your car could soon be running on green energy produced from its own hydrogen-oxygen fuel cell. These fuel cells combine oxygen and hydrogen to form pure water, driving an electrical circuit in the process. The U.S. Department of Energy predict that by 2015, running your car using a fuel cell engine will cost the same as a petrol-powered engine. Cost savings will come as the quantity of platinum catalyst each cell requires is reduced: already, savings of 80 per cent have been achieved by using platinum atoms arranged in nano-wires or latticed with copper.

CO2 to methanol fuel

Researchers in Germany are studying the possibility of using sunlight to convert waste carbon dioxide directly into methanol, a climate-neutral fuel already used in the engines of racing cars and Monster Trucks. The team is using nanoscale particles to increase the absorption of sunlight, aiming to optimise efficiency and reduce costs.

Just add water

Want to reduce soot and nitrous oxide emissions from your diesel engine? Researchers have discovered that adding nano-droplets of water to diesel fuel can cut diesel emissions without using a filter.

Industrial strength

Coal mining

CSIRO researchers hope to use waste gases from coal mining to generate energy and potentially slash global emissions of such waste gas by the equivalent of 237 million tonnes of carbon dioxide. The technology, called a Ventilation Air Methane Catalytic Turbine, uses methane in exhaust air from under ground coal mining to fuel a gas turbine, producing energy that can be used to power the mine or be cycled back into the grid.

Aluminium smelting

The amount of energy required to produce aluminium could be greatly reduced as CSIRO researchers investigate the use of liquid salts to replace cryolite, a mineral solvent that must be heated to 1000 degrees Celsius to extract aluminium. The salts, known as ionic liquids, comprise charged mobile particles that can conduct electricity at around room temperature.

As well as slashing energy bills for the aluminium industry, ionic liquids show potential for use in storing solar energy, recycling plastics, and capturing carbon.

Geopolymers in a footpath like this one, laid at Curtin University in WA, are made from waste fly ash from coal-burning power stations, and slag produced by iron-making blast furnaces. [CRC For Sustainable Resource Processing]

Building and construction

The concrete industry contributes at least five per cent of the world's human-created greenhouse gas emissions. But imagine a building material produced from waste products and designed to be fire-resistant, blast-resistant, acid-resistant, sprayable, castable, adhesive and strong, plus it produces 43 per cent fewer carbon emissions than Portland cement. These new materialsalready exist: they are silica-based geopolymers, and CSIROscientists are working on new applications in construction and manufacturing.

Air conditioning

50% to 275% improved efficiency

Red-hot energy savings are in store for industrial coolers. Researchers have found that adding copper oxide nanoparticles to a mix of standard refrigerants and lubricants can improve heat transfer inside a cooler by 50 to 275 per cent. This improved efficiency could slash the energy required to run massive cooling systems like those used in factories, hospitals, shopping centres and ships.

Eyes on the future

What does the future hold?

This year scientists used a living algae cell to generate a tiny electrical current, for the first time tapping into photosynthesis as a potential power source. Other teams are working to create cars and phones that recharge using power generated by ultra-thin batteries incorporated into their bodywork. Farmers and gardeners are using hydrophobic nano-coated sand to create artificial water tables that help to reduce water use. You are probably using sunscreen that contains nanoparticles to protect your skin from UV rays.

These innovations are part of the race to combat environmental damage and climate change, but how do we know if we're racing too fast?

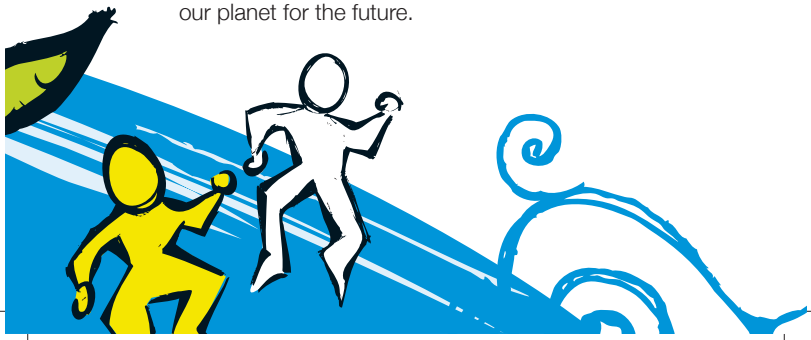
CSIRO is working on new technology that will pave the way for solar power of the future. Most solar thermal power stations require water to operate; CSIRO's solar Brayton Cycle technology does not need water, making it ideal for many parts of Australia, and the world, that receive minimal rainfall.

It is essential that our understanding of the wider impact of these technologies keeps pace with their development.

Health, safety and environment

Technologies such as **biotechnology** and **nanotechnology** can make a huge difference to the way our world works, but their applications require stringent testing and due diligence. Work by the Government's National Enabling Technology Strategy and CSIRO's Nanosafety team, co-operating with bodies like the Organisation for Economic Co-operation and Development (OECD) and the UK's Centre for Nano Safety, are part of an ongoing global effort to ensure new technologies are regulated and properly assessed. Stringent safety standards and tests are being developed alongside these technologies to assess their impact on our health and environment.

Improving our understanding of the healthy and safety issues surrounding these cutting edge technologies is just one of the challenges ahead. Researchers must also find new ways to make these innovations feasible, a process that involves reducing production costs, improving production efficiencies, and developing ways to recover and reuse costly materials. These challenges are part of an international effort to equip our planet for the future.



For more information

For more information about cutting edge technologies and their applications, contact TechNyou – a source of balanced information on emerging technologies supported by the Government in partnership with the University of Melbourne – on the freecall Australia-wide number **1800 631 276** or visit **www.technyou.edu.au**.

Practical information on climate change and ways in which you can reduce your carbon footprint is available from the Department of Climate Change and Energy Efficiency on freecall 1800 057 590 within Australia or www.climatechange.gov.au

Australia's national research agency, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) is conducting a range of research to help Australia respond to the challenges and opportunities presented by a changing climate. CSIRO researchers are contributing to a better understanding of the Earth's climate system, looking at ways to reduce greenhouse gas emissions, and preparing for and adapting to climate change impacts that are now unavoidable.

For more information visit www.csiro.au/science/Climate-Change or call the CSIRO enquiries line on **1300 363 400**.

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