

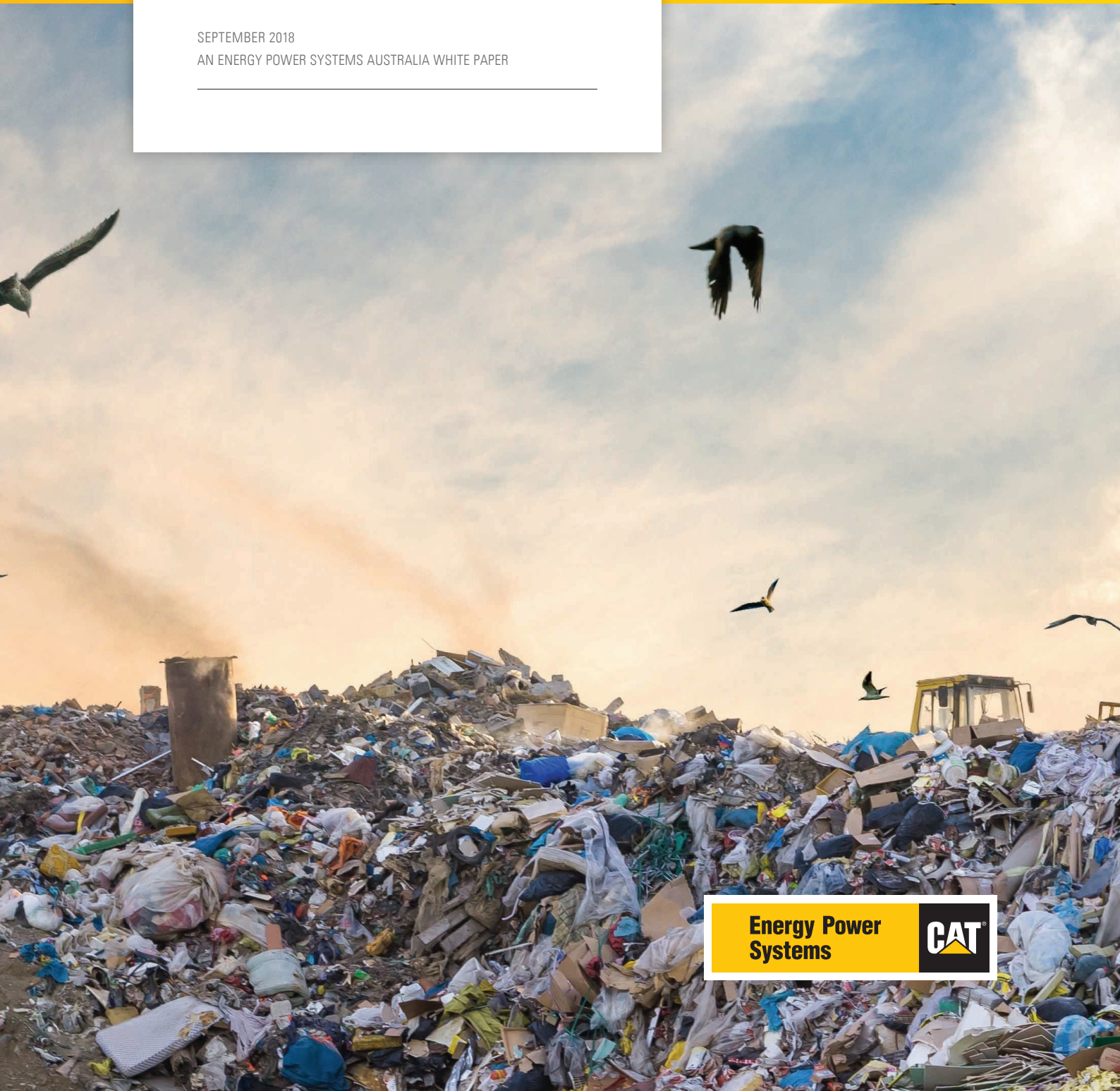
energypower.com.au

Beyond Landfill

Immediate opportunities to
produce energy from waste

SEPTEMBER 2018

AN ENERGY POWER SYSTEMS AUSTRALIA WHITE PAPER



**Energy Power
Systems**

CAT



//

Methane capture is a valuable source of power but, more importantly, it can significantly reduce Australia's methane emissions. However, the opportunity to produce energy from waste is largely being squandered, as up to 80% of the potential methane in waste is not used. If more councils were prepared to invest in better facilities, Australians would benefit from less waste in landfill and more energy in our grids.

//

William Clarke, Professor of Waste Management, The University of Queensland and Bernadette McCabe, Associate Professor and Principal Scientist, University of Southern Queensland.

'CAPTURING THE TRUE WEALTH OF AUSTRALIA'S WASTE' THE CONVERSATION, AUGUST 24, 2017¹

Turning waste into alternative energy

Australia is a very heavy user of landfill to dispose of waste. In fact, the majority of waste that we are not recycling or reusing goes to landfill – and this can detrimentally impact on our air, water and land quality. But there is a positive side to landfill gas too.

The substantial methane content of landfill gas makes it a powerful power generation fuel

In their *2016 Australian National Waste Report*, the Department of Environment and Energy found the highest levels of energy recovery per capita were in NSW, Victoria and Tasmania due to large landfills collecting methane for electricity generation². They also identified a trend towards more recycling and recovery of energy from waste, stating "with several dedicated energy from waste facilities planned for WA and NSW, energy recovery from waste in those states may increase significantly in future years". Landfill gas contributes to global warming and there's potential for our water systems to be contaminated with leachate (the liquid that drains from landfill) or other hazardous substances.

There are also other alternatives to help reduce waste and increase fuel production

Exciting opportunities are ripe for sustainable renewable alternative power generation with capacity to help the environment and community too. Landfill and agricultural wastes are already burned and some methane captured from landfill to generate power development in agricultural biogas from crops such as sugarcane, organic biogas from food waste, and tyre-derived fuel - and there is opportunity to do more.

Now's the time to make the most of waste as Australia faces an imminent energy crisis

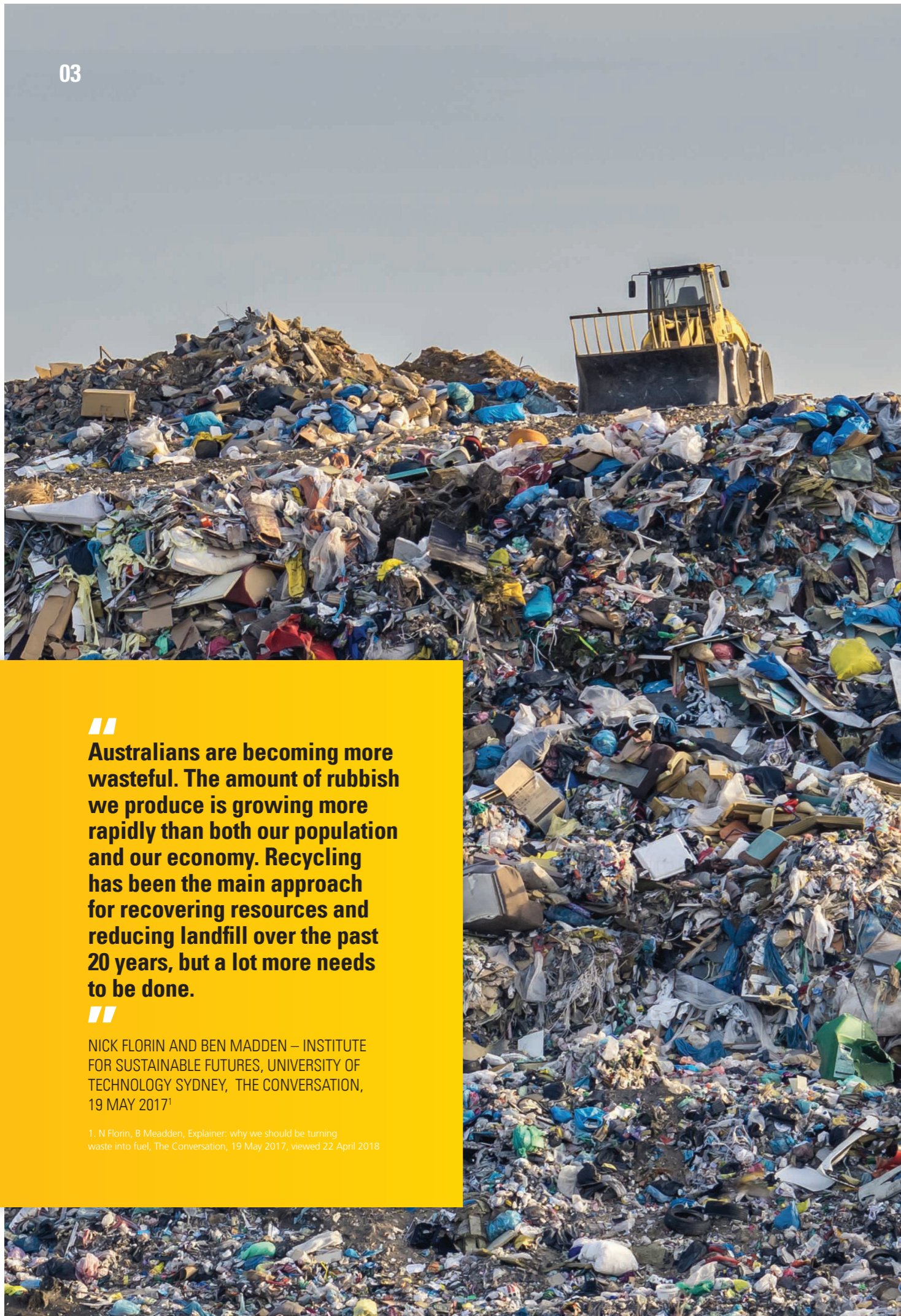
At EPSA, we're at the forefront of working with innovative organisations committed to the development and facilitation of renewable sources of energy alternative ways to provide power generation – especially at a time when energy prices and grid stability are so precarious.

We're also proud to be associated with Caterpillar® and deliver Cat® power systems. Caterpillar® is continually researching, developing and delivering purposefully alternative energy gas generation products. This white paper reveals that the opportunity is right here and right now in Australia to turn waste into innovative forms of energy.

Phil Canning
Managing Director

¹ W Clarke, B McCabe, *Capturing the true wealth of Australia's waste*, The Conversation, 24 August 2017, viewed 9 November 2017

² Dr J Pickin and P Randell, *Australian National Waste Report 2016*, Department of the Environment and Energy and Blue Environment Pty Ltd, 20 June 2017, viewed 9 November 2017



“**Australians are becoming more wasteful. The amount of rubbish we produce is growing more rapidly than both our population and our economy. Recycling has been the main approach for recovering resources and reducing landfill over the past 20 years, but a lot more needs to be done.**”

NICK FLORIN AND BEN MADDEN – INSTITUTE FOR SUSTAINABLE FUTURES, UNIVERSITY OF TECHNOLOGY SYDNEY, THE CONVERSATION, 19 MAY 2017¹

1. N Florin, B Meadden, Explainer: why we should be turning waste into fuel, The Conversation, 19 May 2017, viewed 22 April 2018

Wasting Australia - our garbage habits

64 million tonnes of waste generated in 2014-15¹

20 million tonnes garbage goes to landfill (largely in capital cities)²

75% of landfill waste goes to just 38 sites nationally³

23% Over the past decade⁴, Australia's waste generation has risen by 23 per cent⁵

That's around 2.2 tonnes of waste per person every year that the Australian Bureau of Statistics cite as our "most rapidly increasing environmental and economic metric".⁶

- » Our waste industry recycles around half of the waste Australia generates and landfills the rest.⁷
- » Waste in landfills falls into the categories of household rubbish, commercial and industrial waste, and construction and demolition waste.
- » Local councils are responsible for landfills in their areas, but larger sites are run by private companies.⁸
- » Australia ranks just 17th among OECD nations when it comes to recycling⁹ partly due to the availability of secure markets for the various products produced.

1. Pickin, ibid. 4. Between 2006-07 and 2014-15 7. Pickin, ibid.
2. Clarke, ibid. 5. ABS 2016 cited in Pickin, ibid 8. Clarke, ibid.
3. Clarke, ibid. 6. ABS 2016 cited in Pickin, ibid 9. Pickin, ibid.

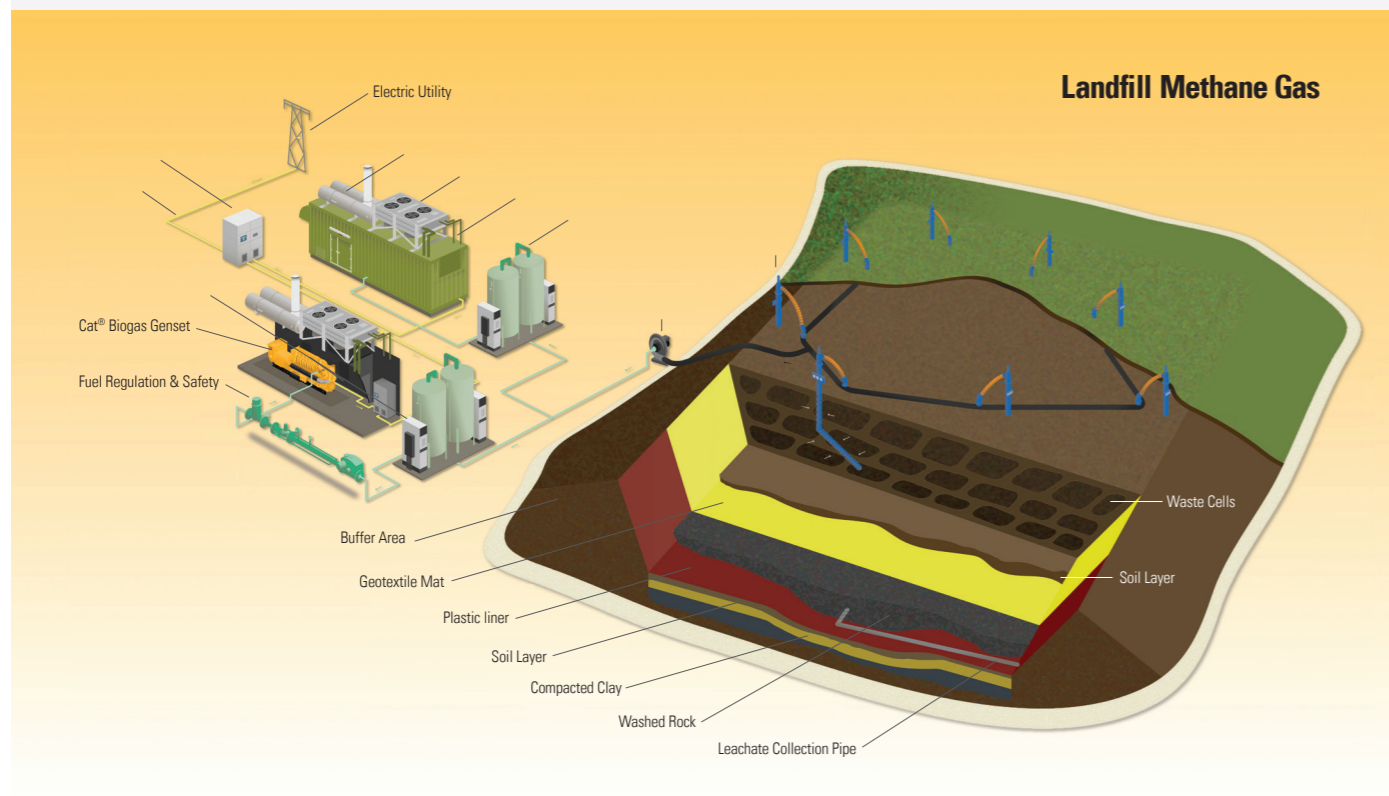
Looking to landfill

Landfill gas is the natural by-product of decomposing organic waste in landfills.

- » It's composed of around half methane (the primary component of natural gas and a potent greenhouse gas) and half carbon dioxide with a small percentage of non-methane organic compounds.
- » Household and other organic waste including paper deposited in landfills can take decades to decay, meaning landfill gas is generated long after waste is first deposited and continues to be produced for many years after the landfill site is closed.
- » Landfills that do not collect and combust landfill gas release large amounts of methane into the atmosphere.
- » By increasing capacity to capture landfill gas, the opportunity to convert it into renewable energy rises while reducing odour, emissions hazards and methane leaking into the atmosphere, which causes smog.
- » Using landfill gas to generate energy and reduce methane emissions is a positive development for both the communities it services and the environment.
- » Around 130 landfills in Australia are capturing methane and using it to generate electricity.¹
- » Australia's largest landfills use 20-30 per cent of the potential methane in waste for electricity generation (based on installed power generation capacity and the amount of waste received).²

The landfill gas energy cycle

Landfill gas is captured through a perforated well pipe and gathering system with the gas extracted from the landfill into a compressor station, processed, and used as a fuel source. Modern landfills install gas collection systems to capture and destroy the naturally produced methane gases – but rather than eliminating the gas by burning it off, it is turned into a renewable fuel via a gas-fuelled generator that produces electric power. Generators designed for landfills collect, clean and run on those harmful gases making for sustainable reliable power that can reduce impacts on our environment.³



1. Clarke, *ibid.* 2. Clarke, *ibid.* 3. © Caterpillar Inc.



“ Part of the methane generated in landfills can be captured and used as a renewable energy source. In contrast, when methane is allowed to escape to the atmosphere, it has a global warming potential that is estimated to be 23 times greater than that of the same volume of carbon dioxide. ”

NICKOLAS J. THEMELIS & PRISCILLA A. ULLOA –
 ‘METHANE GENERATION IN LANDFILLS’, 15 APRIL 2006
 EARTH ENGINEERING CENTER AND DEPARTMENT OF EARTH
 AND ENVIRONMENTAL ENGINEERING, COLUMBIA UNIVERSITY.¹

1. Energy Information Administration, *Emissions of Greenhouse Gases in the United States 2003. Comparison of global warming potentials from the IPCC's second and third assessment reports*; cited in N Themelis and P Ulloa, *Methane generation in landfills*, Earth Engineering Center and Department of Earth and Environmental Engineering, Columbia University, New York, 15 April 2006, viewed 1 December 2017.

Standing up to siloxane

New contaminants like siloxanes and other man-made compounds are an increasing problem in landfill sites but there is a smart solution.

These non-toxic silicon-bearing organic compounds are added to many domestic products like deodorants to improve their texture and feel; and as we use more of them they add to the chemical mix being added to our waste and drainage systems, and consequently our landfills. The problem for landfill gas-to-energy operators is when contaminants like siloxanes react with the engine lube oil causing varied combustion deposits.

The main issue with siloxanes and other silicon-bearing compounds is that they are volatile and evaporate and migrate out with landfill and digester gases – either harmlessly in a flare, or harmfully inside internal combustion equipment.

If untreated, biogas prior to induction can contain varying levels of siloxanes which, during the combustion process, convert to silicates. These form part of the combustion deposits and are highly abrasive substances affecting the combustion chamber, cylinder head valve gear, exhaust systems and turbochargers. These deposits also contain strong acids that have a detrimental effect on the service life of the lubricating oil.

Evidence of siloxanes in biogas is found in the form of a white powder in gas turbine hot section components, as a light coating on various types of heat exchangers, in deposits on combustion surfaces in reciprocating engines, and as a light coating on post-combustion catalysts. The white powder is primarily silicon dioxide (SiO₂), a product of siloxane combustion.

Manufacturers of combustion turbines and reciprocating engines are expressing an increasing desire for siloxane control – despite almost two decades of successful experience without such controls. There is no doubt that some maintenance cost benefit can be realised by siloxane removal (and through the incidental removal of other biogas contaminants that will occur during siloxane removal); however, it does not currently appear that siloxane removal is cost effective in most cases.



The waste-to-fuel opportunity



**Organic waste
food as fuel
beyond the body**



Food waste should have a high value. We're treating it as a resource, and we're making marketable products out of it... Food waste is still carbon – a lot of carbon.



In 2014-15, about 542 kilograms per capita of non-hazardous organic wastes were generated – just over half were recovered mostly through garden composting but some energy recovery was predominantly from organics sent to landfills with gas collection systems linked to the electricity grid.²

But researchers at Cornell University in the US have discovered a way to capture nearly all of the energy in a food waste product, leaving little behind for landfill using a process called hydrothermal liquefaction.³ The waste is 'pressure cooked' to produce a crude bio-oil that can be refined into biofuel, while the remaining food waste is anaerobically digested by microbes and converted into methane.⁴ Currently, with the exception of agricultural and forestry biomass, extensive energy generation from solid organic wastes is not well-developed outside landfill but is promising.⁵



**Blended biofuel
powering flights of
the future**



Sustainable aviation biofuel will decrease carbon emissions and support the continued growth of aviation.



In January 2018, Qantas operated a dedicated biofuel flight between the United States and Australia: QF96 from Los Angeles to Melbourne was a trans-Pacific 15-hour flight using approximately 24,000 kilograms of blended biofuel, saving 18,000 kilograms in carbon emissions.

The biofuel processed from brassica carinata, a non-food, industrial type of mustard seed.

The flight was part of the partnership announced in 2017, which will also see the company work with Australian farmers to grow the country's first commercial aviation biofuel seed crop by 2020.



**Tyre waste
driving another
future energy
source**



Replacing one tonne of black coal with a tonne of tyre-derived fuel can save up to 1.05 tonnes of CO₂.



Around 51 million equivalent passenger units of end-of-life (EOL) tyres are generated in Australia every year.⁸ Less than ten per cent are recycled; illegal dumping, burning and direct incineration presents challenges⁹ – and a big opportunity.

Tyre-derived fuel (TDF) is produced when those EOL tyres (typically cut or shredded tyres and tyre chip) are converted into a product for use as fuel feedstock.

TDF is a viable alternative for fossil fuels in power stations, smelters, cement kilns and paper mills. In Victoria alone, at least 18 per cent of total annual EOL tyres are exported as TDF – offering around \$100 per tonne more revenue for a tyre collector against landfill costs.¹⁰

1. Clarke, *ibid.*. 2. B Friedlander, Cornell engineers transform food waste into green energy, Cornell Chronicle, 13 June 2017. 3. Dr J Pickin and P Randell, Australian National Waste Report 2016, Department of the Environment and Energy and Blue Environment Pty Ltd, 20 June 2017. 4. Friedlander, *ibid.*. 5. R Posmanika, et al, Coupling Hydrothermal Liquefaction and Anaerobic Digestion for Energy Valorization From Model Biomass Feedstocks, Bioresource Technology, June 2017. 6. Qantas <https://www.qantas.com/travel/airlines/sustainable-aviation-fuel/global/en#jump5>. 7. B Nogrady, Transforming waste into fuel with Australian innovations, from tyres to sugar cane and agave, The Guardian, 16 December 2016. 8. Inside Waste, ATRA proves TDF an attractive alternative fuel, 10 February 2017. 9. A study conducted by Arcadis (previously Hyder) in 2015 cited in Inside Waste, *ibid.*. 10. Planet Ark, Fact sheet: tyre recycling

Cat® gas gensets in renewable action

Cleanaway taking advantage of Melbourne's waste.

Cleanaway is Australia's largest waste management, industrial and environmental solutions company, operating eight operational landfills, 15 transfer stations and 25 recycling facilities around Australia. In 2014, they purchased the 1,100 hectare Boral Deer Park Quarry (established in 1965) and turned the site into Melbourne Regional Landfill.

Since inception, production of methane gas at the site has grown in volume and if it outstrips demand from their gensets, the excess is flared. Traditionally, those landfill gases were burned with above-ground flares, but back in 2005 (when still under ownership by Boral), EPSA were engaged to support the site to utilise the gases to power their engines and produce electricity. A Cat® G3516 was supplied with subsequent engines following in 2006, 2008 and 2010.

A further contract was executed with Cleanaway in October 2016 for the supply and installation of an additional four G3516 gensets and the progressive build and commission of an additional plant, will take the total site output to 9MW – enough power for approximately 3,000 homes. This includes supplying, installing and commissioning gensets with acoustic canopies, cooling systems, control systems, transformers, gas treatment skids and various ancillary components to complete an operation system. Once the upgrade is complete the facility will generate enough power for approximately 8,000 homes.



The LMS effect

LMS is a specialist landfill gas recovery and power generation company that pioneered the collection and conversion of landfill gas to energy in Australia back in 1982.

Through the ensuing years LMS has developed extensive proprietary technology and project development experience in landfill gas and energy infrastructure projects throughout Australia, Malaysia, China, Korea, North America, United Kingdom and Europe.

In Australia, LMS are in partnership with over 40 landfill sites, of which there are currently 21 gas recovery sites where the landfill gas is used in internal combustion engines to produce renewable energy and other waste heat bi-products, while additional sites will be developed in the future for the production and sale of green electricity.

LMS sites are currently producing over 390,000 megawatt hours of export power per annum, providing enough power for thousands of homes – making a valuable contribution to the community through both renewable energy production and measurable carbon emissions avoidance.

LMS currently operate over 30 Cat® generator sets at their Australian sites, ranging in size from the 3412 series through to the 3508, 3512, 3516 and culminating in the 3520 series – the first to operate on landfill gas fuel in Australia.

Sunshine and waste in South Australia

Joule Energy is a wholly-owned subsidiary of LMS Energy delivering over 35 years of landfill gas, renewable energy generation and carbon abatement experience. Its core focus is on developing solar power generation systems, both on and adjacent to landfills across Australia.

With little utility once capped due to issues of land settlement and landfill gas, landfills and adjacent zones are ideal for solar development because they provide an economically-viable reuse for sites that may have significant clean-up costs and little potential for commercial or residential redevelopment.

With a successful track record for designing and implementing seamlessly cohabiting landfill gas and solar power systems, Joule is an industry leader in this now emerging field and engaged EPSA in 2017 to support them in their partnership with Northern Adelaide Waste Management Authority (NAWMA) on an innovative first-of-its-kind project to combine solar and methane gas in an energy production farm.

EPSA provided a turnkey solution for the 1.15MW PV solar plant providing engineering, design, construction and commissioning – 11,040 Cat® PV solar modules are mounted on fixed axis steel frames that contour the challenging terrain of the Northern Adelaide foothills.

- » The collective electricity generated from both the landfill gas and solar sources is expected to be over 11,000 megawatt hours per annum of renewable energy, enough to power more than 1,800 homes in South Australia 24/7.
- » The plant is utilising the buffer zone of the Uleybury Landfill site as a solar farm.
- » It channels energy from 11,000 solar PV panels and methane gas from decomposed garbage through shared grid infrastructure which is exported to the grid.



Driving into the future with LMS

LMS Chairman John Falzon says a common criticism of electric vehicles is that electricity is only as “green” as its source, which may be from coal-fired power stations or natural gas power plants.

“The obvious clean alternative is residential solar systems, but a little closer to home is the renewable energy sector of landfill gas power generation. As a leader in this field, we predominately operate Cat® 3516 engines to effectively convert greenhouse gases produced by landfill waste into usable energy in the form of electricity.

“Currently, generated power is exported to the grid, but using it to power passenger vehicles is an interesting thought to pursue,” adds John.

In October 2015, John and his team tested their theory on the Tesla Model-S P85D, which is 100 per cent powered by electricity. It boasted a range of 442 kilometres on a single charge. They found that their Hallam Road Power Station in Victoria produced enough landfill waste energy to run 16,000 Teslas on the road indefinitely.

Adds John: “In fact, one Cat® 3516 engine alone could charge 58 Teslas to full capacity over 4.5 hours at the same time.

“The Eastern Creek Power Station in New South Wales

is one of our larger stations and is equipped with seven of these engines, which would allow for 406 Teslas to be charged at any one time. The opportunities are simply incredible. It is yesterday’s waste powering the cars of tomorrow, today!”

By destroying and reprocessing landfill gas, LMS reduces harmful greenhouse gas emissions and provides a local renewable energy source for the community. As one of the few companies globally to offer a complete, in-house service for energy recovery, they are instrumental in providing ongoing environmental benefits for the community and higher returns for clients.

LMS is the number one provider of Large Scale Renewable Energy Certificates from landfill gas in Australia. LMS projects currently generate over 390,000 MW hours of base-load renewable electricity annually across the country. In addition, LMS abates approximately 3,000,000 tonnes (CO₂e) of carbon each year from its flaring and renewable energy facilities.

Gensets can turn waste into economically-viable electricity

Landfill gas is a cost-effective and reliable renewable base-load power source.

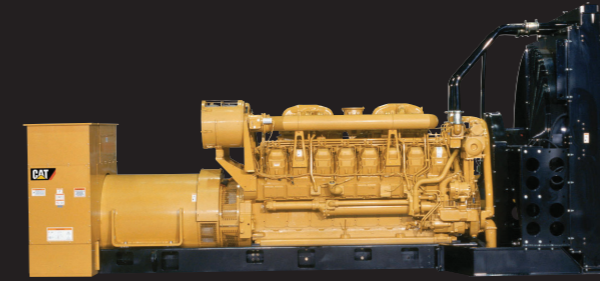
Caterpillar® can help you turn it into a renewable fuel by providing gas-fuelled engine-generators that can produce electric power from landfill gas.

With a big focus on renewable energy and reducing carbon emissions, landfill gas-to-energy projects are fast gaining momentum by using generators to turn waste into economically viable electricity – making landfill gas-to-energy power systems an important and growing application within the world's power generation mix for the collection, process and treatment of this gas for use in generating electricity.



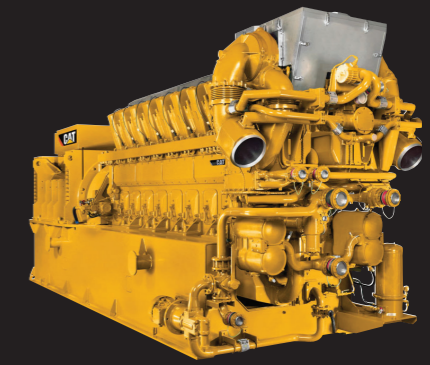
THINK CAT® G3516 specifically designed for landfill gas

To be economically viable, landfill gas energy must produce electrical energy at a market competitive price and the Cat® G3516 delivers with the right mix of longevity and low maintenance operation. It maximises output and engine life simultaneously and is a traditional lean burn spark ignited engine that operates similarly to many vehicles.



THINK CAT® CG RANGE for a smarter energy solution

The Cat® CG range is designed for maximum efficiency in extended-duty distributed generation and cogeneration applications. Already operating in 5,800 installations worldwide, the range uses the very latest gas engine technology with electrical outputs from 400kWe to 4,300kWe. The CG sets can operate on gases of varying quality, including natural gas, biogases such as landfill, digester and sewerage gas, coke gas and coal mine methane.



THINK CAT® K-SERIES LANDFILL COMPACTORS lowering your operating costs

Cat® Landfill Compactors are designed with durability built in for maximum availability through multiple life cycles. With optimised performance and simplified serviceability, they allow more efficient and safe operation. Complementary Cat® Compaction Control provides real time 3D pass mapping guidance to the cab, helps eliminate voids, optimises cell space, documents results and provides detailed compaction analysis.



THINK CAT® FINANCE landfill gas-to-energy and biogas project solutions

Cat® Finance understands how to put capital to work in any regulatory environment with decades of experience developing unique financing packages for landfill developers, owners and managers, including total project financing; and also support biogas projects large and small—from wastewater treatment plants to agricultural and industrial processing facilities. They streamline the process to be up and running fast.



Choose EPSA and the global reputation of Caterpillar® to experience a superior investment and reliable performance.

There are thousands of Cat® generators providing prime power, standby or emergency support in commercial and residential operations across Australia provided by Energy Power Systems Australia (EPSA) – the exclusive Cat® dealer in Australia.

Caterpillar® is renowned for reliability, safety and dependability with Cat® power systems boasting a proven lowest total cost of ownership and highest return on investment. EPSA has significant experience in the planning and construction of gas and diesel-powered generation sites and access to world-leading generator technology and equipment.

EPSA has a wide range of reliable Cat® gas power solutions made to run on your most abundant gas sources with fuel flexible options engineered for high efficiency, low life cycle costs and meet most global emissions specifications.

Ranging from 20 to 9700 ekW with customisable options to match all power needs and tailored designs for landfill gas, natural gas, biogas, coal gas, and alternative fuels; EPSA is your complete Cat® gas solutions partner. Experience EPSA's world-class technical knowledge and engineering expertise and benefit from over 100 Cat® Dealer Partners for service and support across Australia.



GLOBAL COVERAGE, LOCAL SUPPORT.

For new and used engine sales, rental and renewable energy solutions call Energy Power Systems Australia.

FREECALL 1800 800 441
energypower.com.au
epsa@energypower.com.au



©2018 Caterpillar. All Rights Reserved. CAT, CATERPILLAR, BUILT FOR IT, their respective logos, "Caterpillar Yellow", the "Power Edge", trade dress as well as corporate and product identity used herein, are trademarks of Caterpillar and may not be used without permission.

**Energy Power
Systems**

