

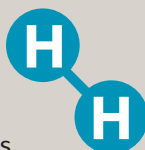
# INDUSTRIES

The Middle Arm Precinct aims to capitalise on the Territory's strategic location and world-class solar and energy resources, and is designed to attract industries reflective of the Territory's future economy. These industries may include low emission hydrocarbons (LNG, methanol, ammonia, urea and ethylene) and hydrogen which are explained in this fact sheet. The precinct also aims to attract critical minerals processing and advanced manufacturing. For more information on the project visit [middlearmprecinct.nt.gov.au](http://middlearmprecinct.nt.gov.au)

## Hydrogen

### What is it?

Hydrogen is the simplest and lightest element in the universe. In standard conditions hydrogen is a colourless, odorless, non-toxic gas.



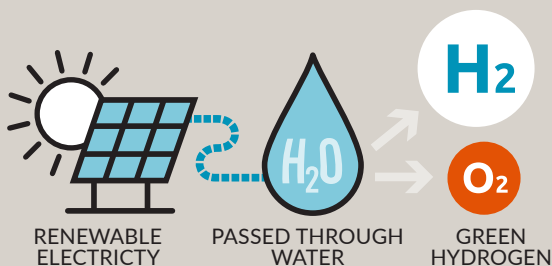
### What is it used for?

- zero-emissions fuel for transport
- power source for high temperature industries
- inputs for fertiliser
- energy storage for large batteries.

### How is it made?

Blue hydrogen is made from energy sources such as natural gas with the inclusion of carbon capture facilities.

Green hydrogen is made by passing renewable electricity such as solar power through water.



Both Hyundai and Toyota presently make hydrogen cars

## HYDROGEN

Hydrogen has long been called the fuel of the future.<sup>1</sup> When hydrogen is used to produce energy, only water is released into the atmosphere. Virtually no greenhouse gas emissions are emitted.

The Middle Arm Precinct masterplan will be designed to allow production of both blue and green hydrogen.

At the precinct, when natural gas is used in the production of hydrogen, blue hydrogen could be achieved by capturing the waste CO<sub>2</sub> and storing it in geological storage.

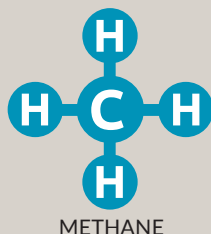
Green hydrogen could be produced multiple ways at the precinct. Water is planned to be sourced from the Adelaide River Off-stream Water Storage project and Manton Dam Return to Service. Water may also be sourced via a desalination plant if required. Electricity could be supplied from solar farms.

1. Mike Scott, Forbes

## Liquefied natural gas (LNG)

### What is it?

LNG is natural gas which has been converted into liquid for easier storage and transportation via truck or ship.



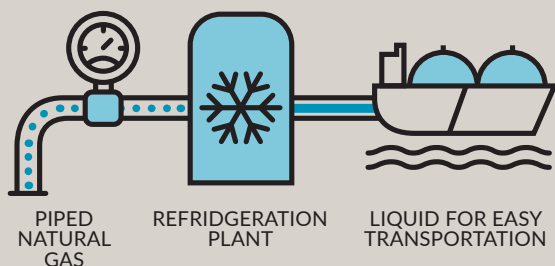
Natural gas is primarily methane with small amounts of ethane and other light gases.

### What is it used for?

LNG is used for domestic and commercial cooking and heating, low emissions electricity generation and transport.

### How is it made?

Natural gas is piped to a plant where it is cooled to  $-162^{\circ}\text{C}$ , changing it from a gas into a liquid.



Manufacturing giants like Japan and Korea rely on Australian LNG to power the production of items we all use such as our cars, whitegoods and electronics.

## LIQUEFIED NATURAL GAS

Liquefying natural gas is as simple as cooling it. The process is simple and transportation is very low risk.

Liquefied natural gas (LNG) plays a significant role as an energy source worldwide. Commercial uses for natural gas include heating, generating electricity, manufacturing products like fertilisers, paints and medicines, and fueling transport vehicles.

Gas supports renewable electricity generation by providing electricity network stabilisation to balance fluctuations from electricity generated by renewable sources such as solar panels and wind turbines.

Australia was the world's largest LNG exporter in 2021, shipping 80.9 million tonnes, up 3.7 per cent from 2020.<sup>1</sup>

Territory LNG exports supply over 10 per cent of Japan's annual gas imports.<sup>2</sup> The natural gas industry contributes \$4.1 billion a year in local economic activity and contributed more than 15 per cent to the NT's gross state product.<sup>3</sup>

1. EnergyQuest <https://www.upstreamonline.com/>

2. <https://cmc.nt.gov.au/advancing-industry/northern-territory-gas-strategy>

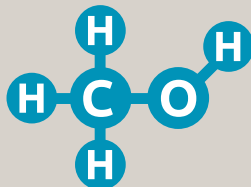
3. Gas Energy Australia, *Business Review NT News*

Left: Ichthys LNG plant, Darwin

## Methanol

### What is it?

Methanol is a simple building block base used to make everyday household items. It's an alcoholic chemical that appears naturally in the environment.

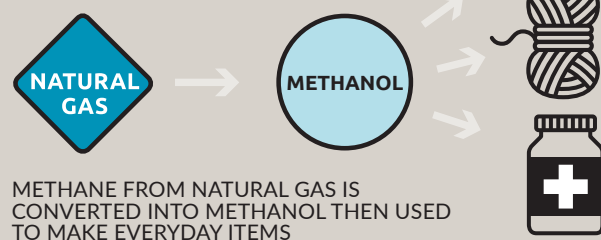


### What is it used for?

- low emissions biodegradable fuel
- textiles and paints
- high performance plastics
- pharmaceuticals.

### How is it made?

Methanol is often made from methane, the most common chemical found in natural gas. Methanol can also be made from waste products like landfill gas, agriculture and timber waste, solid municipal waste and even power plant emissions and carbon dioxide from the atmosphere.



METHANE FROM NATURAL GAS IS CONVERTED INTO METHANOL THEN USED TO MAKE EVERYDAY ITEMS



Methanol can be used to manufacture textiles

### METHANOL

Methanol is used to make a wide variety of useful materials such as fuels, glues, plastics, solvents and antifreeze. As a solvent it is used in the manufacturing of important pharmaceutical ingredients.

Methanol is also used in cleaning products, car parts, agriculture and construction materials.

It's a biodegradable fuel that can substitute or blend into existing fuel for the marine, automotive and electricity sectors and is an emerging renewable energy resource.

As an automotive fuel, methanol can reduce emissions of carbon monoxide, hydrocarbon and nitrogen oxides, compared to conventional petroleum.<sup>1</sup> Performance is comparable or better, especially at high loads. Methanol can be a starting point for producing very low emissions diesel fuel.

Methanol is a highly effective hydrogen carrier, packing almost six times more hydrogen volume density compared to compressed hydrogen itself.<sup>2</sup> Methanol can be transported and stored in liquid form then converted to hydrogen at the point of use.

1. Methanol white paper US Department of Energy

2. Methanol Institute <https://www.methanol.org/fuel-cells/>

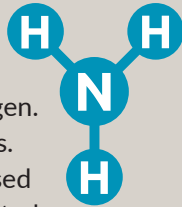


Left: Methanol distillation refinery

## Ammonia

### What is it?

Ammonia is a simple chemical made from hydrogen and nitrogen. In standard conditions it is a gas. When cooled it can be condensed into a liquid and safely transported.

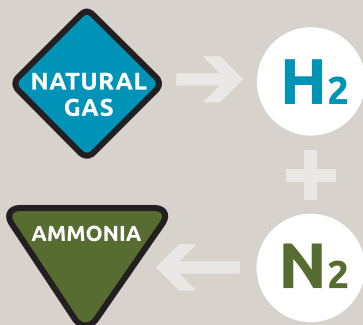


### What is it used for?

- fertiliser
- pharmaceuticals
- cleaning products
- refrigerant
- carbon free fuel for engines.

### How is it made?

Ammonia is made by reducing natural gas molecules to carbon and hydrogen. The hydrogen is then purified and combined with nitrogen to produce ammonia.



NATURAL GAS IS CONVERTED INTO HYDROGEN THEN COMINED WITH NITOGEN TO MAKE AMMONIA



Ammonium nitrate fertiliser helps feed the world

## AMMONIA

Ammonia is used to produce ammonium nitrate fertiliser, an essential nutrient for growing plants, crops and lawns. Around 80 per cent of ammonia is currently used for fertilisers.<sup>1</sup>

Future demand for ammonia is anticipated to shift and be expanded into clean fuels.<sup>2</sup> Ammonia can be used as a fuel in engines and gas turbines for shipping, aviation and power generation.

Ammonia is an efficient carrier of hydrogen. It has a volume density almost three times higher than compressed hydrogen itself.

There are also opportunities for green renewable ammonia. This can be made using renewable energy to turn water into hydrogen which is combined with nitrogen from the air.

1. ACS Energy Lett. 2021, 6, 12, 4390–4394 Publication Date: November 15, 2021 <https://doi.org/10.1021/acseenergylett.1c02189> Copyright © 2021 American Chemical Society

2. IEA (2020), Ammonia – the CO<sub>2</sub>-free fuel of the future?, IEA, Paris <https://www.iea.org/articles/ammonia-the-co2-free-fuel-of-the-future>, License: CC BY 4.0s

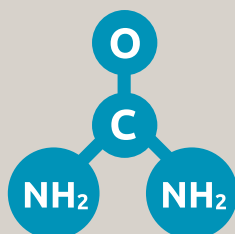
3. Robert F. Service Science <https://www.science.org>

Left: Production of ammonium nitrate

## Urea

### What is it?

Urea is widely used in fertilisers as a source of nitrogen and is an important raw material for the chemical industry. In standard conditions it is a solid.

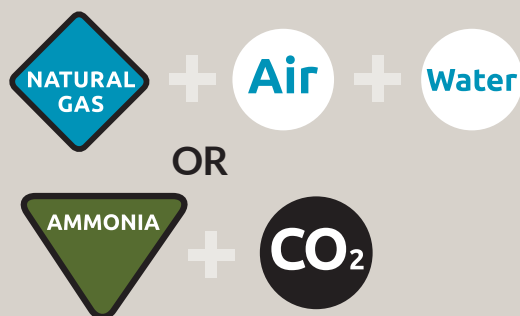


### What is it used for?

- fertiliser
- resins and glue
- fuel additive AdBlue which reduces harmful diesel exhaust
- medical and cosmetics products
- fire extinguishers.

### How is it made?

Urea can be made from natural gas or renewable green ammonia and carbon dioxide.



NATURAL GAS, ATMOSPHERIC NITROGEN AND WATER ARE REACTED TOGETHER TO PRODUCE UREA



Urea is mostly used in agriculture

## UREA

Urea is a safe and useful compound.<sup>1,2</sup> It is a molecule that is produced naturally by protein metabolism and is the main nitrogen-containing substance in the urine of mammals.

More than 90 per cent of urea production goes into agriculture.<sup>2</sup> Urea has a high nitrogen content placing it in high demand as the primary ingredient for fertiliser. Australia imports more than 90 per cent of the urea it requires annually.<sup>3</sup>

Within the precinct, urea has the opportunity to be made using carbon dioxide waste from other industries. This process is the utilisation component of carbon capture, utilisation and storage.

1. Globally Harmonized System of Classification and Labeling of Chemicals
2. American Chemical Society, Molecule of the week archive
3. Australian Government media release 2 February 2022

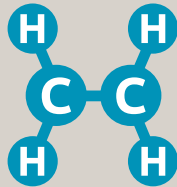


Left: Urea fertilizer in jumbo-bags waiting for shipment

## Ethylene

### What is it?

Ethylene is a colourless flammable gas. It is commonly made from the ethane found in natural gas.



### What is it used for?

- plastic packaging
- rubber tyres and footwear
- fruit ripening
- detergents
- automotive antifreeze
- synthetic lubricants
- welding gas.

### How is it made?

Ethylene is made by steam cracking ethane from natural gas, where natural gas and water are heated together.



ETHANE FROM NATURAL GAS AND WATER ARE HEATED TOGETHER TO CREATE ETHYLENE



Agriculture uses ethylene widely to support plant growth and ripening.

## ETHYLENE

Ethylene forms part of many important products in everyday life. This includes plastic materials used in bike helmets, airbags in cars and packaging for transporting and preserving food. It is also used for electronic components in computers, phones and microwaves. In construction ethylene forms part of paints, linings, adhesives, glues and insulation.

Ethylene is a major natural plant hormone that influences diverse processes in a plant's life cycle.<sup>1</sup> These include seed germination, shoot and root growth, flowering, sex determination, dropping of leaves and ripening of fruits.

Plant responses to ethylene include flowering, color change and fruit ripening to reduce damage and waste. Ethylene is widely used to support freshness in horticulture.

1. Chang *BMC Biology* (2016)



Left: Ethylene plant Above: High density polyethylene pipes

## Carbon capture, utilisation and storage

### WHAT IS CARBON CAPTURE, UTILISATION AND STORAGE?

Carbon capture, utilisation and storage (CCUS) is a proven process that captures carbon dioxide emissions, preventing entry into the atmosphere. Broadly the process covers the following:

#### Capture:

*Technical process that captures carbon dioxide in a gas or exhaust stream. The techniques of capturing carbon typically use a process requiring a catalyst or membrane to separate the carbon from a mix of other gases.*

#### Utilisation:

*Turning carbon that would otherwise be waste into a feedstock (or input) for another industry or purpose.*

#### Storage:

*Transport for permanent storage underground in stable geological formations (porous underground rock).*

According to the International Energy Agency, carbon capture and storage has an important role to play in the global transition to net zero emissions.

### CARBON CAPTURE, UTILISATION AND STORAGE AT MIDDLE ARM

CCUS is a critical emissions reduction technology supporting clean energy transitions. The proposed hub at Middle Arm will be one of the world's largest facilities of its kind and will enable:

- existing LNG production to continue and grow with a significantly lower carbon footprint
- establishment of new low-emission hydrocarbon and hydrogen based industries.

Once carbon is captured and transported to the proposed hub at the precinct, it will either be stored or used. Storage at the precinct would entail carbon being sent via a pipeline to geological storage outside of Darwin. There will also be opportunity for industries to utilise carbon captured at Middle Arm to produce other valuable products.

An example of carbon being utilised, or reused, is using carbon to make urea, a common fertiliser. Another example is cement manufacturers developing technologies to inject carbon into their manufacturing process. This improves product performance and offsets emissions.

The Northern Territory Government in partnership with the CSIRO, industry and engineering companies are collaborating on a business case to map an accelerated pathway to establishing CCUS at Middle Arm.

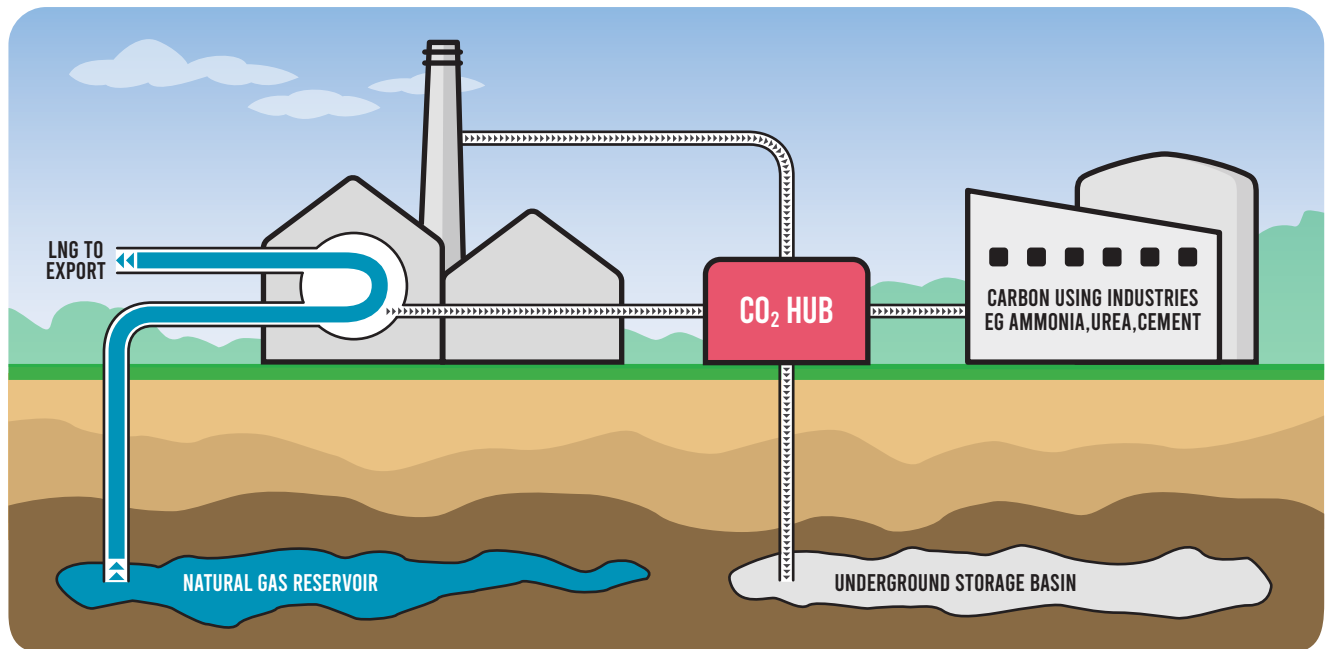
### CURRENT CARBON CAPTURE AND STORAGE PROJECTS AT MIDDLE ARM

Two offshore carbon storage projects are currently proposed or underway at Middle Arm. Both projects will include capturing carbon onsite then transporting it offshore for storage.

INPEX is leading progression of the Bonaparte Carbon Capture, Utilisation and Storage (CCUS) Project in the Petrel Sub-basin. Assessments have indicated the basin has a lifetime storage capacity of 6.48 gigatonnes. This is equivalent to storing Australia's current entire yearly carbon emissions for 16 years in one basin.

Additionally, the proposed Bayu-Undan Santos-led project in the Timor Sea entered front-end engineering and design (FEED) in 2022 with the potential to store up to 10 million tonnes of carbon each year.

## Carbon capture, utilisation and storage cont.



▶▶▶ Natural gas      ▶▶▶▶▶ Carbon dioxide

### SUCCESSFUL CARBON CAPTURE, UTILISATION AND STORAGE PROJECTS AROUND THE WORLD

According to the International Energy Agency, CCUS facilities currently capture almost 45 megatonnes of carbon dioxide globally<sup>1</sup>. There are around 35 commercial facilities applying CCUS to industrial processes, fuel transformation and power generation with around 300 projects in various stages of development.

The Sleipner CCS project was the world's first commercial CO<sub>2</sub> storage project. It commenced in 1996 in response to Norwegian Government policies<sup>2</sup>. CO<sub>2</sub> is removed from the hydrocarbons produced at an offshore platform then pumped back into the ground. By May 2008, the project had successfully stored over 10 million tonnes of CO<sub>2</sub>.<sup>3</sup>

Considerable resources are being dedicated to growing CCUS around the world.

Here in Australia the country's 'leading carbon capture, utilisation and storage research organisation', CO<sub>2</sub>CRC, has more than 19 years of experience safely capturing, storing and monitoring CO<sub>2</sub><sup>4</sup>. As of 2022, the organisation has stored more than 95 000 tonnes of CO<sub>2</sub>. CO<sub>2</sub>CRC owns and operates the Otway International Test Centre, a world class test facility focused on advancing CCUS technology in Australia and around the world.

1 International Energy Agency, <https://www.iea.org/fuels-and-technologies/carbon-capture-utilisation-and-storage>

2 CCS Norway, [https://ccsnorway.com/ambitious-goals/#:~:text=Since%201996-.It%20was%20in%201996%20that%20Statoil%20\(now%20Equinor\)%20commenced%20CO2,the%20Norwegian%20Government%20in%201991](https://ccsnorway.com/ambitious-goals/#:~:text=Since%201996-.It%20was%20in%201996%20that%20Statoil%20(now%20Equinor)%20commenced%20CO2,the%20Norwegian%20Government%20in%201991)

3 Carbon Capture & Sequestration Technologies at MIT, <https://sequestration.mit.edu/tools/projects/sleipner.html>

4 CO<sub>2</sub>CRC, [https://co2crc.com.au/#:~:text=CO<sub>2</sub>CRC%20is%20Australia's%20leading%20carbon,capturing%2C%20storing%20and%20monitoring%20CO<sub>2</sub>](https://co2crc.com.au/#:~:text=CO2CRC%20is%20Australia's%20leading%20carbon,capturing%2C%20storing%20and%20monitoring%20CO2)